CatchmentCARE - Work Package WP T1

Scoping and Targeting Report

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Introduction

The CatchmentCARE Project business case sets out the aim of the project as follows:

"*The aim of the CatchmentCARE project is to establish 3 water quality improvement projects in the Finn, Blackwater and Arney Catchments and install 51 boreholes across the region. This will be achieved through policy actions, catchment actions and community actions which have been selected based on three critical criteria; measurable impact on water quality; transferable beyond the three catchments; and contribute to a project legacy. The actions selected will address water quality issues related to hydromorphology, point and diffuse sources of pollution, farm nutrient management practices, characterisation and monitoring of groundwater quality, lag times in response to the implementation of measures and an economic analysis of the cost of achieving the objectives of the Water Framework Directive in the three catchments*."

The project overall is grounded in the Water Framework Directive (WFD). The WFD takes an integrated approach to the protection, improvement and sustainable management of the water environment. It revolves around a River Basin Management Planning process of action and review to improve water quality and achieve 'good' status in water bodies (rivers, lakes, estuaries and coastal waters, and groundwaters) by 2027.

The CatchmentCARE project commenced in autumn 2017. A key initial work package is that of 'Scoping and Targeting'. Currently available information does not provide the level of detail or spatial resolution required for targeted implementation of actions within sub-catchments at the scale of fields, farms, river reaches, and point source inflows. Targeting actions at this scale will increase the cost-effectiveness of the interventions and is more likely to improve water quality and ultimately water body status. In addition, the scoping study will facilitate the coordination and integration of the different actions (e.g. surface water and groundwater monitoring and the Communications Work Package).

The Scoping & Action Targeting Work Package (WP T1) is comprised of seven actions:

- T1.1 Feasibility of lake remediation via Phosphorus-fixing
- T1.2 Rivers – Prioritizing in-stream works
- T1.3 Rivers – Prioritizing riparian works
- T1.4 Groundwater Programme
- T1.5 Hydrological connectivity & Point Source Pollution: Scoping studies for willow biomass as point and diffuse pollution mitigation actions
- T1.6 Catchment and Farm Scale Nutrient Management Studies
- T1.7 Control of chemical export from land use activities

This 'Scoping and Action Targeting' WP is intended to provide an evidence base for proposed future works based on consistent approaches to data collection and interpretation within the various task areas – hydromorphology, ground water quality, point and diffuse source nutrient enrichment. Given the convergence of some of the actions, the scoping and targeting exercise also allows the potential for synergies among partners in respect of actions to be explored e.g. farm nutrient management practices might be assisted by riparian management actions such as fencing and tree planting; selection of borehole ground water monitoring sites could assist in assessing the success of farm nutrient measures.

It was originally envisaged that the ground work for Scoping and Targeting would be progressed throughout 2018, with final reporting on this Work Package for April 2019. Issues in staff recruitment

etc. meant that not all of the proposed field survey work was completed in 2018. SEUPB granted an extension to the Scoping WP to end July 2019, thereby permitting completion of WFD-compliant surveying of outstanding elements.

This report is a compilation of documentation provided by the individual Project Partners to Inland Fisheries Ireland (IFI), the designated lead on the Scoping and Targeting WP.

The partnership has subsequently contributed to the catchment characterisations which have been included for completeness.

1 CatchmentCARE Project Context

The CatchmentCARE Project aims to support achievement of the objectives of **"Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy"**, more commonly known as the EU Water Framework Directive (WFD). The WFD sets out the environmental objectives which are to be met through the process of river basin planning and implementation of actions prioritised in cyclical River Basin Management Plans. Specific objectives are set out for surface water, groundwater and protected areas.

In summary, the WFD objectives are:-

For Surface Waters:

- To prevent deterioration of the status of surface waters;
- To protect, enhance and restore surface waters, with the aim of achieving good status (ecological and chemical) for all water bodies;
- To protect and enhance heavily modified water bodies and artificial water bodies in order to achieve good ecological potential and good chemical status for those water bodies;
- To progressively reduce pollution from priority substances and cease or phase out emissions, discharges and losses of priority hazardous substances into surface waters.

For Groundwater:

- To prevent deterioration of the status of groundwater;
- To protect, enhance and restore all bodies of groundwater and ensure a balance of abstraction and recharge, with the aim of achieving good groundwater status (quantitative and chemical);
- To reverse any significant and sustained upward trends in the concentration of pollutants in groundwater.

For Protected Areas:

- To achieve compliance with objectives and standards under which the individual protected areas have been established.

The WFD has been transposed into national legislation by the Water Environment (Water Framework Directive) Regulations (Northern Ireland) 2017 in Northern Ireland, and by the European Communities (Water Policy) Regulations 2003 (S.I. No. 722 of 2003) in Ireland. These instruments set out River Basin Districts (RBDs) on the island of Ireland. The CatchmentCARE project primarily operates in three cross-border catchments within the North Western and Neagh Bann International RBDs i.e. the Finn, Blackwater and Arney Catchments (Figure 1-1). The groundwater monitoring component of the project additionally encompasses the eligible area as part of the establishment of the cross-border monitoring network.

The WFD establishes a framework for the protection of all waters including rivers, lakes, estuaries, coastal waters and groundwater, and their dependent wildlife/habitats. The directive requires objectives to be set for waters in River Basin Management Plans and is linked to a number of other EU directives in seeking to achieve those objectives. The key objectives are that all waters will achieve 'good status' as a minimum and, where 'high' and 'good status' already exist, that they will be retained.

Extensive monitoring programmes by a number of agencies are in place to assess the ecological and chemical status of our water resource and determine whether WFD objectives are being met. The monitoring programmes are based on water bodies. These are the smallest coherent geographical

sub-unit in the river basin to which the environmental objectives of the WFD must apply. Hence, the main purpose of identifying “water bodies” is to enable the status to be accurately described and compared to environmental objectives.

Ecological status of surface waters is based on a number of different quality elements. These include biological elements and supporting physico-chemical elements, and in the case of assigning 'high status', it also includes hydromorphological quality.

For rivers the biological elements to be considered are aquatic flora, benthic invertebrate fauna and fish populations. In the case of lakes and transitional waters phytoplankton is an additional element to those above for rivers.

Physico-chemical elements refer to attributes such as water acidity, temperature, transparency, dissolved oxygen levels, salinity and nutrient levels. They also include specific pollutants that are listed in the Surface Water Regulations (Ireland, 2009), and The Water Environment (Water Framework Directive) Regulations (Northern Ireland 2017).

Hydromorphology refers to water flow, continuity in rivers, river depth and width, river bed and riparian zone physical attributes, and connection to groundwater. In the case of lakes it also includes water retention time and for transitional waters, tidal regime and intertidal zone attributes.

Surface water bodies may be assigned to one of five classes (high, good, moderate, poor or bad). The overall status assigned is determined by the status of the poorest quality element. Status determined at the monitoring station in a water body is assigned to all rivers and streams in that water body. This dictates the scale or resolution of WFD water quality classification. Detailed further investigative monitoring within water body units allows water quality within a water body to be determined accurately.

Groundwater status is based on its quantitative status and its chemical status. Chemical status of groundwater may be affected due to the presence of pollutants such as nutrients, metals, pesticides or organic chemicals above stipulated threshold levels within the groundwater body itself, or in the linked surface water body or groundwater dependent terrestrial ecosystem. Groundwater conductivity and indicators of saline intrusion are used in assessing both chemical and quantitative status, as they show over-abstraction such that the use of the groundwater body is impaired. Quantitative depletion of groundwater contributions to rivers and lakes may also result in impact on these surface water systems or on groundwater dependent terrestrial systems (e.g. bogs, fens, dune slacks) and protected areas. Depletion of flows can be indicated by declining groundwater levels.

In ROI Priority Areas for Action were identified for the second cycle River Basin Management Plan 2018 - 2021. These areas were selected based on priorities in the Draft River Basin Management Plan, the evidence from the WFD characterisation process, and the expertise, data and knowledge of public body staff with responsibilities for water and the different pressure types. Following the selection process, the Local Authority Waters Programme (LAWPRO) undertook pubic engagement and feedback sessions on the Areas for Action. The prioritising of catchment areas for action facilitates the targeting of water bodies where evidence suggests they could achieve status improvements during this cycle, and the progression of pilots in sub-catchments with more complex issues that require multidisciplinary and cross-agency approaches.

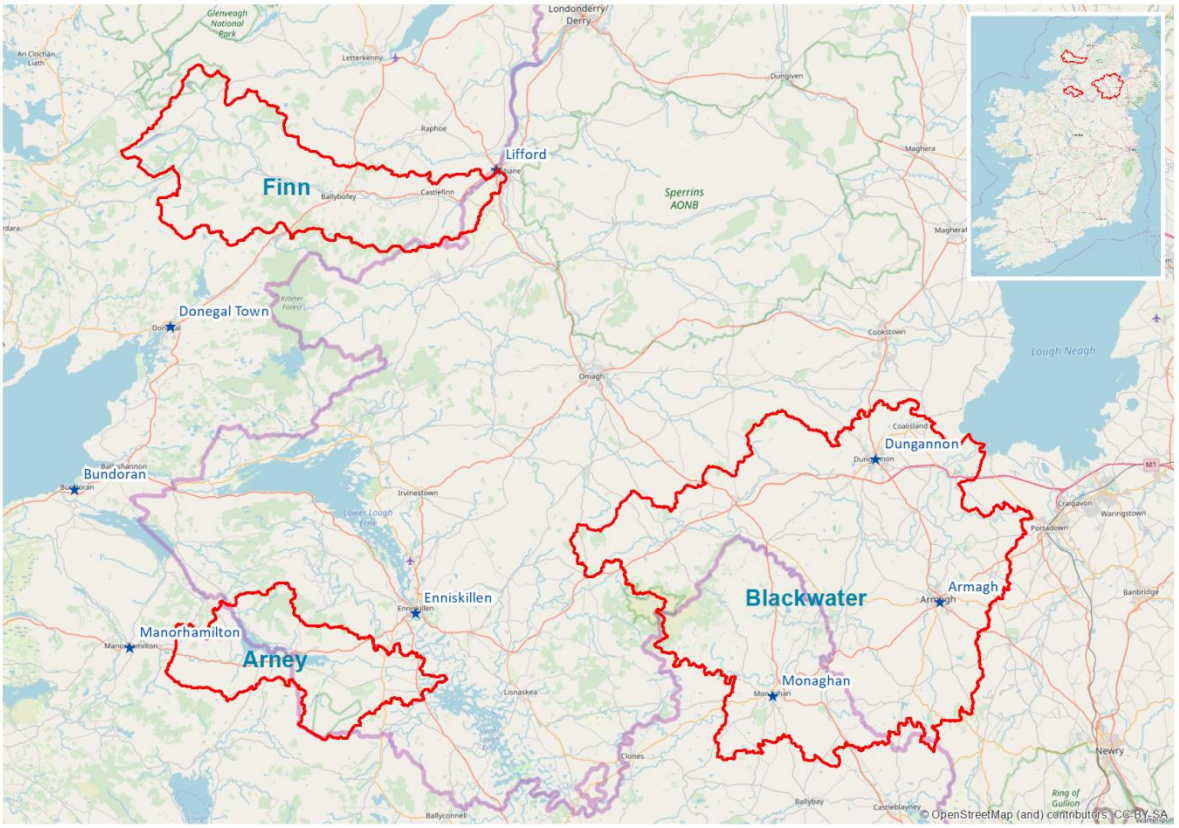

Figure 1-1 Locations of the CatchmentCARE cross-border catchments

The project will undertake a variety of measures in each of these three cross-border catchments. The measures are intended to improve water quality and will support achievement of WFD objectives in these areas. The establishment of the groundwater monitoring network takes place across the wider cross-border area, within the SEUPB eligible area.

2 Catchment Characterisation

Data characterising each of the three selected catchments has been collated to provide descriptions of baseline water quality conditions and pressures operating in each geographic area. The level of detail and the spatial resolution of available data varies in each case. This characterisation process will support and inform further detailed investigations at local level, including identification and prioritisation of work areas.

Water Framework Directive (WFD) catchment datasets have been established for the purposes of surface and ground water monitoring, and water quality management. The catchment dataset is built on clusters of sub-catchments that are in turn derived from river water bodies in a hierarchical tiered arrangement.

2.1 Finn Catchment

The Finn catchment as described here has been defined and delineated in accordance with the WFD catchment boundaries, and is based on the combined GIS datasets developed by authorities in Northern Ireland (NI) and the Republic of Ireland (ROI).

The Finn catchment lies in the North Western River Basin District. It is a natural river catchment within the larger Foyle Catchment. Nine WFD sub-catchments in total have been defined within the Foyle Catchment and four of these together comprise the Finn catchment (Figure 2-1). Details of sub-catchments and waterbodies are discussed in section 2.1.6.

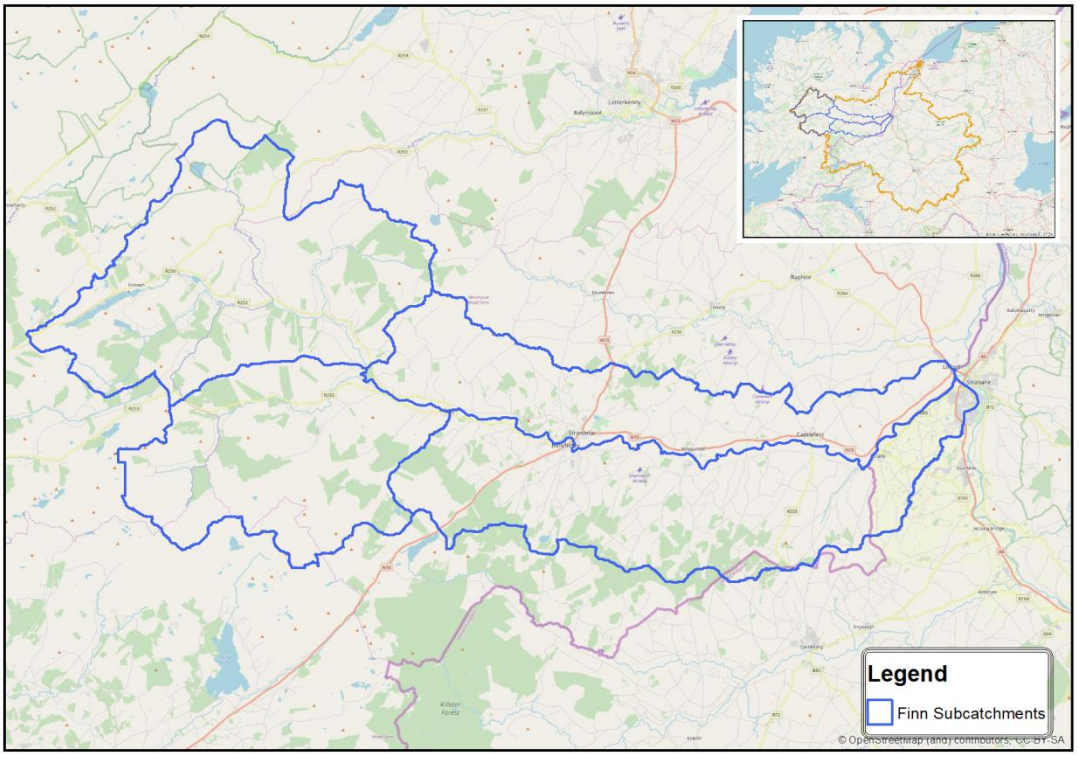

Figure 2-1 Location of the River Finn catchment within the larger Foyle catchment (inset) and the four sub-catchments comprising the Finn catchment

The Finn catchment discharges into, and comprises a significant portion (17% by area) of the larger Foyle catchment. The River Finn rises in the Bluestack Mountains in central County Donegal, Republic of Ireland. It drains a cross border catchment area of 498 km^2. Most of the Finn catchment (478.3 km^2) is in Ireland, with a relatively small portion (19.5 km^2) in Northern Ireland.

The Office of Public Works (OPW) operates a hydrometric station at Ballybofey (Station No. 01043). The upstream catchment size is 313.37 km^2, which is approximately two thirds of the entire Finn catchment. The average daily mean discharge at Ballybofey is 17.4 cubic meters per second and the 95%ile flow is estimated at 1.241m^3/s. The Rivers Agency operates a hydrometric station at Clady Alert (Station No. 201041), but this is level-only due to the fact that this reach of the Finn, even this far inland, is tidal and as such a rating equation cannot be derived to calculate flow volumes.

2.1.1 Landscape

The general topography of the Finn catchment is shown in Figure 2-2. Aghla Mountain stands 593m high above Lough Finn at the head of the catchment. Lough Finn is the biggest lake in the system and lies at 132m altitude. The lake is 4km long but only 400m wide at its widest with an area of approximately 115ha. Surface drainage into the lake comprises a number of mountain rills draining the steep northern slopes of Aghla, and streams draining the hills to the north of the lake, a couple of which have small lakes in their upstream catchments. From Lough Finn the main channel of the river flows in an easterly direction through deeply incised valleys. About 3km downstream of the outfall from Lough Finn, the river flows through Lough Shivnagh, a small lake of about 10ha at 124m altitude. Thence to Ballybofey and Stranorlar, a distance of about 20km, the main channel is joined by a number of significant tributaries.

Stranagoppoge drains the southern slopes of Aghla Mountain and is also fed from Lough Muck (176m altitude and 26ha in extent). It joins the Finn from the southern side just downstream of Lough Shivnagh. The Glashagh River, also draining the southern part of the catchment, joins the Finn a kilometre further downstream.

About half way along the stretch from Lough Finn to Ballybofey a major tributary, the Reelan River, flows into the Finn. The Reelan and its several sub-tributaries drain a significant portion (about 100km^2) of the southern Finn catchment. The steep narrow river valleys in this upper portion of the catchment have a rectilinear field pattern comprised of strips of land extending from the river edge into the upland bog in a ‘rundale’ fashion.

On the north side of the main Finn channel, the Cummirk and the Elatagh rivers drain the higher catchment. The Cummirk River drains a second Lough Muck (205m altitude and 40ha in extent). This Lough Muck, along with Lough Finn and Lough Shivnagh are the only lakes in the Finn catchment included in the Water Framework Directive lakes monitoring programme. There are over twenty lakes of various sizes dispersed throughout the Finn catchment. Many are oligotrophic mountain tarns in the upper catchment.

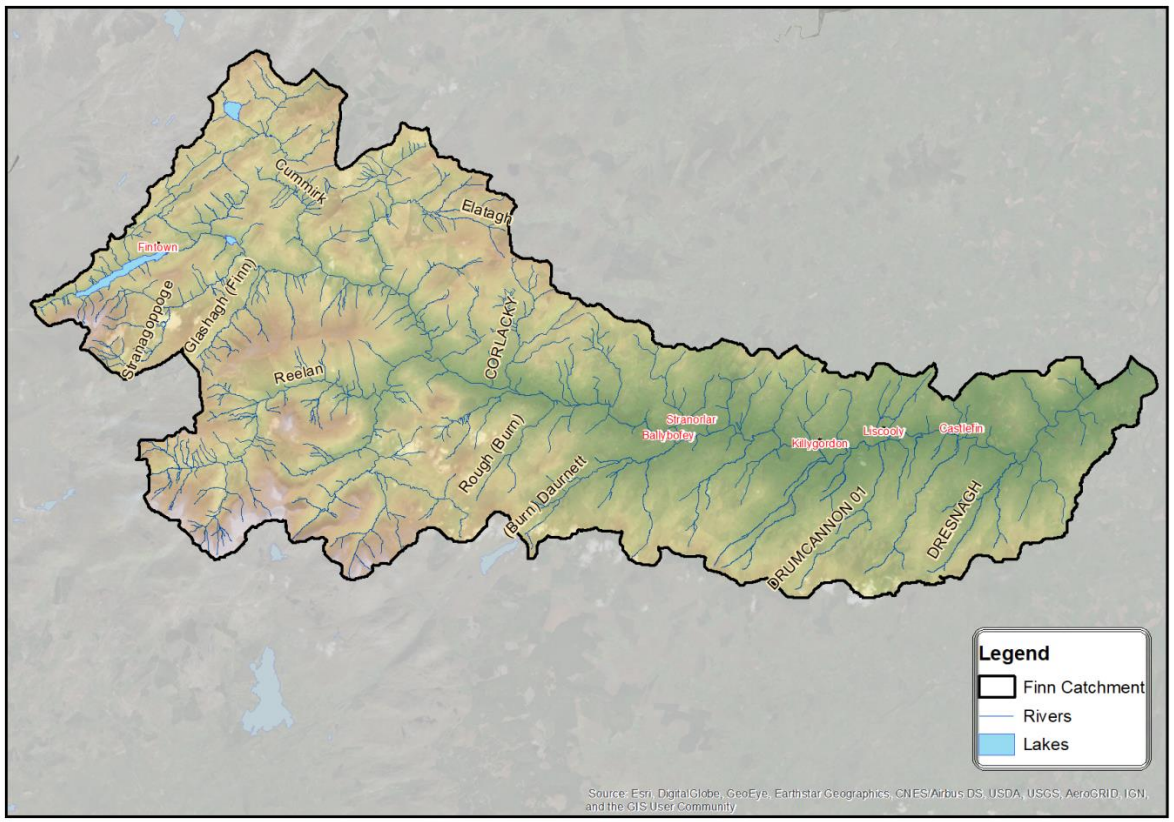

Figure 2-2 River Finn Catchment topography

From its confluence with the Elatagh River, the Finn falls below the 100m contour and the river valley widens and enters the lowland portion of the catchment. A number of smaller tributaries drain this lower section of the catchment notably the Sruthanboy River, Corlacky Burn and Creggan Burn draining the north side of the catchment, and the Rough Burn and Burn Daurnett to the south, the latter two with Lough Sallagh and Lough Trusk in their headwaters respectively.

At Ballybofey-Stranorlar the Finn drops to an altitude of 20m. From this point to its confluence with the Mourne River, approximately 25km away, the river falls to 3 to 4m altitude, passing Killygordon, Castlefinn and Clady on its meandering route. The topography here is gently undulating and fertile agricultural landscape. A number of small tributaries join the main channel along this stretch. The largest of these are on the southern side of the river catchment and include the Killygordon, Drumcannon, Dresnagh and Clady rivers.

At its lower end the Finn joins the Mourne River just downstream of Strabane, and the combined rivers become the tidal Foyle Estuary at this point. The River Finn and its tributaries have a total channel length of approximately 710 km.

2.1.2 Population

The Finn catchment is mostly rural in character and population is largely dispersed. The largest urban centres are in the eastern half of the catchment. These include Ballybofey and Stranorlar with a combined population of 4,852 in the most recent 2016 census, and the smaller towns of Castlefinn, Killygordon and Clady which had populations of 705, 614 and 423 respectively in the most recent censuses. The town of Strabane, with a population of 18,000, lies at the discharge point of the Finn to the Mourne River. Only a portion of Strabane lies within the Finn catchment proper, comprising

about 5,000 people. Any pressures associated with this urban centre are more properly considered with downstream waterbodies and catchments. As such the census figures are not included in the population estimates here.

Population density in the western upland portion of the catchment is very low at less than 10/km^2. The rural part of the eastern catchment is slightly higher, but still low, with a density of less than 50/km^2. Population density is illustrated in Figure 2-3.

The total population of the Finn catchment based on small area census geographies in the All-island Atlas is approximately 16,000. Population can only be approximated since small areas delineated in the Atlas do not coincide exactly with catchment boundaries. Therefore about two thirds of the population reside in dispersed one-off rural housing outside of sewered municipal areas.

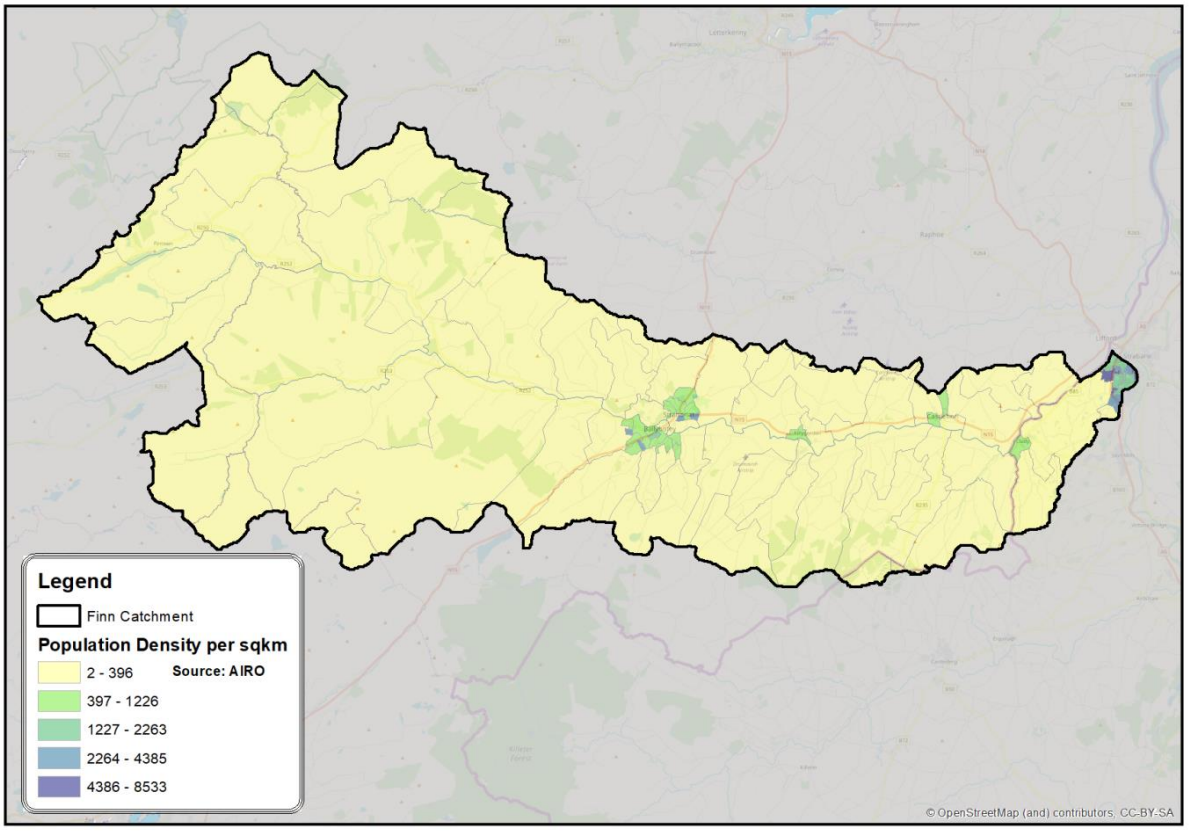

Figure 2-3 Population density in the River Finn Catchment

2.1.3 Catchment Geology, Hydrogeology and Soils

Bedrock Geology

The rocks in this part of Donegal are old, and have been significantly deformed, resulting in a large number of approximately north-east to south-west faults (e.g. Belshade Fault). There are also a number of large-scale folds, resulting in the rocks layers dipping steeply in all directions. As a result, the bedrock geology of the area is complex (Figure 2-4), with a series of different rock units (formations) occurring in broadly parallel bands across the catchment.

The main Donegal and Barnesmore granites underlie the north-west and south-west edges of the catchment respectively. The granite peaks of Croaghnageer, Croaghanirwore and Croaghbarnes at 499m to 571m are dominant features of the upper catchment. Apart from these Silurian-Devonian age granites, rock types in the Finn catchment are predominantly Precambrian metamorphic rocks

from the Dalradian Supergroup. These Dalradian rocks are mainly composed of 'quartzite' – recrystallised pure sandstones, 'schists' – metamorphic (altered) rocks that are platy and layered, 'marbles' – altered limestones, and 'psammite' – metamorphic silty sandstones.

Quartzites form the hills overlooking Lough Finn at the head of the catchment, notably in the peaks of Aghla and Scraigs. A band of black graphitic pelitic schist lies between the quartzite hills along the southern shore of the lake. Quartzite occurs again some 10km to the east at Gaugin Mountain which separates the Reelan valley to its north and the Owengarve valley to its south.

Schists, both pelitic (clayey and silty) and psammitic (sandy), are predominant in the upper catchment. Psammites become more dominant moving eastwards down the catchment. Layers of pebbly grit occur throughout the catchment, and both calcitic and dolomitic marble are frequently associated with quartzite and calcareous pelite and psammite.

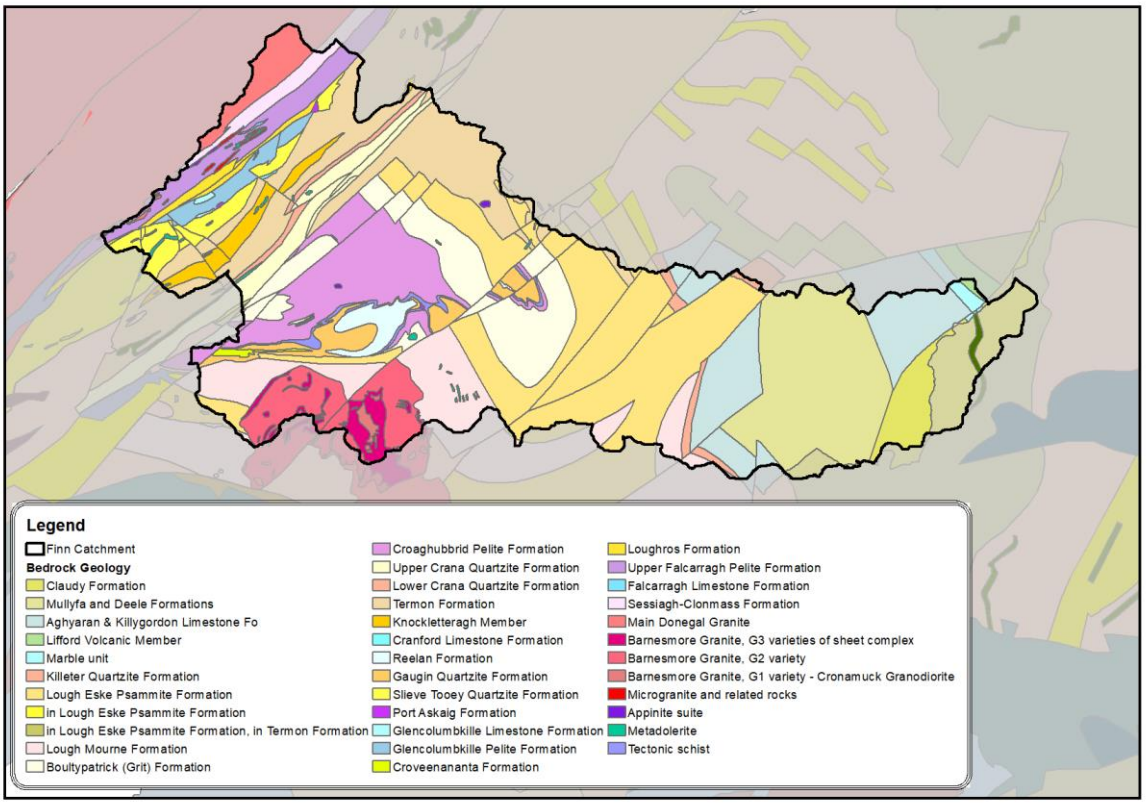

Figure 2-4 Bedrock Geology in the River Finn Catchment (Data source: GSI and BGS/GSNI)

Soils and Subsoil Geology

In the west and southwest of the catchment large areas of exposed outcropping bedrock occur in the quartzite and granite uplands (Figure 2-5). The remaining highland catchment is largely covered by blanket peat. The peat gives way to glacial till ('boulder clay') in the valleys, and is largely absent from the eastern section of the catchment. The glacial till, derived from the underlying metamorphic bedrock, extends over the eastern lowland portion of the catchment. It is generally overlain by gley soils although in some areas the tills are well drained and acid brown earths and brown podzolics may develop (Figure 2-6). Due to the occurrence of marbles and limestone bedrock in the catchment, locally calcareous glacial tills and soils will be present, even if not mapped.

Wide bands of alluvium, left by the flooding of rivers over their floodplains and by the meandering of rivers across their valleys, line the floors of the river valleys. Alluvial deposits along the channels are coarse-grained and gravelly. In a few areas along the alluvial deposits some small pockets of glacio-fluvial gravels occur.

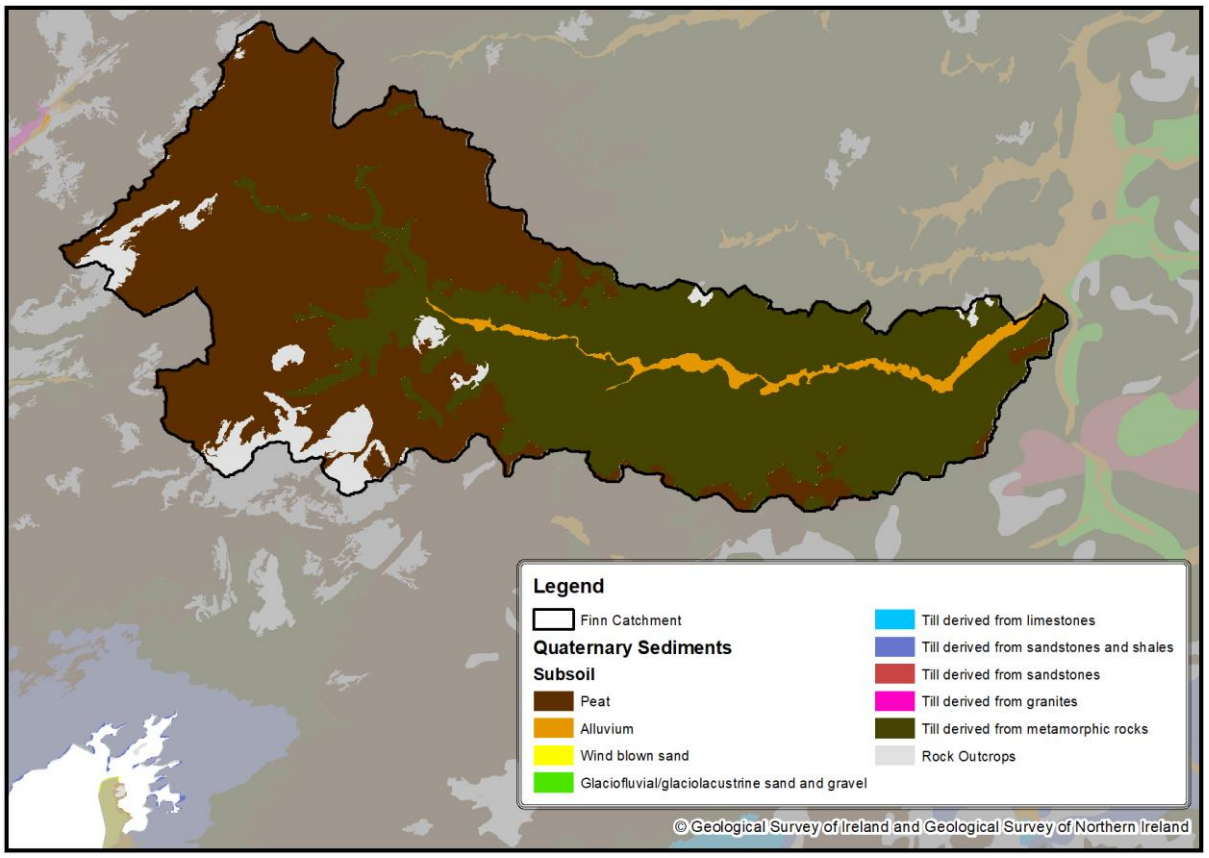

Figure 2-5 Subsoils Geology in the River Finn Catchment (Data source: GSI and GSNI)

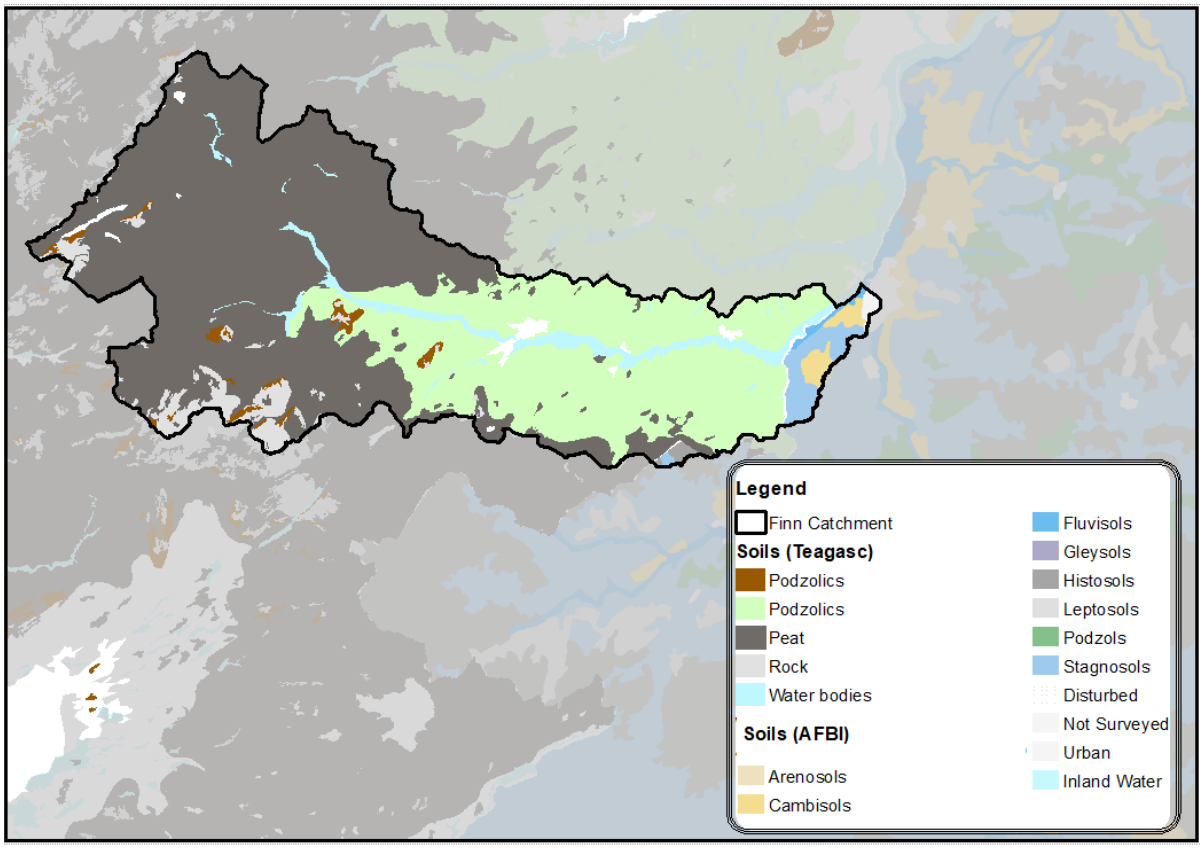

Figure 2-6 Soil Types in the River Finn Catchment (Data Source: Teagasc and AFBI)

Hydrogeology

Groundwater is most at risk where the subsoils are absent or thin. Groundwater that readily and quickly receives water (and contaminants) from the land surface is considered to be more vulnerable than groundwater that receives water (and contaminants) more slowly and consequently in lower quantities. Groundwater vulnerability in the Finn catchment ranges from Extreme to Moderate (Figure 2-7). Areas of Extreme vulnerability coincide with areas of shallow rock, and are mainly found in the areas of higher ground and along ridges in the upper catchment, although there are areas of extreme vulnerability in the lower catchment also. As subsoil thicknesses increase away from the areas of exposed or shallow rock, groundwater vulnerability decreases. In the northwest of the catchment, there are areas of High and Moderate vulnerability. Much of the lower catchment has High groundwater vulnerability.

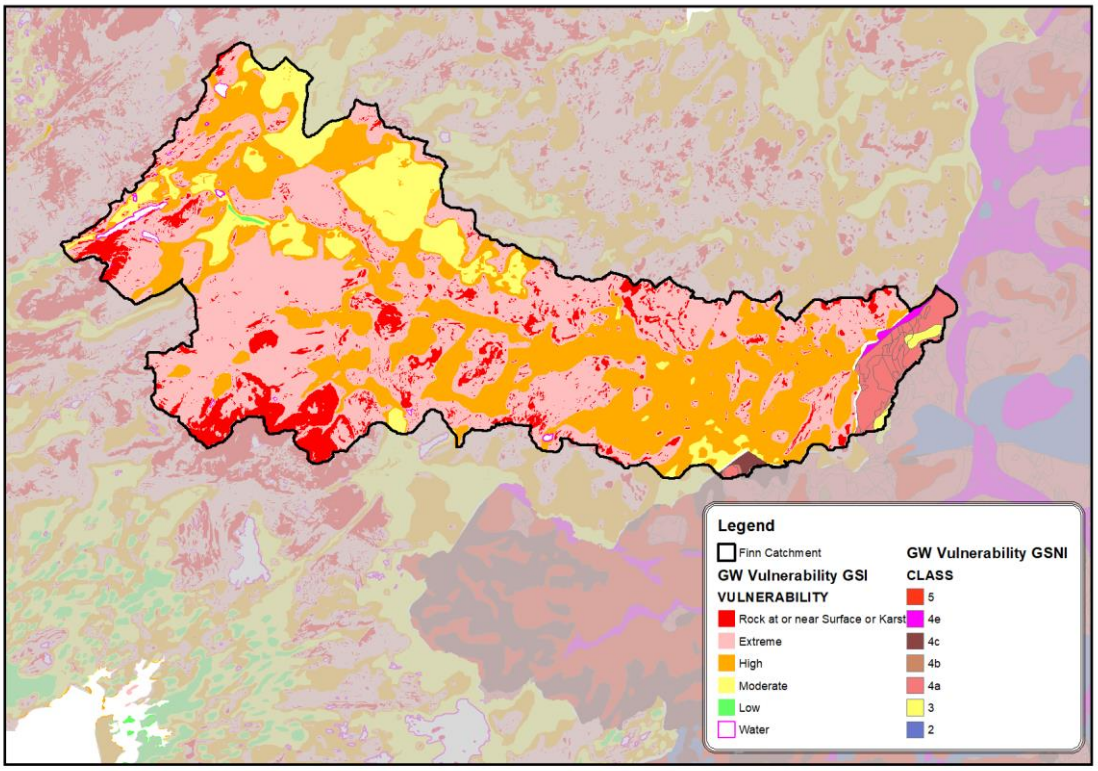

Figure 2-7 Groundwater vulnerability in the River Finn Catchment (Source: GSI and GSNI)

The aquifers in the Finn catchment are all low transmissivity, poorly productive fissured bedrock (Figure 2-8). Aquifer storage is very low. The majority of the catchment is underlain by Poor aquifers that are productive only in local zones (Pl). A small area of marble bedrock in the lower catchment is categorized as a Locally important aquifer that is productive only in local zones (Ll). The finest-grained schist bedrock units are classified as Poor aquifers that are unproductive (Pu). Most of the groundwater flow is likely to be in the uppermost part of the aquifer comprising: a broken and weathered zone typically less than 3m thick and a zone of interconnected fissuring 10- 15m thick. Isolated but generally low-yielding fissures can occur below this.

Groundwater recharge occurs diffusely through the subsoil and rock outcrops, although is limited by any thicker pockets of peat and the limited acceptance capacity of the low permeability bedrock. Therefore, most of the effective rainfall is not expected to become part of the sustainable groundwater resource. Groundwater levels generally within 5m of the ground surface. Shallow groundwater flow paths are likely to be short (30-300m), with groundwater discharging rapidly to the

streams crossing the aquifer, and to small springs and seeps. Typical specific dry weather flows for this rock group across Donegal are low (0.41-1.1 l/s/km^2), indicating that, although groundwater flows into surface water bodies, groundwater-surface water interaction is limited. The exception to this is within the permeable gravelly alluvium lining the river channels.

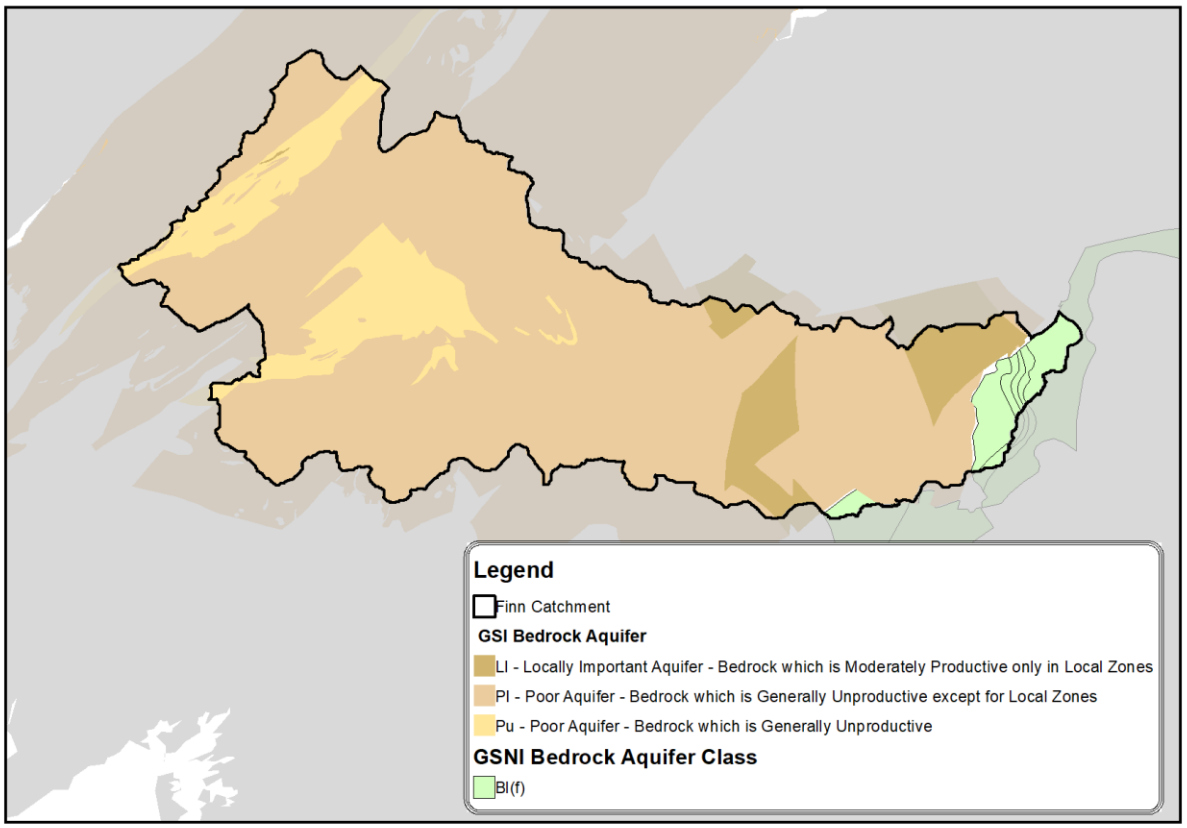

Figure 2-8 Groundwater resources (aquifers) in the River Finn Catchment (Source: GSI and GSNI)

2.1.4 Catchment Land Use

This discussion of land use is based on the Corine Land Cover 2018 data (Figure 2-9).

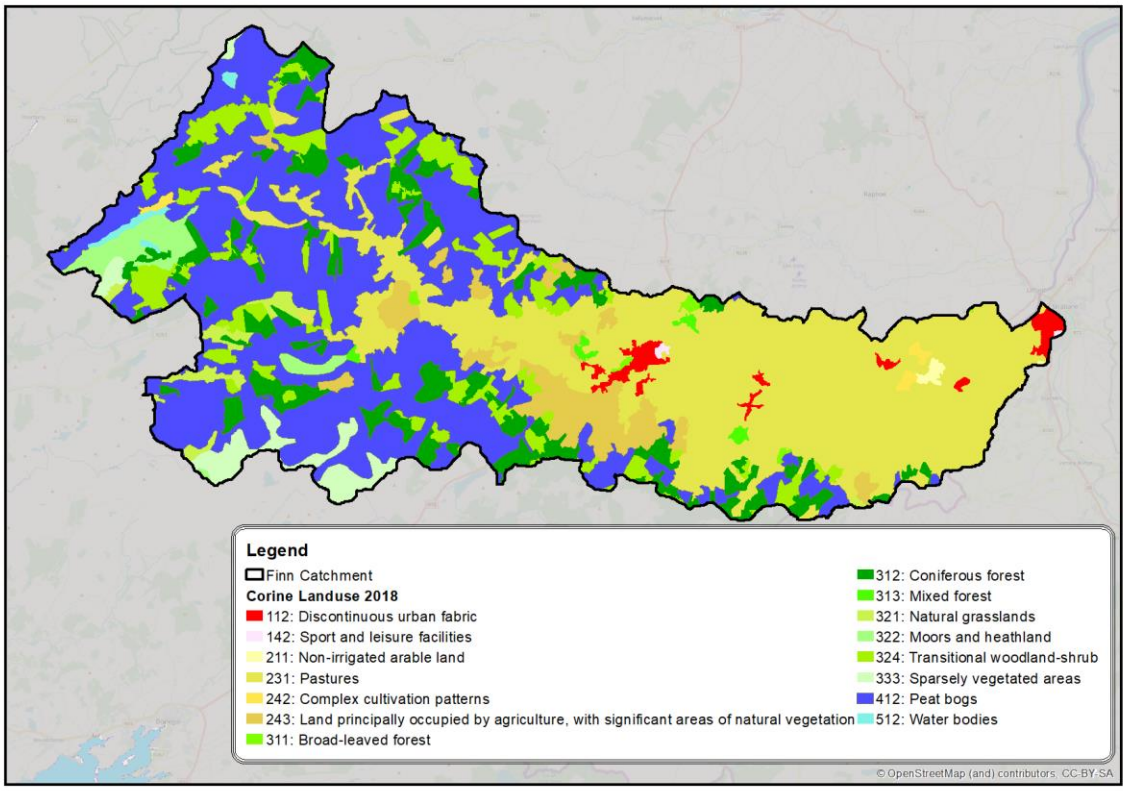

Figure 2-9 River Finn Catchment Land Classifications Map (Data source: CORINE Land Cover 2018, EEA)

Land use is determined largely by the soils and subsoils in the catchment. Some of the very highest catchment areas are bare rock or sparsely vegetated, although some of the drier, better drained mountain slopes support areas of heath and moor, most notably on the slopes of Aghla. However, the predominant feature of the western upland catchment is the extensive blanket bog. Peat harvesting and associated drainage is widespread although relatively intact bog remains in large areas. Commonages are an important feature in many of these areas (Figure 2-10) and sheep grazing is widespread.

There are also some significant areas of natural acid grassland in the upper western catchment, for example on the southern slopes of Aghla and in the Reelan Valley. These grasslands grade into transitional woodland and scrub in many areas. Some mixed and broad leaved forests appear in the lower valleys such as at Drumboe Woods near Ballybofey.

Significant areas of commercial forestry (almost 9,000 ha) have been planted largely in the western upland portion of the catchment. These are mostly coniferous, with sitka spruce being favoured but with lodgepole pine, larch, and Scots pine also planted. Some relatively small areas of hardwood forests also occur consisting mainly of beech, alder, sycamore, oak and ash.

As we move to the valley bottoms and the eastern lowland portion of the catchment, agriculture becomes the dominant landuse. Rough grazing occurs in the transitional areas where significant areas of natural vegetation still occur, but with more productive pastures situated on the alluvial deposits and extensive tills to the east. Much of the grassland is unimproved but improved grassland and silage pastures are also present, particularly east of Ballybofey. The spreading of slurry and fertiliser poses a threat to water quality, particularly as the river is subject to extensive flooding. Some small areas of tillage occur in the east of the catchment.

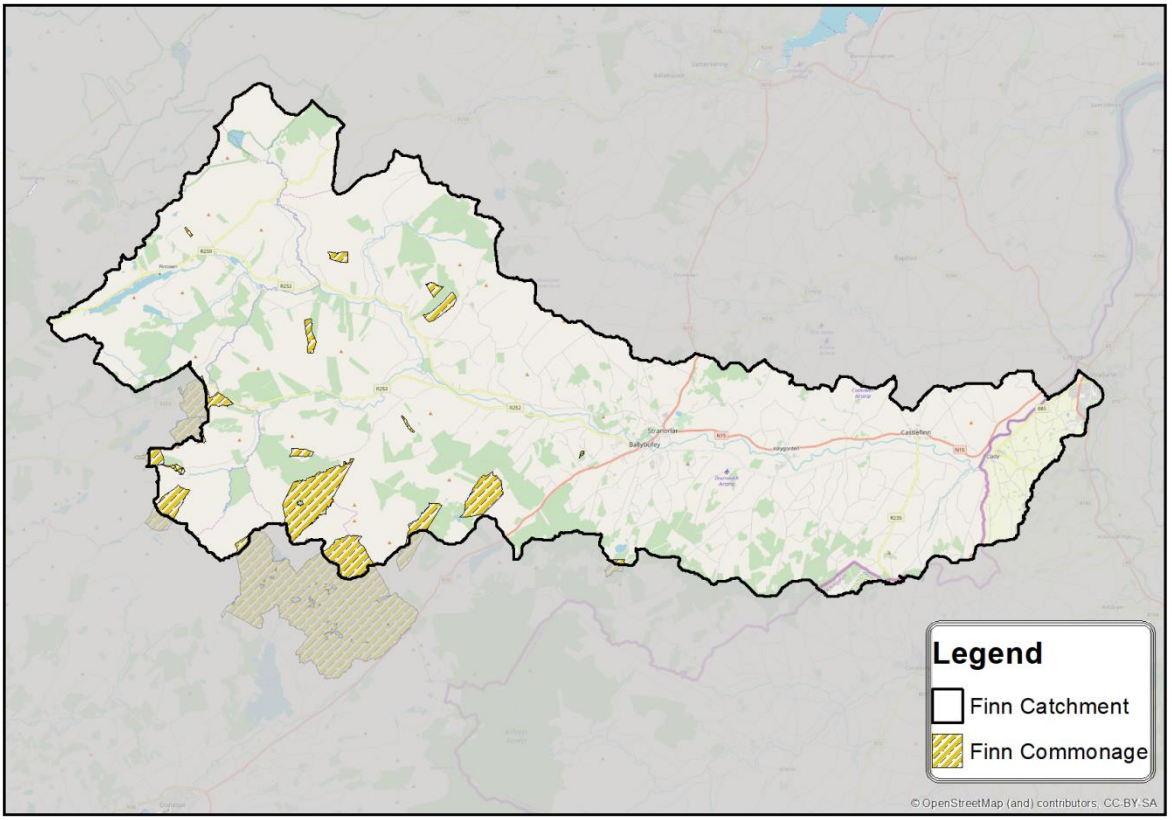

Figure 2-10 Commonage areas in the River Finn Catchment

The proportion of the various land use/land cover classes is illustrated in the pie diagram (Figure 2-11). It shows that peat bogs, followed closely by pastures are the predominant land cover types in the Finn catchment, together comprising 69% of the catchment area.

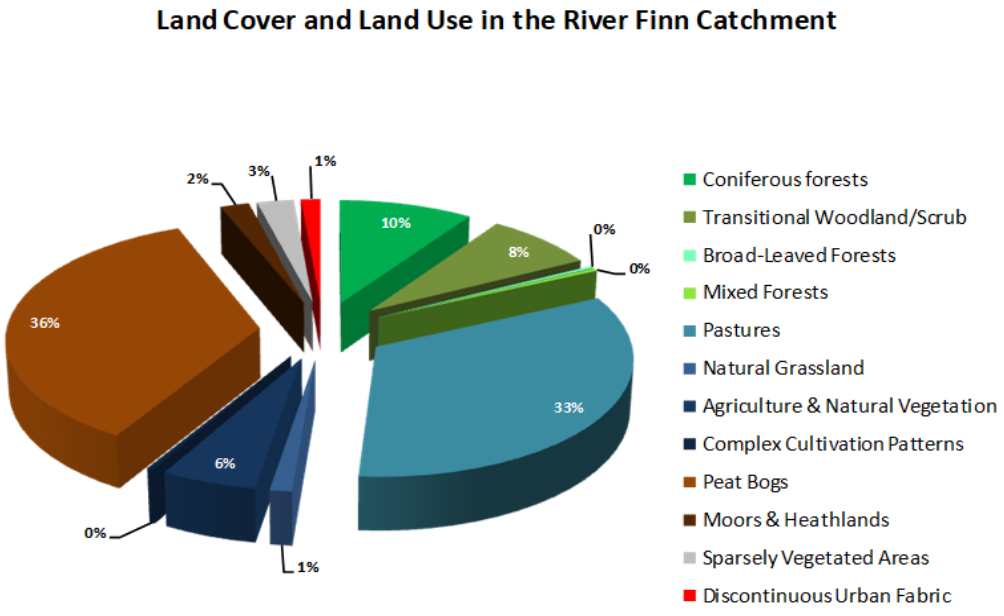

Figure 2-11 Land cover and land use in the River Finn Catchment

2.1.5 Protected Areas

Article 6 of the WFD (2000/60/EC) requires the establishment of a register of all areas lying within each river basin district which have been designated as requiring special protection under specific Community legislation for the protection of their surface water and groundwater or for the conservation of habitats and species directly depending on water. These protected areas are listed in ANNEX IV of the WFD and include:

- areas designated for the abstraction of water intended for human consumption;
- areas designated for the protection of economically significant aquatic species;
- bodies of water designated as recreational waters, including areas designated as bathing waters under Directive 2006/7/EC;
- nutrient-sensitive areas, including areas designated as vulnerable zones under Directive 91/676/EEC and areas designated as sensitive areas under Directive 91/271/EEC;
- areas designated for the protection of habitats or species where the maintenance or improvement of the status of water is an important factor in their protection, including relevant Natura 2000 sites designated under Directive 92/43/EEC (1) and Directive 79/409/EEC (2).

There are no designated drinking water protected areas or safeguard zones, economically significant aquatic species, bathing waters or nutrient sensitive areas in the Finn catchment. (Note, however, that all aquifers (groundwater resources) within the Republic of Ireland are designated as drinking water protected areas. Safeguard zones are zones of contribution to groundwater abstraction points such as springs and boreholes.)

The Finn catchment is an area of high biodiversity and conservation value (Figure 2-12). This is reflected in the number of designations. Five Natura 2000 sites occur wholly or partly within the Finn catchment:

- River Finn SAC 002301
- Meenaguse Scragh SAC 001880
- Meetygrannagh SAC 000173
- Cloghernagore and Glenveagh National Park SAC 002047
- River Foyle and Tributaries SAC UK0030320
- Moneygal Bog SAC UK0030211
- Derryveagh and Glendowan Mountains SPA 004039.

Detailed descriptions of each are available at https://www.npws.ie/ and https://www.daera-ni.gov.uk/protected-areas. The following summary notes some of the salient points of interest relevant to the CatchmentCARE Project.

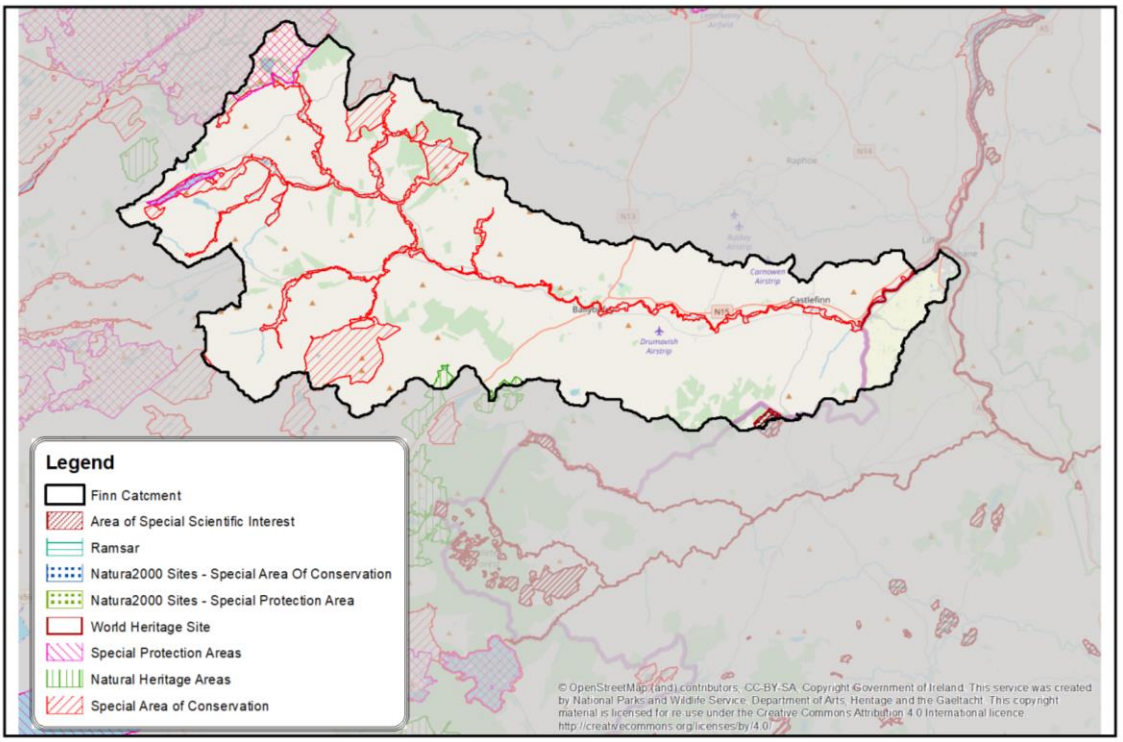

Figure 2-12 Biodiversity and Landscape Protected Areas in the River Finn Catchment (Data Source: NPWS and NIEA)

The River Finn SAC is the major conservation feature in the catchment. It is 5,502 ha in extent and comprises almost the entire length of the River Finn and includes its tributaries and Lough Finn. Areas outside the Finn catchment are also included in the River Finn SAC (e.g. headwaters of the Mourne and Derg Rivers, Lough Derg, Lough Belshade and the tidal stretch of the River Foyle to the north of Lifford).

The qualifying interests for which the River Finn SAC has been designated are salmon (*Salmo salar*), otter (*Lutra lutra*), oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae), northern Atlantic wet heaths with *Erica tetralix*, blanket bogs (* if active bog), transition mires and quaking bogs. All of these species and habitats have a high degree of water dependency in terms of water volume or levels and/or water quality.

While not a qualifying interest of the SAC, a population of Arctic Char (*Salvelinus alpinus*) occurs in Lough Finn. This fish represents an arctic-alpine element in the Irish fauna and occurs only in a few cold, stony, oligotrophic lakes. Arctic Char are very sensitive to water quality. It is listed in the Irish Red Data Book as threatened. The Arctic Char in Lough Finn are unusual in that they are dwarfed, an attribute that only occurs in one other lake in Ireland, Lough Coornasahom, Co. Kerry. They are therefore of national importance.

Moneygal Bog lies at the southern boundary of the catchment within Northern Ireland. It is situated in a basin surrounded by low hills directly north of Castlederg and represents the most north-westerly lowland raised bog in Northern Ireland. The bog lies at a moderate elevation between 130m and 140m O.D., and displays some characteristics of transitional/ intermediate bog. It is set within a landscape which has largely been improved for agricultural use.

Meentygrannagh Bog SAC in the northwest of the Finn catchment is interesting because it contains a diversity of bog habitats within a small area. The juxtaposition of domed valley bogs with fen is unusual in Donegal and indeed in blanket bog regions generally, while the western half of the site contains one of the best examples of highland saddle bogs in the county.

A portion of the Cloghernagore and Glenveagh National Park SAC and Derryveagh and Glendowan Mountains SPA encroach into the catchment at its northern fringe. The SPA is one of only a few locations where Red-throated Diver (*Gavia stellata*) breed in Ireland and the birds also use a number of lakes within the site for feeding.

Other Red Listed species that occur in the Natura sites and more widely in the Finn Catchment include ring ouzel (*Turdus torquatus*) and red grouse (*Lagopus lagopus scoticus*). A number of threatened bird species listed in Annex I of the Bird Directive also occur, with some nationally important breeding populations present. The overall diversity and ecological value of the Finn catchment and its associated designated areas is increased by the presence of populations of several rare or threatened birds, mammals, fish and plants.

2.1.6 Water Framework Directive Status

The Finn catchment is divided into 21 river water bodies, 20 of which are in ROI and 1 in NI. Only three lakes in the catchment have been included as WFD lake water bodies. The catchment is underlain by 4 groundwater bodies. Figure 2-13, Figure 2-14 and Figure 2-15 show the river, lake and ground water bodies respectively in the Finn catchment.

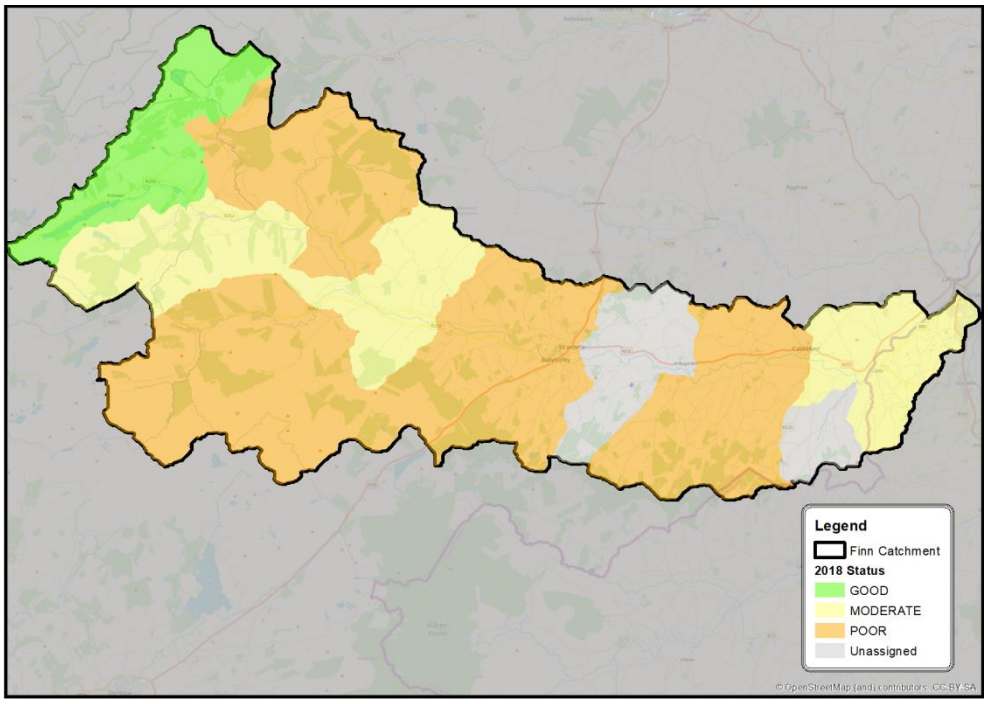

Figure 2-13 River water bodies and WFD status in the River Finn Catchment

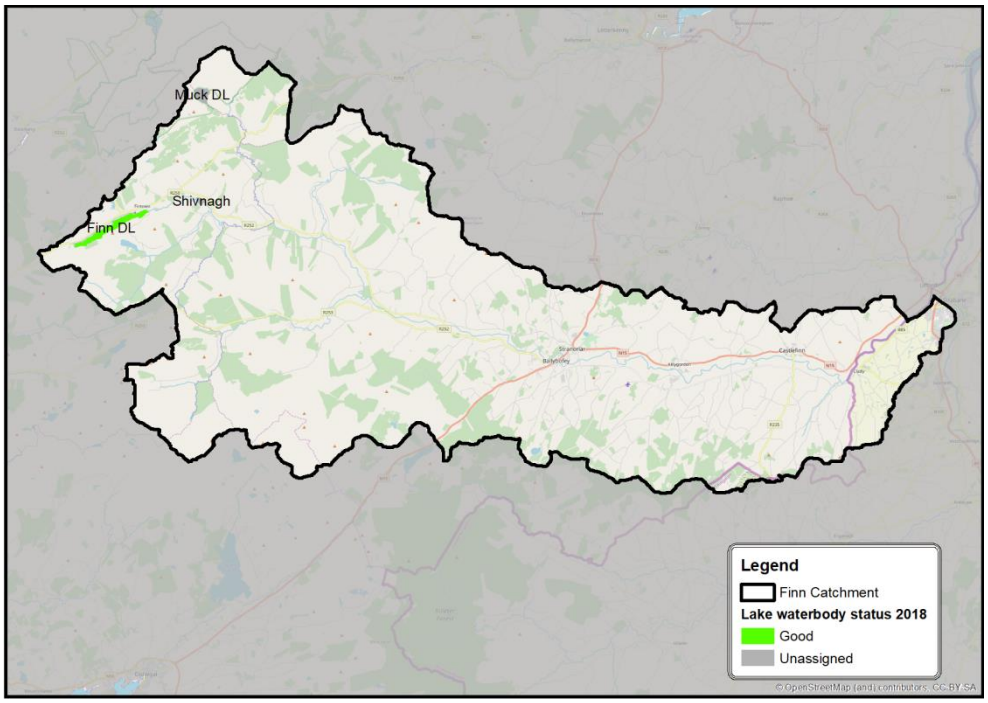

Figure 2-14 Lake water bodies in the River Finn Catchment and WFD status

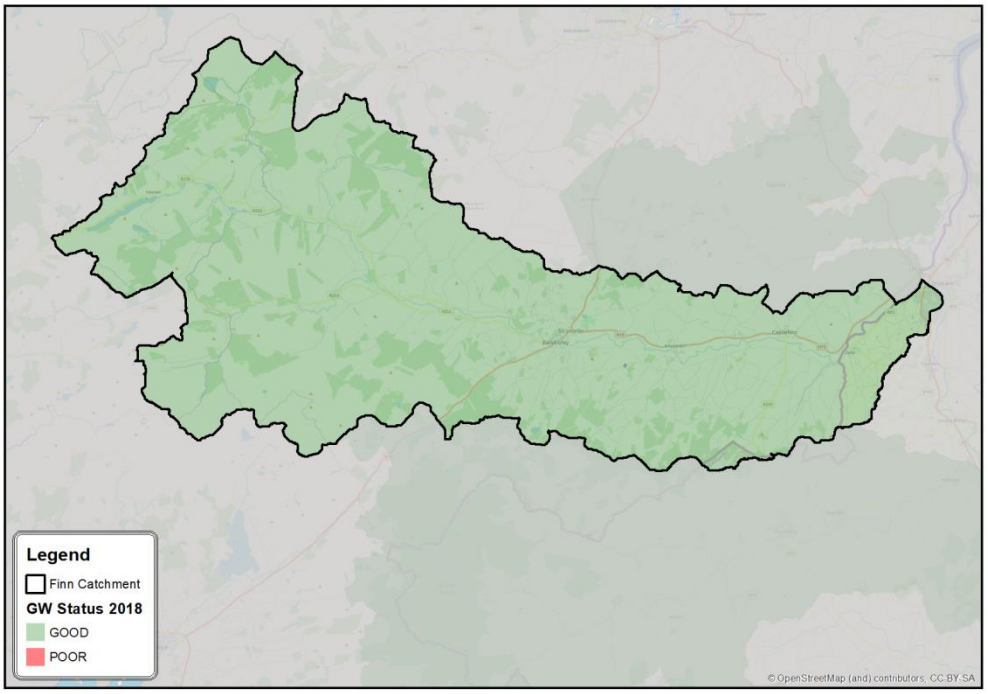

Figure 2-15 Groundwater bodies in the River Finn Catchment and WFD status

A summary of the status of all water bodies in the Finn catchment is provided in Table 2.1. The table also indicates whether the water body is at risk of failing to achieve the WFD objectives set for it in the River Basin Management Plan. Where relevant, the potential source of the risk as determined by the EPA in consultation with Donegal County Council is also indicated. There are no current risk maps

for Northern Ireland water bodies as they have not been revised since the first River Basin Management Planning cycle (pers. comm. Northern Ireland DAERA).

River Water Bodies (RWB)

The headwaters of the catchment are of varied status. While a number of headwaters in the catchment are of good status (the upper Finn, the Cummirk), many of the headwater rivers are significantly impacted and at poor ecological status. These include the Elatagh, the Reelan, Rough Burn, and Burn Daurnett. Large sections of the main channel of the Finn are also classified at poor status, and therefore below the WFD objective of good status. Two river water bodies remain to be classified as yet due to lack of data. The distribution of waterbodies and their status is shown in Figure 2-13.

A comparison of ecological status as determined in 2015 with that in 2018 indicates that 9 water bodies have deteriorated in status. By comparison only 2 water bodies have shown improved ecological status. The remaining 9 water bodies (including 2 that are unassigned) are unchanged in status. In two instances water bodies improved by one status classes from poor to good and the other from poor to moderate. However, in a further three cases, water bodies fell two status classes from good to poor and six waterbodies fell from moderate to poor.

Of the parameters comprising status assessment, general chemical and nutrient conditions are satisfactory in many areas, and in a number of cases total ammonia, ortho-phosphate and total oxidised nitrogen levels have shown modest decreases in recent years. Therefore, in many of the waterbodies macroinvertebrate status has been the driving factor – i.e. the status element with the lowest rating – in determining overall status. Macroinvertebrate sampling has been a long-standing element of river monitoring programmes and lengthy datasets enable long term trends to be assessed. In almost all instances in the Finn catchment there has been a steady decline in macroinvertebrate biotic quality indices (Q-value). Figure 2-16 shows examples of this decline. In the Cummirk River the Q-value has declined from 4/5 (high status) in 1990 to 3 (poor) in 2016. Over the same interval in the Reelan the Q-value has declined from near pristine conditions at Q5 (high status) to 2/3 (poor). Finally, from a starting Q-value of 4 in 1994, the Rough Burn has seen a decline to Q3 in 2016. The locations of these monitoring stations are shown in Figure 2-17.

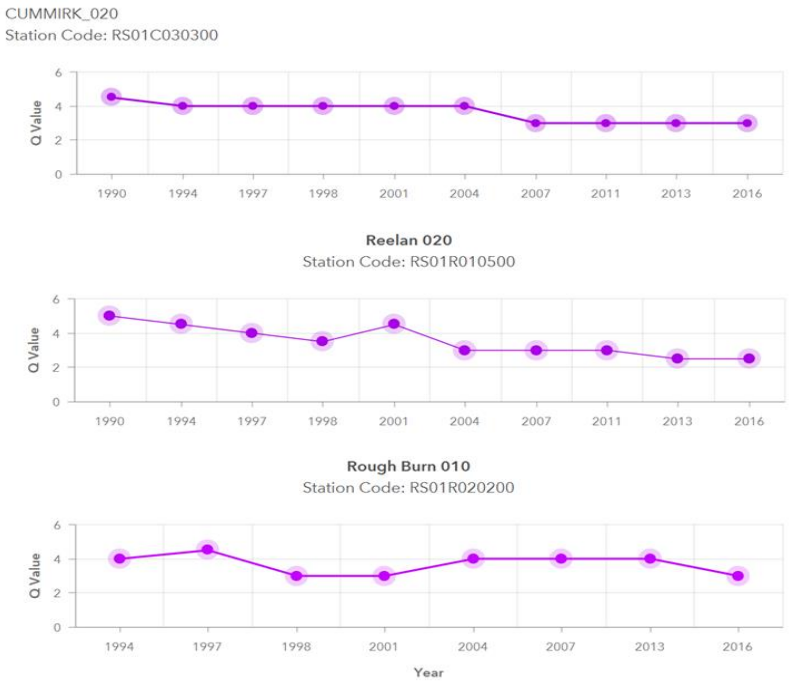

Figure 2-16 Trends in Q-values at sites in the River Finn Catchment from 1990 to 2016

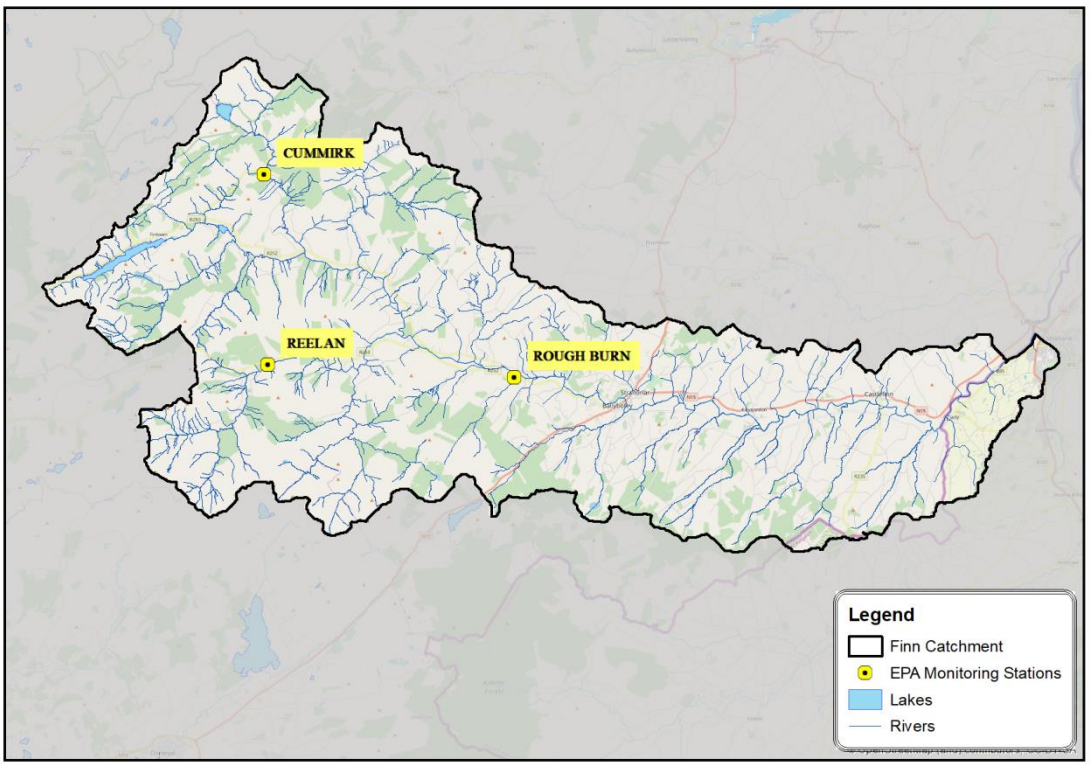

Figure 2-17 Locations of Cummirk_020, Reelan_020 and Rough Burn_010 Macroinvertebrate Monitoring Stations

In some waterbodies indications of toxic effects on the macroinvertebrate communities have been noted, e.g. in the Elatagh River and in the Finn downstream of its confluence with the Elatagh, and in the lower Reelan River and its tributary the Clogher River. The herbicide MCPA has been highlighted as an issue in the Stranagoppogue, as well as forestry pressures. Indications of heavy siltation were also noted in the Elatagh River. Potential pressures giving rise to these impacts are discussed below.

In summary, 2 RWBs are currently at good status, 4 at moderate status, 13 at poor status and 2 are unassigned. The objective for the 2 RWBs at good status is to retain that status, and for the remainder the WFD objective is to achieve good status by 2027. Of the 21 RWBs in the Finn catchment 3 are not at risk, and a further 3 are for review based on lack of data/information. The remaining water bodies are considered to be at risk of not achieving their WFD objectives. The spatial distribution of these RWBs and their risk assessment is shown in Figure 2-18.

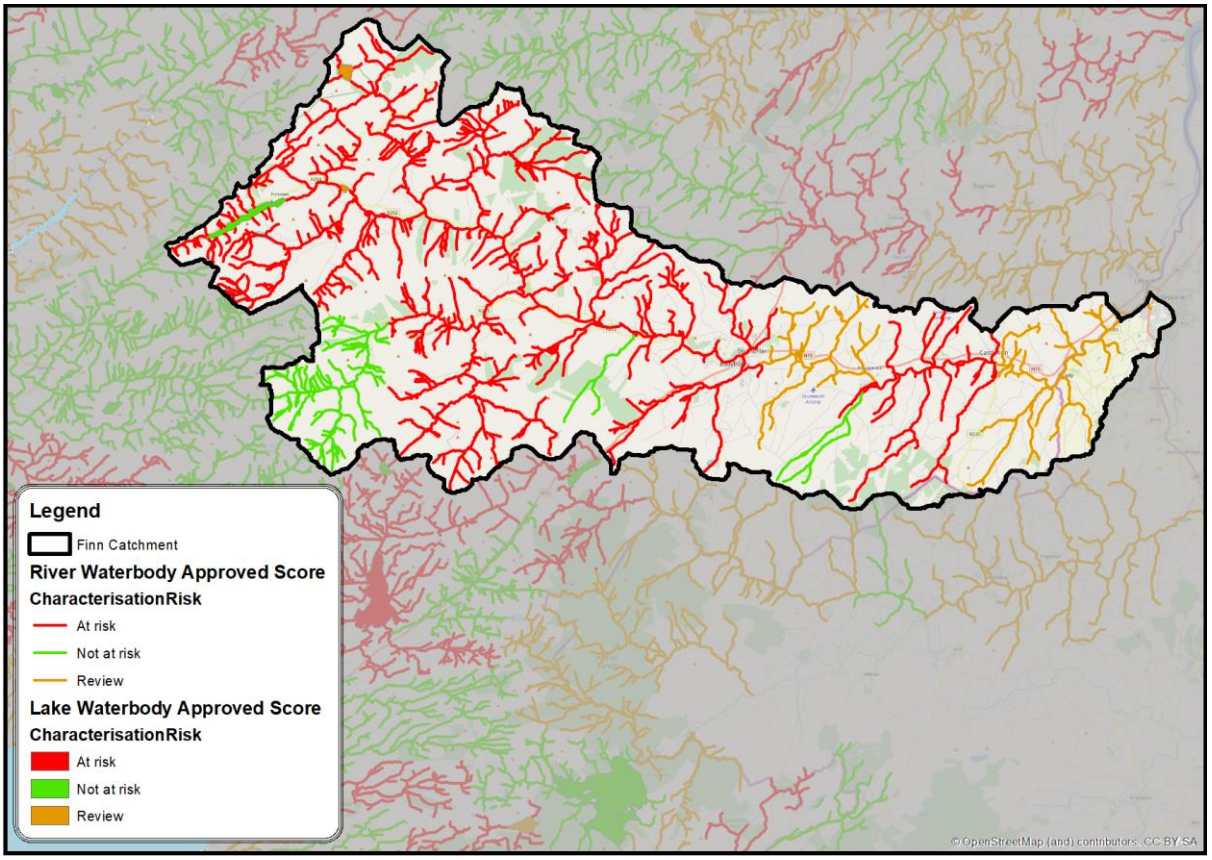

Figure 2-18 Locations of water bodies and WFD risk assessments in the River Finn Catchment

The pressures potentially impacting status in each waterbody are listed in Table 2.1 and are discussed in section 2.1.7 below.

Lake Water Bodies (LWB)

One lake WB in the catchment, Lough Finn, is at good status and is considered not at risk. The remaining two WFD lakes (Shivnagh and Lough Muck) are unclassified as yet and are marked for review.

Groundwater Bodies (GWB)

The catchment is underlain mainly by the Ballybofey Groundwater body. This is a poorly productive aquifer and is currently at good status. It is not considered to be at risk. The Raphoe GWB underlies the northern fringes of the catchment, and the Killygordon GWB transects the catchment north to south at Killygordon; both of these GWBs are poorly productive, but are comprised of marble bedrock. A small Waste Facility GWB has been defined around the Donegal County Council landfill site at Churchtown, 2km northeast of Clady on the north side of the River Finn.

All of the above GWBs including the Waste Facility GWB are currently at good status (Figure 2-15).

Table 2.1 WFD water bodies, status and significant pressures in the River Finn Catchment. Source: NIEA and EPA.

Sub Catchment	River Waterbodies	Status 2015	Status 2018	Pressures
01_8	Finn (Donegal)_010	Moderate	Good	Agriculture, Pasture Peat & Urban.
	Finn (Donegal)_020	Moderate	Moderate	Agriculture &Peat
	Finn (Donegal)_030	Moderate	Poor	Overgrazing, Land Drainage & Agriculture
	Stranagoppoge_010	Poor	Moderate	Pasture, Herbicide, Clearfelling & Peat
	Cummirk_010	Poor	Good	Peat & Forestry
	Cummirk_020	Poor	Poor	Forestry, Peat, Agriculture, Waste Water Discharge.
	Elatagh_010	Poor	Poor	Forestry
	Elatagh_020	Moderate	Poor	Agriculture & Peat
01_3	Clogher (Finn)_010	Moderate	Poor	Pasture & Sheep dip
	Reelan_010	Good	Poor	Forestry, Sheep Dip (DCC)
	Reelan_020	Poor	Poor	Pasture, Sheep dip, Forestry, Peat & Waste Water Discharge.
01_2	Finn (Donegal) _040	Moderate	Moderate	Pasture, Sheep Dip, Forestry & Peat.
	Finn (Donegal) _050	Moderate	Poor	Pasture & Forestry
	Finn (Donegal) _060	Moderate	Poor	Combined sewer outflows, Diffuse source runoff & Section 4.
	Finn (Donegal) _070	Unassigned	Unassigned	Urban Waste Water, Industry (Section 4), Anthropogenic pressure (unknown).
	Finn (Donegal) _080	Moderate	Poor	Urban Waste Water, Domestic Waste Water & Agriculture (Pasture).
	Finn River (NI)	Moderate	Moderate	Urban Waste Water, Agricultural, Invasive Species & Anthropogenic Pressure (Unknown).
01_7	Rough Burn_010	Good	Poor	
	Crossroads Stream_010	Good	Poor	
	Burn Daurnett_010	Poor	Poor	Sediment and Nutrients Forestry & Agriculture.
	Dresnagh_010	Unassigned	Unassigned	
	Lake Water Bodies			
	Lough Finn	Good	Good	
	Shivnagh	Unassigned	Unassigned	
	Muck DL	Unassigned	Unassigned	
	Groundwater Bodies			
_048	Ballybofey	Good	Good	
_056	Killygordon	Good	Good	
_054	Raphoe	Good	Good	
_085	Waste Facility	Poor	Good	

2.1.7 Catchment Pressures

Terrestrial and aquatic environments in the Finn catchment are impacted upon by a wide range of anthropogenic pressures which have been identified in the WFD initial characterisation of catchments. Pressures include agriculture, sand and gravel extraction, commercial forestry, commercial and recreational fishing, industry, water abstraction, sewage treatment, diffuse and point source pollution, invasive plant species, urban sprawl, drainage and flood defences.

Robust scientific assessments as part of the WFD River Basin Management planning process have determined the risk of a water body not achieving the WFD objectives set for it in the River Basin Management Plans. The most significant pressures have been identified based on a large array of datasets, suites of modelling tools and local knowledge of staff from numerous agencies. This process provides focus for more detailed appraisals through further investigations and guides resource application in programmes of measures.

Significant pressures have been identified for waterbodies that are at risk of not meeting their water quality objectives under the WFD. These are listed in Table 2.1 and locations shown in the relevant sections below. While there are often multiple pressures in operation in waterbodies, the significant pressures are those pressures that need to be addressed in order to improve water quality. Many waterbodies may have a number of significant pressures in operation.

The percentage of river waterbodies in the Finn catchment in which specified pressures are operating is shown in Figure 2-19. It shows that agriculture is the most widespread pressure, impacting in 67% of all the waterbodies. This is followed by peat extraction and forestry which are each significant pressures in 38% of the Finn waterbodies. Wastewater discharges from urban wastewater treatment plants and from on-site wastewater treatment systems (mostly septic tanks) are significant pressures in 29% and 14% of waterbodies respectively. Unspecified anthropogenic pressures affect 14% of RWBs and industry 10%. The remaining pressures (hydromorphological, urban runoff and invasive alien species) have only been identified as significant in a single waterbody each.

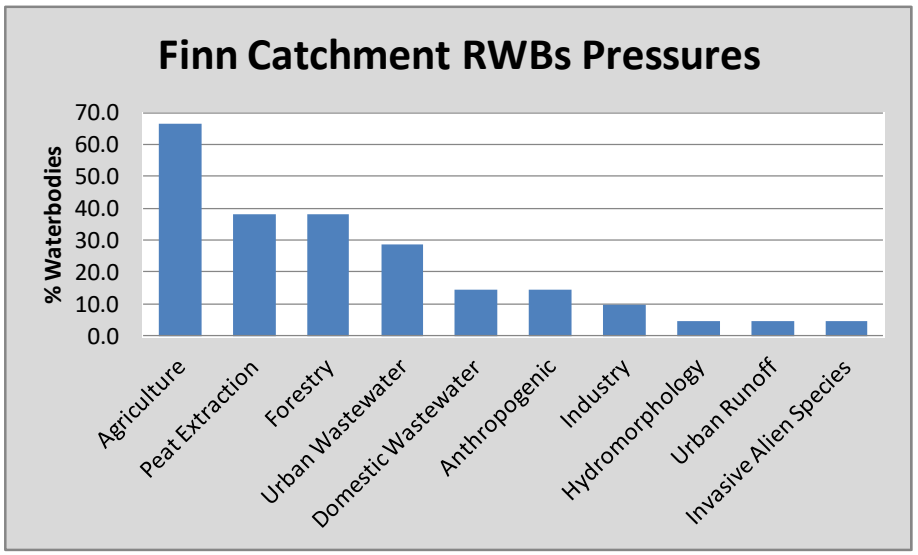

Figure 2-19 Percentage of waterbodies in the River Finn Catchment in which the listed pressures are significant

Agriculture

Given the extensive nature of agriculture in the catchment it is not surprising that agricultural pressures affect such a large proportion of its waterbodies (Figure 2-20). The average farm size in Donegal is 27.9 ha (Agricultural Area Utilised), and although farm sizes are increasing, almost half of all farms are less than 20 ha (CSO - Census of Agriculture 2010 Final Results, 2012). Impacts from agriculture include nutrient and organic pollution and these may arise from diffuse or point sources such as pasture, arable and farmyard sources. Other agriculture related pressures may give rise to hydromorphological impacts, e.g. land drainage, bank erosion and soil export and deposition in channels due to overgrazing which is exacerbated by local topography in steep upland areas.

Agriculture in the western portion of the catchment is generally more extensive with widespread sheep grazing on rough pasture and peatland commonages. Sheep farming plays a significant role in the rural economy, and Donegal has significantly more sheep and the greatest number of flocks of any County in Ireland. The average flock size per farm is 114 sheep (5,042 farms). The use of sheep dip in these areas has also resulted in chemical pollution. There are over 103 known sheep dips in the Finn catchment, principally west of Cloghan. While some are no longer in use, a significant number remain in active use. Improper use and disposal of dip may be impacting surface waters. Sheep dips are scattered throughout the Upper Finn, Stranagoppoge, Elatagh, Cummirk and in particular the Reelan catchments.

Beef production is significant in the eastern portion of the catchment but average herd size in Donegal at 36 cattle per farm is substantially below the national average of 60 cattle per farm (The Donegal Local Economic & Community Plan 2016-2022: Appendix 1 The Profile of the County). Permanent pastures are the most extensive landuse type in the eastern portion of the Finn catchment with significant areas of permanent grass silage also.

The use of herbicides, in particular MCPA to control rushes (*Juncus effusus*) may also be impacting the River Finn and some of its headwater rivers and streams.

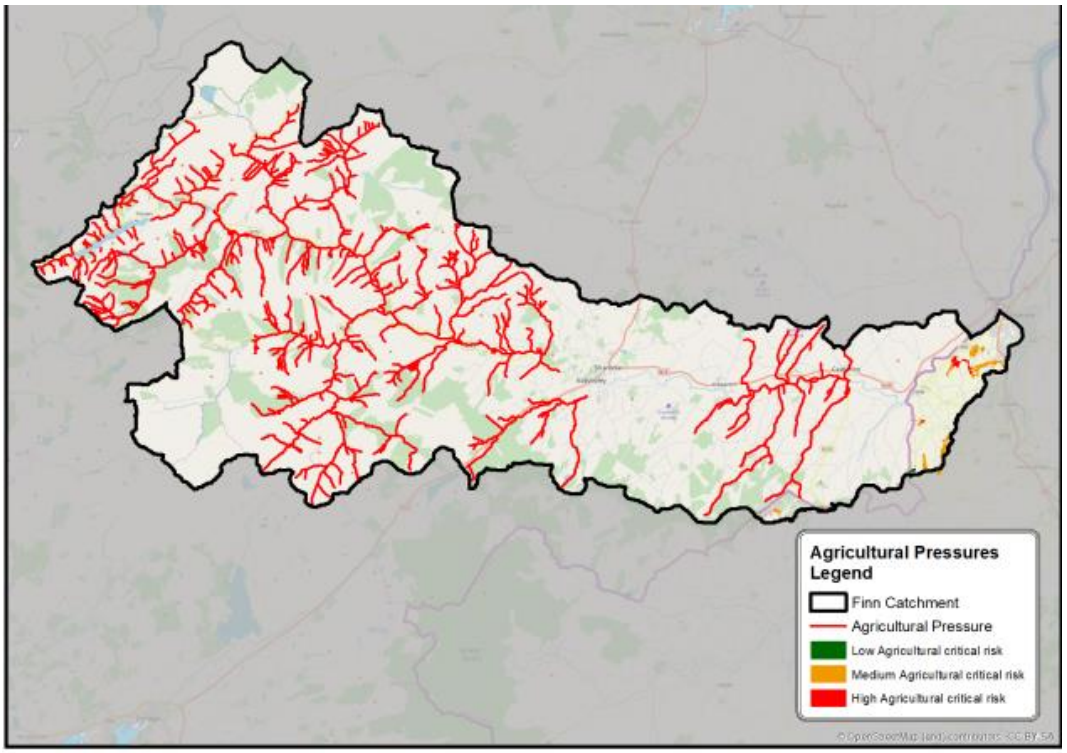

Figure 2-20 Significant agricultural pressures on water bodies in the River Finn Catchment.

Forestry and Peat Extraction

Significant areas of commercial forestry (almost 9,000 ha) have been planted particularly in the western upland portion of the catchment (Figure 2-21) and forestry comprises about 18% of the total catchment landuse. This compares with forestry cover at 11% nationally, and just over 12% in Donegal (The Donegal Local Economic & Community Plan 2016-2022: Appendix 1 The Profile of the County). Planting has mostly been coniferous, sitka spruce being favoured but with lodgepole pine, larch, and Scots pine also planted. Some relatively small areas of hardwood forests also occur consisting mainly of beech, alder, sycamore, oak and ash (Figure 2-21).

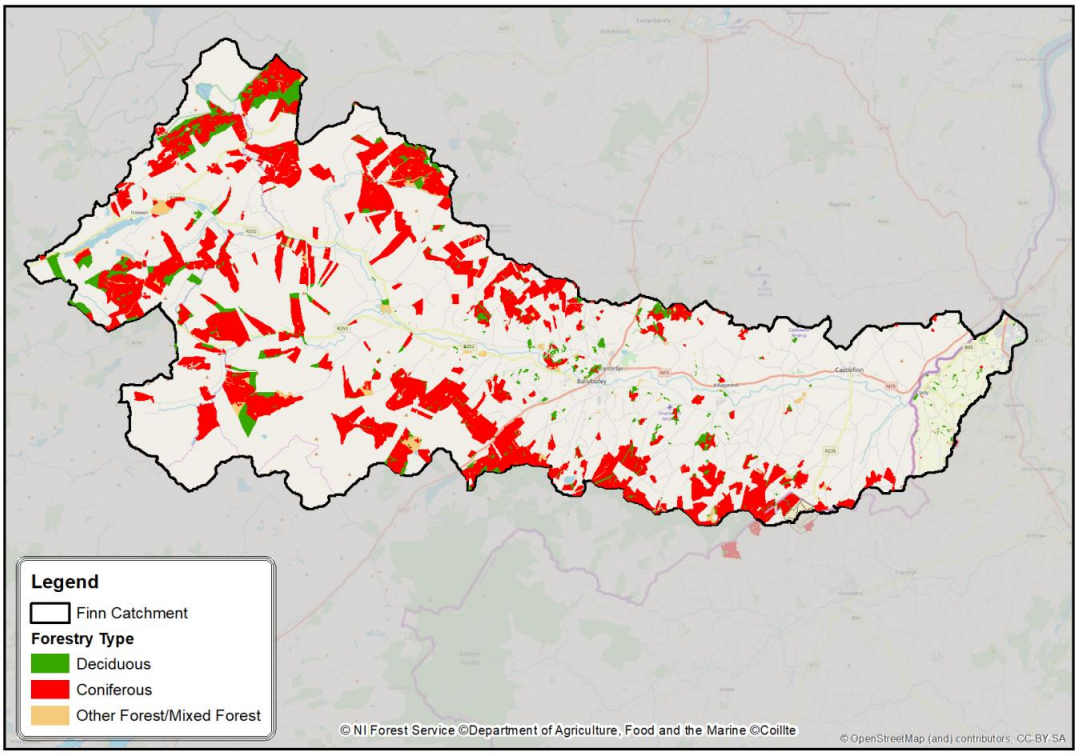

Figure 2-21 Forest cover in the River Finn Catchment (2017).

The forest estate is almost equally divided between private and public ownership. However, many of the public owned forests in the catchment are older and managed by Coillte (Ireland's state owned commercial forestry company). Many of the older forests were planted on blanket peats and the management of these forests poses particular environmental risks and pressures. Environmental impacts are primarily associated with critical stages in the forest management cycle, especially at forest establishment/ reafforestation, and at harvest. The impacts of such activities include the release of nutrients and sediment to receiving waters. Such impacts are especially prevalent on blanket peat sites due to the erodible nature of the substrate and the inability of peat soils to bind phosphorus released from brash (Clarke et al., 2015; Kelly-Quinn et al., 2014). Given their association with stages in the forest management cycle, these impacts tend to be episodic but may persist for a period of years. They are also perpetuated by staged clearfelling in individual coups in multiannual felling programmes. Acidification of poorly buffered waters in blanket peat areas may also be a chronic issue resulting in impact.

The control of forest pests, in particular pine weevil, may also give rise to contamination of water bodies with pesticides due to spray drift or lack of adequate buffer zones. Pesticides in use in the Finn catchment include cypermethrin, acetamiprid and organophosphates. Note that cypermethrin and organophosphates may also be used in sheep dips.

Forestry has been identified as a significant pressure in most of the headwater waterbodies in the Finn catchment including the Cummirk, upper Elatagh, Stranagoppoge, Reelan and Burn Daurnett (Table 2.1, Figure 2-22). WFD monitoring has noted heavy siltation in some of these areas.

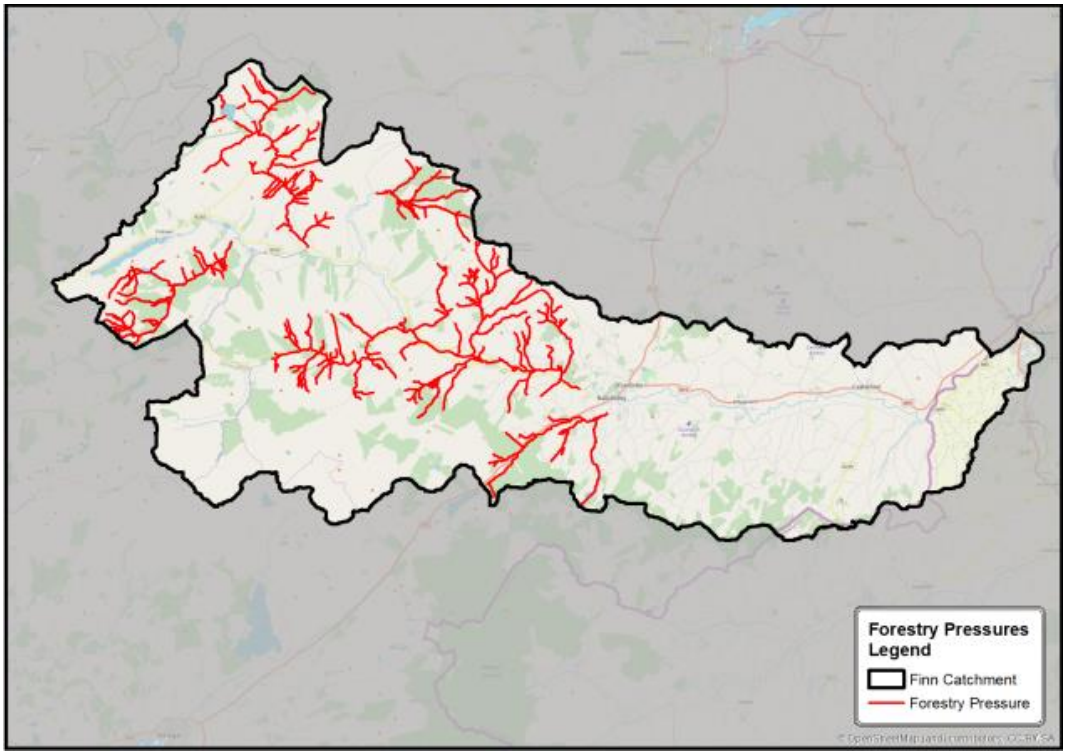

Figure 2-22 Significant forestry pressures on water bodies in the River Finn Catchment

Peat extraction is a widespread activity on many blanket bog areas in the west of the catchment where afforestation has not taken place. Peat extraction entails extensive drainage of bogs and results in significant changes to hydrological regimes. Many of the drains are over deepened and severely eroding. Exposed, unvegetated areas of peat are also susceptible to drying and erosion.

Oxidation of dried peats also gives rise to nutrient release to watercourses.
Peat extraction has been identified as a significant pressure in the upper Finn, the Cummirk, Elatagh, Stranagoppoge, and Reelan catchments (Table 2.1, Figure 2-23). Given the spatial overlap of forestry and peat harvesting and the similarity of impacts, detailed investigations may be required to resolve effects of these pressure sources.

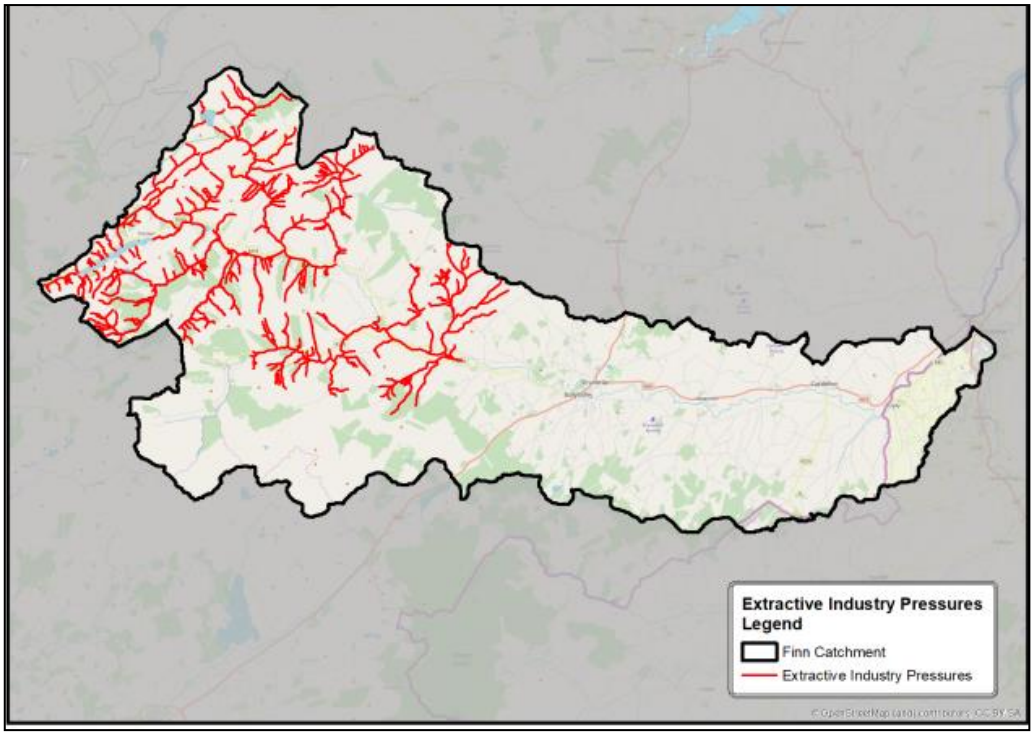

Figure 2-23 Significant extractive industry pressures on water bodies in the River Finn Catchment

Urban Waste Water Treatment and On-site Wastewater Systems

Impacts from urban waste water include nutrient, organic and microbiological pollution. Impacts may arise due to inadequately treated effluent discharges or due to operation of combined sewer overflows.

There are 10 wastewater treatment plants in the River Finn Catchment, one of which is in Northern Ireland and nine in the Republic of Ireland. The locations of the treatment plants and their associated storm overflow points are shown in Figure 2-24.

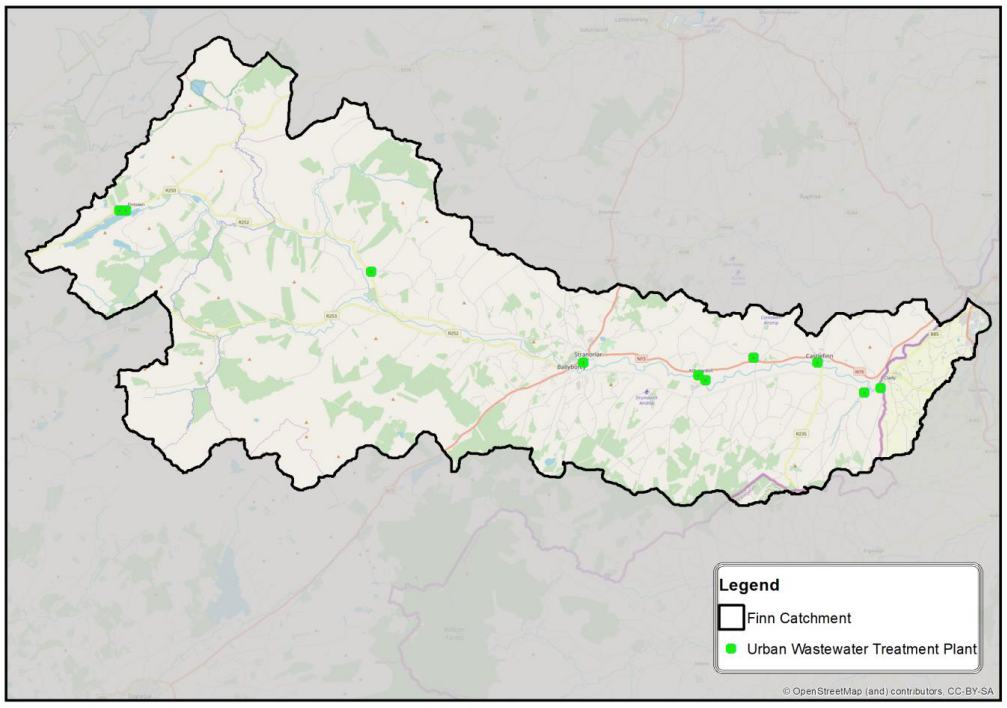

Figure 2-24 Locations of Urban wastewater treatment plants (UWWTPs) and CSOs in the River Finn Catchment

The largest of the wastewater plants is at Ballybofey-Stranorlar serving a population equivalent (PE) of almost 6,000. Smaller plants at Castlefinn and Killygordon serve PEs of 960 and 430 respectively. The remaining plants are small (PE <150). A number of these UWWTPS (shown in bold) receive influent loads that are greater than their original design capacity and are failing to comply with regulatory discharge standards (Table 2.2).

Table 2.2 Urban wastewater treatment plants (UWWTP) in the River Finn Catchment

Reg No.	Name	PE	Design PE	Treatment Type	No. Storm Water Overflows	1°/2° Effluent Emission Point
D0120	**B'bofey-Stranorlar**	**5754**	**4000**	**Secondary**	5	1 (Finn)
D0514	**Castlefinn**	**960**	**600**	**Primary**	1	1 (Finn)/1
D0518	Killygordon	430	600	Secondary	1	1 (Finn)
A0485	Doneyloop Housing Scheme	42	NA	Secondary		
A0449	Liscooly Housing Scheme	60	70	Primary		
A048	Cloghan/Brockagh	45	45	Primary		
A0492	Fintown No.2 Housing Scheme	30	NA	Secondary		
A0484	Fintown No.1 Housing Scheme	24	NA	Primary		
A0364	**Curragh housing Scheme**	**110**	**140**	**Primary**		
S04149	Clady Tyrone	757	800	NA		1(Finn)

As expected, pressures from urban wastewater treatment plants are prevalent around the main conurbations in the eastern portion of the Finn catchment. Urban run-off has also been identified as a significant pressure in these areas.

As discussed in section 2.1.2, the Finn catchment is largely rural in character and population is dispersed. Figure 2-25 shows the locations of one-off housing in the catchment. These are houses that are not on sewered collection systems and are served by on site wastewater systems. Although some high specification proprietary treatment systems are in use, the vast majority of systems are septic tanks with solids removal and effluent disposal to percolation zones. Figure 2-25 shows that large numbers of one-off housing occurs in the Finn catchment, primarily in river valleys and in the eastern portion of the catchment.

Discharges from non-compliant septic tanks may impact on surface waters where percolation is inadequate due to peaty and heavy soils, or poorly productive bedrock, and surface ponding and runoff/ interflow may result. Many septic tank systems are old and surveys suggest that as many as one in three may be structurally deficient, inappropriately sited, or lacking appropriate maintenance to ensure effective mitigation of effluent impacts. High densities of septic tanks, especially in susceptible areas or at times of low surface water flows may result in cumulative impacts on receiving waters.

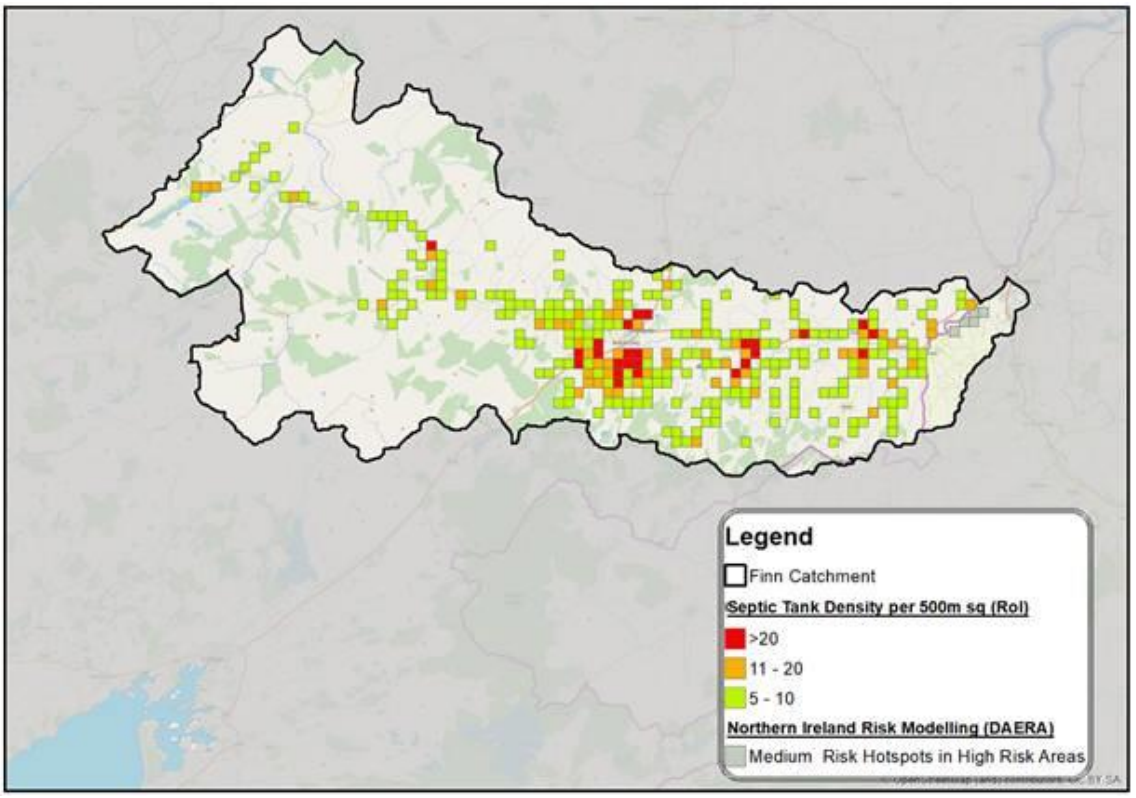

Figure 2-25 Domestic on-site wastewater treatment system pressures in the River Finn Catchment, represented by septic tank density in RoI and areas designated as High, Medium and Low risk categories in NI. (Source: EPA and WMU @ DAERA)

Waterbodies in which domestic wastewater has been identified as a significant pressure are shown in Figure 2-26. These include the Cummirk and Reelan river valleys in the upper catchment area, and the lower Finn in the Killygordon and Castlefinn areas where significant numbers of one-off housing are located.

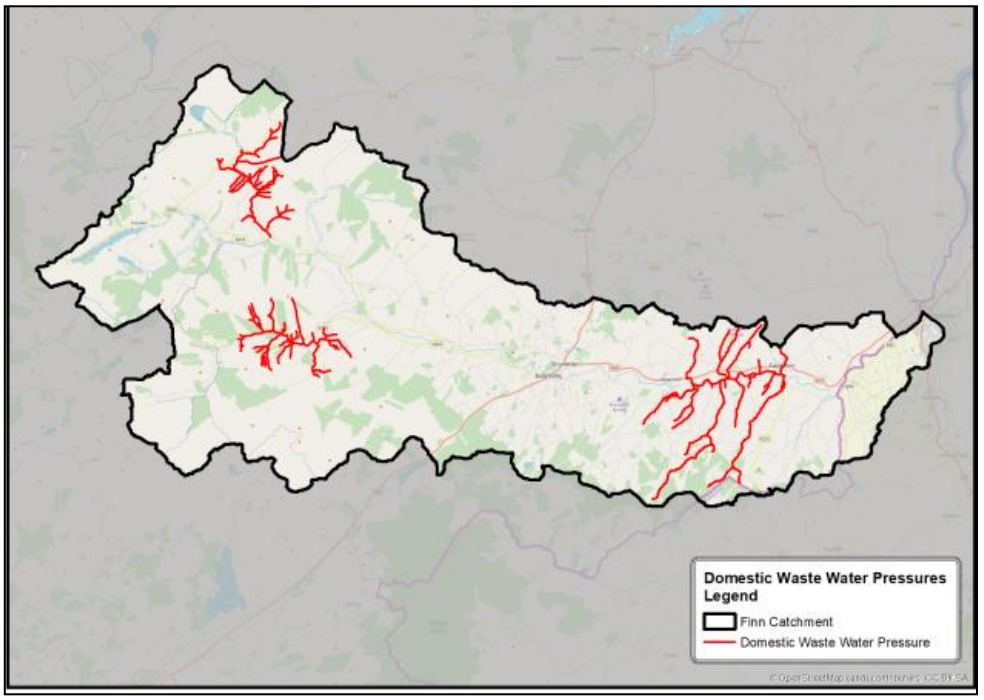

Figure 2-26 Significant domestic wastewater pressures on water bodies in the River Finn Catchment

Licensed Discharges

The Finn catchment is not heavily industrialised and there are only 4 discharges licensed under Section 4 of the Local Government (Water Pollution) Act, 1977 (Figure 2-27). Two of these are in Ballybofey and discharge to the Finn. One is a cooling water stream and the second is a wash discharge. The remaining two discharges relate to a quarry near Stranorlar, and a creamery in Killygordon, both also discharging to the Finn.

There are 2 IPPC (Integrated Pollution Prevention and Control) Licensed Industries in Ballybofey, a sawmills and a biogas generation plant.

Donegal County Council operates a licensed landfill facility at Churchtown approximately 3km south west of Lifford that occupies an area of approximately 9.7ha. The south-eastern boundary of the landfill site is formed by the River Finn.

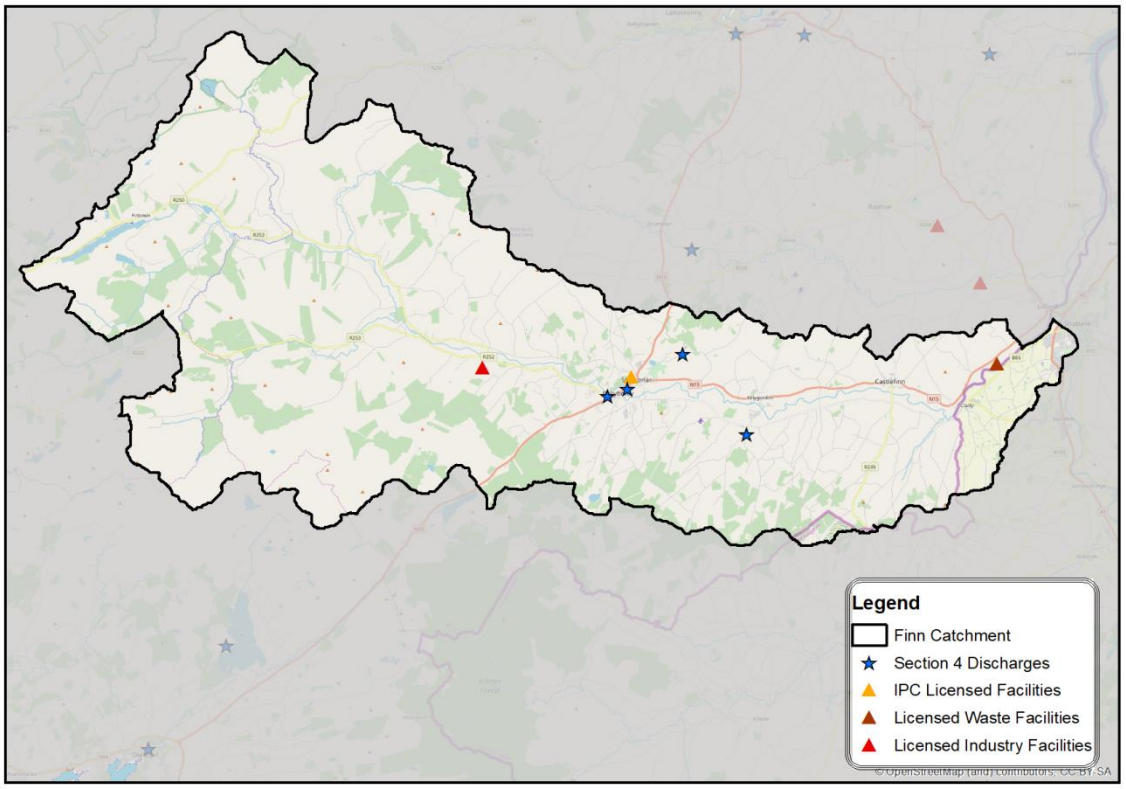

Figure 2-27 Licensed discharges to surface waters in the River Finn Catchment

Section 4 trade effluent licensed discharges have only been identified as a significant pressure in one waterbody in the catchment, the river Finn_060 waterbody (Table 2.1).

Hydromorphological Pressures

Hydromorphological pressures include impacts on the quantity of water and its flow conditions (hydrology) and the condition of various aspects of the physical habitat such as bed materials, width and depth of the channel (morphology). It also includes impacts on the degree of 'connectivity' of surface waters, i.e. presence or absence of barriers to movement of water, materials and biota throughout surface water systems and access to flood plains.

Hydromorphology is influenced by numerous land use and management practices. Extensive land drainage for agriculture, forestry and peat extraction may have profound effects on catchment hydrology and connectivity with surface waters. It creates rapid transport routes for drainage water, entrained sediment and adsorbed nutrients to receiving streams and rivers. Erosion risk may already be high in steep mountainous catchment areas.

Hydromorphological pressures have been identified as a significant pressure in the upper Finn catchment between the inflow of the Elatagh River and the confluence of the Finn with the Reelan downstream (Figure 2-28). A significant number of potential barriers exist in the Finn catchment including two large barriers on the Reelan and the Rough Burn.

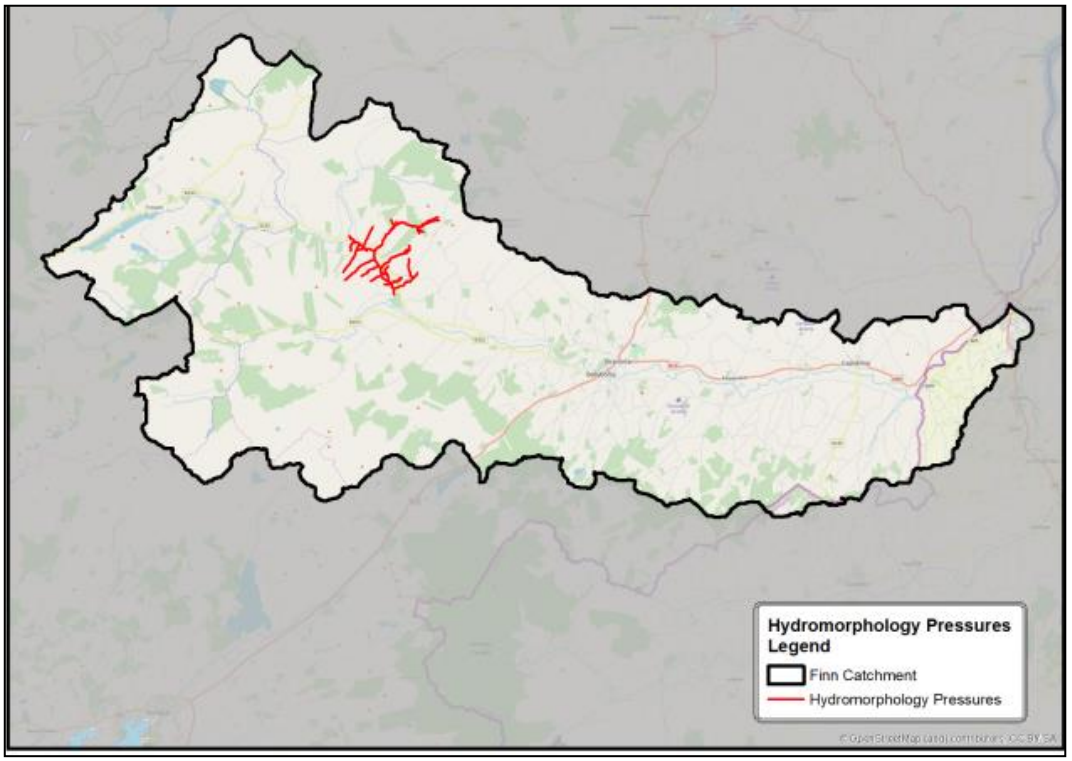

Figure 2-28 Significant hydromorphology pressures on water bodies in the River Finn Catchment

Priority Areas for Action

The second cycle River Basin Management Plan for Ireland 2018 - 2021 has identified 'Areas for Action'. These consist of waterbodies where actions will be prioritised to achieve WFD objectives. They have been selected based on priorities in the River Basin Management Plan, evidence from the WFD characterisation process, and the expertise, data and knowledge of public body staff with responsibilities for water, and the different pressure types. Selection also took account of the wider socio-economic and feasibility considerations. Initial selection of priority areas for action (PAAs) was followed by public consultation. The PAAs will be kept under review and may change during the WFD planning cycle.

The PAAs in the Finn Catchment are shown in Figure 2-29. Almost all water bodies in the catchment have been prioritised for action in the second cycle River Basin Management Plan. Local authority catchment assessment teams will drive the implementation of mitigation measures in the PAAs with particular emphasis on driving collaborative and cross-sectoral actions to deliver water-quality improvements. Actions will be mainly directed towards pressures from agriculture, urban wastewater, domestic waste-water and forestry.

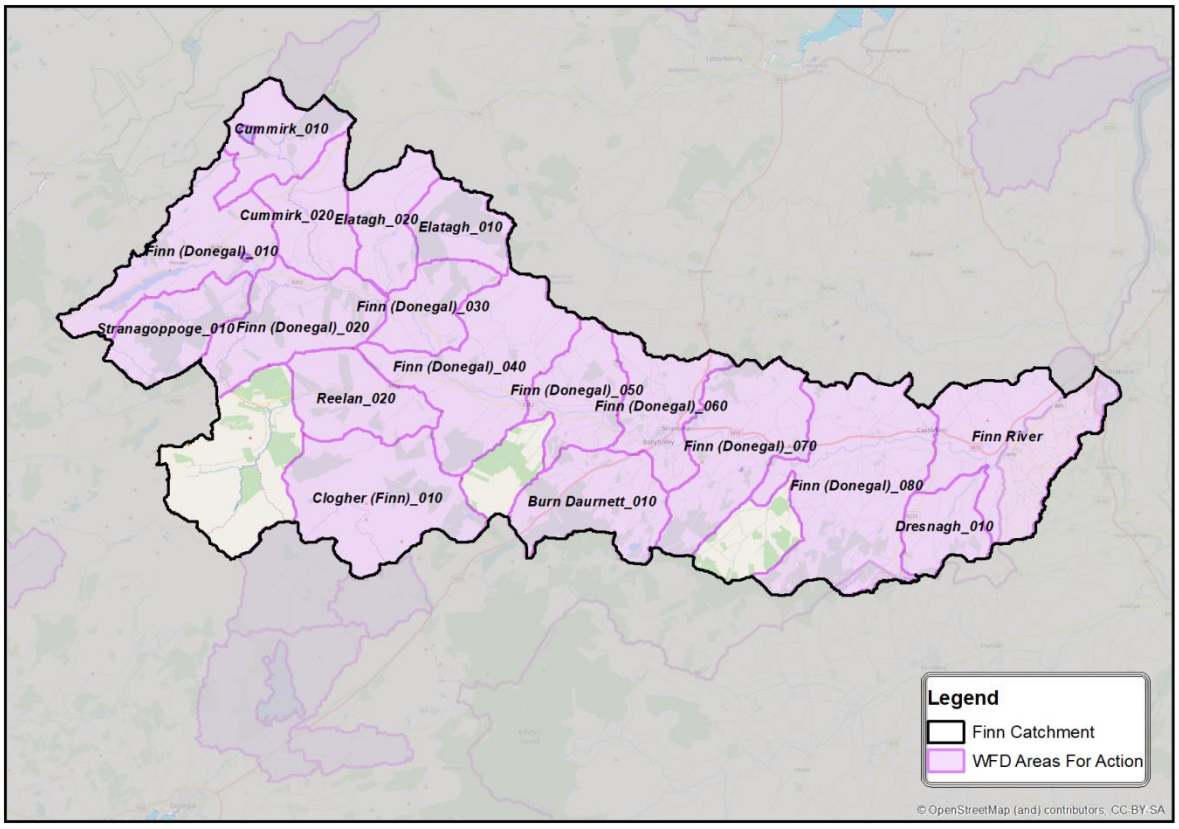

Figure 2-29 Priority Areas for Action in the River Finn Catchment (source: EPA)

2.2 Arney Catchment

The Arney catchment lies in the North Western International River Basin District and is part of the larger River Erne catchment (Figure 2-30). The Erne is a cross border catchment with a surface area of 3,440.52 km², of which 43% and 57% approximately of the area is located in NI and ROI respectively.

Flowing from the west, the Arney River joins the River Erne just downstream of the outflow from Upper Lough Erne. The Erne catchment is divided into 28 sub-catchments and eight of these comprise the natural catchment drained by the Arney River discussed here. This catchment covers an area of 304 km^2 of which 204.4km^2 (67%) is located in NI and 99.26km^2 (33%) is located in ROI.

The Rivers Agency operates a hydrometric station (Station Number 236058) at Tilery Bridge on the Arney (Figure 2-31). This gauging station measures larger catchment areas and incorporates flow contributions from numerous springs. These are particularly significant in the Cuilcagh Mountains where some of the largest springs in the region discharge from cave and conduit systems of the Dartry Limestone (e.g. Marble Arch). The downstream gauging station on the Arney River reflects a multitude of hydrological influences including through flow and storage within the Loughs Macnean.

Figure 2-30 Location of River Arney Catchment within the larger Erne Catchment (inset) and the eight sub-catchments comprising the River Arney Catchment

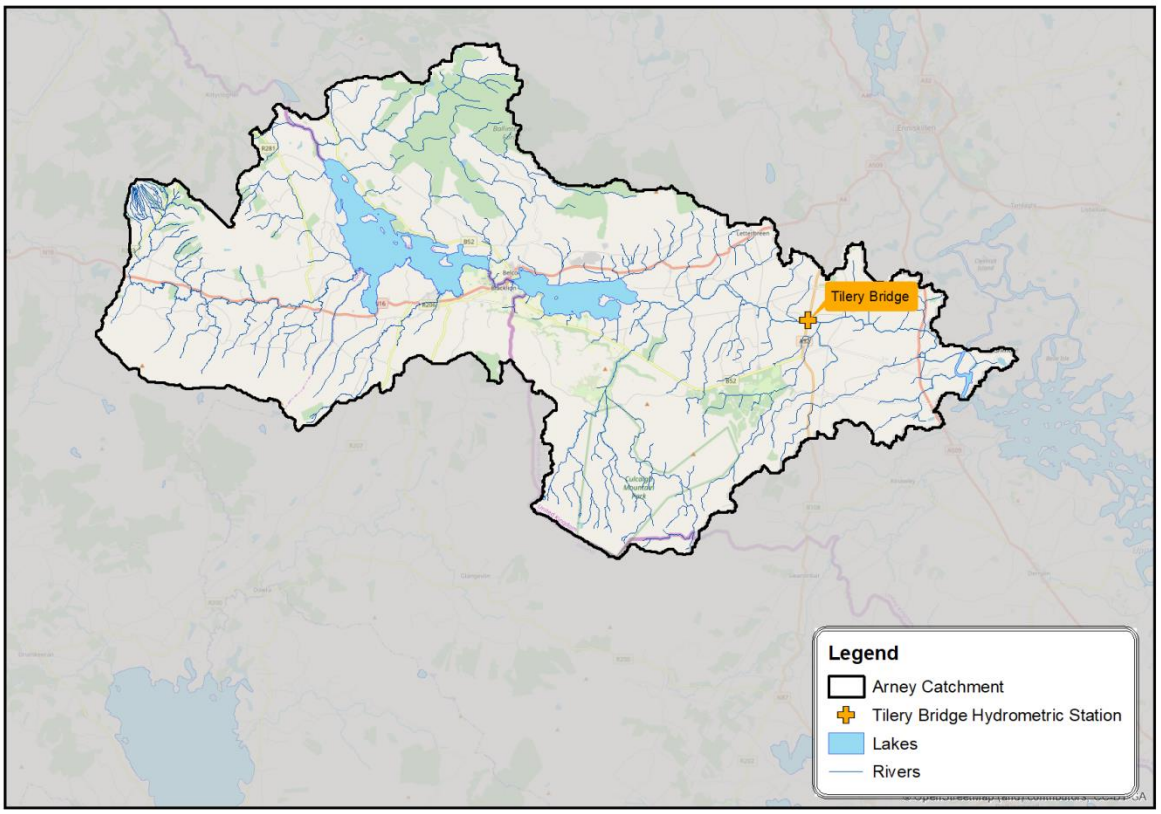

Figure 2-31 Location of Tilery Bridge Hydrometric Station

2.2.1 Landscape

Although there are a number of small lakes scattered throughout the catchment, it is dominated by two major lakes, Lough Macnean Upper (approximately 990ha) and Lough Macnean Lower (approximately 457ha), both at an altitude of just over 50m (Figure 2-32). The Lough Macnean valley is glacial in origin with deep basins excavated in varied Carboniferous-age rocks, creating steep valley sides and rocky scarps.

The larger Lough Macnean Upper has wooded promontories and sheltered bays with fringing reed swamps, fen and carr woodland. Surrounding fields are largely wet, rush-dominated grassland. Lough Macnean Lower is confined by a steep limestone escarpment. It has a more developed agricultural shoreline, with open wet meadows contrasting with occasional thick woodlands. Limestone soils along the southern shores and lower slopes produce better quality grassland and these are farmed intensively. Farm units are smaller to the north of the loughs, but there is also intensive sheep and cattle grazing. The valley has some significant archaeological sites, including raths and crannogs.

To the east the valley opens out into the flat Arney Valley and to the north-west it connects with the Garrison lowlands.

In the catchment of the Upper lake, Dough Mountain (462m) stands at the western boundary of the catchment. The Cornavanogue River rises in a number of parallel rills falling off the southern slopes of the mountain. The river continues south to the N16 road and thence flows eastwards, following the road, to enter Lough Macnean Upper.

The southern boundary of this upper catchment section is formed by a ridge, mostly over 400m high, and stretching some 10km from the summits of Ballaghnabehy Top (413m) to Naweelogue Top (441m). A number of small streams, most notably the Esky River, flow northwards from this ridge to the lake.

The northern boundary of the upper lake's catchment is formed by the Ballintempo Uplands, a moderately high plateau at about 350m. The plateau is drained largely by the Black River which enters the lake at its north-western extremity, and by the Lurgan River that flows into the eastern end of the upper lake.

The Belcoo River connects the two lakes. Apart from the Belcoo, the most significant inflow to Lough Macnean Lower is Drumharriff Burn at its north eastern end.

The Arney River flows eastwards from the lower lake to the River Erne, a distance of about 15km. It meanders through a wide, flat glacial trough between the uplands of Fermanagh, Belmore and the Cuilcagh Mountains. The steep-sided drumlins of the Sillees Valley are to the north, and the wetlands of Upper Lough Erne lie to the east. The valley is characterised by wide flat lowlands with low hills. This lowland has damp peaty soils with some farming, scrub woodland and raised bogs. The shallow hills are better drained.

Just below its outflow from the lake, the Arney is joined by the Cladagh River which drains the southern section of this lower catchment. The southern boundary is marked by the long sandstone ridge of Cuilcagh Mountain (660m). Many streams flowing off the upper northern slopes of Cuilcagh enter the karstic limestone below. The hydrology of the area is complex and underground stream pathways are poorly understood. The karst hydrological system is fed by a large number of sinks.

The Florencecourt River drains a significant portion of the catchment east of Cuilcagh and joins the Arney about halfway between Lough Macnean Lower and the Erne.

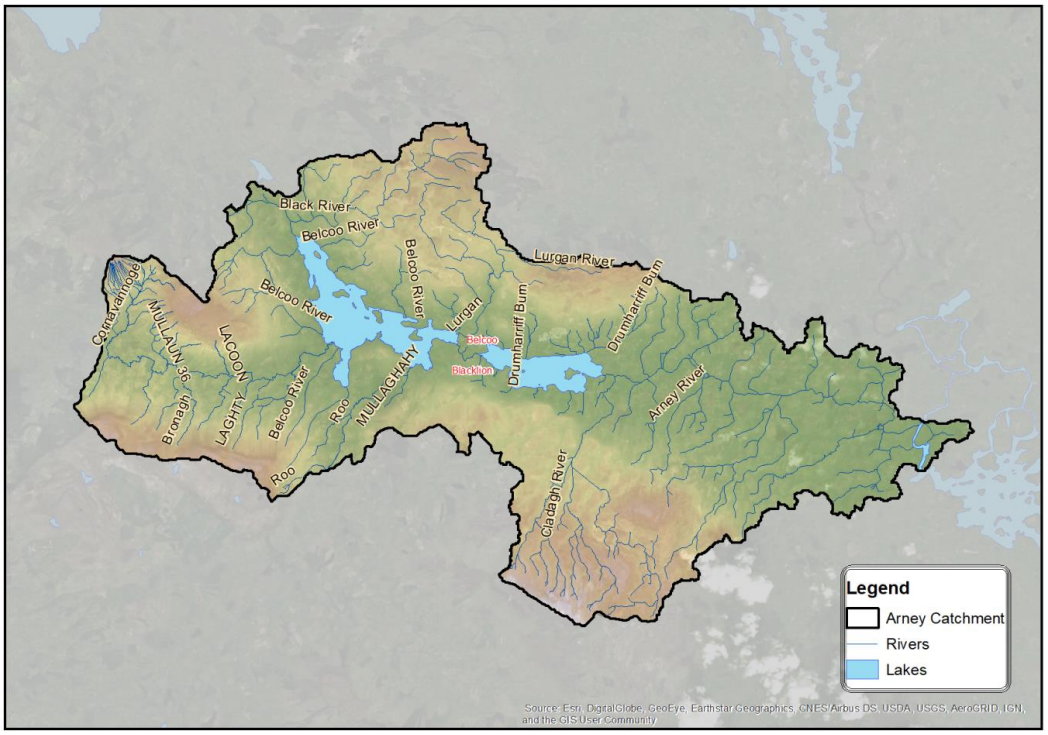

Figure 2-32 River Arney Catchment topography

2.2.2 Population

The population of the Arney catchment is approximately 9,800 people. This is equivalent to a density of about 32/km^2 (Figure 2-33).

The biggest settlements in the catchment are Blacklion in County Cavan (population 194 in the 2016 census), and Belcoo/Holywell in Fermanagh (population 540 in the 2011 census). Therefore some 85% of the population distribution in the catchment is dispersed rural, often as ribbon development.

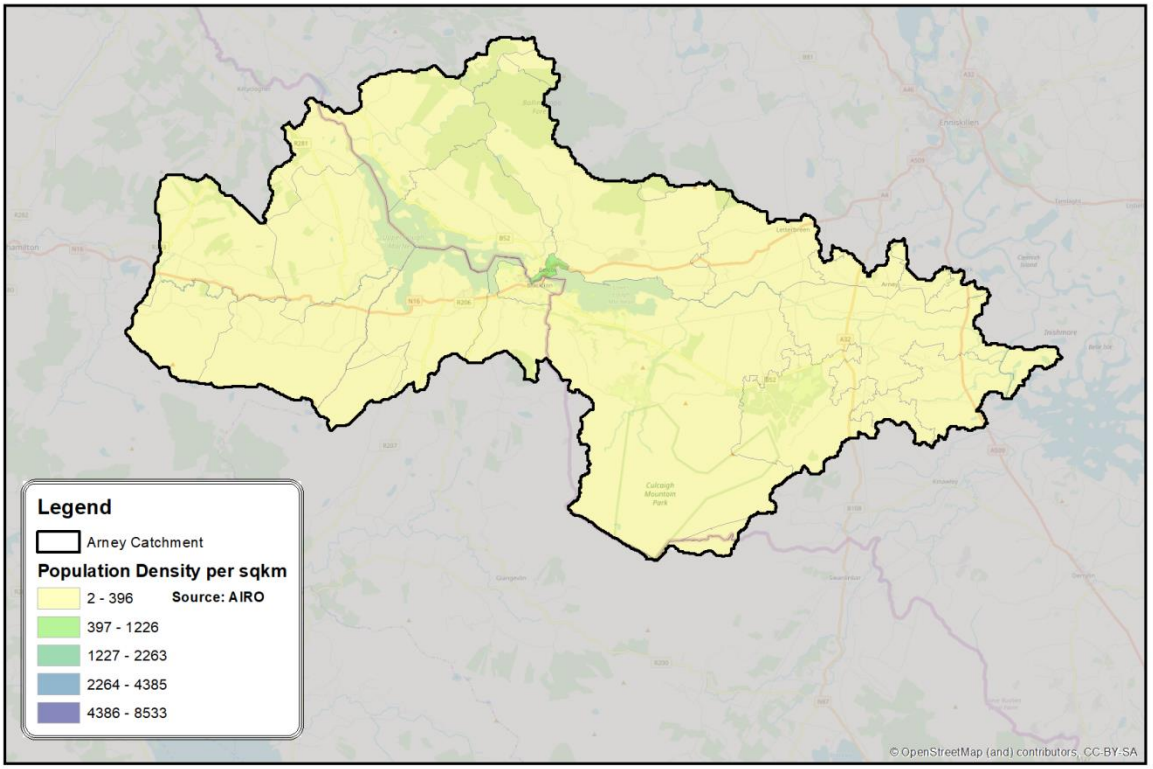

Figure 2-33 Population density in the River Arney Catchment

2.2.3 Catchment Geology, Hydrogeology and Soils

Bedrock Geology

The Arney Catchment is underlain by Carboniferous age rocks. The rim of high ground, including the peaks and ridges, around the upper catchment is largely sandstone (Figure 2-34). The Glenade sandstone forming the north western catchment boundary is homogeneous with only minor amounts of shale. The peaks of Dough and Thur mountains, and the ridge from Ballaghanabahy to Naweelogue peaks are sandstone interbedded with shale.

Descending from the high ground, the sandstone gives way to shale rock units (formations). In the upper catchment valley the shales are part of the Carraun Shale Formation, composed of grey to black fossiliferous shales and mudstones, with thin subordinate limestones and dolomites.

The central third of the catchment is underlain by limestone of the Dartry Limestone Formation. The limestones in the catchment are karstic, meaning that channels have been dissolved out within them, resulting in much higher permeability and rapid underground flow paths. Approximately half way down Lough Macnean Lower the limestones give way to shale which underlies most of the Arney

lowland catchment. Limestone reoccurs, however, north of the Arney River from Arney village to the Erne River.

The geology of the Cuilcagh mountain area is complex and highly faulted. The cliff-edged summit of the mountain is formed from the hard-wearing Lackagh Sandstone which overlies the Briscloonagh Sandstone. The sandstone escarpment of Cuilcagh is bordered to the north by a shale and minor sandstone formation, and then a much faulted zone with sandstone and shale. Glenade sandstone occurs again in the high ground above Marble Arch with a band of karstified Dartry limestone before reaching the shales of the lower catchment.

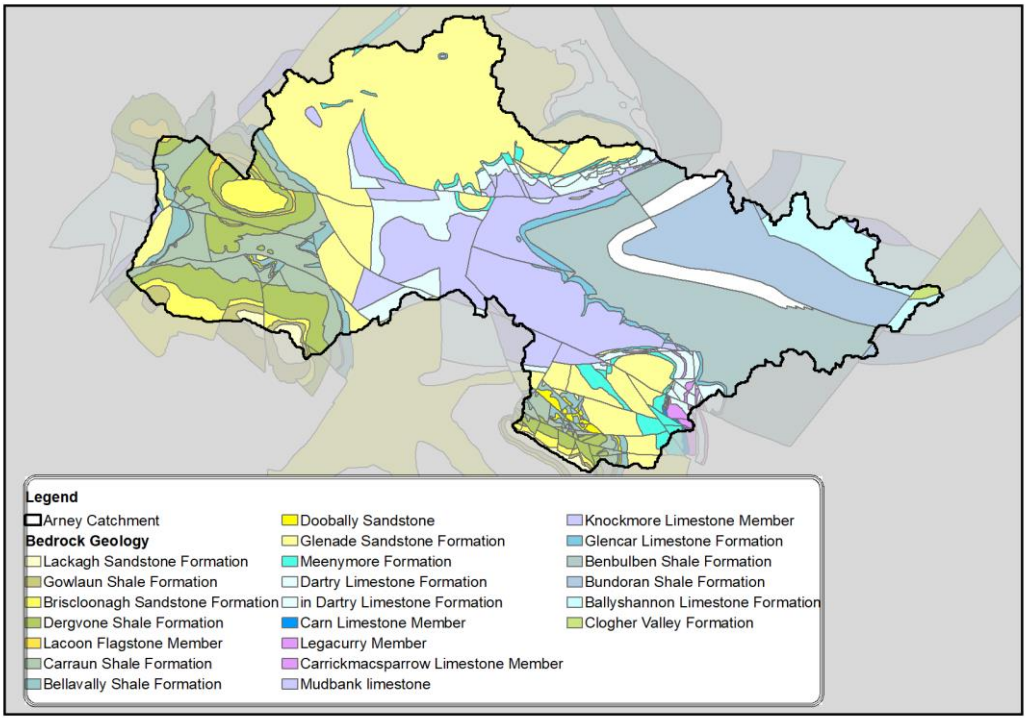

Figure 2-34 Bedrock Geology in the Arney Catchment (Data source: GSI and BGS/OSNI)

Soils and Subsoil Geology

The upland catchment areas are largely covered by blanket peat (Figure 2-35). Smaller areas of cut peat also occur in the Arney lowlands. There are some areas of exposed bedrock and karstified bedrock outcrop or subcrop such as at Corratirrim, south of Blacklion. However, the greater part of the catchment is covered by glacial tills ('boulder clay') derived from Namurian sandstones and shales, and from limestones.

The river valley floors are covered by alluvial sands and silts particularly along the lower Lurgan and Cornavanogue rivers, along the Belcoo River, and the Arney River from the lower lake to the A32. Lacustrine alluvial clay, silts and sand deposits occur along the Arney further to the east near Upper Lough Erne.

The mineral soils of the upland catchment are substantially gleys and leptosols (Figure 2-36). Soils in the eastern lowland catchment are largely poorly drained stagnosols and acidic. Fluvisols are most extensive in the riverine and lacustrine alluvial deposits along the Arney River.

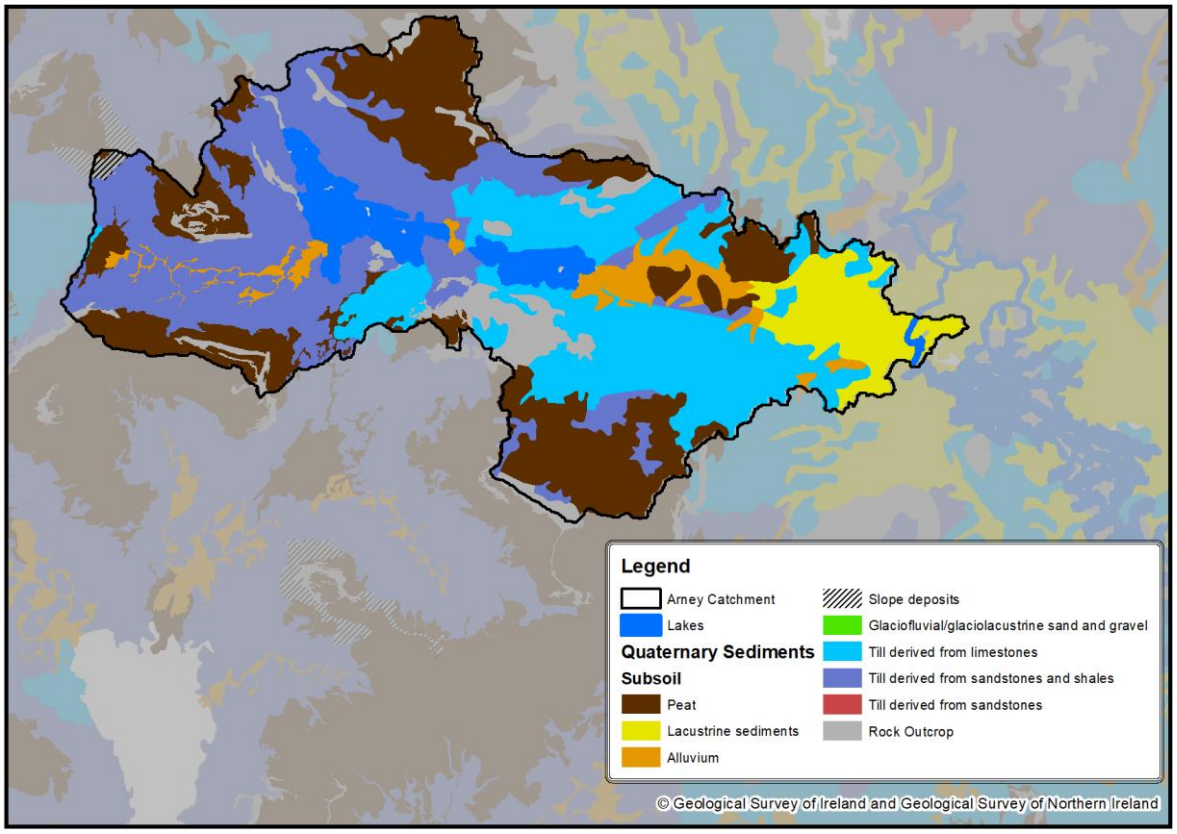

Figure 2-35 Subsoils Geology in the River Arney Catchment (Data source: GSI and GSNI)

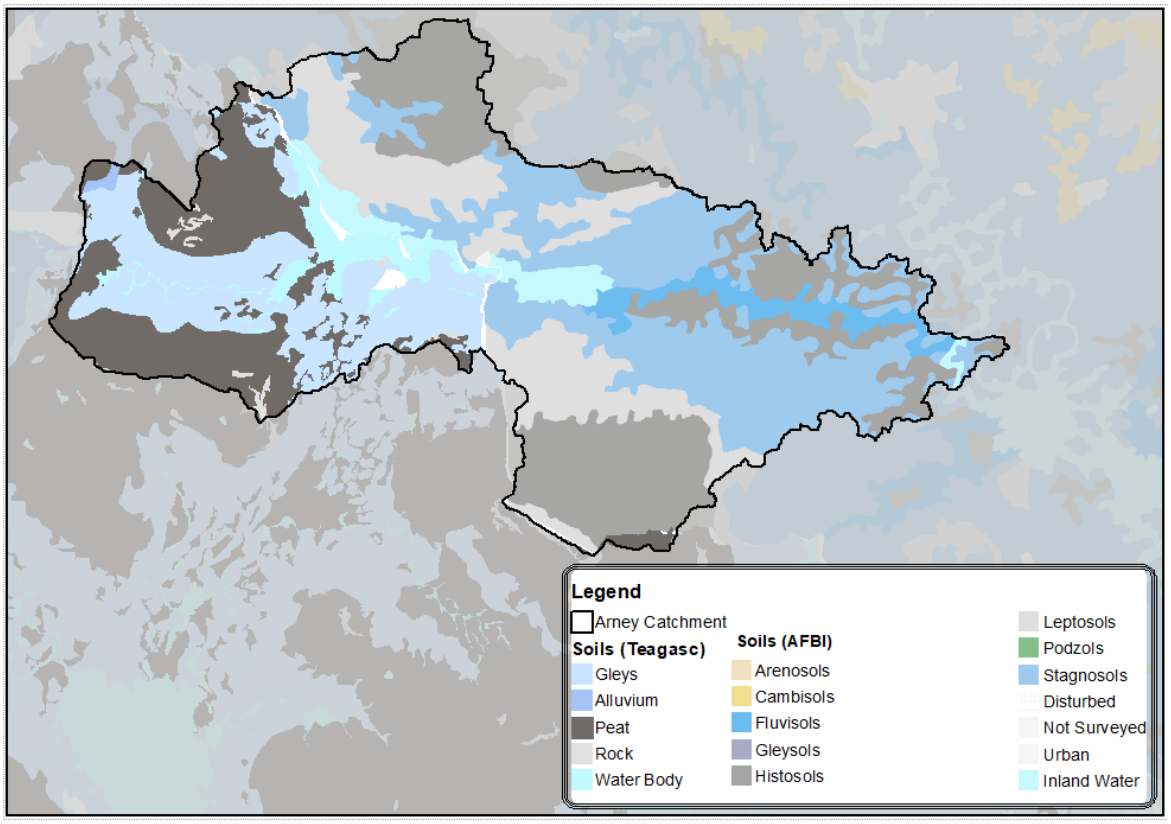

Figure 2-36 Soil Types in the River Arney Catchment (Data Source: Teagasc and AFBI)

Hydrogeology

Groundwater vulnerability in the Arney catchment ranges from Extreme to Low in ROI. In NI, groundwater vulnerability ranges from class 2 to 4, with a very small area of class 5 (Figure 2-37). (In the NI classification scheme, 1 is the least and 5 the most vulnerable.) Groundwater is most vulnerable where the subsoils are absent or thin, in areas of karstic limestone where surface streams sink underground at swallow holes, and where the water table in certain aquifer types is shallow. Areas of Extreme vulnerability associated with shallow or exposed bedrock are mainly found in upland areas. Extreme vulnerability points are also related to karst features such as swallow holes and enclosed depressions that puncture the thick, protective subsoil layers overlying the karst limestone aquifers. In the valleys, sediments are thicker and the groundwater beneath is better protected.

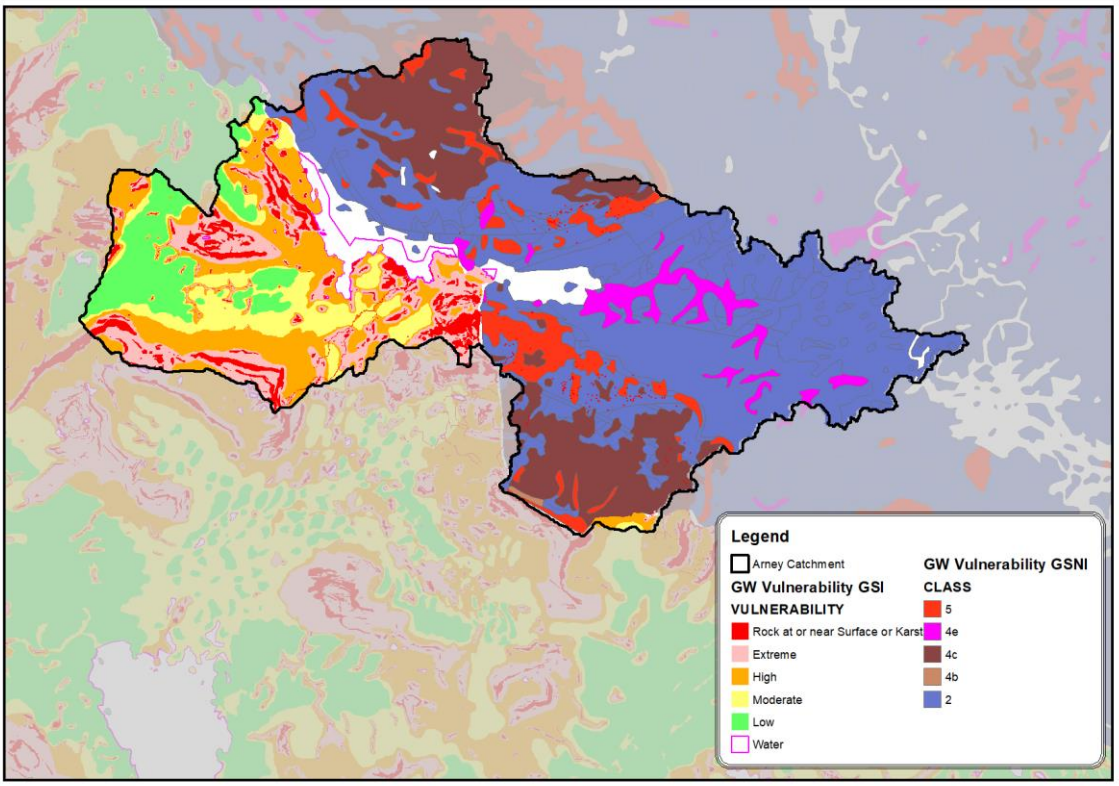

Figure 2-37 Groundwater vulnerability in the River Arney Catchment (Source: GSI/GSNI)

In the Arney catchment, the highly permeable karst limestones are the principal aquifers (Figure 2-38). Rainwater recharging these aquifers can sink into them diffusely through soils, or at points. Streams sinking in to the karstified limestone travel underneath the ground through cavities, rather than over it. Groundwater then emerges at springs towards the base of the limestones. Many of the streams that feed in to the main Arney River, as well as Upper and Lower Lough Macnean are fed by springs emerging from the limestone. Existing dye tracing studies indicate that the groundwater catchment extends further south than the surface catchment, because water emerging at springs may have originated as streams sinking into the limestone outside of the surface water catchment. Connection between stream sinks and springs is well known around Cuilcagh Mountain, but there is little known about of the streams coming off Belmore Mountain.

The mudstone-dominated rocks have low transmissivity and contain limited groundwater resources and can act as boundary to water flow in some cases. Most of the groundwater flow is likely to be in

the uppermost part of the aquifer comprising a broken and weathered zone and a zone of interconnected fissuring. Isolated fissures can be encountered at greater depths, but typically less than 150m. Recharge occurs diffusely through the subsoil and rock outcrops, although is limited by any thicker low permeability subsoil and ability of the aquifer to accept the rainfall. Most of the effective rainfall over the poorly productive aquifers is not expected to become part of the sustainable groundwater resource, but will discharge quickly to springs, seeps and surface waters. Flow paths are likely to be short (<500m). Some of the sandstones are well-fractured and allow groundwater to flow through them, but not in such significant quantities as the karstified limestones. Higher transmissivity values are expected in the sandstones, resulting in longer flow paths (up to 2,000m).

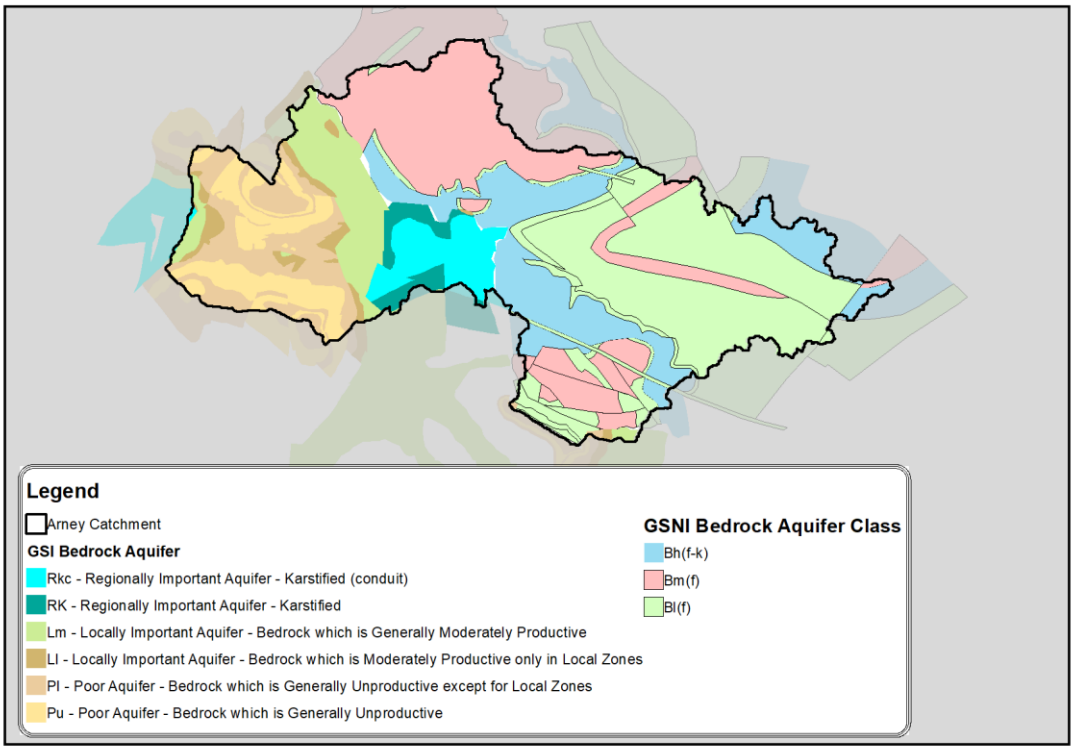

Figure 2-38 Groundwater resources (aquifers) in the River Arney Catchment (Source: GSI/GSNI)

2.2.4 Catchment Land Use

The upland catchment is covered in extensive blanket peats (Figure 2-39). Cuilcagh Mountain has one of the largest expanses of blanket bog in Northern Ireland, on a relatively high elevation upland landscape, bounded by limestone grassland to the north and montane habitats to the south. Peat extraction occurs in a number of areas. On drier slopes the peats are replaced by moors and heathlands. Montane heath is found on the summit of Cuilcagh Mountain.

Parcels of coniferous forestry occur throughout, particularly in the upland areas. The most significant area is Ballintempo forest in the northern catchment. Transitional woodland and scrub is also widespread in the uplands and on the slopes, but broadleaved woodland is restricted to small areas. The valleys of the western catchment, in particular the Cornavanogue valley, support agriculture but with an admixture of significant areas of natural vegetation. The eastern lowland catchment, is dominated by pastures.

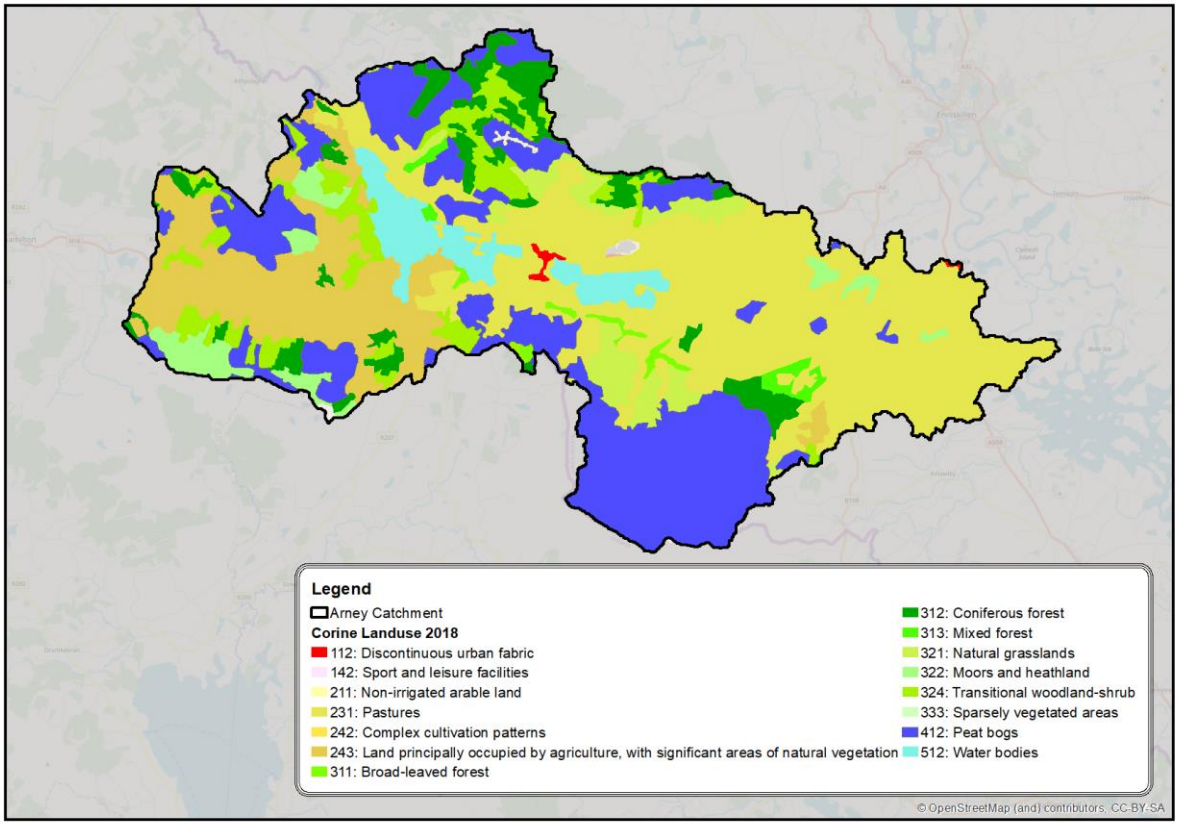

Figure 2-39 River Arney Catchment Land Classifications Map (Data source: CORINE Land Cover 2018, EEA)

The proportion of the various land use classes is illustrated in the pie diagram (Figure 2-40). It shows that pastures and peat bogs are the predominant land cover types in the Arney catchment, together comprising 59% of the catchment area.

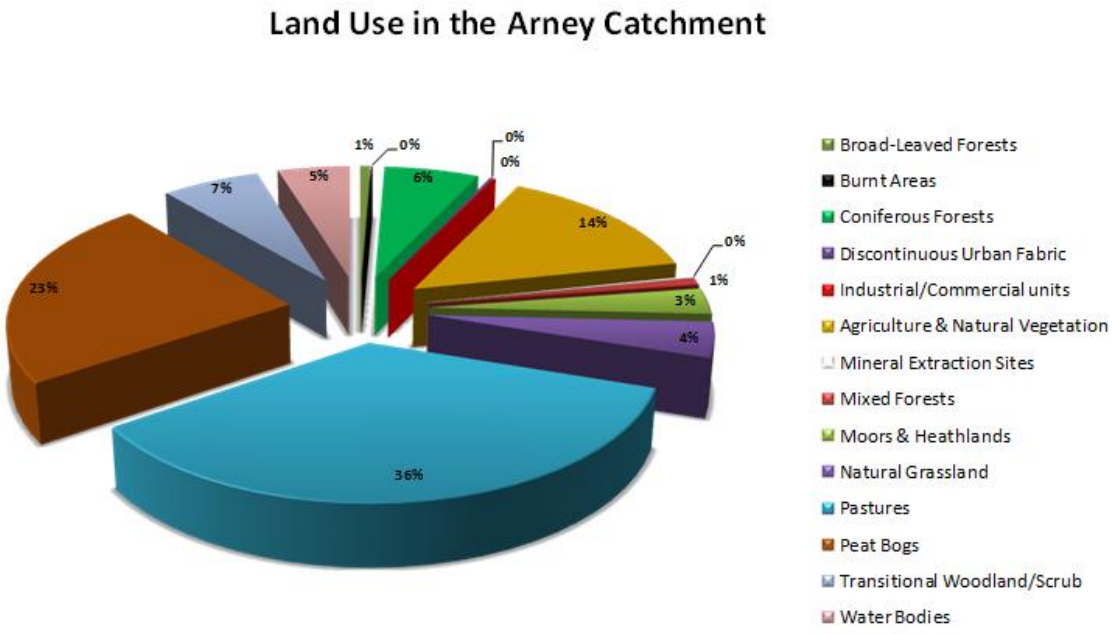

Figure 2-40 Land cover and land use in the River Arney Catchment

2.2.5 Protected Areas

Four Natura 2000 sites occur wholly or partly within the Arney catchment:

- Boleybrack Mountain SAC 002032
- Corratirrim SAC 000979
- Cuilcagh Mountain SAC UK0016603
- West Fermanagh Scarplands SAC UK0030300

Detailed descriptions of each are available at https://www.npws.ie/ and https://www.daera-ni.gov.uk/protected-areas. The following summary notes some of the salient points of interest relevant to the CatchmentCARE Project and locations of Natura sites are shown in Figure 2-41.

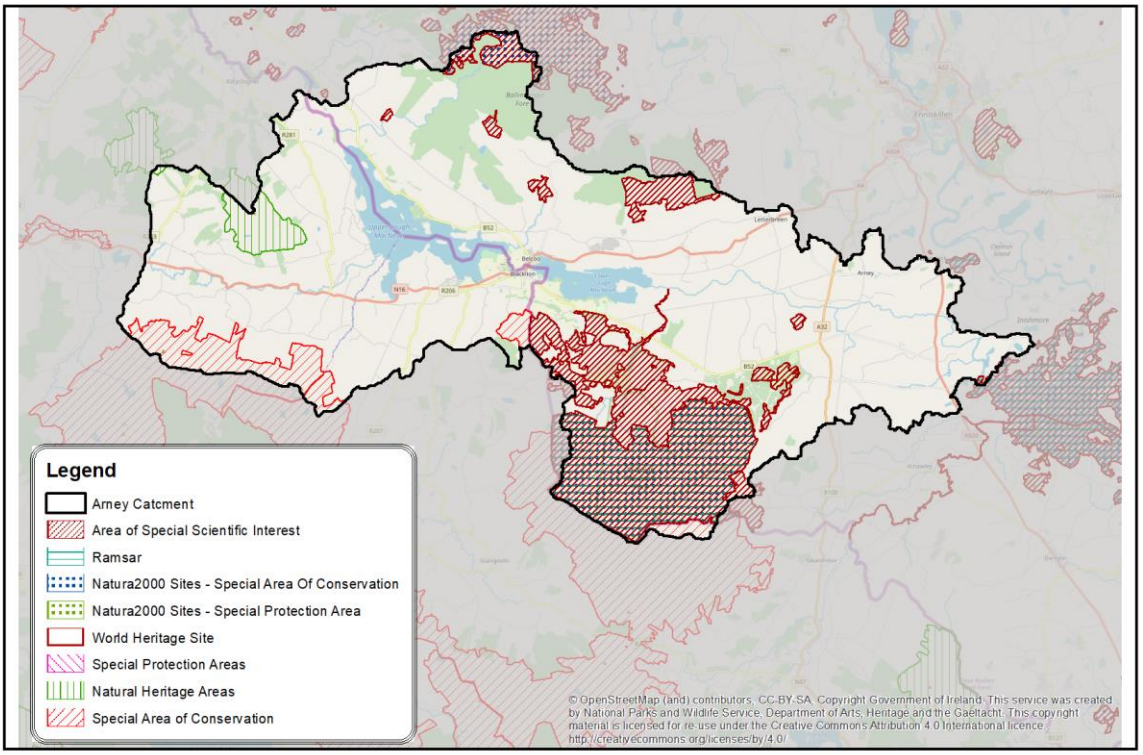

Figure 2-41 Biodiversity and Landscape Protected Areas in the River Arney Catchment (Data Source: NPWS and NIEA)

Boleybrack Mountain SAC comprises an extensive upland plateau situated in Counties Leitrim and Cavan. It extends across the south western Arney catchment border on the Ballaghbehy Top to Naweelogue Top plateau.

The habitats for which the SAC has been designated include dystrophic lakes and ponds, Northern Atlantic wet heaths with European dry heaths, meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae), and blanket bogs (* if active bog).

The SAC is dominated by excellent examples of active mountain blanket bog and wet heath, with small oligotrophic/dystrophic lakes scattered throughout. The site also contains low rocky cliffs, areas of dry heath and a variety of grassland types, including heathy grassland dominated by Purple Moor-grass (*Molinia caerulea*), upland acid grassland, orchid-rich meadows and wet, rushy pastures.

The site also provides excellent feeding habitat for Red Grouse, Snipe, Curlew and Ravens. Golden Plover nests within the site (2-3 pairs), while Hen Harrier may use the site for foraging.

The upland plateau contains approximately 20 lakes, many of which conform to the dystrophic lake category. Nearly all of these lakes, except perhaps for some small dystrophic ponds, are outside the Arney catchment.

Although the site is lightly grazed by sheep and locally affected by burning and turbary, the presence of a number of rare plant species and of a variety of bird species adds to the conservation significance of the site.

At Corratirrim, approximately 2km south of Belcoo, the limestone that underlies the shales and grits of the Cuilcagh range outcrops at the surface with patches of limestone pavement for which the site has been designated. The rare and protected Small-white Orchid (*Pseudorchis albida*) is found on the steep south-west facing slope in these limestone uplands. Throughout the site grazing by sheep and cattle is carried out which generally prevents the spread of scrub.

Cuilcagh Mountain SAC contains one of the most extensive areas of upland blanket bogs in Northern Ireland. The area is situated at a relatively high altitude in a high rainfall area and has a wide range of features, including well-developed pool, hummock and lawn complexes, acid flushes and bog bursts. The site also contains transitions to montane, rock and lake habitats.

Other important habitats in the SAC are dystrophic lakes, wet and dry heaths, alpine and boreal heaths, siliceous scree, rocky slopes and chasmophytic vegetation.

West Fermanagh Scarplands contains representatives of many of the habitats listed above, and has been designated for a number of these. These include semi-natural dry grasslands and scrubland facies on calcareous substrates which are important orchid sites. Species rich Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae) and limestone pavement also occur in this SAC. The West Fermanagh Scarplands represents the largest area of *Tilio-Acerion* forests in Northern Ireland. The limestone soils tend to be freely-draining and the canopy is generally dominated by ash (*Fraxinus excelsior*), with hazel (*Corylus avellana*) and occasional hawthorn (*Crataegus monogyna*), rowan (*Sorbus aucuparia*) and holly (*Ilex aquifolium*) in the understorey.

2.2.6 Water Framework Directive Status

The Arney catchment is divided into 11 river water bodies and two lake water bodies (Figure 2-42). It is associated with 11 groundwater bodies.

The extent of monitoring for status assessment at individual stations varies in terms of the range of parameters covered. All river water bodies in the catchment are monitored for the assessment of ecological status. However, of the biological elements, only macroinvertebrates were assessed at the ROI monitoring points. Supporting physico-chemical elements were monitored at one ROI monitoring station. In Northern Ireland, all elements were assessed in all monitoring stations except for fish, which were not monitored in three NI water bodies, and morphology which was not assessed in two water bodies.

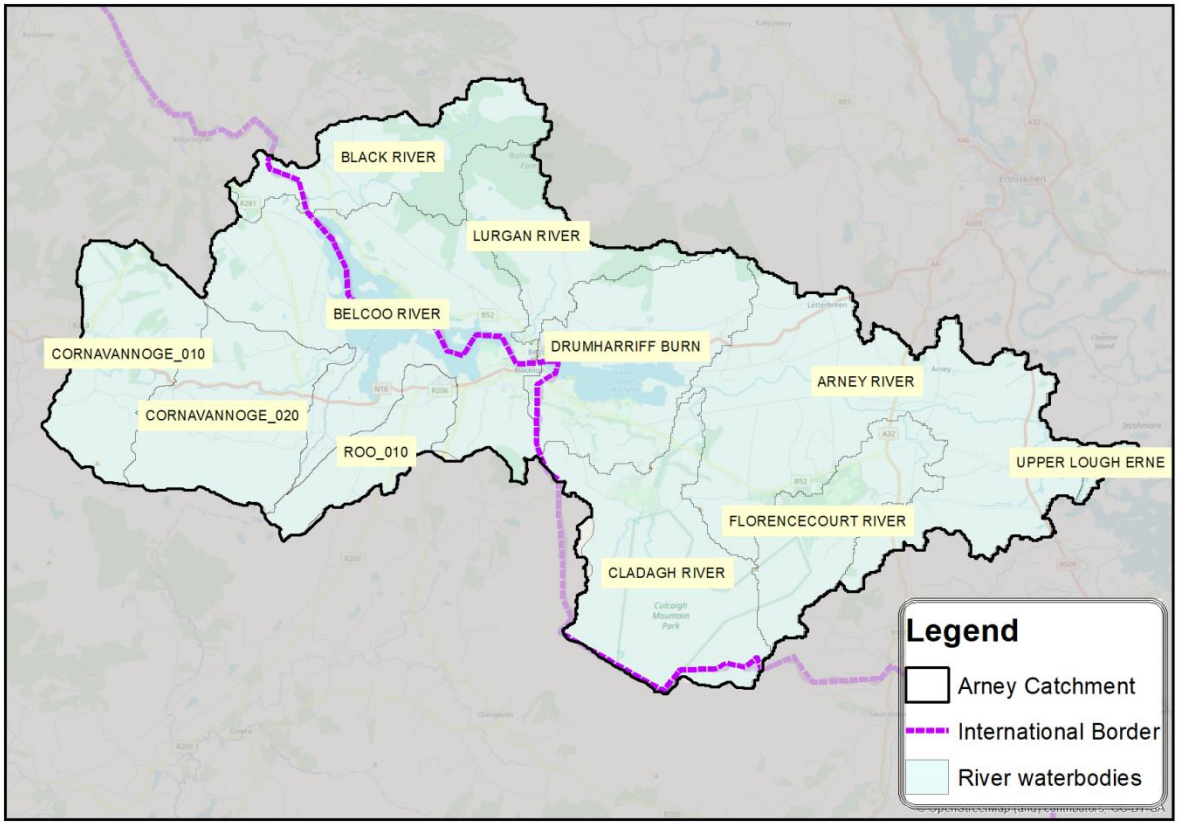

Figure 2-42 River water bodies in the River Arney Catchment

A summary of the status of all water bodies in the Arney catchment is provided in Table 2.3 and illustrated in Figure 2-44. Table 2.3 also indicates significant pressures that are operating in water bodies.

River Water Bodies (RWB)

Of the eleven RWBs in the Arney catchment, 1 is at high status, 5 are at good status, and 5 are at moderate status (Table 2.3). The high and good status water bodies are in the upland headwater reaches where significant pressures are largely absent (Figure 2-44). However, one headwater river, the Black River, is at moderate status and agriculture is a significant pressure in this area of the catchment. The element driving status in this case is fish, and all other status elements are high or good.

The RWBs in the eastern half of the catchment, around Lough Macnean Lower and in the Arney lowlands, are all at moderate status.

One RWB has improved in status since the previous assessment in 2015. This waterbody, Roo_010, has improved one status class from poor to moderate. Septic tanks, agriculture and forestry had all been identified as significant pressures in Roo_010, but recent trends have shown a decrease in total ammonia and in ortho-phosphate. Cornavanogue_020 has improved to high status, and status has disimproved in one case only since the last assessment. The Florence Court River has dropped from high status to good status.

The Black River, Roo stream and Drumharriff Burn are all considered to be at risk of not achieving their WFD objectives (Figure 2-43). Agriculture is a significant pressure in the first two of these, and

anthropogenic pressures are impacting in the Drumharriff Burn water body. Domestic waste water pressures have also been identified as a significant issue in the Roo stream.

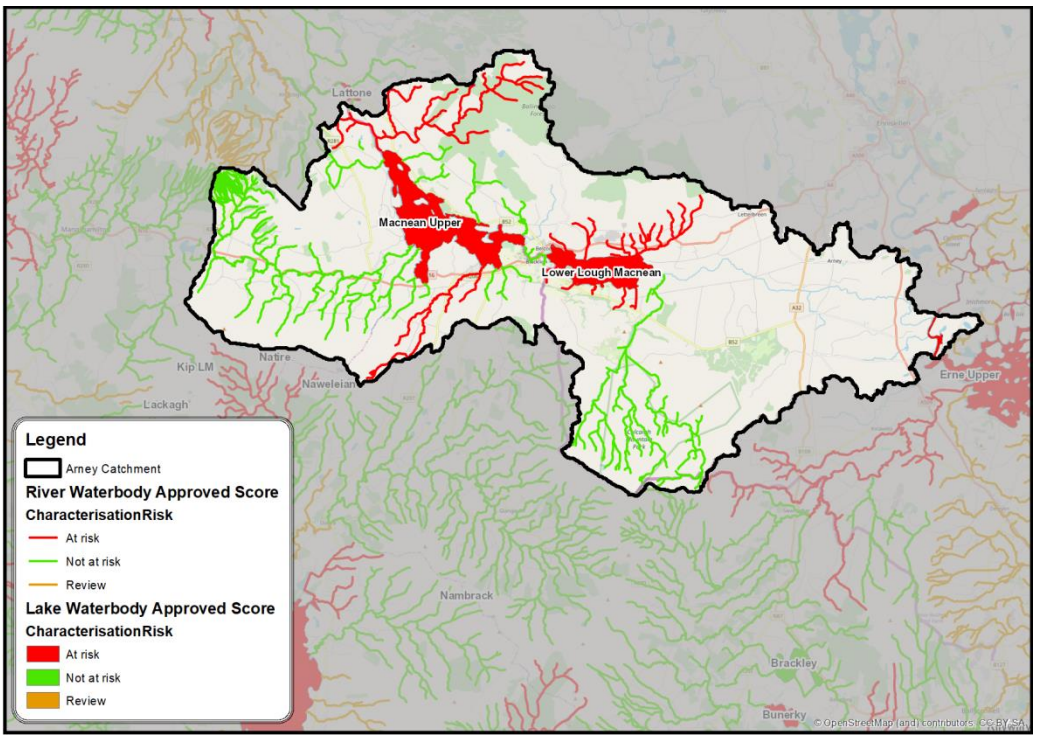

Figure 2-43 Locations of water bodies and WFD risk assessments in the River Arney Catchment

Lake Water Bodies (LWB)

The most recent classification for Upper and Lower Lough Macnean is in 2018. Lough Macnean Upper was classified at poor status (Figure 2-45). Significant pressures in the lake's catchment include forestry, agriculture and septic tanks. While the biological, and hydromorphological elements were all at good status, dissolved oxygen was classified at moderate status only.

Lough Macnean Lower is at bad status (Figure 2-45). Macrophytes, classified at bad status, was the driving element of status. Although phytoplankton and phytobenthos status were at high and good respectively, fish status was poor. The Blacklion WWTP has been identified as the sole significant pressure on the water body at risk of not meeting its environmental pressures. Although tertiary treatment is available, there have been regular breaches of emission limit values for ammonia, total phosphorus and suspended solids at the Blacklion WWTP. In 2018 the EPA reported that the plant was hydraulically overloaded.

Groundwater Bodies (GWB)

The Arney catchment is associated with 11 GWBs. Five of them are karstic, three are productive fissured bedrock aquifers, with the remainder poorly productive. Eight of them are at good status and not at risk. One groundwater the Marble Arch has improved from poor status to good status. In NI the Belcoo Boho GWB and the Enniskillen GWBs have been assigned poor status (Figure 2-46). These have been classified on the basis of failing the Groundwater Dependent Terrestrial Ecosystems and the Surface Water Chemical tests.

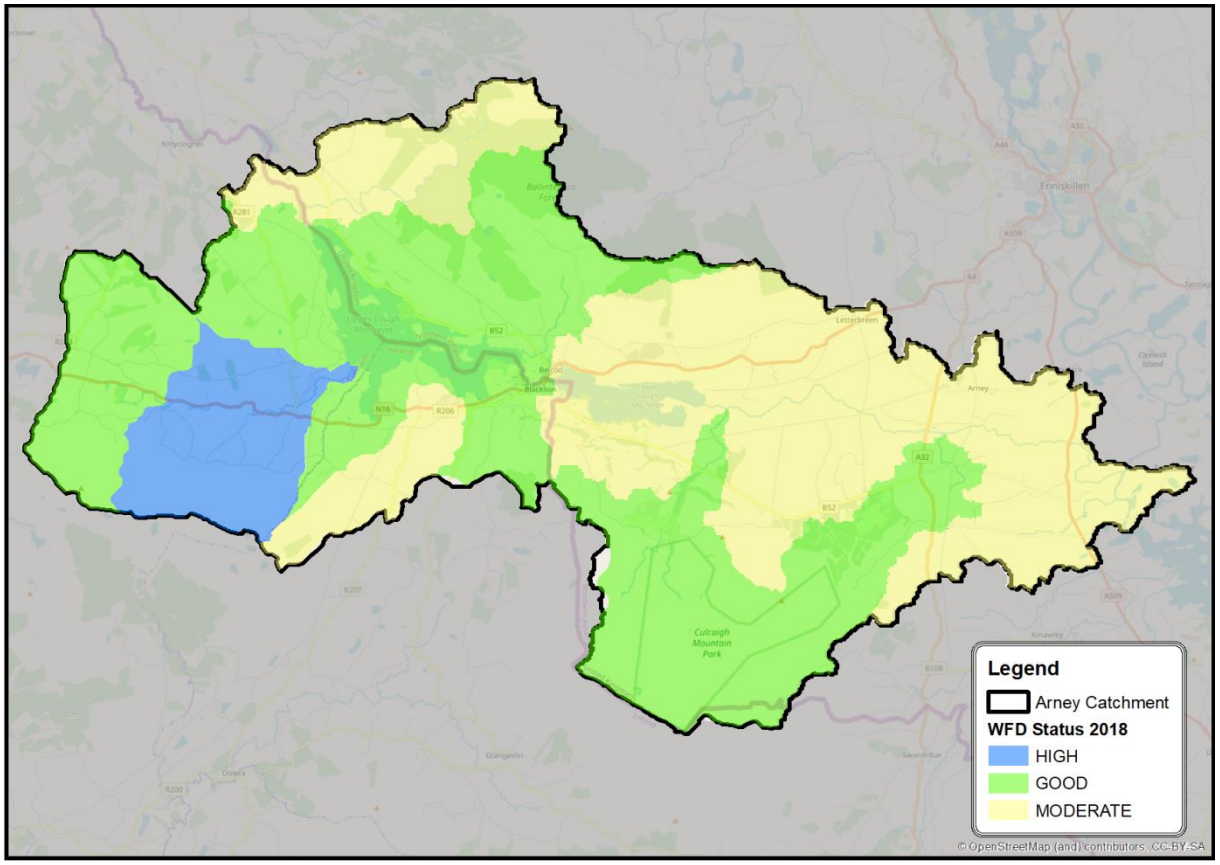

Figure 2-44 River water bodies and WFD status in the River Arney Catchment

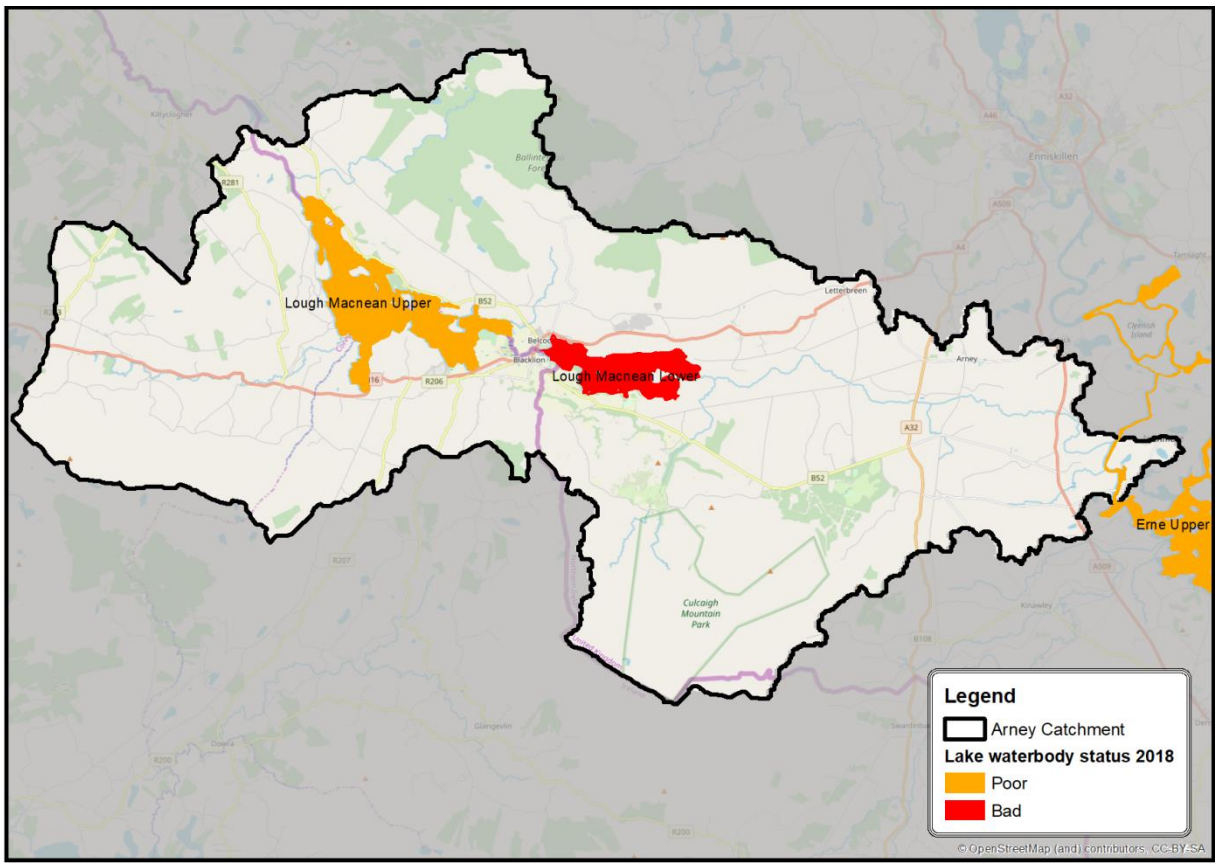

Figure 2-45 Lake water bodies in the River Arney Catchment and WFD Status

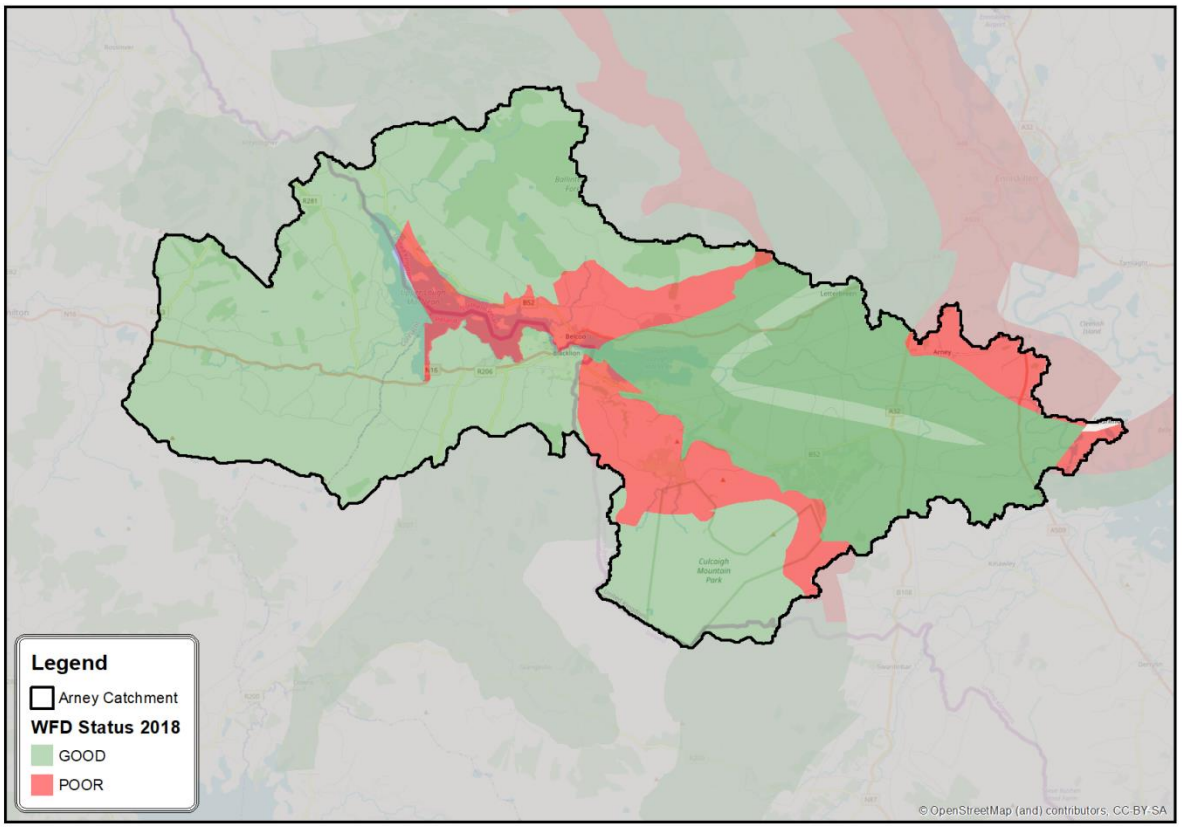

Figure 2-46 Groundwater Bodies in the River Arney Catchment and WFD status

Table 2.3 WFD water bodies, status and significant pressures in the River Arney Catchment. Source: NIEA and EPA.

Sub Catchment	River Waterbodies	Status 2015	Status 2018	Pressures
SC_010 (Lough Macnean connector)	Cornavannoge_010	GOOD	GOOD	NONE
	Cornavannoge_020	GOOD	HIGH	NONE
	Roo_010	POOR	MODERATE	Septic tanks, Agriculture & forestry. (EDEN ROI)
_036	Black River	MODERATE	MODERATE	Agriculture (EDEN ROI)
_084	Cladagh River	GOOD	GOOD	NONE
_092	Belcoo River	GOOD	GOOD	NONE
_093	Drumharriff Burn	MODERATE	MODERATE	Anthropogenic Pressures (EDEN ROI)
_007	Lurgan River	MODERATE	GOOD	
_049	Florence Court River	HIGH	GOOD	
_063	Upper Lough Erne	MODERATE	MODERATE	
_059	Arney River	MODERATE	MODERATE	
	Lake Water Bodies			
_445	Lough Macnean Upper	MODERATE	POOR	Forestry, Agriculture & Septic tanks.(EDEN ROI)
_673	Lough Macnean Lower	BAD	BAD	WWTW (EDEN ROI)
	Groundwater Bodies			
_020	Belcoo Boho (KA)	POOR	POOR	
_022	Florence Court-Drumgormley (PP)	GOOD	GOOD	
_042	Glenfarne (PP)	GOOD	GOOD	
_021	Ballintempo (FI)	GOOD	GOOD	
_036	Marble Arch (KA)	POOR	GOOD	
_003	Shannon Pot (KA)	GOOD	GOOD	
_038	Enniskillen (KA)	POOR		
_035	Anierin-Cuilcagh East (PP)	GOOD	GOOD	
_040	Claddagh-Swanlinbar (FI)	GOOD	GOOD	
_024	Derrygonnelly (FI)	GOOD		
_037	Tempo (PP)	POOR		

2.2.7 Catchment Pressures

The range of pressures impacting on the water environment, and the methods used to identify them have been outlined in section 2.1.7 for the Finn Catchment above. Significant pressures impacting on water quality in the Arney catchment include agriculture and forestry, urban wastewater treatment effluent, domestic wastewater discharges, and anthropogenic pressures.

Agriculture

Figure 2-47 shows the catchment areas where agricultural pressures are deemed to be a significant risk. The extent of significant agricultural pressures (amber and red areas) in the eastern catchment is clear. Agriculture in the western upland portion of the catchment is generally more extensive with sheep grazing on rough pasture and commonages (Figure 2-48). It is not identified as a significant pressure in these areas.

More intensive farming is confined to the river valleys in these uplands such as the Black River and Roo stream, and in particular to the eastern half of the catchment where more fertile soils occur around the lower lake and in the Arney lowlands. In the latter area, farms typically consist of small fields that are grouped on low hills above surrounding damp soils, but the holdings also include intensive grassland on large improved fields. The main types of farming in these areas are beef, dairy, and sheep. Most of the agricultural land is used as grassland for grazing and silage or hay rather than for other crops.

The main impact of agriculture in the catchment is diffuse nutrient enrichment. Evidence of nutrient enrichment has been indicated in water bodies affected by impacts on macrophyte and diatom communities, including Drumharriff Burn and Lower Lough Macnean.

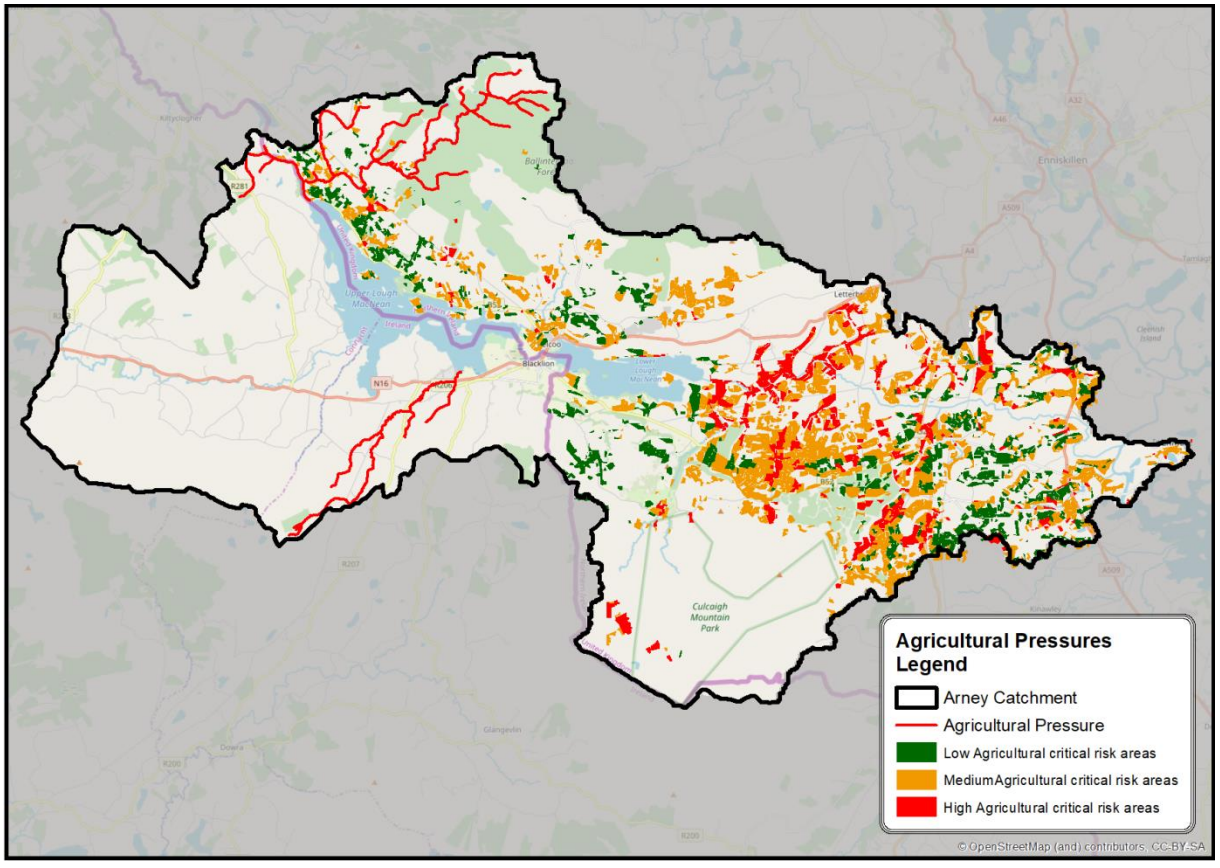

Figure 2-47 Agricultural pressures in the River Arney Catchment

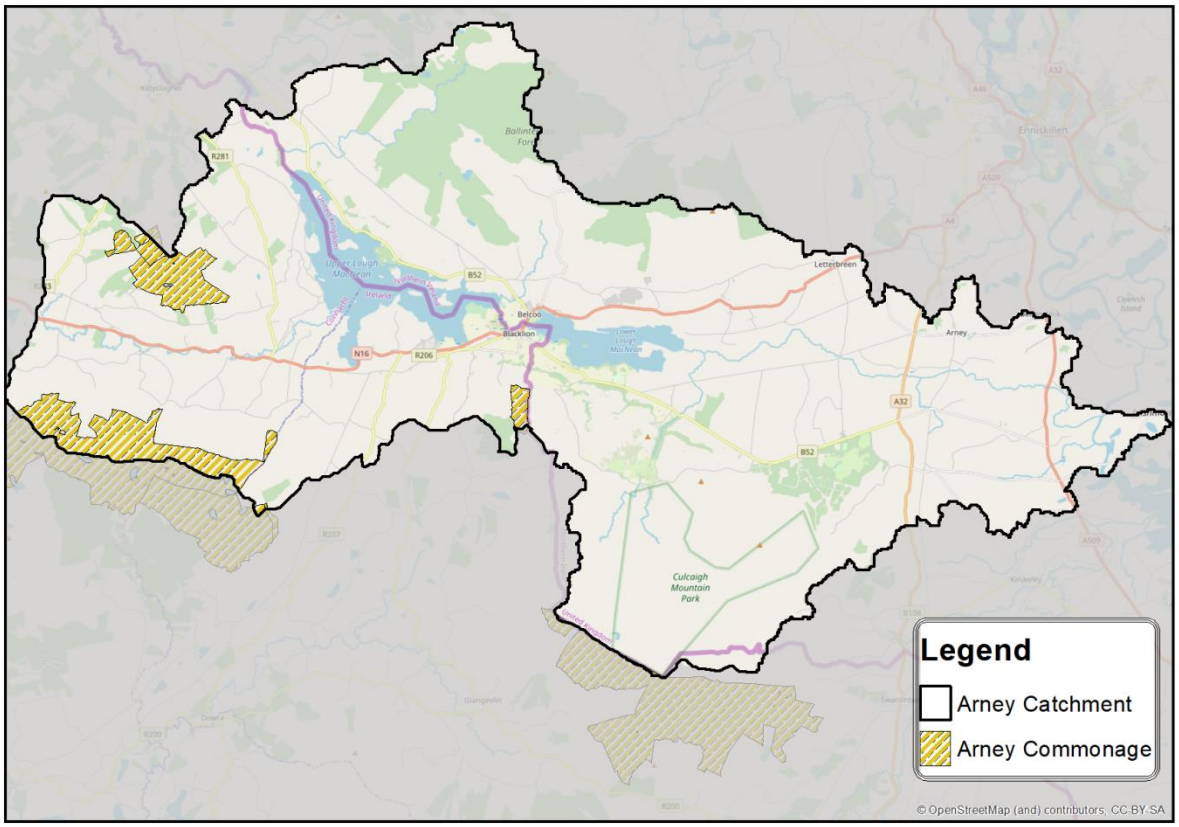

Figure 2-48 Commonage areas in the River Arney Catchment

Forestry and Peat Extraction

The forest estate is predominantly commercial conifer plantations (Figure 2-49). These are distributed throughout the upland catchment areas, and many have been planted on blanket peats. Forestry has been identified as a significant pressure in the Lough Macnean Upper catchment. The area of greatest cover is in Ballintempo forest. The forest estate is of mixed age and many areas have been recently clear felled. Greatest impacts are often associated with clear felling and subsequent forest re-establishment. Impacts include sediment and phosphorus release, the latter particularly where forests are growing on peats.

Peat extraction is also ongoing in many areas, often the same areas as forestry, and is obvious in the upper Roo valley and around the margins of the lowland raised bogs in the Arney valley. Extensive areas of upland blanket peats have been cut mechanically. Drainage and exposure of bare peat can give rise to sediment and nutrient release, and changes in hydrology. Peat extraction has not been identified as a significant pressure in the Arney catchment to date, although this may need to be revisited.

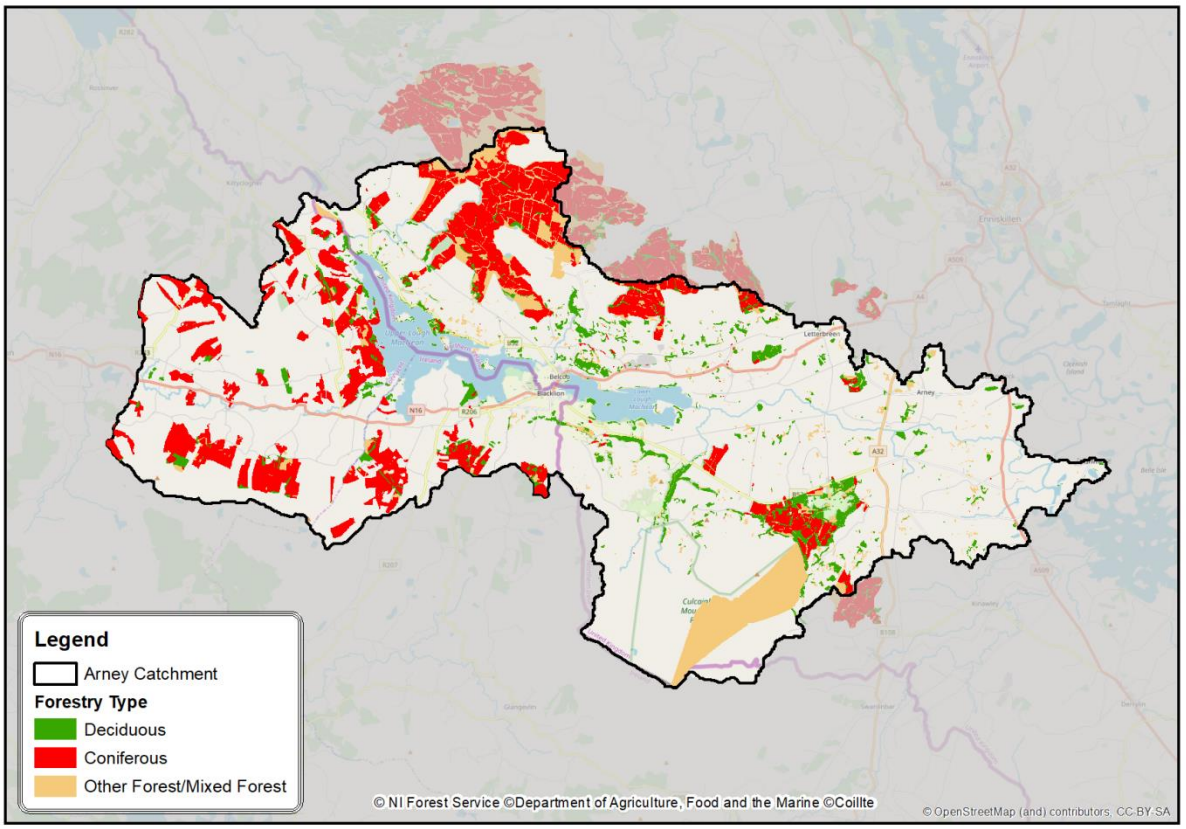

Figure 2-49 Forestry areas in the River Arney Catchment

Urban Waste Water Treatment and On-site Wastewater Systems

There are 7 waste water treatment plants (WWTPs) in the Arney catchment and their locations are shown in Figure 2-50.

Blacklion WWTP was built in the late 1960s and the current plant has been upgraded to treat a population equivalent (PE) of up to 990 persons. The current PE (2015) of the plant is 768. Blacklion is listed amongst the urban areas where improvements are needed to address environmental priorities. The EPA consider that the waste water discharge from Blacklion UWWT plant is the sole significant pressure on the Macnean water body at risk of not meeting its environmental objectives. Although tertiary treatment is available, there have been regular breaches of emission limit values for ammonia, total phosphorus and suspended solids at Blacklion, and the plant was reported to be hydraulically overloaded in 2018.

The remaining WWTWs in the Arney catchment have been assessed as compliant in 2018. Belcoo WWTW has a design PE capacity of 1578, and an actual PE load of 769. It is the largest WWTW in the Arney catchment.

NI Water has a number of smaller treatment works in the Arney catchment. The Derryaghna Treatment Works near Arney has a design PE capacity of 20, and an actual PE load of 18, i.e. it is operating at 89% capacity. Florencecourt Treatment Works has a design capacity of 320 PE, and an actual load of 289 PE, i.e. it is operating at 90% capacity. Improvement works are planned for both these works. The Carrontreemal WWTW, about 2 km north east of Belcoo has a design capacity of 81 PE, and is operating well within capacity with an actual PE load of 39. The Arney WWTW has a design capacity of 291 PE, and is operating at an actual PE load of 212 (i.e. 73% of design capacity). Finally,

Letterbreen WWTW has a design capacity of 513 PE, but is only operating at 88 PE (i.e. <20% of its capacity).

As discussed above, the Arney catchment is largely rural in character and population is dispersed. Figure 2-51 shows the locations of one-off housing in the catchment (ROI) and the hotspots where on-site wastewater treatment systems (OSWWTS) pose a risk to water quality (NI). The majority of systems are septic tanks with solids removal and effluent disposal to percolation areas. Figure 2-51 shows that one-off housing and hot spots occur in almost all parts of the catchment except the most remote mountainous areas. Recent settlement has included many houses in ribbon developments along roadways.

The Roo valley has been specifically identified as an area with significant pressures from domestic wastewater systems. The concentration of one-off housing in this area is obvious. The potential impacts of septic tanks have been discussed previously, along with the potential for synergistic and in-combination impacts.

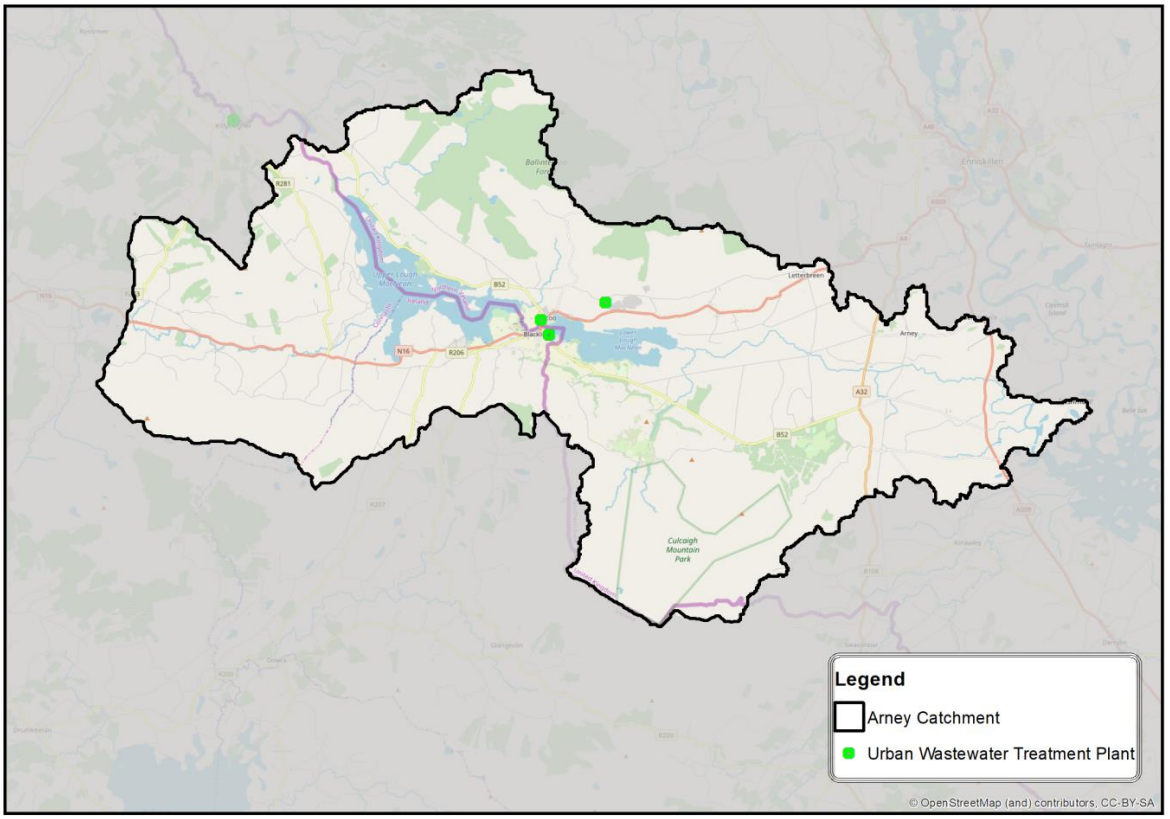

Figure 2-50 Locations of Urban wastewater treatment plants (UWWTPs) in the River Arney Catchment

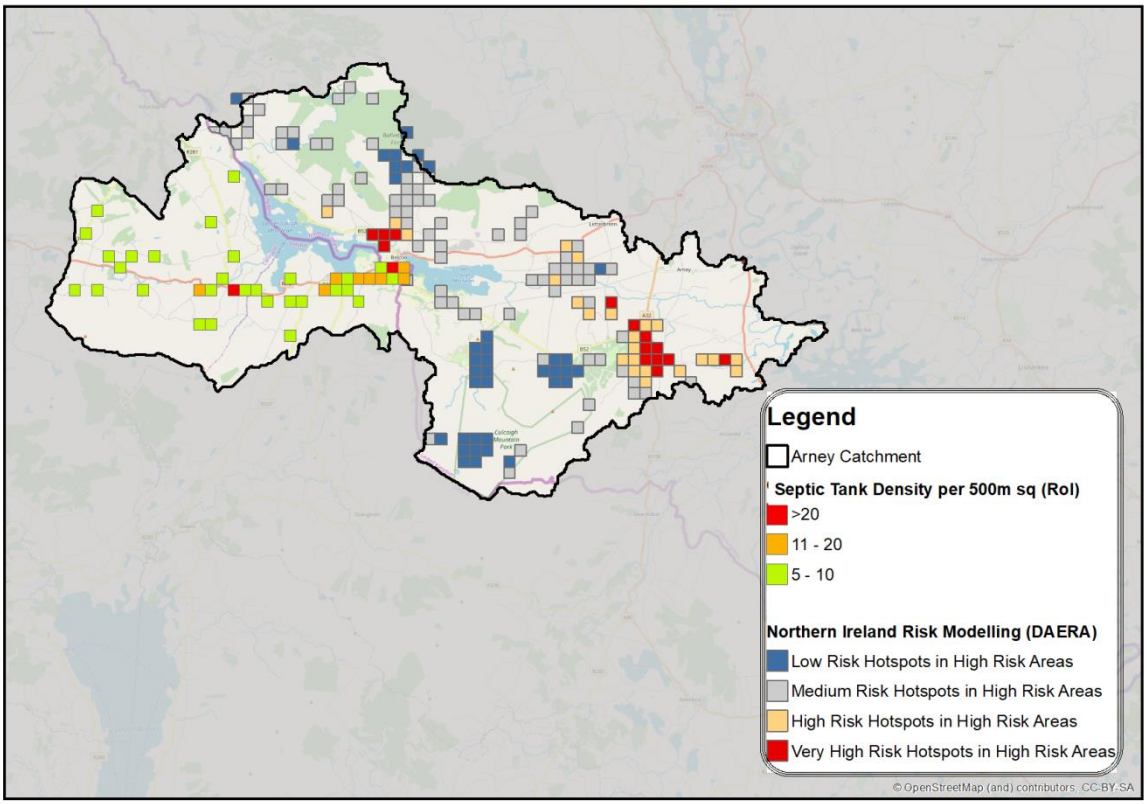

Figure 2-51 Domestic on-site wastewater treatment system pressures in the River Arney Catchment, represented by septic tank density in RoI and areas designated as High, Medium and Low risk categories in NI. (Source: EPA and WMU @ DAERA)

Licensed Discharges

Figure 2-52 shows the location of licensed discharges in the catchment. There is one integrated pollution prevention and control (IPPC), and two Section 4 Licences in the ROI Arney catchment.

Glenfarne Wood Products Limited is located approximately one mile from the village of Glenfarne. The principal activity at the site is saw milling. There are no process emissions to air or water from the treatment plant.

Section 4 licences for discharge of trade effluent to waters have issued to Killinagh Rectory Termoy (SS/W006/05) and to Loughan House Detention Centre Blacklion (SS/W033/86).

Licensed discharges are not identified by the EPA as a significant pressure in any waterbody in the Arney catchment.

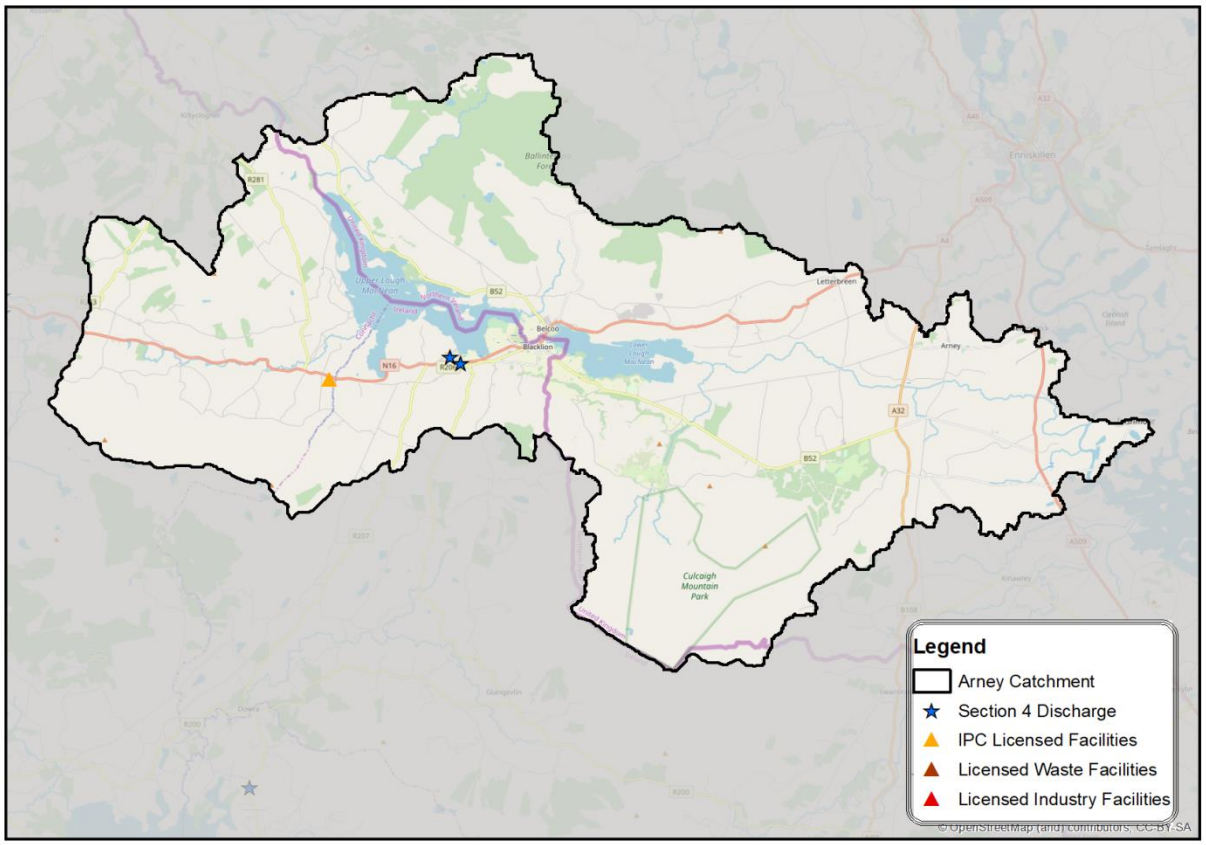

Figure 2-52 Licensed discharges to surface waters in the River Arney Catchment

Hydromorphological Pressures

Changes to morphology have been identified in a number of waterbodies. The rivers affected included the Arney, Lurgan, and Cladagh. However, the changes to these rivers did not downgrade the overall status and they will continue to be monitored for any further changes.

Priority Areas for Action

The process, and objective of selecting PAAs in the ROI second cycle River Basin Management Plan has been described in section 2.1.7. The PAAs in the Arney Catchment are shown in Figure 2-53. The Roo river has been selected for Local Authority catchment assessment teams to drive the implementation of mitigation measures, with particular emphasis on driving collaborative and cross-sectoral actions to deliver water-quality improvements.

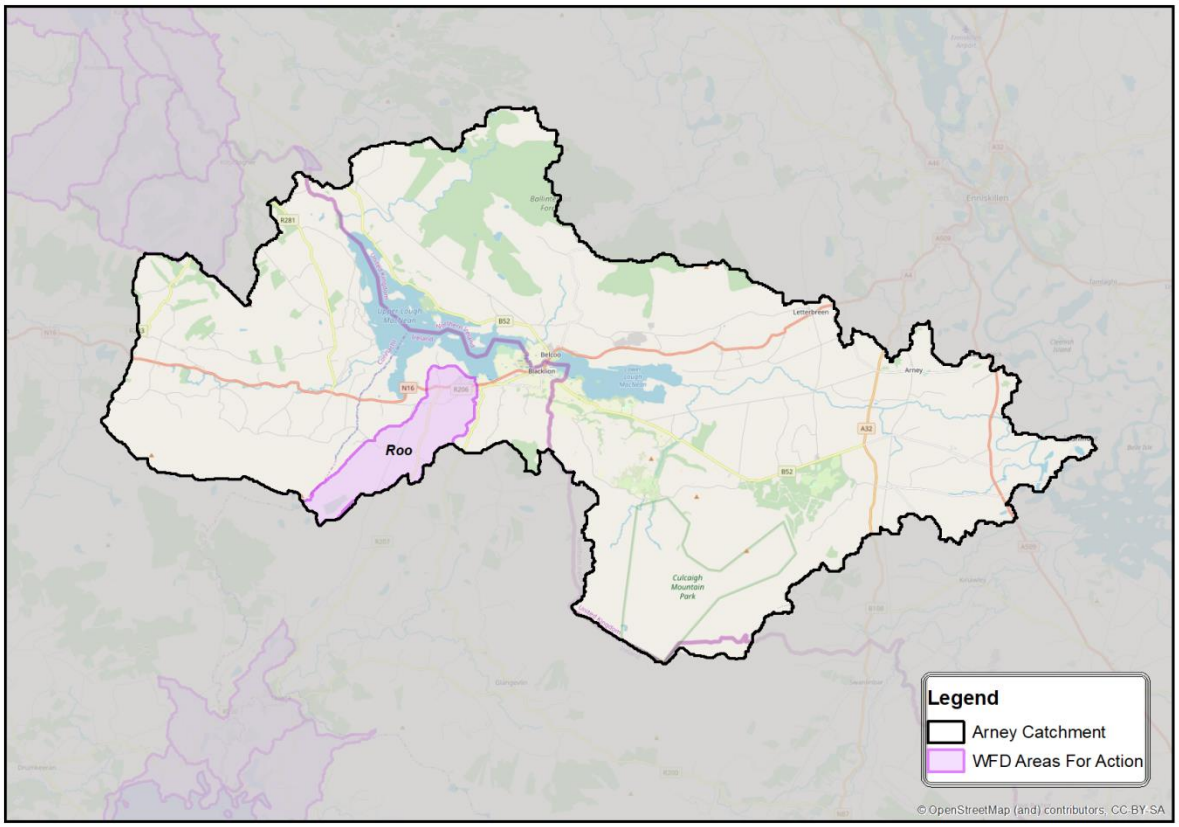

Figure 2-53 Priority Areas for Action in the Arney catchment (source: EPA)

2.3 Blackwater Catchment

The Blackwater catchment lies in the Neagh Bann International River Basin District and is part of the larger Lough Neagh-Lower Bann catchment (Figure 2-54). The Blackwater is a cross border catchment with a surface area of 1,491km², of which 1,097 km² (74%) lies in NI (County Armagh and County Tyrone) and 393.8km² (26%) is located in ROI (County Monaghan).

The Blackwater River rises to the north of Fivemiletown in County Tyrone. The upper Blackwater flows through the broad valley between Slieve Beagh to the south and Brougher Mountain to the north. The river flows a distance of 91km to the southern shore of Lough Neagh at Maghery. For some 25km of this course it forms the border between NI and ROI. It is fed by a large number of tributaries on route, from both NI and ROI, their meandering routes reflecting the drumlin topography of the region. The maximum altitude in the catchment is 382m (Slieve Beagh), and approximately half of the catchment is above 100m AOD.

The north western boundary of the catchment is formed by the long upland ridge stretching from Ballyness Mountain, through Kockmany, Slievemore, Crocknanavark, Cappagh Mountain to Barrack Hill. The catchment extends south through the Monaghan lowlands, and Carrigatuke (365m) stands at its south eastern corner.

A number of hydrometric stations are operated by NI Rivers Agency, Monaghan County Council, and the EPA in this catchment. Some groundwater is abstracted but its hydrological significance is unknown. Flows in the Blackwater have been influenced by major arterial drainage schemes that started in 1983 and finished in 1995. The hydrometric station on the Blackwater at Maydown Bridge has operated since 1970, and its upstream catchment is 970km^2 i.e. about 65% of the Blackwater catchment. The mean flow at Maydown Bridge is 18.0m^3/s.

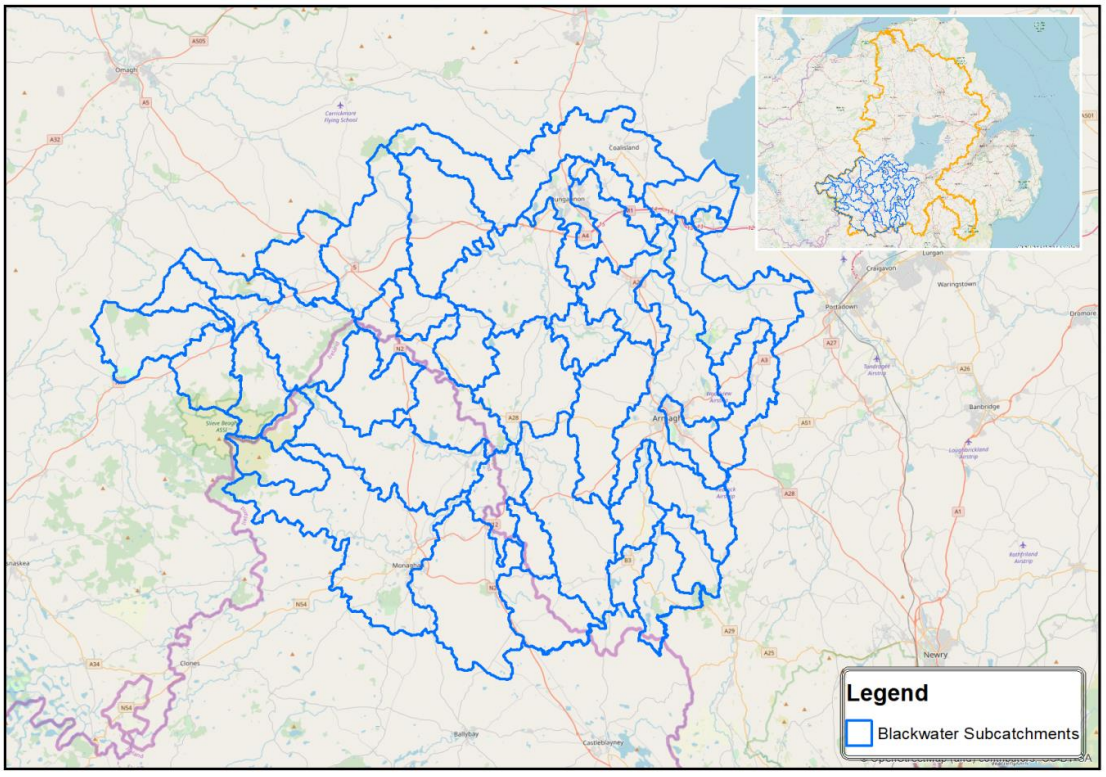

Figure 2-54 Location of the Blackwater River Catchment within the larger Lough Neagh-Lower Bann catchment (inset) and the 43 sub-catchments comprising the Blackwater catchment

2.3.1 Landscape

Much of the catchment is typified by lowland undulating topography with river corridors meandering through an extensive drumlin landscape (Figure 2-55). The Clogher Valley in the south west of the catchment is considered to be a fine example of an undisturbed fluvio-glacial landscape. Wet marshy areas, fens, basin peats and lakes are abundant between the drumlins. The low gradients of the rivers, especially on the clay lowlands immediately around Lough Neagh, create inherent drainage problems, and frequently it is only the slopes of the many drumlins that provide permanently dry sites. The southern shore of Lough Neagh is a low-lying marshy landscape with small, protruding drumlins. The area has been previously worked for peat, and has been extensively modified through extraction which has left distinct sharp changes in level where it has taken place. There are areas of regenerating birch and willow scrub and farmland, wherever drainage permits.

In more elevated areas, drumlins are separated by pasture and gently rolling mixed farmland. To the south-west, towards Augher and Clogher, much of this area has been drained to produce good agricultural land, and arable fields are interspersed with pastures. Grasslands, almost all improved pasture, account for a high proportion of the catchment land cover. Rough grassland dominated by rushes occurs in inter-drumlin hollows and on higher areas.

Between Fivemiletown and Rosslea there is an extensive area of rolling sandstone uplands, rising to the rounded summit of Slieve Beagh (382m aOD). The Slieve Beagh uplands straddle the borders of Tyrone, Fermanagh and Monaghan. Undulating peatland and moorland dominate this area which has one of the most extensive areas of intact blanket bog in Northern Ireland, although mechanised peat cutting has occurred in the area. Occasional loughs are located in this upland peatland landscape.

Long river valleys dissect the hills, and the upland is bounded by a prominent escarpment on the south. The southern escarpment slopes were historically in agricultural use, with fields extending from the lower valleys up the slopes. Ladder field patterns on the escarpment are a local feature. However, some of these small farms are now derelict, and fields are rush-dominated. There are also large areas of commercial forestry below the 300m contour, and smaller forestry parcels are scattered throughout the catchment with occasional small broadleaf woodlands and copses. The latter are largely associated with demesnes.

The Mountainwater River and Blackwater River valleys comprise relatively flat floodplains with large lowland areas of drumlin farmland that extend south to the Monaghan-Clones depression. These areas support wet meadows, pasture and bog.

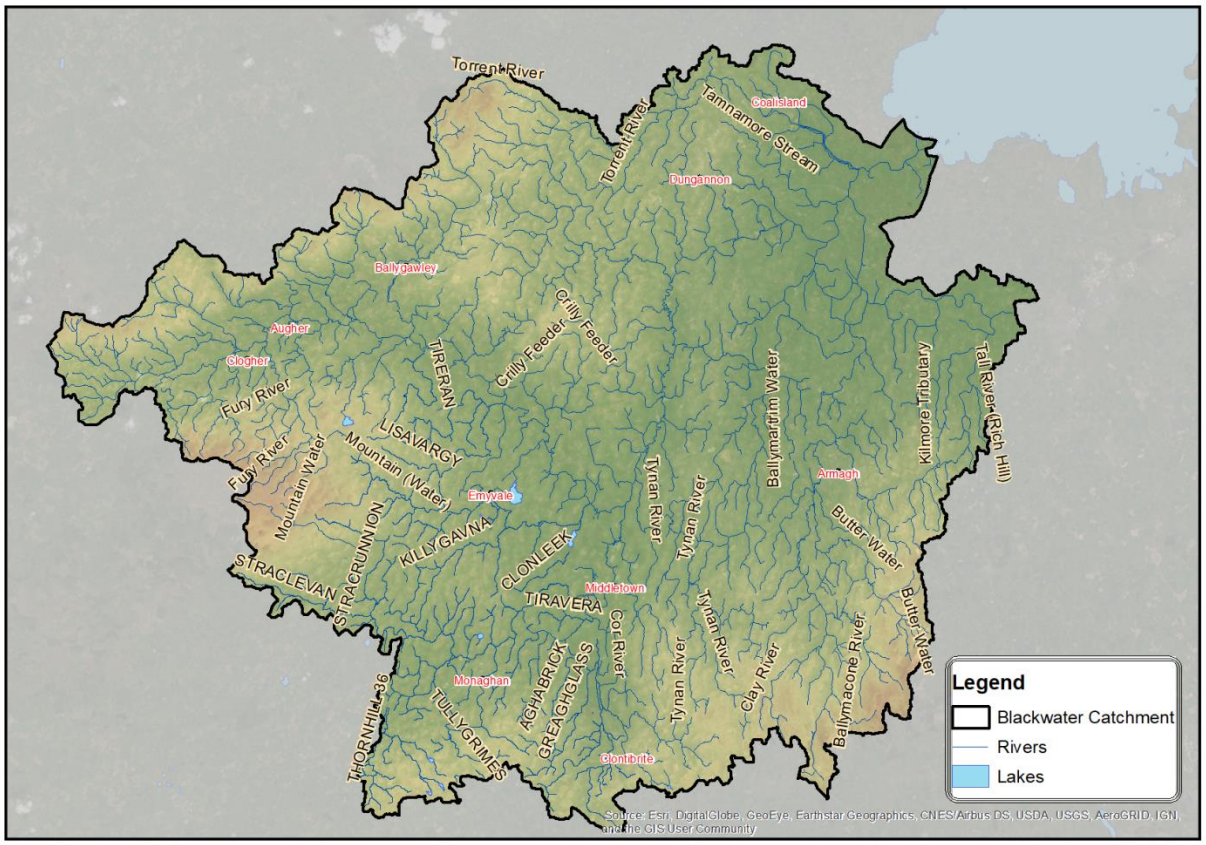

Figure 2-55 Blackwater River Catchment topography

2.3.2 Population

The population of the Blackwater catchment is approximately 136,000 people. This is equivalent to about 91 persons/km^2 (Figure 2-56).

Nucleated settlements with populations above about 300 are listed in Table 2.4. The biggest settlements are in the NI portion of the catchment, Armagh and Dungannon, and in the eastern part of the catchment. Monaghan is the only large town in the ROI portion of the catchment. The total population of the settlements listed in Table 2.4 is 55,620. Therefore, approximately 41% of the total catchment population are town dwellers. The remaining 59% are largely in dispersed one-off dwellings, and rely on on-site wastewater treatment systems. About 85% of the total Blackwater catchment population live in NI. The rural/urban divide is similar in both NI and ROI, but the population density is lower in ROI at 55/km^2.

Table 2.4 Large Settlements in the Blackwater Catchment

Settlement	Population	Settlement	Population
Armagh	14,777	**Donaghmore**	1,122
Dungannon	14,332	**Aughnacloy**	1,045
Monaghan	8,012	**Ballygawley**	711
Coalisland	5,682	**Castlecaulfield**	659
Keady	3,036	**Emyvale**	574
Richhill	2,821	**Blackwatertown**	376
Moy	2,129	**Caledon**	344

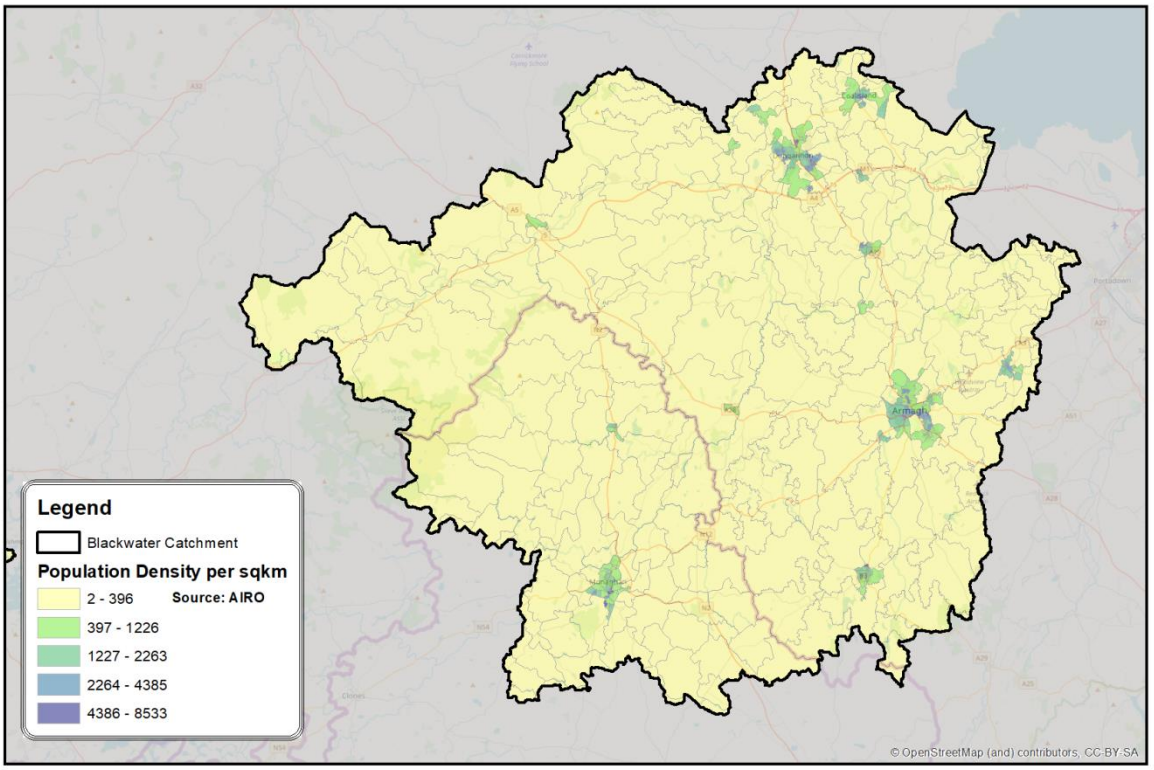

Figure 2-56 Population density in the Blackwater River Catchment

2.3.3 Catchment Geology, Hydrogeology and Soils

Bedrock Geology

The bedrock geology is largely lower Carboniferous, much of it impure limestones and shales, although Silurian, Ordovician, Devonian and Triassic-age rock units (formations) also occur. As a result, the Blackwater Catchment is underlain by a wide range of different rock types (Figure 2-57). Many of the geological features follow a northeast to southwest trend.

Ordovician/Silurian sandstones, mudstones and shales underlie much of the southeastern part of the catchment. The rock layers are steeply dipping. The southwest-northeast orientation of these rock units has influenced the geological trend of younger rocks in the catchment.

The western Blackwater catchment is dominated by the rolling Carboniferous sandstone and shale uplands of Slieve Beagh. Underlying the plateau are calcareous shales (Meenymore Formation), which occur in the centre of a U-shaped northeast-southwest fold. Occuring as a thick layer within the shales, there are very coarse-grained to medium-grained sandstones (Carnmore member). These rock units form a prominent escarpment to the south of Slieve Beagh, at the foot of which is the underlying highly fractured and karstified pure Dartry Limestone.

The Monaghan lowlands to the south west of the catchment are mainly underlain by generally laminated, dark-grey calcareous shale. Parallel narrow bands of fossiliferous dark-grey muddy limestone, calcareous sandstones and siltstones, conglomerate and sandstone, and pale brown-grey flaggy silty mudstone run roughly north east to south west through Monaghan Town. There is a thin pure limestone rock unit (Ballyshannon Formation).

To the north of Slieve Beagh, the Clogher valley is largely underlain by impure limestones containing layers of siltstone (Clogher Valley Formation). Further north again, the uplands bounding the Clogher-Augher valley are composed of Devonian-age conglomerate and red-grey sandstone. A band of shaley limestone and siltstone extends in an arc eastwards from Aughnacloy, through Emyvale to Armagh. This is known as the Maydown Limestone Formation.

In the north east of the catchment, north of Armagh, red, fine-grained Triassic-age sandstones and siltstones occur. Similar, very heavily faulted Permian-age sandstones are found beneath Armagh itself. These sandstones are known for having high porosities.

The lowest section of the catchment, within 5 to 8km of the shores of Lough Neagh, are underlain by Oligocene grey mudstone and lignite of the Lough Neagh Clays Group.

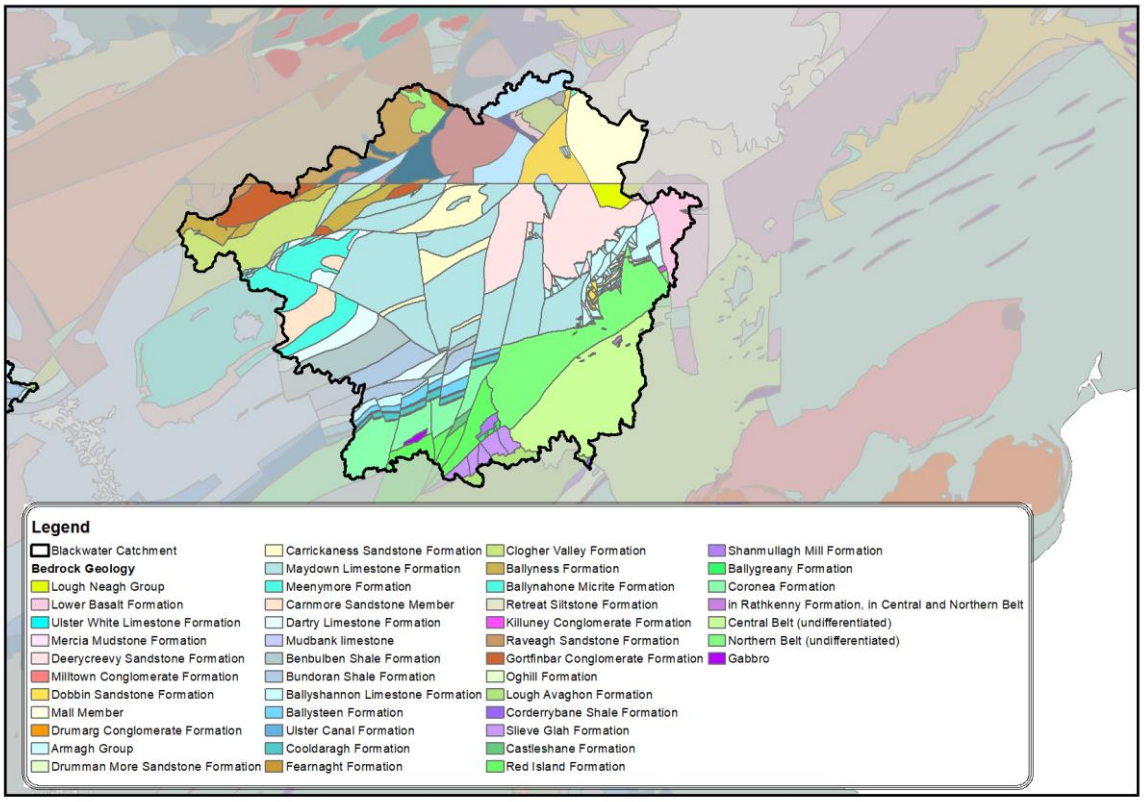

Figure 2-57 Bedrock Geology in the Blackwater River Catchment (Data source: GSI and BGS/GSNI)

Soils and Subsoil Geology

The upland catchment areas are largely covered by peat (Figure 2-58), notably on Slieve Beagh, but also at Slievemore and Cappagh Mountain. Lowland fen and basin peats are widespread between the drumlins, and also on the shores of Lough Neagh.

Most of the rest of the catchment is covered by glacial tills ('boulder clays') derived relatively locally from the underlying limestones, sandstones and shales. These glacial sediments were sculpted by the passage of the ice-sheet above them, resulting in the drumlin landscape across much of the catchment. In some areas, such as the slopes south of Slieve Beagh, subsoil thicknesses can reach more than 30 m. In general, the drumlins comprise thick glacial sediments, whilst in the inter-drumlin areas, the subsoils are a lot thinner.

Ribbons of alluvium are prevalent along the rivers that meander through the inter-drumlin areas. The Blackwater River lowland catchment areas reveals an extensive floodplain containing abundant alluvial material, and glacio-fluvial deposits of silt, sand, gravel and boulders.

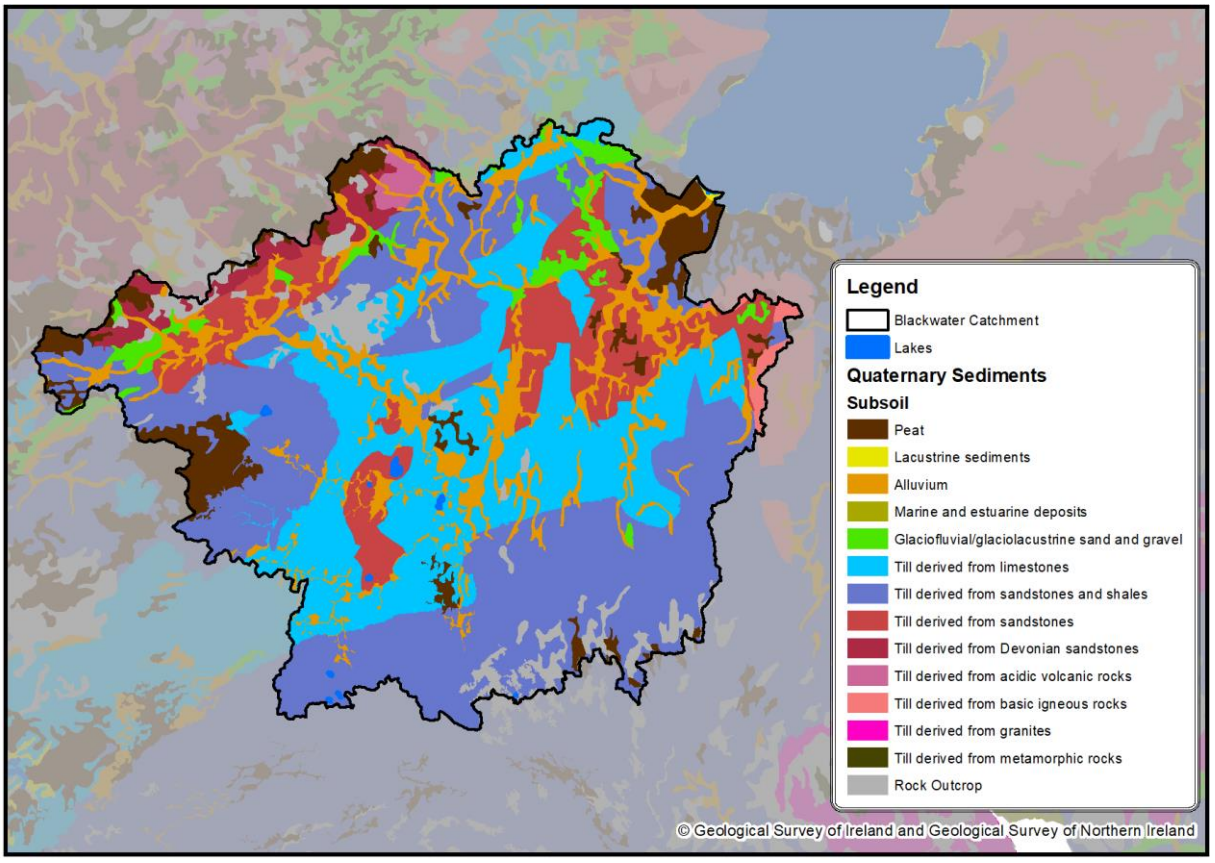

Figure 2-58 Subsoils Geology in the Blackwater River Catchment (Data source: GSI and GSNI)

The poorly drained tills of the catchment have given rise to extensive stagnosol/surface water gleys development over most of the catchment (Figure 2-59). Fluvisols/alluvium occur in riverine and lacustrine alluvial deposits along the Blackwater River and along the lower reaches of its main tributaries e.g. Mountain Water, Blackwater (Monaghan), Callan River, River Torrent and Oona Water. Peats, particularly cutover or cutaway bogs, occur in the hollows throughout the drumlin landscape.

Podzols have developed on the higher ground north of Augher. Significant areas of cambisols occur and support more intensive agriculture, such as in the upper Blackwater valley between Fivemiletown and Clogher. Acid brown earths over shales, sandstone and siliceous material, brown podzolics and lithosols are present in the south east of the catchment. Brown earths over limestone and calcareous material are predominant from the south western catchment boundary, running in a band north eastwards through Monaghan town to Glaslough.

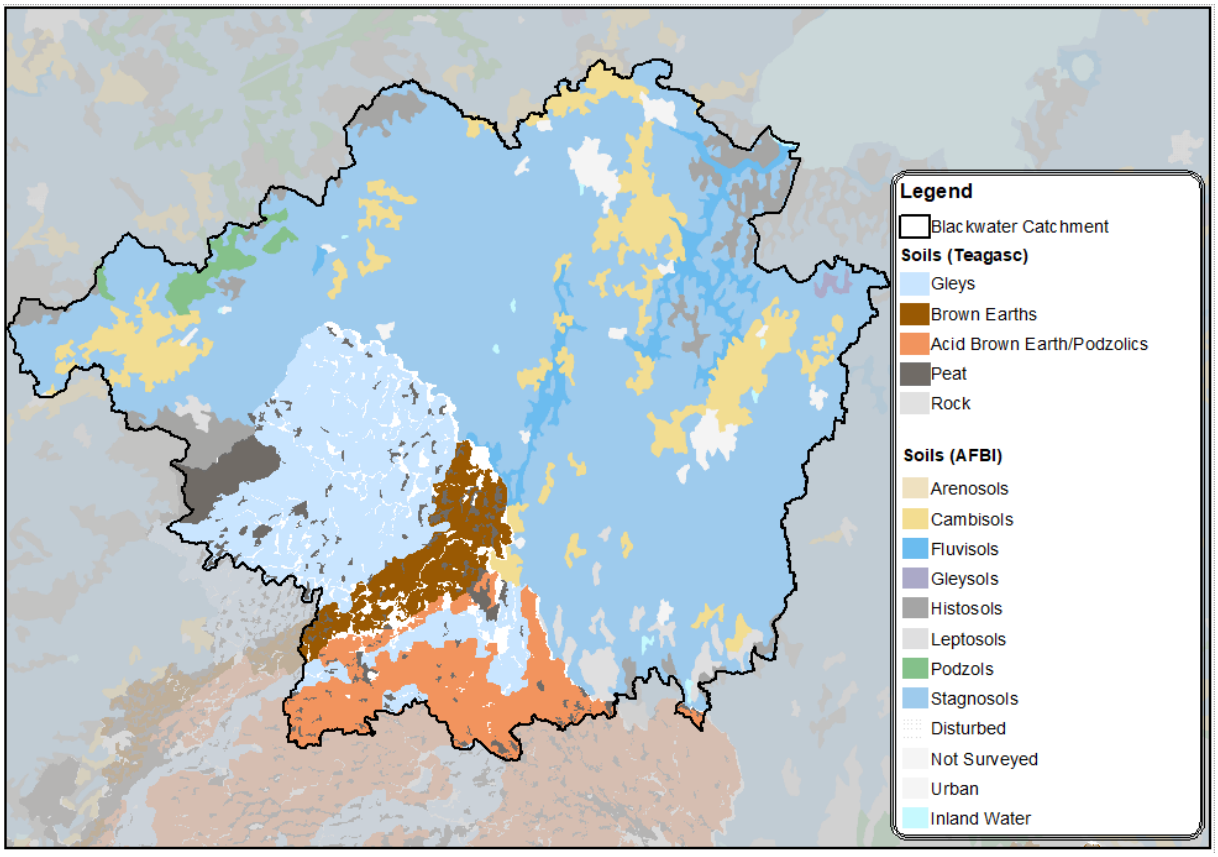

Figure 2-59 Soil Types in the Blackwater River Catchment (Data Source: Teagasc and AFBI)

Hydrogeology

Groundwater is most vulnerable where the subsoils are absent or thin, in areas of karstic limestone where surface streams sink underground at swallow holes, and where the water table in certain aquifer types is shallow. It is lowest where there are thick subsoils overlying the groundwater resource. Groundwater vulnerability in the part of the Blackwater catchment south of Slieve Beagh is predominantly Low. There are areas of Extreme vulnerability beneath the blanket bog, in some inter-drumlin areas, and in the southwest of the catchment. Smaller areas of Moderate and High vulnerability occupy the lowland areas around Monaghan Town and Killyneil. In NI, groundwater vulnerability ranges from class 1 to 4 (Figure 2-60). (In the NI classification scheme, 1 is the least and 5 the most vulnerable.) The majority of the catchment is classified as class 2. In the sand and gravel aquifers along the main rivers and tributaries, which act as the 'lungs' of the rivers, groundwater vulnerability is class 4 due to the high water table. In the area underlain by the porous Triassic sandstones, vulnerability is class 3 due to a deeper water table. It is class 1 in the area underlain by the clays and peats just southwest of Lough Neagh, due to the very low permeability nature of these deposits and absence of groundwater resources.

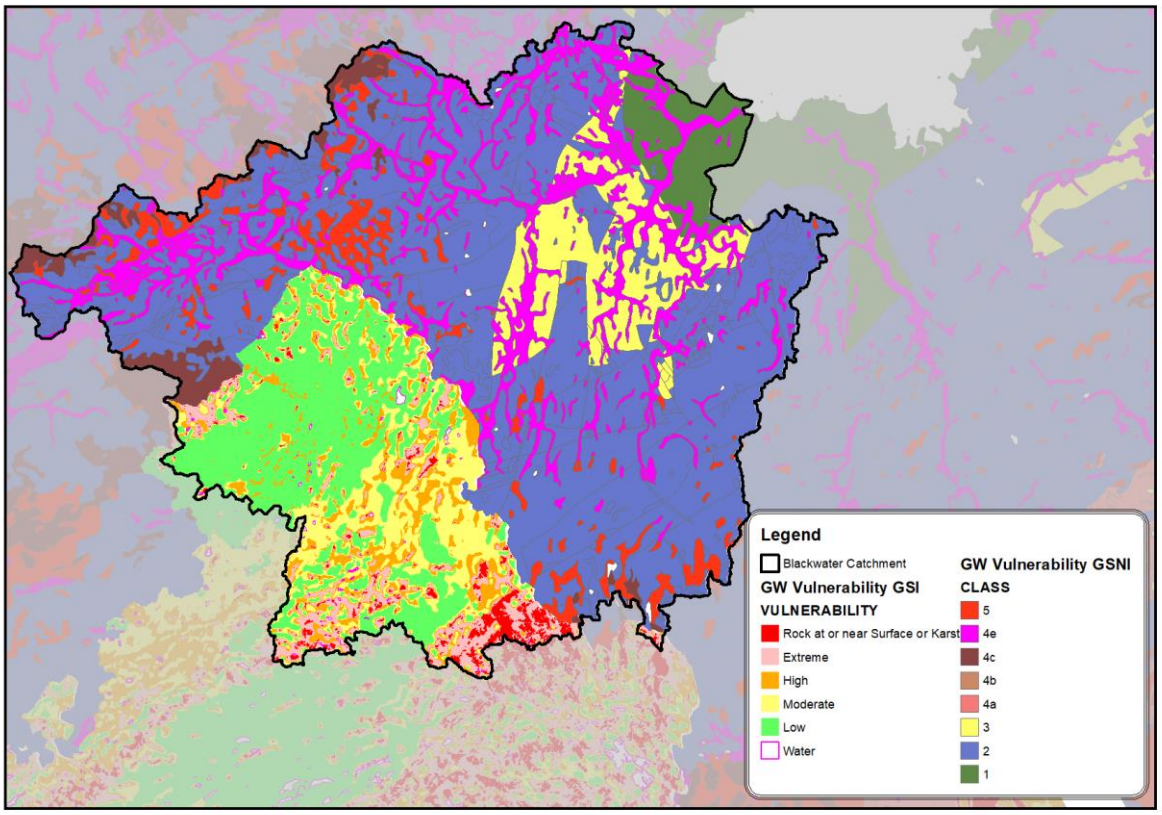

Figure 2-60 Groundwater vulnerability in the River Catchment (Source: GSI/GSNI)

The Blackwater Catchment is underlain by a wide range of different rock types and therefore many different aquifer types. The majority of the aquifers are fractured bedrock. The nature of the bedrock and the amount of deformation and fracturing the rock has undergone determines how well-fissured the aquifer is, and therefore how productive it is. In the southern portion of the catchment, the old and shaley Ordovician and Silurian bedrock is poorly productive, with very limited groundwater resources. In the area around Slieve Beagh, although the rocks are mainly fine-grained and shaley, due to the extensive faulting the aquifers are moderately to highly productive. The pure limestones have additionally been karstified, which has caused cavities to develop and permeability to be enhanced. However, thick subsoil cover can severely limit groundwater recharge, which limits the sustainability of the groundwater resource. The Clogher Valley Limestone is thought to be a highly productive aquifer but despite it being extensive within this catchment, there is limited information about its hydrogeology.

The Triassic Sherwood Sandstone aquifer south of Dungannon contrasts with the rest of the aquifers, due to its primary porosity and permeability and high storage and transmissivity. This is a major aquifer with high groundwater prospectivity potential.

There are also various glacio-fluvial sand and gravel complexes along the Blackwater and tributaries in NI that are distinct aquifers in their own right. Around Shanmoy, the sand and gravels have been used for public water supply and are known to be in connection with the River Blackwater.

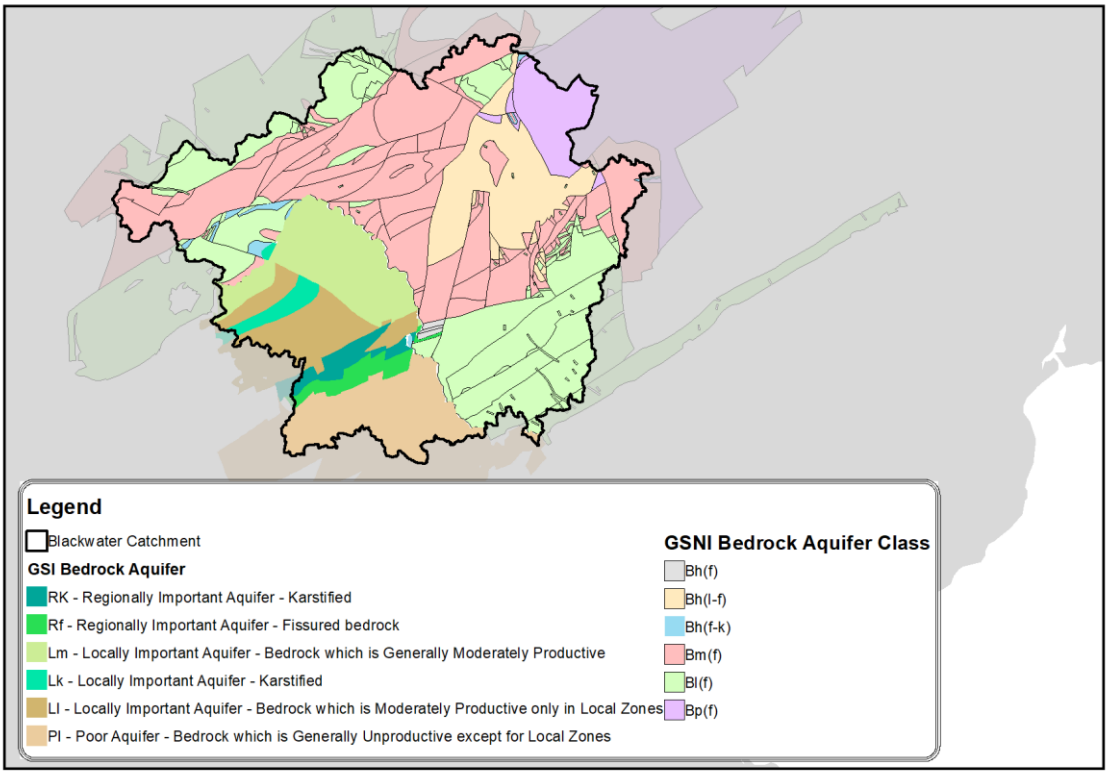

Figure 2-61 Groundwater resources (aquifers) in the Blackwater River Catchment (Source: GSI/BGS/GSNI)

2.3.4 Catchment Land Use

The overwhelming land use in the catchment is agricultural pasture (Figure 2-62). These are mostly improved grasslands.

Tree cover is relatively low. Small areas of deciduous and mixed forest are scattered throughout the lowland catchment, many associated with past or present demesnes, but the largest areas of forest are coniferous plantations on marginal upland soils. These occur along the northwestern catchment boundary on the southern slopes of Ballyness Mountain, and at Kockmany and Slievemore. Coniferous plantations also occur on the Slieve Beagh uplands, but with significant areas of deciduous and transitional woodland shrub at bog margins and in the lower stream valleys, including isolated pockets of hazel-dominated scrub. Isolated small wet woodlands are often associated with inter-drumlin lakes and wetlands.

The most extensive areas of blanket bog in the catchment are at Slieve Beagh. Heathland habitats are located on the bog margins and on some of the drier slopes. The lower-lying upland areas are principally occupied by agriculture, with significant areas of natural vegetation, mainly wet grassland.

Basin peats are scattered throughout the drumlin landscape but these are largely cutover.

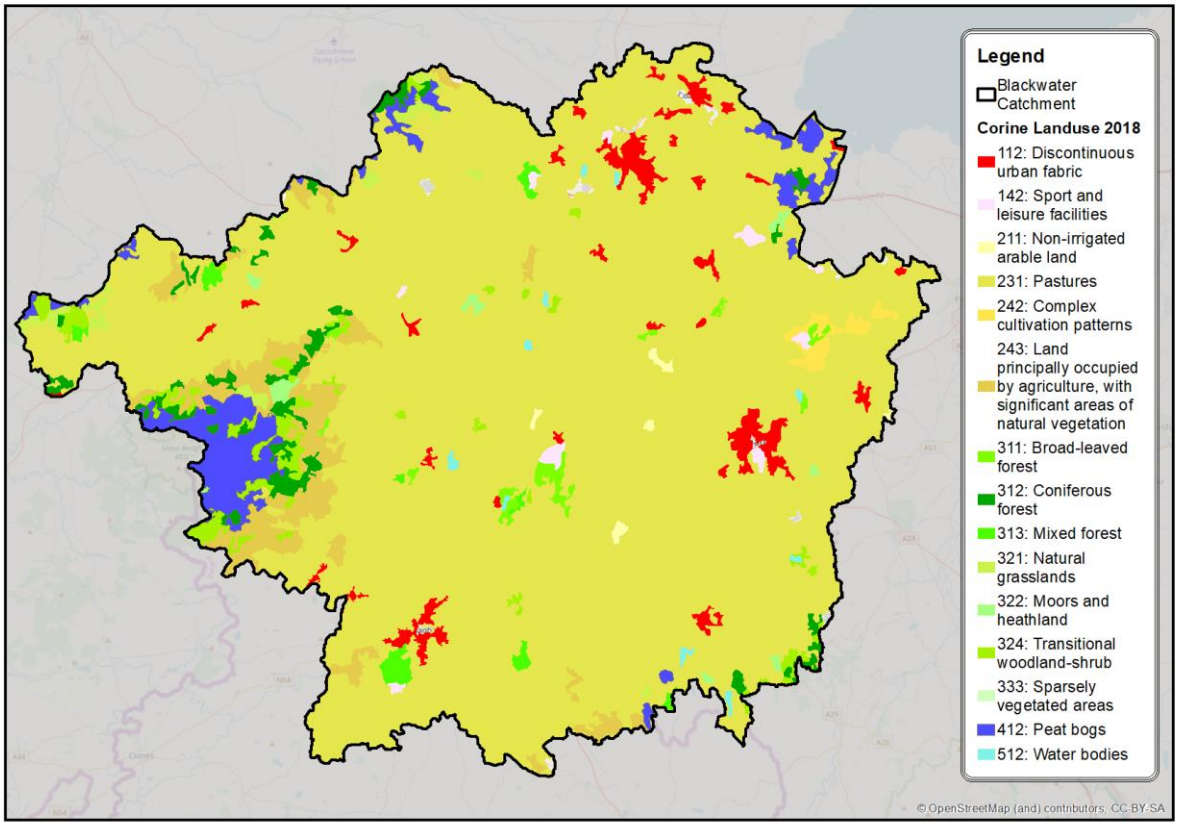

Figure 2-62 Blackwater River Catchment Land Classifications Map (Data source: CORINE Land Cover 2018, EEA)

The proportions of the various land use classes are illustrated in the pie diagram (Figure 2-63). It clearly shows the predominance of pastures at 84% of the land cover in the catchment. Agriculture and natural vegetation (mostly rough grazing), and natural grassland contribute a further 5% between them.

Peat bogs are a relatively small component of the catchment's land cover. This, along with the frequency of nucleated settlements in this catchment (urban fabric at 2% cover), underline the difference in character of the Blackwater catchment when compared to the other catchments in this project (Finn and Arney). Woodlands and forests of all types only comprise 5% of the catchment cover.

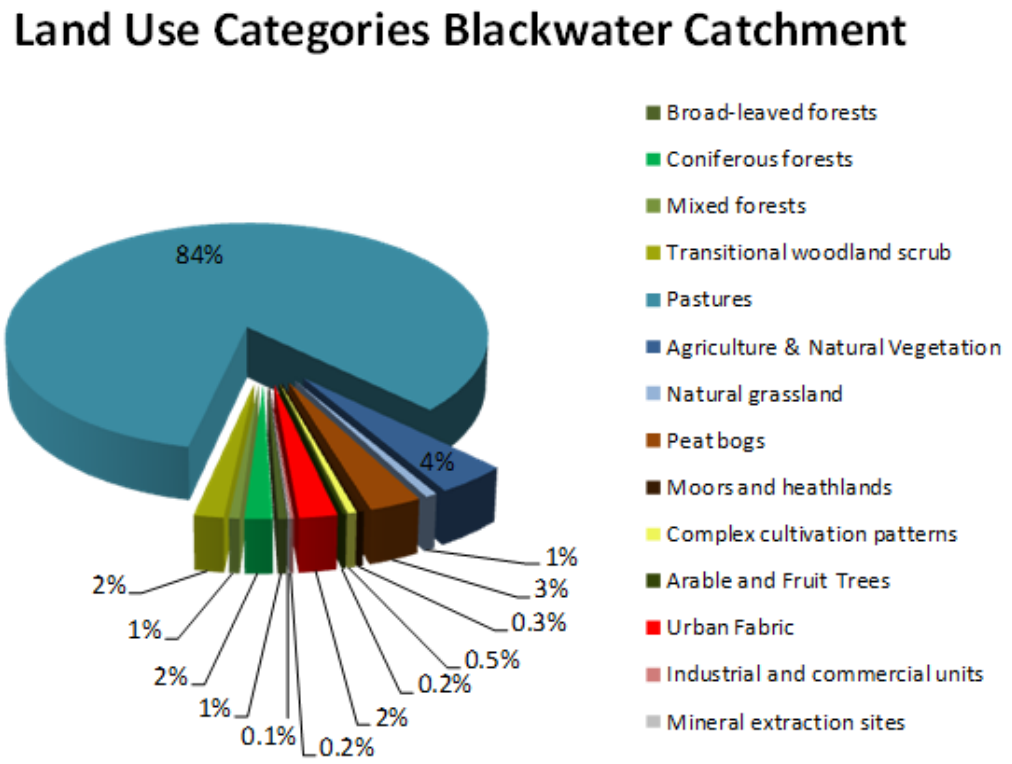

Figure 2-63 Land cover and land use in the Blackwater River Catchment

2.3.5 Protected Areas

Five Natura 2000 sites occur wholly or partly within the Blackwater catchment:

- UK9020091 Slieve Beagh-Mullaghfad-Lisnaskea SPA
- 004167 Slieve Beagh SPA
- UK0016622 Slieve Beagh SAC
- UK0030236 Peatlands Park SAC
- UK9020091 Lough Neagh and Lough Beg SPA

Detailed descriptions of each are available at https://www.npws.ie/ and https://www.daera-ni.gov.uk/protected-areas. The following summary notes some of the salient points of interest relevant to the CatchmentCARE Project and locations of Natura sites are shown in Figure 2-64.

The Slieve Beagh-Mullaghfad-Lisnaskea SPA in NI and the Slieve Beagh SPA in ROI are contiguous areas and are treated as one here. Both are designated for the breeding population of Hen Harrier, estimated at 10 pairs in 2004. Habitat within the site is a mosaic of upland heath, blanket bog, commercial forestry and largely unimproved grassland. Forest Service is a major landowner within the site, and the broad management objective is to ensure a balanced mix of woodland stages. Threats include inappropriate use of lands, and reclamation for agricultural purposes.

The Slieve Beagh SPA overlaps with Slieve Beagh SAC. Qualifying interests for which the SAC has been designated include natural dystrophic lakes and ponds. The peatland complex in the SAC contains the largest concentration of medium- to large-sized dystrophic lakes in Northern Ireland, which range

in size from 5.5 ha to less than 0.5 ha. Such waterbodies have characteristically impoverished flora and fauna, but the lakes are also important for a range of upland invertebrates.

Blanket Bog is also a primary reason for designation of this SAC. The site is considered to be one of the best blanket bog areas in the United Kingdom. Although not a primary reason for site designation, the SAC also supports a significant presence of European dry heaths.

Peatlands Park is a large lowland raised bog that has been extensively cut for turf in the past. Degraded raised bogs still capable of natural regeneration is a primary reason for selection of this SAC. It represents one of the largest areas of degraded raised bog in Northern Ireland. Regeneration is taking place over a large part of the site. The peatland interest also incorporates an area of intact lowland raised bog at Mullenakill.

An extensive area of cutover raised bog close to the southern shores of Lough Neagh supports bog woodland that has developed over a shallow, peat-bottomed lake. Downy birch is dominant, with grey willow as one of the main associates. The woodland floor is soft and spongy, with occasional quaking areas, dominated by acid fen communities.

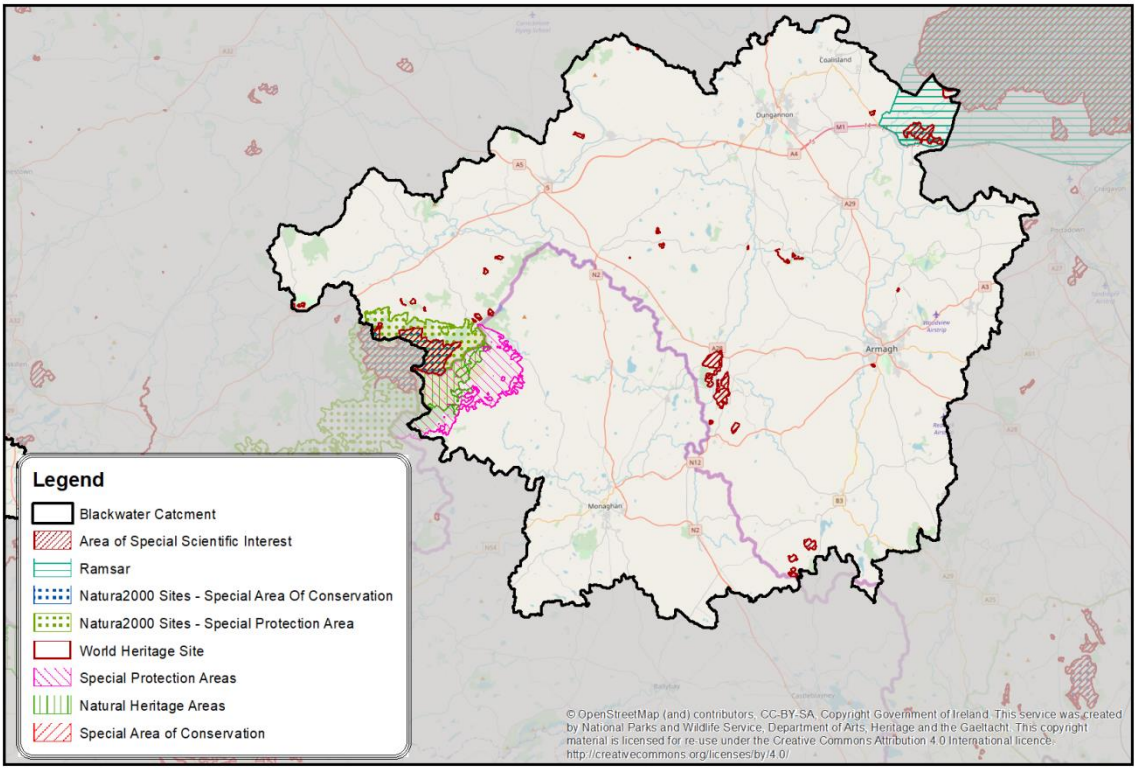

Figure 2-64 Biodiversity and Landscape Protected Areas in the Blackwater River Catchment (Data Source: NPWS and NIEA)

The Blackwater discharges into the Lough Neagh and Lough Beg SPA. Lough Neagh is a large, shallow, eutrophic lake and supports nationally and internationally important numbers of wintering waterfowl and an important assemblage of breeding birds. Important habitats in the SPA include purple moor-grass and rush pastures, wet woodlands, reed beds and swamps, and fens.

Significant changes in land management and disturbance are key considerations for the site. Alteration of habitat quality through diminution of water quality, invasive species, and water abstraction and lake level controls are all identified as pressures that could also impact on the SPA and its interests.

In terms of other WFD protected areas, there are no economically significant aquatic species, or bathing water areas in the Blackwater catchment.

Two surface water drinking water protected areas occur in the catchment (ROI), Emy Lough (IEPA1_NB_03_102) and Lough More MN (IEPA1_NB_03_87). There are also several important groundwater drinking water abstractions, including large well-fields, in the ROI part of the catchment. These include: Tydavnet GWS, which uses 4 boreholes and a small lake (Lough Antraicer) to supply more than 1,100 connections; and Monaghan Public Water Supply, which uses up to 10 boreholes in 3 clusters to supply Monaghan town and surrounding areas. Safeguard Zones (zones of contribution) have been delineated for all these supplies. (Note, as highlighted in Section 2.1.5, all aquifers (groundwater resources) within the Republic of Ireland are designated as drinking water protected areas.)

One nutrient-sensitive area has been designated, IEGBNIRI_NB_200 1_0011 Blackwater (River) Nutrient Sensitive Area (PA4_0011). The Blackwater (Monaghan)_040 downstream of Monaghan town overlaps partly with this protected area. Tertiary treatment is in place in the relevant waste water treatment plant (D0061 Monaghan), and the plant is compliant with the requirements of the wastewater discharge license.

2.3.6 Water Framework Directive Status

The Blackwater catchment is divided into 57 river water bodies (Figure 2-65), and contains 9 WFD lake water bodies, all of which are in the ROI. The catchment is associated with 14 groundwater bodies.

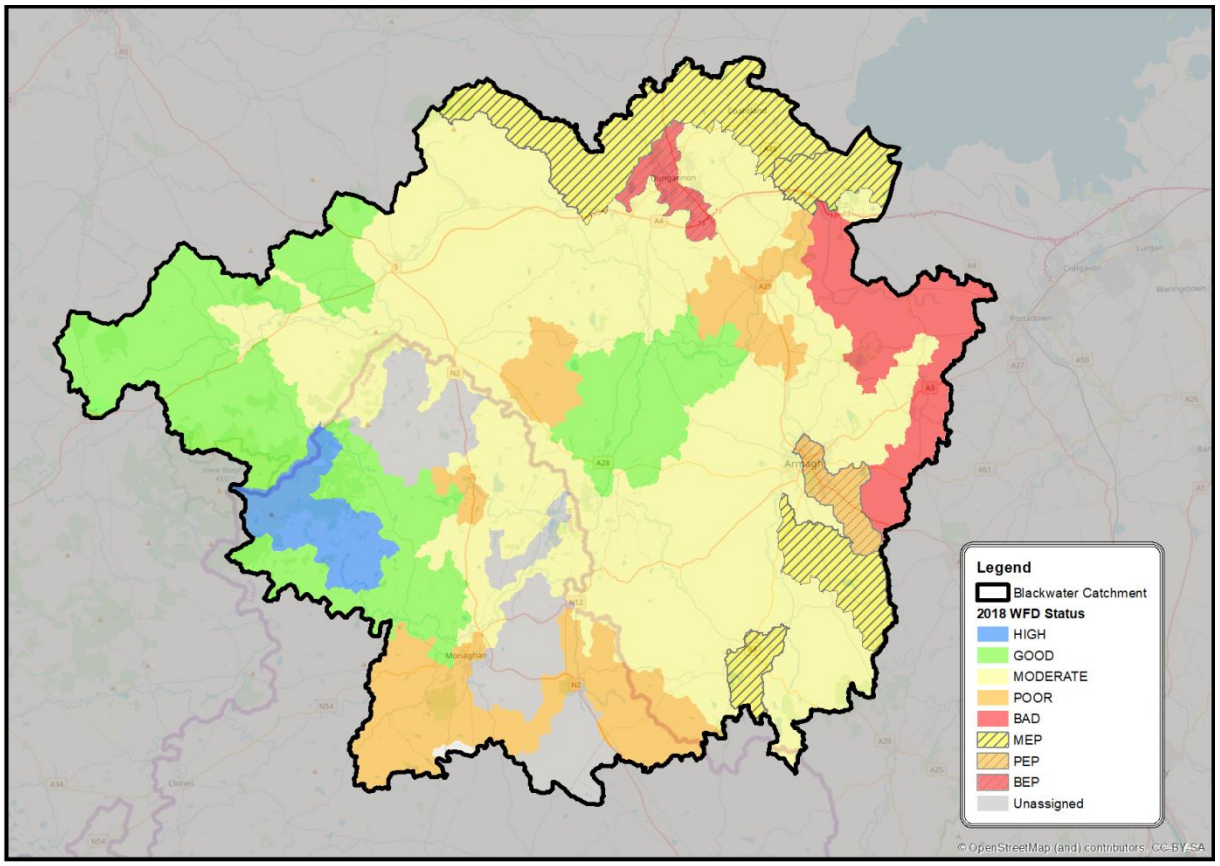

Figure 2-65 River water bodies and WFD status in the Blackwater River Catchment

The extent of monitoring for status assessment at individual stations varies in terms of the range of parameters covered (Table 2.5). No monitoring was carried out at some stations (Clontibret Stream_020, Lisavargy_010, Mountain Water_060, Mullamurphy_010, Tireran_010, and Mountain Water (NI) and no status has been assigned to these water bodies yet.

Of the biological elements, macroinvertebrates were assessed at 18 of the 21 ROI monitoring points and fish at only 1. Supporting physico-chemical elements and some specific pollutants were monitored at 10 ROI monitoring stations.

In Northern Ireland, biological elements were assessed at 34 of the 37 monitoring stations, except for fish, which were monitored in 4 NI water bodies. Supporting physico-chemical elements and specific pollutants were measured at 34 stations, hydrology at all 37, and morphology at 11 stations.

A summary of the status of all water bodies in the Blackwater catchment is provided in Table 2.6 and illustrated in Figure 2-65. Table 2.6 also indicates significant pressures that have been identified as operating in water bodies.

Table 2.5 Percentage (%) of stations measuring each quality element in the Blackwater catchment. Source: NIEA and EPA

BLACKWATER CATCHMENT		Republic of Ireland	Northern Ireland
Number of stations		21	37
% Stations measuring each element			
Biological elements	Invertebrates	86%	92%
	Macrophytes	0%	92%
	Fish	5%	11%
	Diatoms	0%	92%
Physico-chemical elements	Dissolved Oxygen	48%	92%
	Soluble Reactive Phosphorous	48%	92%
	pH	48%	92%
Specific Pollutants	Ammonia	48%	92%
	Other	5%	92%
Hydromorphology	Morphology	0%	29%
	Hydrology	0%	100%

River Water Bodies (RWB)

The risk of ROI waterbodies not reaching their WFD objectives has been assessed and is shown in Figure 2-66. Factors placing RWBs at risk are varied and may be multiple in a given RWB. Urban wastewater discharges place a number of RWBs at risk, e.g. in the Shambles and Blackwater downstream of Monaghan town. Agriculture is a significant risk factor in some instances, including the Conawary River. A number of RWBs are at risk based on their currently less than good ecological status, e.g. Cor River and Cor River Tributary, Mountain Water. Others have been targeted for review because status remains unassigned e.g. Mullamurphy_010 and Mountain Water_060.

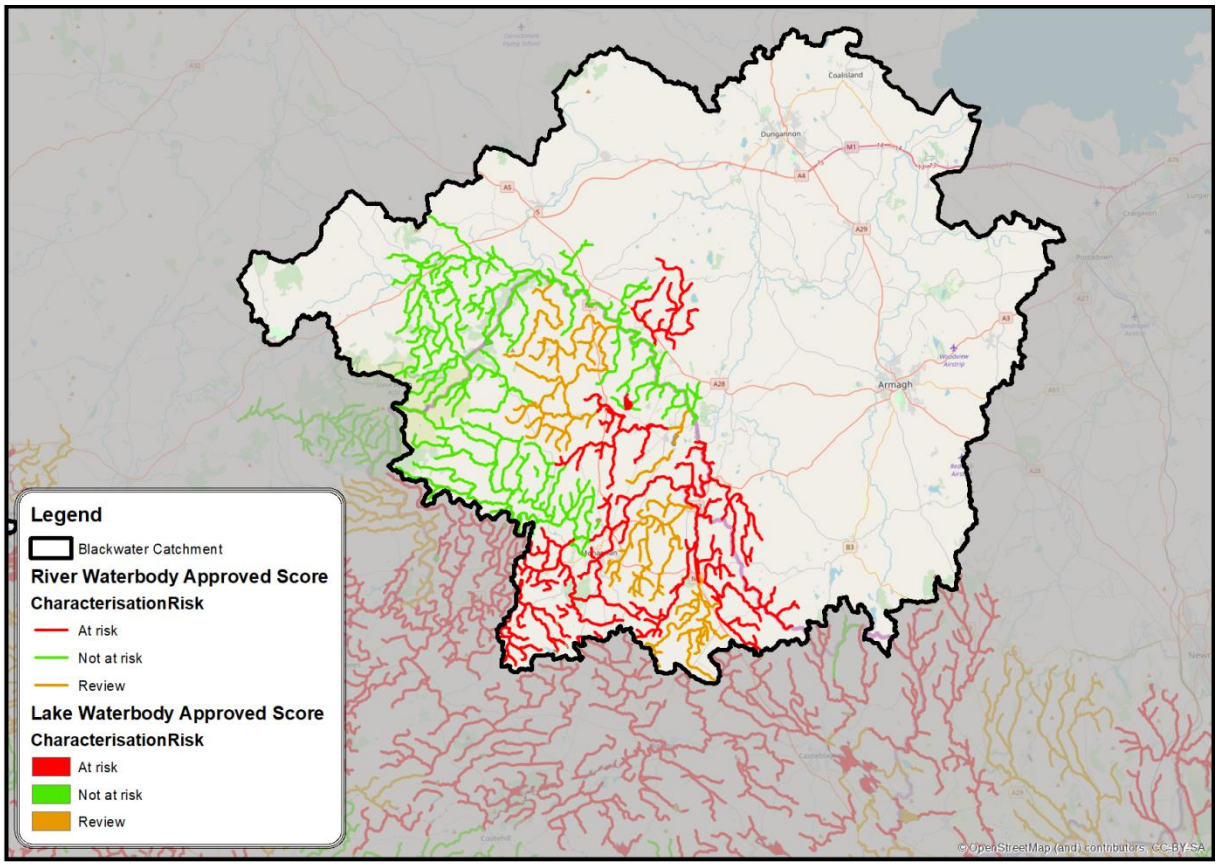

Figure 2-66 Locations of water bodies and WFD risk assessments in the Blackwater River Catchment. Risk is only available for ROI waterbodies.

Of the 57 RWBs in the Blackwater catchment, 3 are at high status, 13 are at good status, 19 are at moderate status, 9 at poor status, and 2 at bad status, 1 at PEP, 1 at BEP and 4 at MEP (Table 2.6). The high and good status water bodies are generally in the upland headwater reaches in the western side of the catchment (Figure 2-65).

Twelve RWBs have changed status in the most recent assessment in 2018 (Figure 2-65). In 5 cases status has declined; from high to good in 2 instances; and from good to moderate in 3 cases. In 7 cases status has improved; moderate to good in 2 RWBs ; poor to moderate 4 cases; and, in the case of one highly modified waterbody Lough Neagh Peripherals, from bad ecological potential to moderate ecological potential.

A number of rivers are at bad status (Tall River), or bad ecological potential (Rhone). In the latter cases of BEP, the rivers have been heavily modified or extensively urbanised. In the case of the Tall River, fish is the driving status element, although invertebrates are at poor status.

Lake Water Bodies (LWB)

The most recent classification for lakes is in 2018. Emy Lough was classified at moderate status, and Lough More at good status (Figure 2-67).

Emy Lough moderate status is driven by phytoplankton, macrophyte and chlorophyll conditions. The likely pressures impacting Emy Lough include a combination of unsewered properties and diffuse urban runoff. The role of abstraction and a possible altered hydrological regime may also be impacting status and needs to be considered.

Lough More MN is in a drinking water protection area. It is at good status and not at risk.

Status for the remaining lakes is unassigned and they are marked for review. However, White lake, Annayalla lies in the upper Clontibret river which is currently at poor status. Lambs Lake, Grove Lough and Glaslough are all assigned for review due to their unassigned, unmonitored status. Although Glaslough is unmonitored, pressure information and available evidence suggest eutrophication problems are likely, particularly with regard to diffuse urban runoff. Grove Lake is also unmonitored, but with agriculture and abstraction as possible significant pressures.

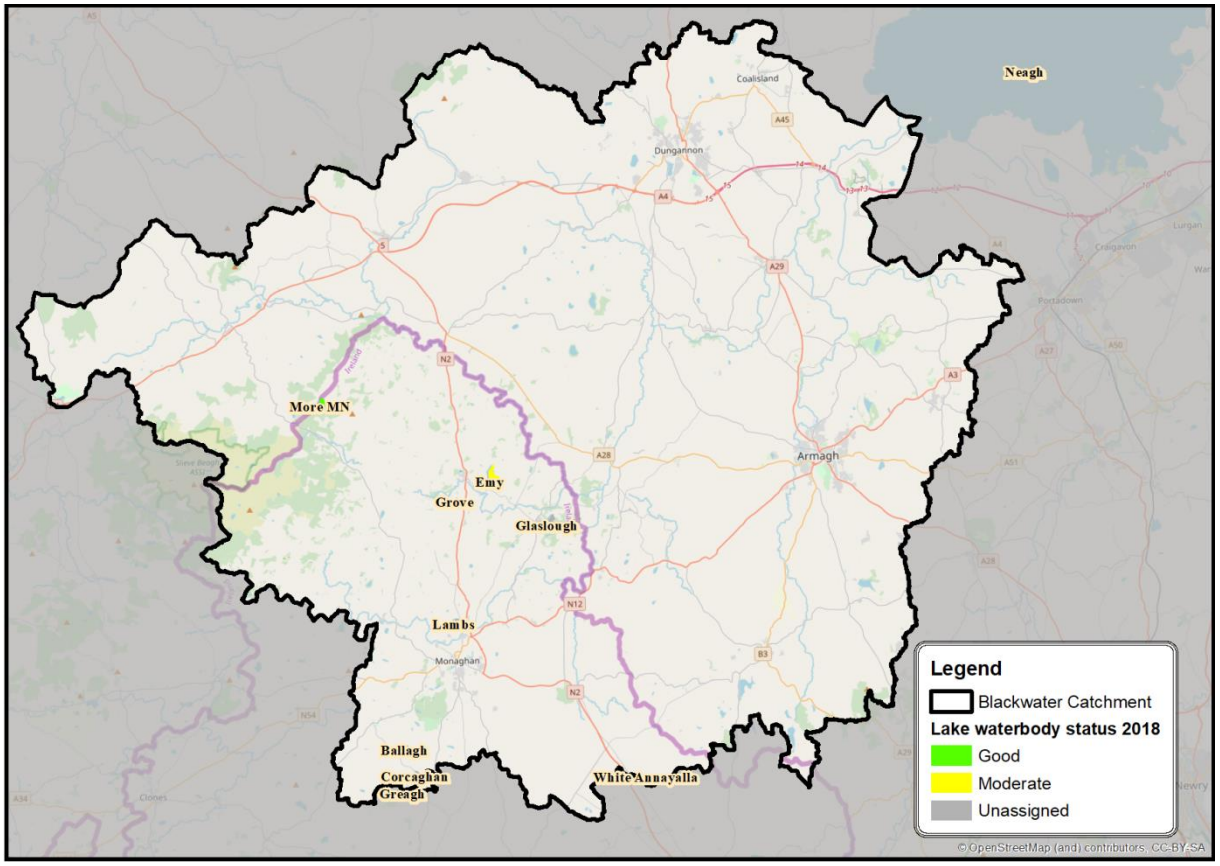

Figure 2-67 Lake water bodies in the Blackwater River Catchment and WFD status (ROI only)

Groundwater Bodies (GWB)

Aquifers in the catchment range from 'poorly productive' (Magheraveely and Tydavnet GWBs) to 'productive' in the remaining fissured bedrock aquifers.

A small GWB has been delineated around a waste facility at Annyalla. The Scotch Corner non-hazardous landfill and Material Recovery Facility was originally permitted under licence number W0020-01. A new licence (W0020-02) was issued in 2010. It is in poorly productive bedrock. This GWB is currently at Poor status. The 2018 AER for the waste facility reports that an analysis of surface water and groundwater at the Scotch Corner facility indicates that there is contamination of surface water and groundwater by leachate from the old landfill, and ammonia levels are high.

The remaining groundwater bodies in ROI are all at 'Good' status (Figure 2-68). However, a number of them are considered to be at risk and are marked for review. In the case of Clones GWB, some monitoring points are exhibiting upward trending ammonia and chloride levels. Risk assessments showed that the Keady groundwater body is possibly under pressure from mine seepages on the Tynan River/ Balteagh Stream Upper.

In NI the Aughnacloy and Moygashel GWBs are classified at poor status. The Aughnacloy groundwater body is currently at poor status due to failure of the intrusion test (high chloride and conductivity values), surface water quantity and quality test (contribution of P to surface waters). Without a chemical baseline study it is not possible to ascertain whether increased chloride and conductivity values are due to natural or anthropogenic causes. The Moygashel groundwater body is at poor status due to the surface water quality test (contribution of P to surface waters).

Some of the results of these tests are confusing, such as the saline test. These assessments are made on the basis of limited monitoring. Therefore these groundwater bodies have a high density of increased monitoring requirements. Investigation of groundwater flow paths and groundwater-surface water interaction within the catchment would clarify groundwater's role in P contribution to surface waters better.

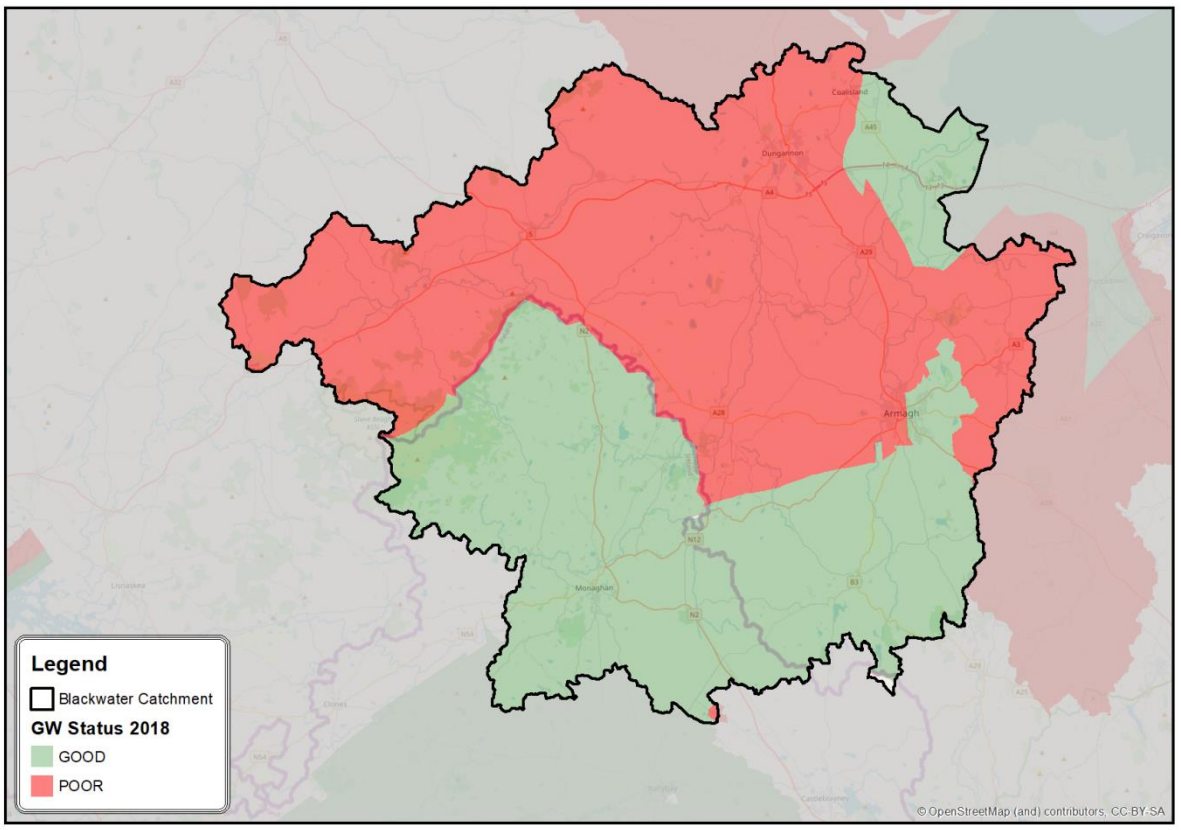

Figure 2-68 Groundwater bodies in the Blackwater River Catchment and WFD status

Table 2.6 WFD water bodies, status and significant pressures in the Blackwater River Catchment. Source: NIEA and EPA. Current status for the ROI is from 2015 and from 2018 for NI

WATERBODY NUMBER	WATER BODY NAME	STATUS 2015	STATUS 2018	Pressures
IE_NB_03B010130 (ROI)	Blackwater (Monaghan)_010	Good	Good	
IE_NB_03B010300 (ROI)	Blackwater (Monaghan)_020	Good	Good	
IE_NB_03B010510 (ROI)	Blackwater (Monaghan)_030	Good	Good	
IE_NB_03B010800 (ROI)	Blackwater (Monaghan)_040	Moderate	Moderate	DU, UWW
IE_NB_03C011400 (ROI)	Clontibret Stream_030	Poor	Poor	DWW Hymo - Channelisation Ag - Pasture
IE_NB_03C021100 (ROI)	Conawary (Lower)_010	Poor	Poor	Ag Hymo - Channelisation
IE_NB_03C021300 (ROI)	Conawary (Lower)_020	Poor	Poor	Ag - Pasture DWW
IE_NB_03M010200 (ROI)	Mountain Water_020	High	Good	
IE_NB_03M010400 (ROI)	Mountain Water_030	Good	Good	
IE_NB_03M010500 (ROI)	Mountain Water_040	Poor	Poor	Ag - Pasture DU DWW Hymo UWW (agglom. 1000 - 2000 pe) Hymo - dams, barriers, locks, weirs, channelisation
IE_NB_03M010650 (ROI)	Mountain Water_050	Poor	Moderate	Ag Hymo - channelisation
IE_NB_03S010500 (ROI)	Shambles_010	Poor	Poor	DU UWW - Agglomeration PE > 10,000
IE_NB_03S020500 (ROI)	Scotstown_020	High	High	
IE_NW_36M010150 (ROI)	Magherarney_010	Poor	Poor	
IE_NB_03C011200 (ROI)	Clontibret Stream_020	Unassigned	Unassigned	
IE_NB_03L100990 (ROI)	Lisavargy_010	Unassigned	Unassigned	Ag
IE_NB_03M010700 (ROI)	Mountain Water_060	Unassigned	Unassigned	
IE_NB_03M050960 (ROI)	Mullamurphy_010	Unassigned	Unassigned	Ag -pasture DWW Hymo - Channelisation
IE_NB_03T170930 (ROI)	Tireran_010	Unassigned	Unassigned	Ag
UKGBNI1NB030307175 (NI)	Ballygawley Water	GOOD	MODERATE	
UKGBNI1NB030307111 (NI)	Ballymacone River	MODERATE	MODERATE	
UKGBNI1NB030307045 (NI)	Ballymartrim Water	POOR	MODERATE	
UKGBNI1NB030308255 (NI)	Scotstown_10	HIGH	HIGH	
UKGBNI1NB030307048 (NI)	Butter Water	MEP	MEP	
UKGBNI1NB030308225 (NI)	Callan River (Derryscollop)	MODERATE	MODERATE	
UKGBNI1NB030307044 (NI)	Callan River (Milford)	MODERATE	MODERATE	
UKGBNI1NB030307112 (NI)	Callan River (Tassagh)	MODERATE	MODERATE	

WATERBODY NUMBER	WATER BODY NAME	STATUS 2015	STATUS 2018	Pressures
UKGBNI1NB030307049 (NI)	Clay River	MEP	MEP	
UKGBNI1NB030308202 (NI)	Clontibret Stream_10	POOR	POOR	DU DWW Hymo - channelisation
UKGBNI1NB030308245 (NI)	Cor River	POOR	MODERATE	Ag Hymo - channelisation, sediment deposition risk
UKGBNI1NB030307096 (NI)	Cor River Tributary	MODERATE	MODERATE	Ag - pasture
UKGBNI1NB030307042 (NI)	Crilly Feeder	POOR	POOR	Anthropogenic Pressures
UKGBNI1NB030307238 (NI)	Fury River	GOOD	GOOD	Ag - Medium and high risk Erosion - high risk on high ground
UKGBNI1NB030307109 (NI)	Killeen Water	PEP	PEP	
UKGBNI1NB030307047 (NI)	Kilmore Tributary	POOR	MODERATE	
UKGBNI1NB030307242 (NI)	Knockmany Burn (Blackwater)	HIGH	GOOD	
UKGBNI1NB030308243 (NI)	Lough Neagh Peripherals	BEP	MEP	
UKGBNI1NB030308254	Mountain Water_10	HIGH	HIGH	
UKGBNI1NB030308217 (NI)	Oona Water (Eglish)	MODERATE	MODERATE	
UKGBNI1NB030308213 (NI)	Oona Water (Killymaddy)	MODERATE	MODERATE	
UKGBNI1NB030308201 (NI)	River Blackwater (Annaghroe)	GOOD	MODERATE	Ag - medium and high risk
UKGBNI1NB030308203 (NI)	River Blackwater (Argory)	POOR	POOR	Hymo - over deepened and widened, bank, poaching IAS - Himalayan balsam and giant hogweed
UKGBNI1NB030308223 (NI)	River Blackwater (Augher)	GOOD	MODERATE	Hymo modifications recorded - Derrygorry tributary straightened, extensively deepened, minimal flow variation. IAS - Himalayan balsam
UKGBNI1NB030307043 (NI)	River Blackwater (Benburb)	GOOD	GOOD	Hymo - weirs, sluices and licensed impoundments Ag - high and moderate risk
UKGBNI1NB030308204 (NI)	River Blackwater (Caledon)	GOOD	GOOD	Ag - medium, and high risk IAS - Himalayan balsam
UKGBNI1NB030307196 (NI)	River Blackwater (Ratory)	GOOD	GOOD	
UKGBNI1NB030307041 (NI)	River Blackwater Tributary (Aughnacloy)	MODERATE	MODERATE	
UKGBNI1NB030307180 (NI)	River Blackwater Tributary (Ballygreenan)	MODERATE	GOOD	Hymo - high and medium sediment deposition risk
UKGBNI1NB030307243 (NI)	River Blackwater Tributary (Killyfaddy)	MODERATE	GOOD	
UKGBNI1NB030307239 (NI)	River Blackwater Tributary (Lisboy)	GOOD	GOOD	
UKGBNI1NB030307036 (NI)	River Rhone (Dungannon)	MODERATE	MODERATE	Hymo -hydrology, culverted streams, moderate sedimentation risk Ag - high and moderate risk and some reaches at

WATERBODY NUMBER	WATER BODY NAME	STATUS 2015	STATUS 2018	Pressures
UKGBNI1NB030307025 (NI)	River Rhone (Moygashel)	BEP	BEP	Hymo - flood risk management, urbanised, weirs, impoundments and culverts, Eskragh Lake sluice IAS - Japanese knotweed
UKGBNI1NB030307050 (NI)	Tamnamore Stream	Moderate	Moderate	
UKGBNI1NB030308224 (NI)	Tall River (Richill)	BAD	BAD	
UKGBNI1NB030307129 (NI)	Tall River (Derrycrew)	BAD	BAD	
UKGBNI1NB030308222 (NI)	Torrent River	MEP	MEP	
UKGBNI1NB030308236 (NI)	Tynan River	MODERATE	MODERATE	
Groundwater				
IEGBNI_NB_G_007 (ROI) UKGBNI4NB007 (NI)	Aughnacloy	GOOD POOR	GOOD	
IEGBNI_NB_G_012 (ROI) IEGBNINBG012 (NI)	Monaghan Town	GOOD GOOD	GOOD	
IE_NB_G_013 (ROI)	Tydavnet	GOOD	GOOD	
IEGBNI_NB_G_014 (ROI) UKGBNI4NB014 (NI)	Knockatallon	GOOD GOOD	GOOD	
IEGBNI_NB_G_011 (ROI) UKGBNI4NB011 (NI)	Keady	GOOD GOOD	GOOD	
IE_NB_G_026 (ROI)	Waste facility	POOR	POOR	
UKGBNI4NB020 (NI)	Neagh	GOOD		
UKGBNI4NB008 (NI)	Tandragee	POOR		
UKGBNI4NB003 (NI)	Cookstown	GOOD		
UKGBNI4NB006 (NI)	Moygashel	POOR		
Lakes				
IE_NB_03_87	More MN	Good	Good	DW Protected Area
IE_NB_03_102	Emy	Moderate	Moderate	DWW
IE_NB_03_03	Grove	Unassigned	Unassigned	Ag
IE_NB_03_90	Lambs	Unassigned	Unassigned	
IE_NB_03_79	Glaslough	Unassigned	Unassigned	Urban Run off
IE_NB_03_97	Ballagh	Unassigned	Unassigned	Ag
IE_NB_03_51	Greagh	Unassigned	Unassigned	Ag
IE_NB_03_71	Corcaghan	Unassigned	Unassigned	Ag
IE_NB_03_86	White Annayalla	Unassigned	Unassigned	Ag

2.3.7 Catchment Pressures

Significant pressures impacting on water quality in the Blackwater catchment include agriculture, hydromorphological pressures, diffuse urban run-off, urban wastewater treatment effluent, domestic wastewater discharges, and anthropogenic pressures. Significant pressures acting on 'at risk' water bodies in ROI are shown in Figure 2-69. It shows that agriculture, followed closely by

hydromorphology are the most frequent pressures. Multiple pressures are impacting water quality and status in many water bodies.

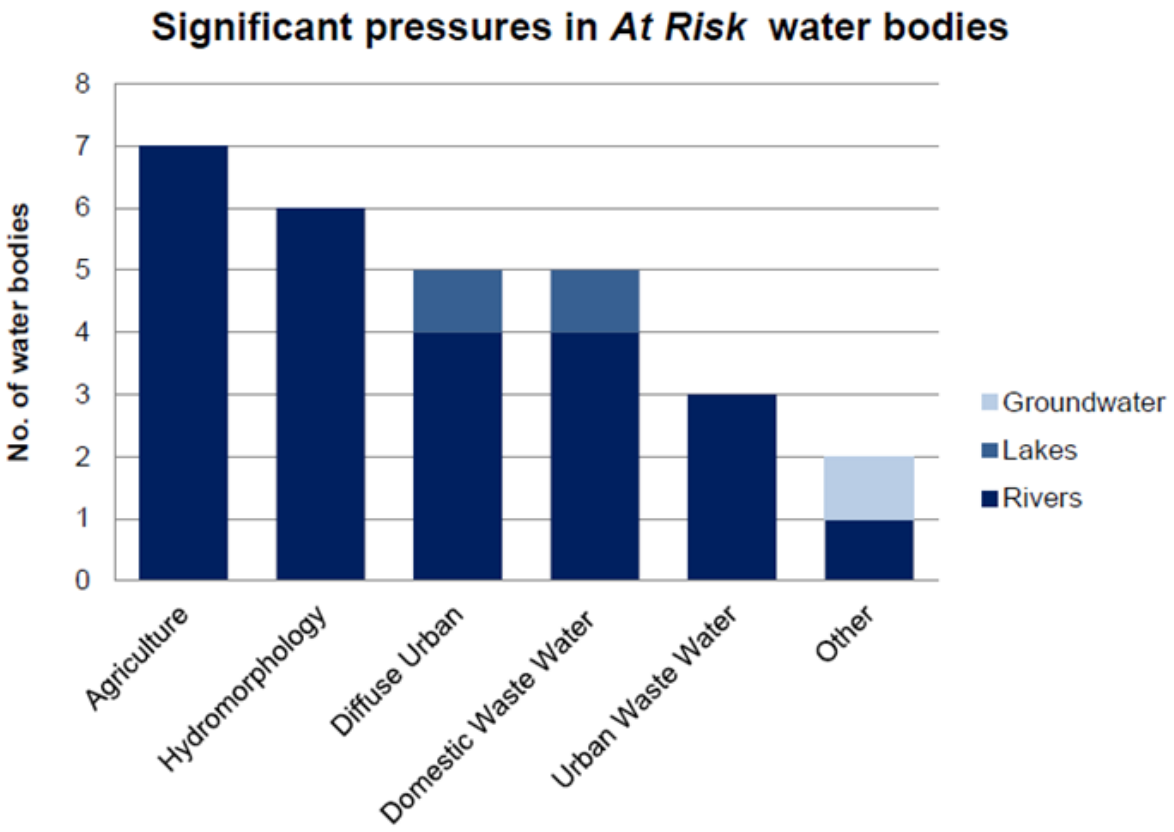

Figure 2-69 Number of waterbodies in the Blackwater River Catchment in which significant pressures are impacting on ROI 'At Risk' water bodies

Agriculture

Figure 2-70 shows the catchment areas where agricultural pressures are deemed to be significant.

In NI medium- and high- agricultural critical risk areas are widely, and rather evenly, distributed throughout the catchment. There are a number of areas where agricultural pressures are more concentrated. These include the upper Blackwater valley, the Keady area in the south of the catchment, the Blackwater valley between Aughnacloy and Caledon, and particularly in the lower reaches of the Torrent River and Tamnamore Stream between Coalisland and the Blackwater River.

In ROI, agriculture is a significant pressure in the south and east of the catchment, in the more intensively farmed areas around Emyvale, Glaslough and south of Monaghan town. The average farm size in Monaghan is 23 ha. Agriculture in these areas is mainly dairy and beef farming, but intensive pig and poultry farming also occurs.

The impact of agricultural pressures includes phosphorus loss to surface waters from, for example, direct discharges, or runoff from yards, roadways or other compacted surfaces, or runoff from poorly draining soils. Sediment may also be a problem from land drainage works, bank erosion due to animal access, or stream crossings.

The herbicide MCPA has been detected in a number of water sources in Monaghan. Exceedances in pesticides were detected during 2018 in the Emyvale Public Water Supply, and Glaslough Public

Water Supply. The herbicide MCPA has been detected in Monaghan, Emyvale, and Glaslough supplies over the past two years, albeit mostly at very low levels.

Agriculture in the western portion of the catchment, near the Slieve Beagh uplands, is generally more extensive grazing on rough pasture. It is not identified as a significant pressure in these areas.

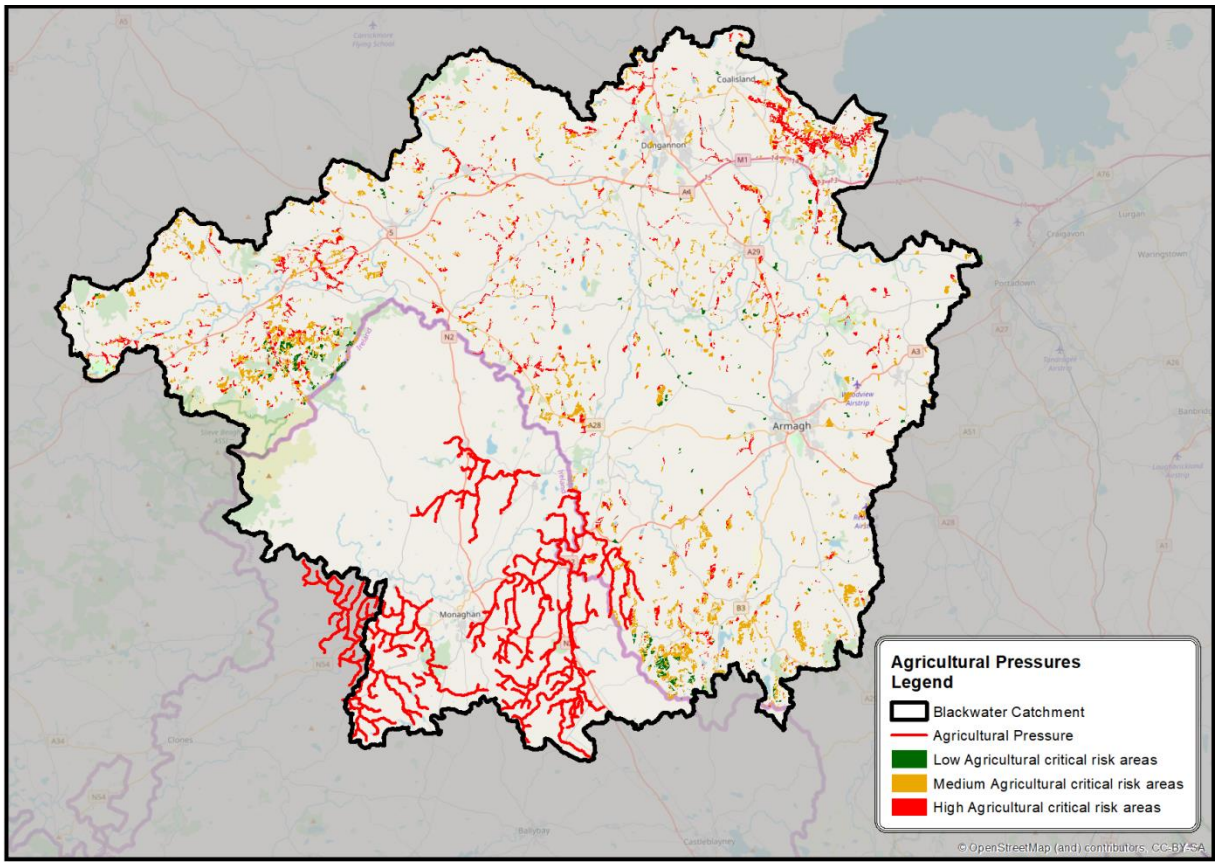

Figure 2-70 Agricultural pressures on water bodies in the Blackwater River Catchment

Hydromorphology Pressures

Hydromorphology pressures are particularly prevalent in this catchment due to its history of major arterial drainage schemes, flood protection, high level of urbanisation, and land drainage for agriculture. The now disused Ulster Canal (built in the 1800s) also travels through County Armagh and County Tyrone. Remnants of the canal are still evident today. Hydromorphology pressures are prominent in many of the same water bodies as agricultural pressures (Figure 2-71).

River water bodies within the Mountain Water, Clontibret Stream and Blackwater [Monaghan] sub-catchments have been subject to extensive modification. Drainage schemes and weirs have led to altered flow, high levels of siltation, and habitat degradation.

Recent hydromorphology assessment data (using the River Hydromorphology Assessment Technique, RHAT2) is available for 6 of the 28 water bodies listed on the Blackwater system. These scored mainly moderate and poor for habitat. An additional 4 water bodies were surveyed to link the 6 areas RHAT surveyed. Issues identified in the survey areas include a lack of vegetated buffer, and heavily trampled banks containing invasive alien species such as giant hogweed, and Himalayan balsam.

The Blackwater channel was historically deepened, reducing floodplain interaction. Though the entire Blackwater catchment has not yet been surveyed for in-channel barriers, the limited surveys that have occurred found several notable barriers along the river channels. These include structures of concern at Benburb, at least three on the Butterwater tributary, and one at Emyvale.

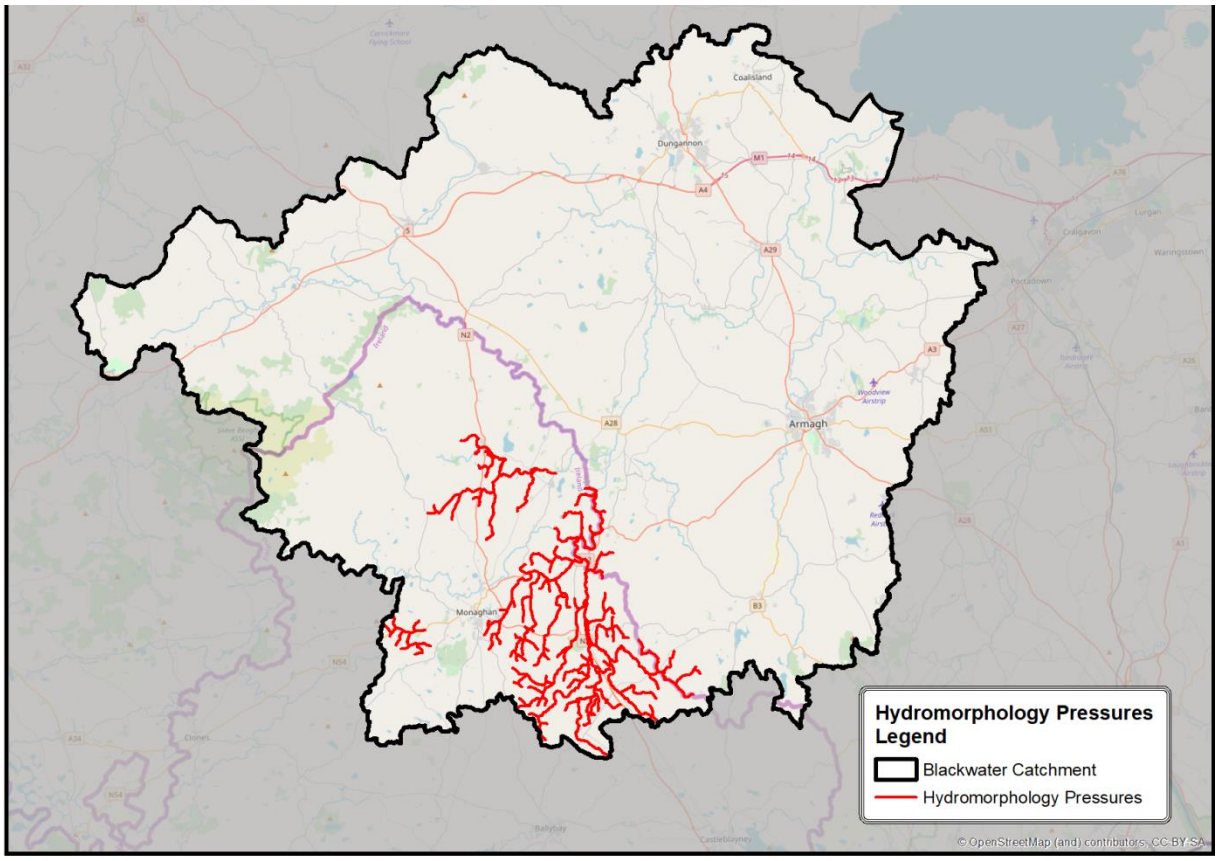

Figure 2-71 Hydromorphology pressures on water bodies in the Blackwater River Catchment

Forestry and Peat Extraction

Forestry is limited to the higher areas in the west of the catchment and to a small area southeast of Keady at the catchment boundary. The forest estate is predominantly commercial conifer plantations (Figure 2-72). Forestry is not identified as a significant pressure in the catchment.

Peat extraction has occurred on all bogs throughout the catchment. Peat has been harvested mechanically on the blanket bog on Slieve Beagh and in the Lough Neagh wetlands. Historically, peat cutting has been most extensive in the Lough Neagh peatlands, where many of the bogs have been drained, cutover or improved for agriculture. This has impacted the hydromorphology of these areas.

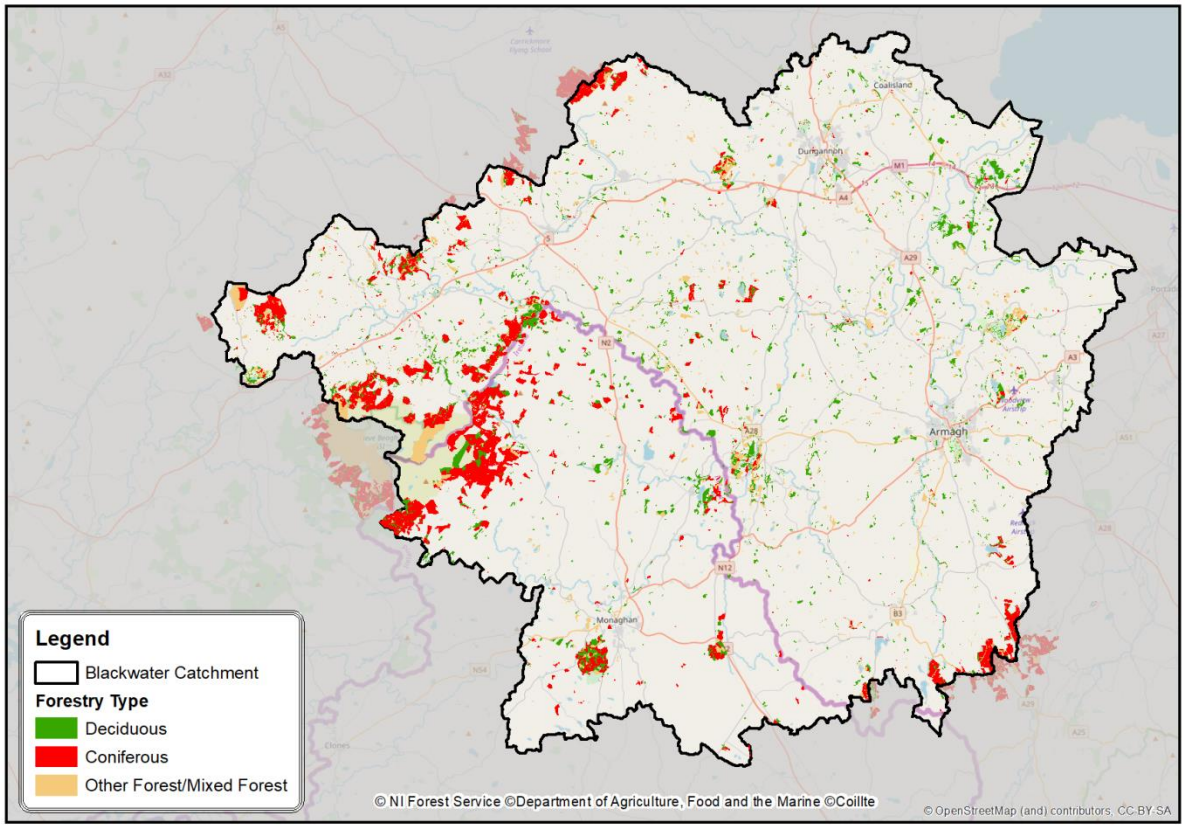

Figure 2-72 Forest cover in the Blackwater River Catchment

Urban Waste Water Treatment and On-site Wastewater Systems

Urban wastewater treatment plants (UWWTPs) are widely distributed throughout the catchment and some rivers are being impacted by effluent discharges (Figure 2-73). A list of WWTPs is provided in Table 2.7, with details of the design and actual population equivalents where available. Where the actual load exceeds the design capacity the WWTPs are in bold. The locations of UWWTPs are also shown in Figure 2-74. Of the 79 UWWTPs listed in Table 2.7, 38 have actual organic loads of less than 100PE.

There are 10 UWWT agglomerations within the Blackwater catchment in Monaghan (5 are Licensed, and 5 are certified). There are 18 WW emission points of which 8 are storm overflows and 10 are primary effluent emission points.

Urban Waste Water Treatment Plants have been identified as a significant pressure in three ROI water bodies that are at risk: Blackwater (Monaghan)_040, Shambles_010 and Mountain Water_0405 (Figure 2-73). The two WWTPs impacting these water bodies are Monaghan (D0061) with a PE of greater than 10,000, and Emyvale (D0346), with a PE of 1,000–2,000.

Loadings at Clontibret, Blackwatertown, and Aghinlig WWTPs are approximately twice the design capacity of the plants. In percentage terms, Scotstown is at 140% of capacity, but this is an excess of about 397 PE.

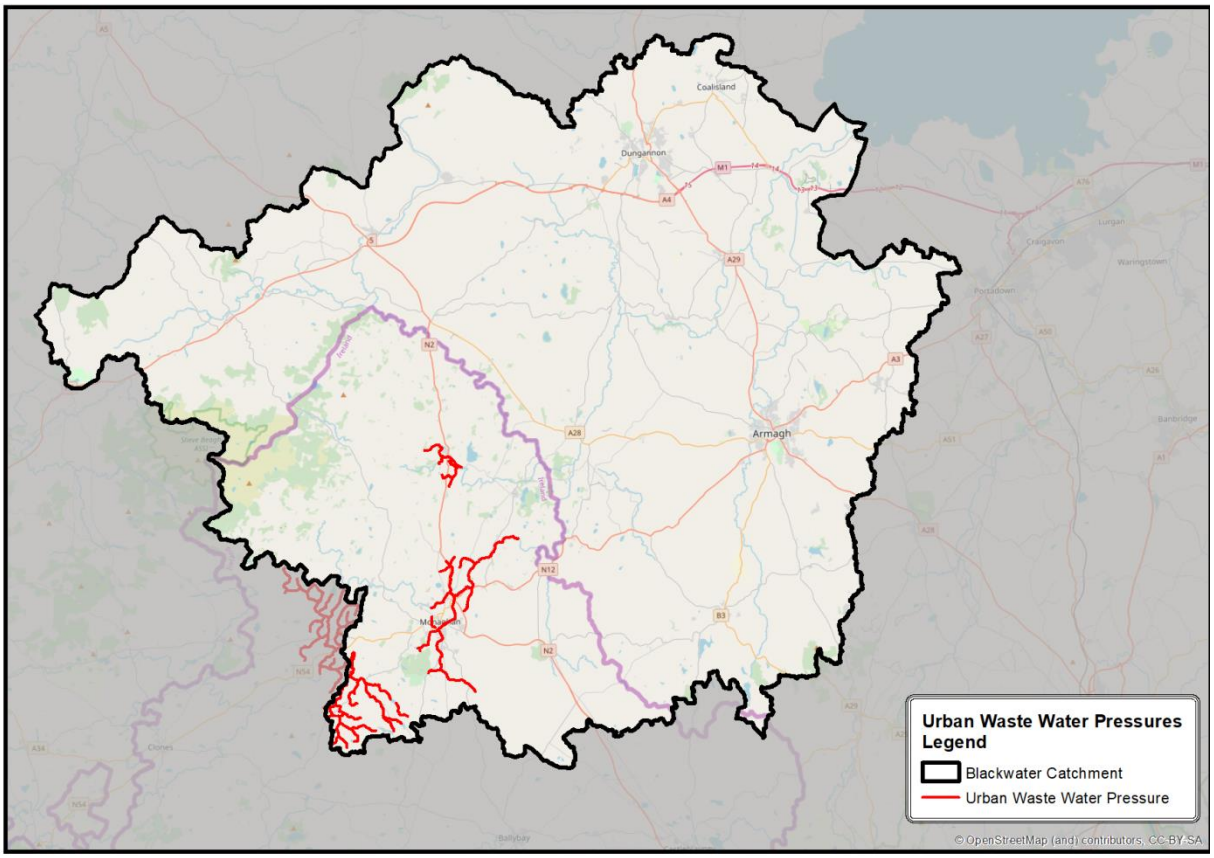

Figure 2-73 Urban Wastewater Pressures in ROI on 'at risk' water bodies in the Blackwater River Catchment

The Blackwater catchment is largely rural in character and population is dispersed, often in ribbon developments. Figure 2-75 shows one-off housing where the density is greater than 20/km^2 in the catchment (ROI), and the hotspots where on-site wastewater treatment systems (OSWWTS) pose a risk to water quality (NI). The majority of systems are septic tanks with solids removal and effluent disposal to percolation zones. Figure 2-75 shows that one-off housing pressures and hot spots occur in almost all parts of the catchment except the most remote mountainous areas.

Domestic wastewater pressures are prominent in many of the same WBs as agricultural pressures. Domestic wastewater has been identified as a significant pressure in the Clontibret Stream, the Conawary, Mountain Water and the Mullamurphy, and in Emy Lough. High and very high risk hotspots are associated with one-off housing development around the major settlements e.g. near Dungannon at Donaghmore and Edendork.

The impacts are associated with inadequate treatment systems, and unsuitable percolation areas and/or direct pipe discharges, usually in areas of poorly draining soils and subsoils, resulting in elevated nutrient concentrations.

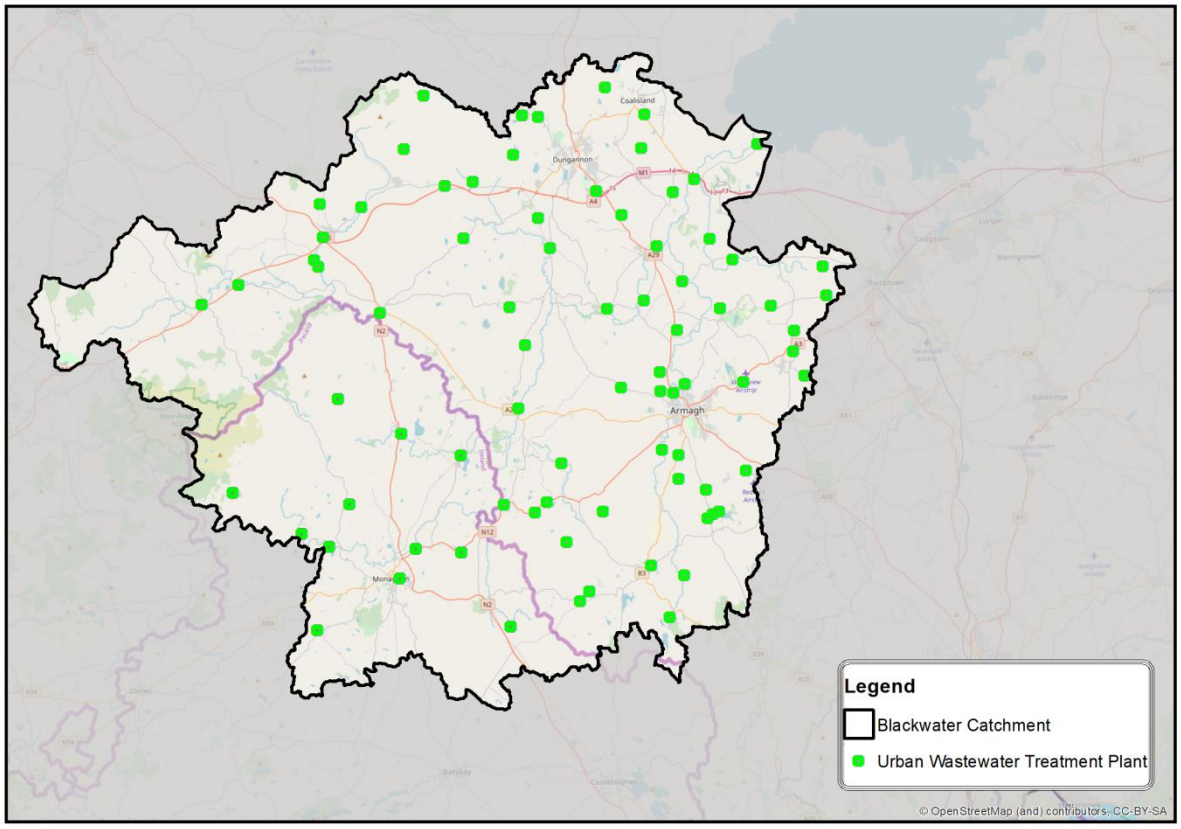

Figure 2-74 Locations of Urban wastewater treatment plants (UWWTPs) in the Blackwater River Catchment

Table 2.7 Urban wastewater treatment plants (UWWTP) in the Blackwater River Catchment

ID	NAME	Actual	Design PE	ID	NAME	Actual	Design
WW002063481	Dungannon	77643	78826	A0034	Carrickroe	80	150
D0061	Monaghan	19408	37400	WW002063458	Drumhillery	71	100
WW002063473	Coalisland	10010	14511	WW002063514	Dyan	64	70
WW002063506	Keady Armagh	4571	5800	WW002063440	Farmacaffley	62	100
WW002063480	**Moy**	**3770**	**3300**	WW002063539	Lisdoart One	58	150
WW002063484	Donaghmore	1982	4000	A0032	Knockatallon	45	180
WW002063536	Aughnacloy Mill	1614	1615	WW002063448	**Ballynahinch Armagh**	**42**	**25**
WW002063466	Caledon	1427	2050	WW002063496	Grangemore	42	48
D0494	**Scotstown**	**1397**	**1000**	WW002063470	Cavanagrow	38	60
WW002063537	Ballygawley	1237	1500	WW002064036	Drumard Primate	37	54
WW002063813	Clogher	1184	1220	WW002063468	Ballymacnab	30	68
D0346	Emyvale	1126	2000	WW002063522	Bovean	30	53
WW002063501	Benburb	1078	1687	WW002063451	Mullaghbane Armagh	29	50
WW002063512	Castlecaulfield	1069	1729	WW002063469	Ballynagalliagh Armagh	27	50
D0347	Glaslough	901	1750	WW002063510	Brantry	26	50
WW002063503	**Blackwatertown**	**754**	**354**	WW002063513	Derrygortrevy	24	70
WW002063486	Newmills	727	846	WW002063445	Seagahan	24	25
WW002063500	Loughgall	638	890	WW002063518	Tullyleek	24	28
WW002063526	Tamnamore	617	850	WW002063472	Dundrum Keady	23	25
D0435	Ballinode	606	1000	WW002063504	Kiltubbrid	23	37
WW002063511	**Cabragh**	**577**	**350**	WW002063497	Lisdown	22	28
WW002063814	Augher	570	700	WW002063442	Lisnadill	21	50
WW002063463	Middletown	557	800	WW002063517	Mullyroddan	20	40
WW002063485	**Eglish**	**527**	**423**	WW003166470	Diviny New RBC	19	20
WW002063456	**Darkley**	**438**	**433**	WW002063509	Aghnagar	18	36
D0463	Knockaconny	422	1000	WW002063455	Crossnamoyle	18	30
WW002063545	Maghery	363	410	WW002063465	Derrynoose	18	100
WW002063453	Annahugh Road	323	410	WW002063495	Grange Blundel	18	22
A0031	**Clontibret**	**306**	**150**	WW002063538	Knockonny	18	50
WW002063487	Redford	278	289	WW002063457	Doogary	17	24
WW002063490	**Aghinlig**	**225**	**120**	WW002063475	**Drumkee**	**17**	**12**
WW002063460	Madden	144	200	WW002063535	Lisdoart Two	16	17
A0037	Tyholland	143	150	WW002063516	Inishmagh	15	58
WW002063552	Kilmore Richhill	135	250	WW002063462	Manor House	12	14
A0020	Threemilehouse	133	250	WW002063498	Teeraw	12	16
WW002063519	Cappagh	131	200	WW002063505	Derryhaw	10	15
WW002063447	Ardress	123	239	WW002063499	Tullyelmer	6	6
WW002063520	Edencrannon	118	153	WW002063452	Richhill	NA	
A0029	Tydavnet	100	350	WW002063491	Armagh Drumcarn	NA	
WW002063527	**Tullyroan**	**85**	**24**				

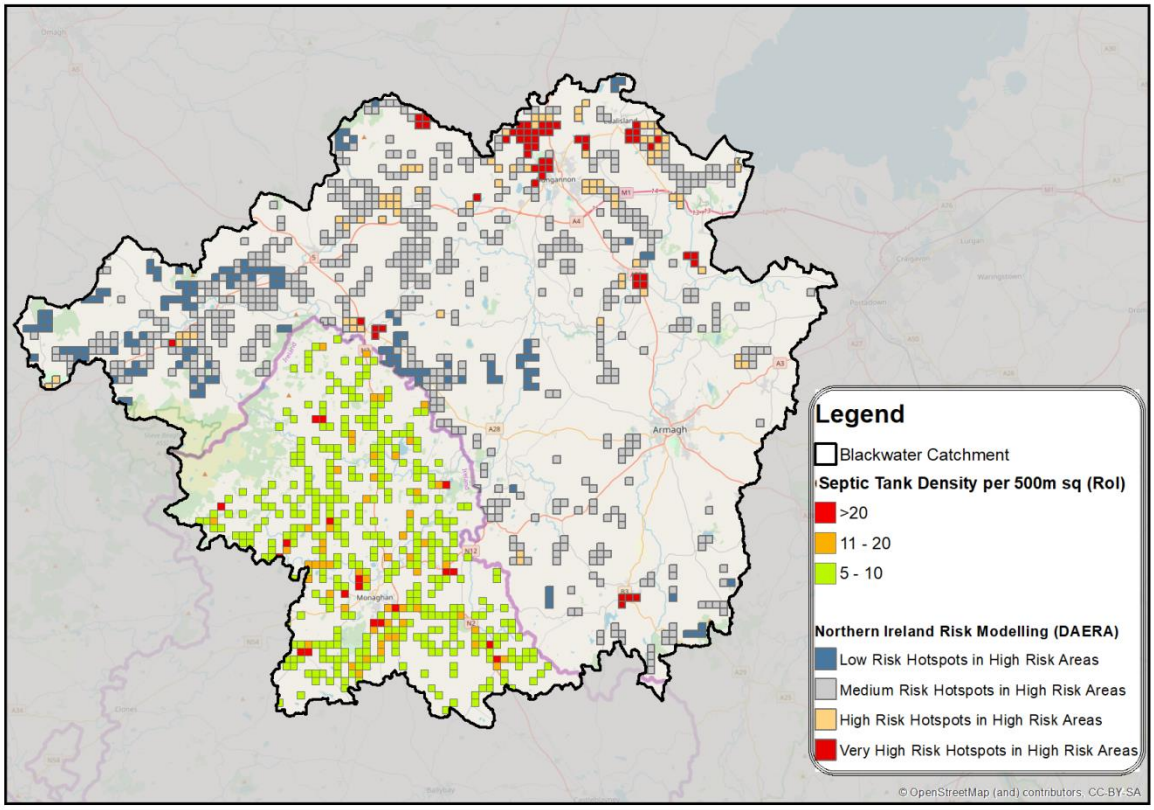

Figure 2-75 Domestic on-site wastewater treatment system pressures in the River Blackwater Catchment, represented by septic tank density in RoI and areas designated as High, Medium and Low risk categories in NI. (Source: EPA and WMU @ DAERA)

Diffuse Urban Run-Off

Diffuse urban pressures resulting from misconnections, leaky sewers and runoff from paved and unpaved areas, have been identified as significant in a number of surface water bodies.

In the ROI water bodies 'at risk', urban run-off is a significant pressure in the Shambles River and Blackwater (Monaghan) downstream of Monaghan Town. Emyvale is also producing urban run-off that is impacting the Mountain Water River locally, and Emy Lough has significant urban run-off pressures. Clontibret Stream is also subject to urban run-off pressures (Figure 2-76).

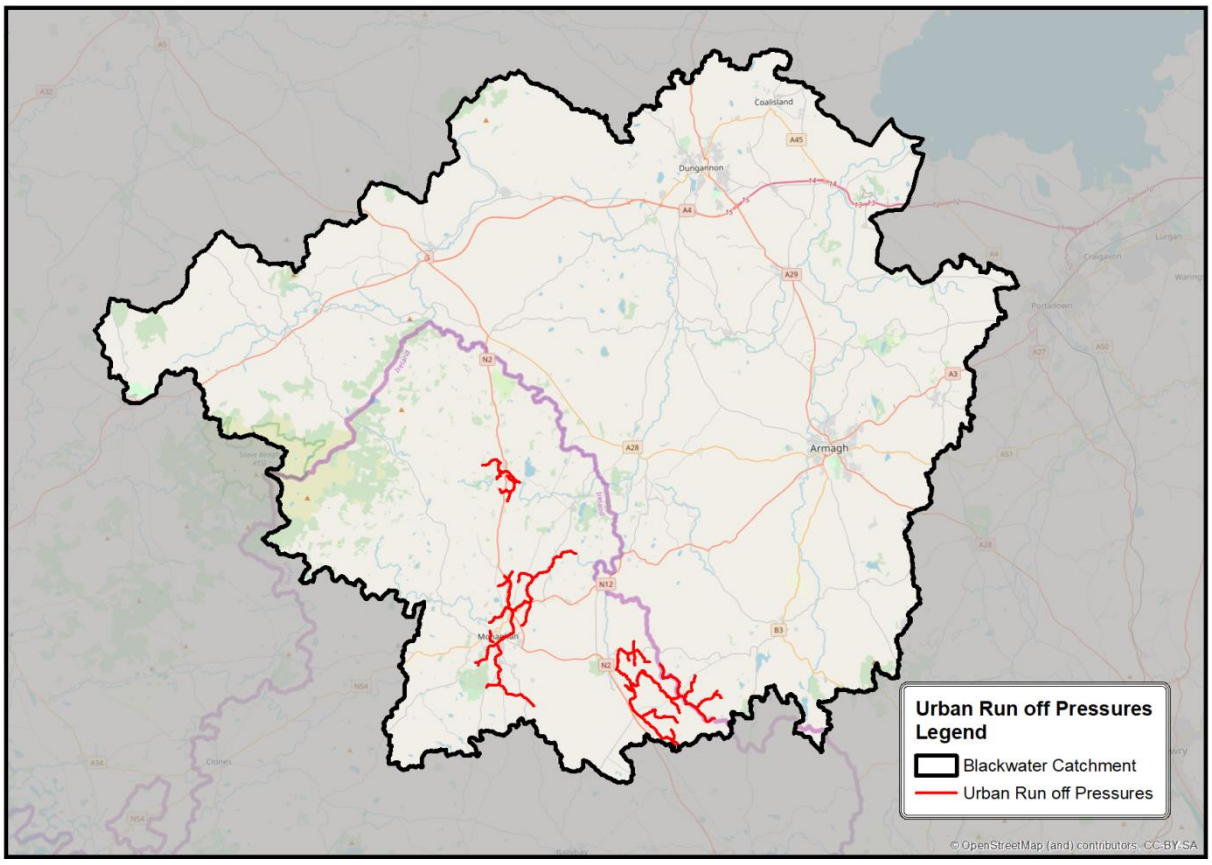

Figure 2-76 Urban runoff pressures in ROI 'at risk' waterbodies in the Blackwater River Catchment

Licensed Discharges

Figure 2-77 shows the location of licensed discharges in the ROI Blackwater catchment. In ROI, there are 2 licensed waste facilities, over 50 existing, or applied for, industrial emission licenses, 6 Integrated Pollution Prevention and Control (IPPC) licenses, and 10 Section 4 licensed discharges to surface waters.

Many of the licensed discharges are from agrifood industries including mushroom, poultry, dairy and vegetable production. Waste (poultry litter) has been identified as a significant pressure in one river water body (Clontibret Stream_010). Elevated organics and phosphorous are the significant issues arising from waste.

Licensed discharges are not identified as a significant pressure by the EPA in the Blackwater Catchment.

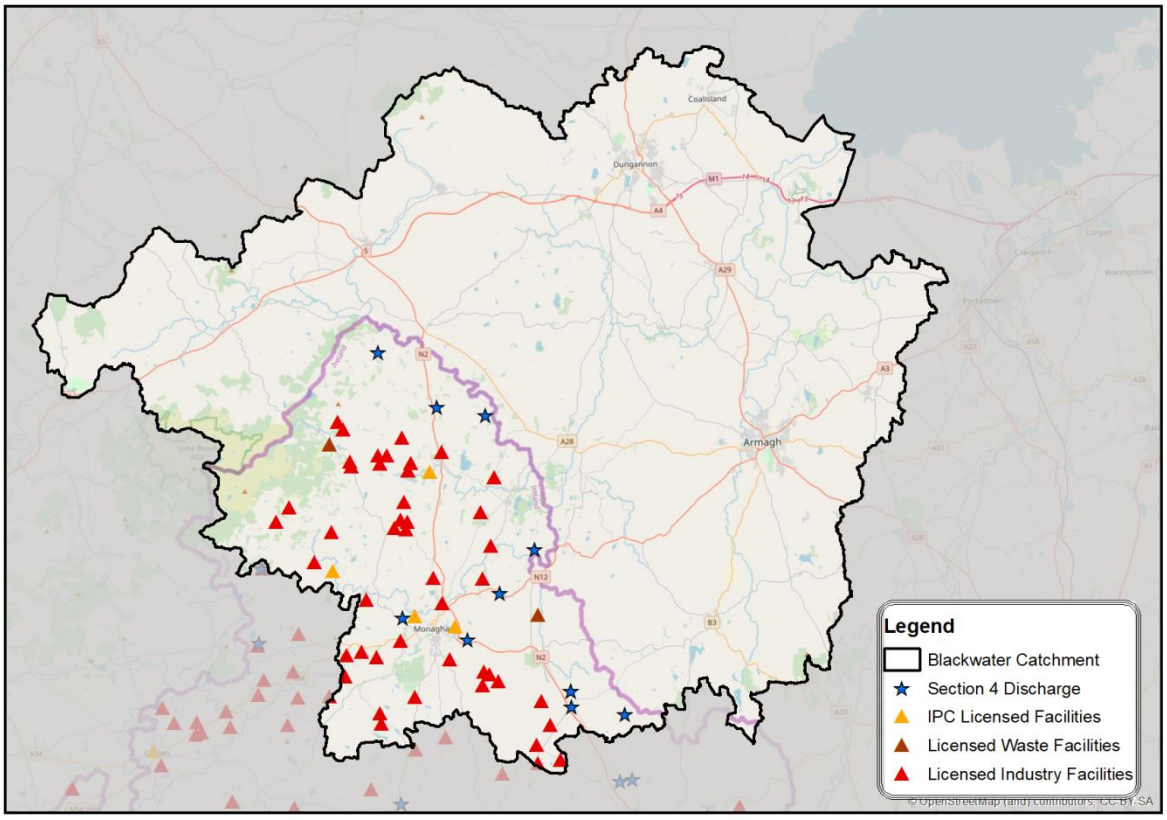

Figure 2-77 Licensed discharges to surface waters in RoI in the Blackwater River Catchment

Priority Areas for Action

The process, and objective of selecting PAAs in the ROI second cycle River Basin Management Plan has been described in section 2.1.7. The PAAs in the Blackwater Catchment are shown in Figure 2-78. The Mountain Water and Emy Lake have been selected for local authority catchment assessment teams to drive the implementation of mitigation measures, with particular emphasis on driving collaborative and cross-sectoral actions to deliver water-quality improvements.

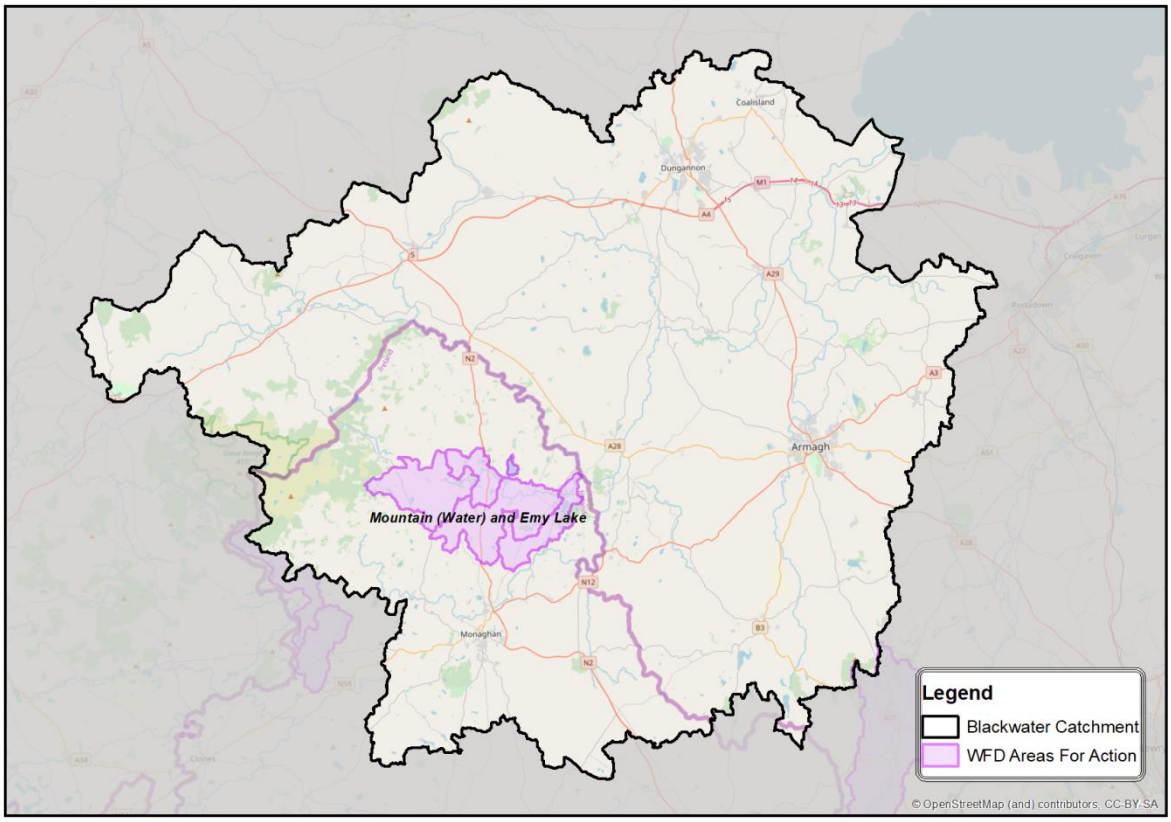

Figure 2-78 Priority Areas for Action in the Blackwater River Catchment (source: EPA)

3 The Scoping and Targeting Programme

The Scoping and Targeting programme identifies detailed work programmes within each sub task. The work programmes are founded on evidence-based initial catchment characterisation and further investigations to identify specific locations and appropriate mitigations to achieve water quality improvements. This process has also been informed by the detailed local knowledge of project partners. The programme also seeks to optimise synergies between the various work elements in order to maximise cost effectiveness and project impact.

To aid in decision-making in relation to project actions, a catchment matrix tool has been prepared, and is available to all project partners. The matrix lists all waterbodies in the selected catchments, along with relevant details of risk, status, objectives, pressures, works planned, numbers of landowners involved, and consents or permits required.

The matrix will be maintained as a 'live' project management document. It will be updated throughout implementation, and will ensure that all pre-commencement requirements are identified and discharged in a timely manner. It will also assist in early identification of opportunities for collaboration and thus optimise effective project delivery.

As outlined in Chapter 1 above, the Scoping & Action Targeting Work Package (WP T1) is comprised of seven scientific and management actions directed at enhancing ecological quality of waters:

- T1.1 Feasibility of lake remediation via Phosphorus-fixing
- T1.2 Rivers – Prioritizing in-stream works
- T1.3 Rivers – Prioritizing riparian works
- T1.4 Groundwater Programme
- T1.5 Hydrological connectivity & Point Source Pollution: Scoping studies for willow biomass as point and diffuse pollution mitigation actions
- T1.6 Catchment and Farm Scale Nutrient Management Studies
- T1.7 Control of chemical export from land use activities

A brief outline of each sub-task is provided next along with tabulated related activities. Detailed accounts of individual sub-tasks are provided by the relevant technical leads in Appendices 1 to 7 below.

3.1 Feasibility of Lake Remediation via Phosphorus-fixing (T1.1)

Nutrient enrichment is a major factor in many catchments in contributing to a decline in water quality. This task addresses the issue of nutrient enrichment in lakes, in particular enrichment by phosphorus which is normally the limiting nutrient in freshwater systems. Mitigation of nutrient enrichment is generally through addressing sources and pathways of nutrient losses to receptors i.e. surface waters. This is the approach taken in tasks 1.6 and 1.7 of this project. However, the approach in this task is to investigate the potential of removing excess phosphorus through chemical precipitation so that it becomes unavailable biologically within the lake ecosystem.

A desk based analysis of available databases on lake chemistry, bathymetry, and on WFD waterbody status was undertaken on waterbodies in all three catchments. Based on this analysis, 5 lakes in total, 4 in the Blackwater catchment and 1 in the Arney catchment, were shortlisted using relevant literature-based criteria considered critical for this topic area. T1.1 is scheduled for completion in June 2020 and investigations into the feasibility of phosphorus-fixing in the shortlisted lakes are on-going. Additional physico-chemical and biological data collection on the target lakes will provide a robust evidence base for final lake selection.

Laboratory-based investigations on this topic are also on-going (end date June 2020) and informal discussions have taken place with regulatory authorities during the Scoping phase. Formal discussions will await the completion of scoping elements. There will also be a need for local community engagement in the context of this task proceeding.

Activity title: T1.1 Feasibility of Lake Remediation via Phosphorus-fixing

	Deliverable Title	Deliverable Description
T1.1.1	Ecological status of those lakes	Establish the ecological status of those lakes where status is unknown or uncertain, and report based on chlorophyll and total phosphorus concentrations.
T1.1.2	Report on phosphorus fixing chemicals	Complete desktop and laboratory studies on the effectiveness, toxicity, ecological effects and costs of at least three phosphorus fixing chemicals and compile report.
T1.1.3	Negotiations with regulatory authorities for the use of phosphorus fixing chemicals in lakes	Complete negotiations with regulatory authorities in the relevant jurisdictions to produce a generic risk assessment for the use of phosphorus fixing chemicals in lakes and gain approval for their use.

3.2 Rivers – Prioritising in-stream works (T1.2)

Sub-tasks T1.2 and T1.3 are closely integrated since both deal with issues relating to river corridors. Measures under both sub-tasks are likely to be implemented in tandem.

Damage to instream and riparian zones of rivers can arise due to various hydromorphological impacts. Bank damage and erosion may lead to increased sediment loads. Deposition of sediments in-stream can impact on flows and also provide a matrix for plant growth, further exacerbating impact. Occlusion of bed materials with fine sediments results in habitat loss for invertebrates and fish. Drainage and removal of materials, and in-stream physical barriers may change channel form and depth and result in loss of river and stream connectivity.

Surveys of ecological quality elements (fish) and hydromorphology (RHAT survey and barrier surveys) commenced in August 2018 in the Finn, Arney and Blackwater catchments and is scheduled for completion in July 2019. A common survey methodology was agreed by the agencies undertaking this task. The surveys focused on waterbodies at moderate status, as these are considered most likely to respond to hydromorphology mitigation measures to improve status.

The number of candidate locations for measures implementation substantially exceeds the 6 sites initially envisaged. Sites will be ranked during scoping. There was agreement among partners that candidate locations should be of a substantial or adequate length to provide for tangible improvements. Channel lengths of circa 2 km minimum were considered appropriate for this purpose. The CatchmentCARE Project is liaising with the agencies responsible for arterial drainage in the chosen catchments (DFI Rivers and OPW) to identify works in channels scheduled for maintenance. Such cross border liaison will inform any future environmental protocols for channel works.

Monitoring of system response to measures implemented will be based on Ecological Quality Ratios (EQRs), a standard WFD metric that can quantify water quality improvements within and between status classification bands.

Activity title: T1.2 Rivers – Prioritising in-stream works

Deliverable Number	Deliverable Title	Deliverable Description
T1.2.1	monitoring strategy to assess water body status improvement	Identification of an appropriate monitoring strategy to assess water body status improvement e.g. RHAT, SNIFFER barrier passibility
T1.2.2	Ranking of fish passage issues	Ranking of fish passage issues across the three catchments with up to 6 locations selected
T1.2.3	Ranking of riverine reaches for habitat improvement	Ranking of riverine reaches for habitat improvement, based on hydromorphology criteria

T1.2.4	Environment protocol for river maintenance work	Agreed environmental protocol for river maintenance work to be developed with OPW and Rivers Agency for general implementation during river maintenance works

3.3 Rivers – Prioritising riparian works (T1.3)

Surveys described under sub-task T1.2 above also inform this work element. Significant bank erosion is occurring in some areas in the catchments, often as a result of previous channel straightening. A number of riparian habitat locations have also been identified where bank stabilisation may be undertaken, or where bank modification can provide a degree of re-naturalisation and re-linkage to old meander locations. Such works will be undertaken in a manner that is consistent with enhancing the hydromorphology status of the location.

Livestock access into watercourses permits entry of nutrients and pathogens into the water, as well as the physical impact on the instream and riparian zones. The CatchmentCARE Project will fence selected locations where impact is occurring to exclude livestock from waterways, and will provide alternative drinking facilities in fenced areas such e.g. nose-pumps.

Where appropriate, and in tandem with fencing, buffer strips will be created to mitigate nutrient loss to water courses. Creation of buffer strips may include planting of native deciduous tree cover, and bank re-profiling may be required in some instances.

Activity title: T1.3 Rivers – Prioritising riparian works

Deliverable Number	Deliverable Title	Deliverable Description
1.3.1	habitat for bank stabilisation	Ranking of riparian habitat for bank stabilisation strategies based on appropriate hydromorphology criteria; up to 10km selected per catchment
T1.3.2	Identification and ranking of cattle access points per catchment	Identification and ranking of cattle access points per catchment– to develop strategy for exclusion and installation of off-line livestock drinkers
T1.3.3	Ranking of riparian habitat for buffer strips	Ranking of riparian habitat for buffer strips based on the River Hydromorphology Assessment Technique (RHAT); up to 10Km ranked in each catchment.
T1.3.4	management of problem riparian tree/scrub over	Identification of areas for management of problem riparian tree/scrub cover

3.4 Groundwater Programme (T1.4)

This task will deliver a specific groundwater programme to enhance knowledge of groundwater resources in the three catchments under study, in other cross-border catchments, and in the wider eligible area. The work package involves the drilling of 50 groundwater monitoring boreholes within the eligible area, with a focus on the three priority CatchmentCARE catchments. These groundwater monitoring stations (GMSs) are required to characterise the groundwater pathway element of the hydrological cycle in catchments within the region and develop a groundwater conceptual model. They must be representative of the groundwater system and will also form part of a cross-border groundwater monitoring network and contribute to Water Framework Directive monitoring requirements and other aims, such as measuring climate change impacts on groundwater. The drilling plan envisages installation of some GMSs in 2019 and further work in 2020.

Selection of sites for GMSs aims to address the shortfall in groundwater monitoring across the eligible region, and add to the understanding of catchment hydrology of the three river improvement projects. Candidate drilling sites have been identified through liaison between partners, discussions with NIEA, EPA and other stakeholders, and community linkages to allay any concerns about drilling operations. Selection has also been informed by studies undertaken by GSNI and NIEA to identify gaps in the WFD groundwater monitoring network.

To date, up to five drilling sites in the Finn catchment have been identified. A drilling site in the Arney catchment has been provisionally scoped. Two further drilling sites in the Derg catchment have been identified that will tie-in with the Source-to-Tap project. Sites in the Blackwater catchment will be identified after selection of farm nutrient study sites by AFBI in sub-task T1.6 in order to maximise synergies with the nutrient management Work Package. Sites in the AFBI farm at Hillsborough are being advanced to link with experimental willow planting under sub-task T1.5 (Section 3.5).

Relevant data on groundwater within the eligible region has been collated and initial conceptual models derived. Four preliminary hydrogeological catchment characterisation reports have been drafted for the Finn, Arney, Blackwater, and Derg catchments. These conceptual models are live and will be updated as new data are collected.

The work package will also contribute to increased awareness of the groundwater element of the water cycle through education packages and community events. This will be facilitated by Catchment Project Officers that have been appointed by the project to each catchment.

Several drilling sites have been selected with educational objectives in mind, and to create a long-term educational resource. The project has engaged with colleges, schools and community centres in the catchments. Live data from a number of the GSMs (groundwater level, temperature and electrical conductivity) will be shared with some of these entities via telemetry or via a web interface.

Activity title: T1.4 Groundwater Programme

Deliverable Number	Deliverable Title	Deliverable Description
T1.4.1	Suitable drilling sites and understanding of the local geology	Identification of suitable drilling sites and increased understanding of the local geology
T1.4.2	Hydro-geological knowledge on catchments	Report on existing hydro-geological knowledge on suggested catchments
T1.4.3	Role of groundwater within catchment management	Greater awareness of the role of groundwater within catchment management by landowners and the wider community

3.5 Hydrological connectivity & Point Source Pollution: Scoping studies for willow biomass as point and diffuse pollution mitigation actions (T1.5)

This sub-task addresses mitigation of point source nutrient loss at the small-scale urban level. It will also examine the potential for willow tree planting on a small, but commercial scale, to harvest nutrients from wastewater treatment works (WWTW) outfalls. This low-technology system provides an additional layer of effluent treatment and a cash crop that can be harvested annually for biofuel. Other tertiary treatment systems have been considered, including integrated constructed wetlands, but such solutions have been found to be less acceptable to landowners.

Desk and field surveys, and discussions with relevant public authorities have aided in selecting WWTWs for investigation. The AFBI farm at Hillsborough has topography, soils and geology characteristic of much of eastern Northern Ireland. The farm has been LIDAR-assessed in advance of experimental planting. Long term data on water quality, including phosphorus levels, has also been collated to locate potential sites. Four candidate sites have been identified in the Finn system and a series of 13 sites are at various stages of investigation in the Blackwater. Two locations have been examined within the Arney system.

A process of landowner consultation is now underway to confirm land owners that are disposed to participate. This is a pre-requirement before the necessary licences / planning is sought before proceeding to tender for planting of willow and construction of the willow irrigation system.

Activity title: T1.5 Hydrological connectivity & Point Source Pollution: Scoping studies for willow biomass as point and diffuse pollution mitigation actions

Deliverable Number	Deliverable Title	Deliverable Description
T1.5.1	WWTW influences on existing downstream WFD monitoring sites and ecological status	An analysis and rank of small WWTW influences on existing downstream WFD monitoring sites and ecological status and a selection of up to three for action and one for control following survey and consultation
T1.5.2	Alternative treatments available for small WWTW	An assessment of the alternative tertiary treatments available for small 250PE WWTW
T1.5.3	Targeting of willow using LiDAR imaging	LiDAR imaging and interpretation of site and maps to reveal spatial locations within selected sub-catchments where the targeting of willow will have the greatest impact in terms of reducing nutrient input to water bodies
T1.5.4	Historical stream quality data and climate linkage to inform run-off mitigation schemes	Analysis of historical stream quality data and climate linkage before implementation of run-off mitigation schemes
T1.5.5	SRC willow biomass for diffuse pollution mitigation	An analysis of the regional potential for emplacement of SRC willow biomass for diffuse pollution mitigation
T1.5.6	Market analysis of SRC willow as a bio-energy crop	A regional market analysis of SRC willow as a bio-energy crop
T1.5.7	Stakeholder commitment to the principle of SRC willow planting	An assessment of stakeholder commitment to the principle of SRC willow planting and how this fits with national strategies

3.6 Catchment and Farm Scale Nutrient Management Studies (T1.6)

This sub-task examines diffuse farm nutrient management and control. Measures developed and shown to be successful will inform farm management practices on the island.

A total of 17 farms have been identified within the Blackwater catchment for inclusion in T3 Catchment Landuse Actions. These farms are all extensive beef and sheep enterprises, which form a large proportion of farming enterprises in Ireland. They are significant contributors to phosphorus export to waterbodies within catchments. Improving the efficiency of phosphorus use on these farms will enhance their productivity, profitability and overall sustainability as well as minimising environmental impact. Five farms were identified for inclusion in the project in the Caledon/Emyvale area, five farms in the Moy/Benburb area, four in the Derrynoose/Mullamurphy area and three in the Augher/Clogher area. The selection criteria for these farms were as follows:

- representativeness of farm types;
- soil type: a range of soil types was identified as an important criterion;
- location: a cross-border element was essential;
- farmer willingness to participate.

In total, 400 fields across the 17 farms were soil sampled during January and February 2019. Each farmer will receive advice on how to best manage the nutrient status of these fields. Grass silage and meal samples will be collected to enable overall farm nutrient balances to be calculated. In addition, field plot trials have been established on three of the 17 farms in order to evaluate the effectiveness of soil P recommendations for extensive grassland farms included in the recently revised Nitrates Action Programmes. Grass growth and grass quality will be monitored at two harvests per year during 2019, 2020 and 2021. Field plots established on one field in each of three farms will receive a number of phosphorus fertiliser application rates. Two of the fields have been managed by grazing, while the third field is operating under a silage regime, therefore presenting management differences between farms. Grass growth and grass quality will be compared between rates of P applied. An economic analysis of the impact of changes in nutrient management practices on farm profitability will be carried out on each of the 17 farms.

Initially two farms were identified and had agreed to participate in the water quality monitoring program. However, following assessment it was determined that one of the proposed farm's monitoring point was not fit for purpose. Water quality monitoring to disaggregate nutrient sources at farm scale (i.e. nutrients coming from soil, slurry and farmyards) was a key objective. However this is now deemed unlikely because of the large contributing areas beyond the area of the two farms.

Further examination of the 17 farms recruited to participate in the nutrient management study found that no farm was deemed suitable. As a result it was decided that this work will instead focus on assessing the contribution of farmyards to nutrient loss. A modelling approach will be taken to identifying the nutrient contribution from soils and slurry. One farmyard has been identified for monitoring and a further 2 will be identified following the development and implementation of a farmyard risk assessment carried out on up to 50 farmyards in the coming months. The purchase and installation of monitoring equipment requires completion of this farmyard risk assessment.

To date 50 farms in the Blackwater catchment have been visited by the ABC Catchment officer. AFBI and ABC have had discussions on the integration of their individual work programmes; 17 AFBI farms and 50 ABC farms. ABC and AFBI will work together to implement a soils sampling scheme, collect nutrient management data, and implement a knowledge exchange programme in the Blackwater

catchment. In addition, ABC will explore options to engage farmers on the 50 farms through the CatchmentCARE community engagement scheme in activities such as nutrient management training.

Activity title: T1.6 Catchment and Farm Scale Nutrient Management Studies

Deliverable Number	Deliverable Title	Deliverable Description
T1.6.1	Farm Participation in monitoring programme	15 farms recruited for participation in the monitoring program
T1.6.2	High frequency water quality analysis	Identification of 2 sub-catchment for high frequency water quality analysis
T1.6.3	Water quality monitoring	Installation of water quality monitoring points and equipment
T1.6.4	Farm participation in the nutrient control programme	50 farms recruited for participation in the nutrient control programme

3.7 Control of chemical export from land use activities (T1.7)

This sub-task will investigate the extent of occurrence, identification of sources, and treatment strategies for specific chemicals being discharged to water. In particular the task will focus on agriculture-linked products used for sheep dipping. Characterisation has identified that sheep dips and associated toxic impacts are a feature of the Finn catchment in particular.

Such chemicals impact on the ecology of watercourses and the impact is manifest in various elements of the biota such as fish, invertebrates and benthic diatoms. These biological indicators are used for WFD monitoring of waterbody status. They provide information on baseline conditions, and can also indicate changes in impact associated with such pollutants. Additional monitoring of benthic invertebrates and water chemistry will be undertaken in the Finn catchment.

As part of the T1 Scoping and Targeting aspect of the CatchmentCARE Project a Chemical Export Literature Review (T1.7) was composed which investigated several chemicals which are believed to be commonly used in the Finn River Catchment. Initial chemicals assessed included Cypermethrin, Acetamiprid and Organophosphates. Cypermethrin and Organophosphates are currently widely used in the Catchment as pesticide controls on areas of commercial forestry and agriculture, particularly sheep dipping. Acetamiprid is earmarked to replace Cypermethrin use in commercial forestry and phasing in of this chemical as a replacement for Cypermethrin began in February 2019.

The report gives information on the molecular structure of the pesticides, their environmental persistence, how they are used etc. as well as recommendations for mitigating the potential negative effects they have on the aquatic environment. Further investigations into the use of these chemicals, in particular relating to locations in the Finn Catchment which have a higher probability of affecting the water quality of receiving waters, are ongoing.

It should be noted that the above list of chemicals is not exhaustive and that the Chemical Export Literature Review is expected to evolve over the course of the CatchmentCARE Project to incorporate

any other potentially harmful chemicals in the catchment. Therefore the report will be presented in stages over the lifetime of the project.

In addition to the above pesticides, an herbicide containing MCPA is also being assessed due to its recorded environmental persistence and high toxicity at very small concentrations and will be included in the next edition of the report. A summary of the relevant legislation concerning the proper use of these chemicals will also be included.

Activity title: T1.7 Control of chemical export from land use activities

Deliverable Number	Deliverable Title	Deliverable Description
T1.7.1	Areas impacted upon by chemical export	Report on areas that are most likely to be impacted upon by chemical export
T1.7.2	Prevention of chemical export from land use	Report outlining possible actions to prevent chemical export from land use in the identified areas

4 Monitoring Strategy to Assess Hydromorphology Status and develop evidence base for prioritisation of in-stream and riparian works

Activities T1.2 and T1.3 were allocated to Inland Fisheries Ireland in the Arney and Blackwater catchments and to the Loughs Agency in the Finn catchment. This chapter is framed within task **T1.2 Rivers: prioritizing in-stream works** and gathers the outcomes of the first subtask **T1.2.1. Identification of an appropriate monitoring strategy to assess water body status improvement**. The present chapter has been structured to incorporate the main objectives of subtask T1.2.1 as follows:

- Analyse the statutory requirements under the WFD with regards to monitoring programmes for river waterbodies.
- Summarise the existing implementation in the Republic of Ireland (RoI) and Northern Ireland (NI).
- Justify a rationale for a complementary monitoring strategy.
- Describe the survey techniques proposed.
- Present the results from the application of the proposed techniques.
- Extract the candidate river restoration sites based on the results from the complementary monitoring strategy.
- Include a complementary river restoration site list based on other sources of information.
- Propose a specific monitoring programme for the follow-up of the restoration works.

This chapter applies a consistent approach for a monitoring strategy from evidence collected both by Inland Fisheries Ireland in the Arney and Blackwater catchments, and by the Loughs Agency in the Finn catchment. It is expected that the results from this report will inform actions in the following **WP T2: Water Body Actions in Catchments (Implementation)**.

The review of available monitoring data and status assessment of waterbodies is strongly dependant on specific biological indicators. Within CatchmentCARE, there is a specific tasking to establish hydromorphology status in waterbodies in order to examine what, if any, hydromorphology measures may be undertaken that would lead to improved ecological status.

In order to address this requirement, and in absence of a hydromorphology (or more specifically, a morphology) platform of data and status assessment there was a clear requirement on the project team to establish such a platform. Given the fisheries background of Inland Fisheries Ireland and of the Loughs Agency and their lead role in regard to in-stream and riparian works it was inevitable that status assessment for fish would also be examined. Given the shortfall in fish survey work for status, the choice of fish assessment was also appropriate in regard to this quality element.

4.1 Rationale for a Monitoring Strategy in CatchmentCARE Complimentary to Available National Data

4.1.1 Gap analysis

Current monitoring programmes both in the Republic of Ireland and Northern Ireland sufficiently cover the assessment of benthic invertebrates, and to some extent, hydrology diatoms, macrophytes, all physio-chemical elements and specific pollutants. The majority of monitoring stations have little or no survey data for fish or for morphology these elements.

Hydromorphology is identified in the Water Framework Directive (WFD) as "a supporting element" in determining ecological quality in waterbodies. The term combines the quantity of water (hydrology) and the physical form (morphology) of the river. The term in WFD also includes "connectivity", i.e. the free passage both upstream and downstream for living things and for downstream movement of river sediments and bed materials.

Moreover, under Article 5 (1) of the WFD there is a requirement for Member States to carry out, for each River Basin District, *"a review of the impact of human activity on the status of surface waters and groundwaters*". The identification of significant morphological alterations to waterbodies is listed in Annex II of the WFD as a specific pressure which had to be addressed in the risk assessment.

Therefore, regarding hydromorphological conditions, it is not sufficient to base the assessment of these elements only on hydrology since the physical form and the connectivity reflect very different physical scenarios and these will also affect biological communities (Table 4.1).

On the other hand, from the indicator point of view, **fish** have their own characteristics that differentiate them from other biological elements (phytobenthos, zoobenthos, macrophytes) and make them an essential element to monitor. Their greater longevity allows fish to be witnesses and indicators of historical alterations and impacts to waterbodies, even when drivers have already disappeared. In addition, their larger size and mobility and their use of a range of niche elements in the river habitat allow them to play a significant role in ecosystems, by being indicators at the scale of the meso-habitat (river segments), while the other biological elements represent the scale of the micro-habitat. Moreover, the composition and structure of the fish community integrate the information from the lower trophic levels (especially of phytobenthos and zoobenthos), and reflect the quality status of the entire aquatic ecosystem.

Finally, river continuity is a very important element of hydromorphology which is a requirement under WFD. It is in this context that **barriers** to fish migration and sediment transport need to be assessed. The absence or reduced abundance of fish species due to barriers will result in reduced fish status. Although barriers would be part of the hydromorphological assessment, a more detailed identification and assessment is necessary for fish assessment.

Table 4-1 Physicochemical and hydromorphological pressures affecting biological quality elements and their response.

Indicator	Physico-chemical pressures	Hydromorphological pressures
Macrophytes	• Reduction of water transparency •Variations of mineralization conditions (conductivity and salinity) • Eutrophication	• Variations of the flow regime, river continuity and morphological characteristics of the riverbed
	Response	**Response**
	They are indicators of changes in the medium and long term reflecting the quality conditions existing during the last months or even years. The disappearance of a species from an aquatic system (especially those of small size) can be highly significant	Their response to flow stabilisation is usually the increase in the coverage of the species
Diatoms (phytobenthos)	• Eutrophication • Increases in organic matter • Salinity • Acidification	They are not very sensitive to hydromorphological pressures (alterations of the hydrological regime, river continuity and morphological conditions of the bed), so their use is not recommended for the detection of these pressures. Macrophytes, within plants, are the best indicators of hydromorphological alterations
	Response	
	They are short-term indicators and respond to the increase of nutrients (mainly N and P) in the water through changes in their composition that, in some cases, suppose the decrease in diversity and the increase in biomass	
Macro-invertebrates (zoobenthos)	• Thermal pollution • Increases in organic matter •Variations of mineralization conditions (conductivity and salinity) •Pollution by metals or other pollutants	• Variations of the flow regime, river continuity and morphological characteristics of the riverbed
	Response	
	Benthic invertebrates indicate alterations in the medium and long term, since their species have life cycles between less than a month and up to more than a year. Their intermediate temporal scope complements that of other biological elements with shorter response times (e.g phytobenthos) or longer ones (e.g fish).	

Fish	• De-oxygenation of the water • Water contamination • Eutrophication and appearance of toxicity due to algae	• Alteration of habitat with changes in: - Depth and width of the river, - Water velocity, - Granulometric composition, - Morphology of the riverbed, - Riparian vegetation. • Variations in the continuity of the river
	Response	
	Their particular indicator value lies in being indicators with a larger spatiotemporal scale, even when drivers of alterations have already disappeared	

4.1.2 Proposals for enhanced data collection to inform water body status and actions

To implement effective hydromorphology measures it is necessary to have some understanding of both the biological and the physical or morphological conditions in any river or stream. In their hydromorphology role for prioritising in-stream and riparian works within the CatchmentCARE project, Inland Fisheries Ireland and the Loughs Agency identified the appropriateness of developing a knowledge base of both the biological and physical elements of the three catchments. It was agreed that the following studies would provide a common platform to identify issues and potential hydromorphological solutions:

1. Fish surveys on a catchment-wide basis
2. Physical habitat surveys on sites incorporating the fish survey sites
3. Detection of longitudinal barriers and recording their location, dimensions and passability

In the case of the Finn, additional issues relating to chemical pollution/enrichment to waterbodies was identified and in this context it was proposed that additional monitoring processes for benthic invertebrates and for water chemistry would be undertaken in this catchment. In this context, the Loughs Agency have been tasked with producing a report on Chemical Export in the Finn Catchment to research the likely chemical pollutants which constitute a threat to the water bodies in the area.

From initial investigations, several likely chemicals were identified which merited further research. These included Cypermethrin (a pesticide used in conifer plantations and sheep dips), Organophosphates (used in sheep dips) and Acetamiprid (which is designated to replace Cypermethrin use on conifer plantations).

As the literature review is an investigative document it is envisioned that it will evolve over the course of the CatchmentCARE project therefore the above list of chemicals investigated is not exhaustive.
Stage 1 of the Chemical Export Literature Report has been completed as a separate document and there are plans in place to produce a second stage report which will incorporate an investigation in to MCPA (an herbicide) and a section on the relevant legislation around the responsible use of

pesticides. This second stage will also outline a scoping strategy to identify specific areas where pesticide and herbicide mismanagement is of concern.

4.2 Description of Survey Techniques Used

Based on the foregoing, Inland Fisheries Ireland (IFI) and the Loughs Agency (LA) agreed on a series of protocols for data collection, to complement existing status assessment data and to address the identified gaps in existing data sets. The following items 1 to 3 were agreed for the three catchments, and item 4 was identified only for the Finn catchment to assess additional issues relating to chemical pollution/enrichment to waterbodies in this catchment:

1) **Fish surveys** to establish the current fish status in a range of locations,

2) Hydromorphological or **RHAT surveys** to establish the current status of the in-stream and riparian zones in the locations assessed for fish, and

3) **Barrier surveys** to establish the location, nature and dimensions of barriers.

4) **Macroinvertebrate surveys** to complement fish assessments in the Finn catchment.

Protocols for each of Items 1 and 2 can generate a single scoring – the Ecological Quality Ratio or EQR (standard Water Framework Directive reporting format for waterbody status) for that element for a specific site. EQR scores then determine the status of the water body in terms of the categories HIGH, GOOD etc. The collection of this information prior to undertaking any instream or riparian works provides a platform of consistently collected evidence to support any measures in the project's Catchment Actions Work Package. The sampling protocols can be used subsequent to any works programme as a mechanism to assess improvement.

The protocols are as follows:

4.2.1 Fish surveys

Electric fishing is undertaken as the standard sampling strategy. A timed, 10-minute fishing protocol is used (following Matson *et al.*, 2018). In shallow water locations bank-based generators are used as a power source and a team of two or three persons undertake the fishing, wading in an upstream direction, one undertaking the fishing and one carrying a bucket to retain captured fish (Figure 4-1). Boat-based fishing is appropriate for larger and/or deeper river sections. The same principle of creation of an electric field is applied. A larger generator is used and a three-person team is required – one to handle the boat and two to fish, using extended poles to form the electric field and landing nets to collect any stunned fish. The boat-based fishing is undertaken in a downstream direction.

All fish encountered during the 10-minute fishing period, including crayfish and larval lamprey, are collected and retained in a holding bucket of clean water. All fish are subsequently measured (Figure 4-2) and held in a recovery bin of water from the sampling site until all data collection is completed. Fish are then returned into the sampling site on completion of the site survey. Key elements of the data collection are (a) recording of all fish species encountered i.e. the fish community composition

and (b) the length range of all fish within any species (Note: Loughs Agency record length range for salmonids only).

Outputs can be inserted into WFD fish tool to generate EQR for fish in a consistent manner across the three catchments.

Figure 4-1 Bank based electrofishing

Figure 4-2 Fish measurement

4.2.2 RHAT surveys

The River Hydromorphological Assessment Technique (RHAT) is a survey developed by NIEA specifically for the Water Framework Directive (Murphy and Toland, 2012). Hydromorphology describes the physical habitat of a river constituted by the physical form (abiotic and biotic) and flow of the river.

RHAT is designed to be a holistic visual assessment and can be used to assess individual sites. This generates data for 8 relevant variables of habitat quality within 10 sub-sections of a 500m length of channel. Key elements include the flow, sediment type, channel and floodplain dimensions, topography and substratum, continuity and connectivity of a river. Anthropogenic features such as bank protection works, artificial barriers (weirs, dams) and modifications to processes are also included. It is assumed that natural systems support ecology better than modified systems. Hence the RHAT method classifies river hydromorphology based on a departure from naturalness. It assigns a morphological classification directly related to that of the WFD: High, Good, Moderate, Poor and Bad, based on semi-qualitative and quantitative criteria.

More detailed information can be found in the RHAT guidance handbook: https://www.daera-ni.gov.uk/sites/default/files/publications/doe/Surface%20water%20alteration%20handbook%20-%20updated%202017%20version.pdf

Figure 4-3 RHAT survey

4.2.3 Barrier surveys

Obstructions or barriers to longitudinal connectivity within the river channel can affect the migratory patterns of fish species, both upstream and downstream, as well as natural sediment transport

processes. IFI has identified the need to assess the location and extent of barriers along rivers for the CatchmentCARE project and assess their impact on a range of fish species, including species protected under the Birds and Habitats Directives.

An IFI-developed desk study tool is used to identify locations of 'potential barriers'. A significant number of barriers to fish migration are caused by bridge aprons, fords and other river crossings. Using Geographical Information System, locations of road-river interceptions throughout the catchments were identified. Information on the location of weirs, damns and sluices etc. were obtained from a number of sources including IFI's National Barriers Programme, EPA and NIEA, historical maps and local knowledge, as well as knowledge from other CatchmentCARE partners: the Armagh City, Banbridge and Craigavon Borough Council (hereinafter ABC), and the Agri-Food and Biosciences Institute (hereinafter AFBI). An inventory of potential barriers is produced by merging the data sets.

Following the desk study, site surveys are carried out to examine all potential barriers and to measure and record all actual barriers (Figure 4-4).

IFI has developed a field survey barrier assessment form, in line with EU best practice, to capture information on barrier location, type and dimensions in order to assess the risk to fish species and impact on channel morphology elements. A digitised version of this form is currently used by IFI, loaded onto mobile phones and tablets. This form is used as a Level 1 assessment measure to find, locate and assess barriers. From this dataset, a national inventory of barriers is being developed which will be interrogated to prioritise barriers for mitigation.

Figure 4-4 Barrier survey

4.2.4 Macroinvertebrate surveys

An agreement between the Loughs Agency and IFI was made to use the 'Small Stream Risk Score' method as a component of the overall EQR value for waterbodies on the Finn. These will be carried out by LA and DCC staff at the same sites that 10 minute electrofishing surveys take place, which are an additional component of the overall EQR scoring system. These data will be used to establish a baseline and will be monitored throughout the life of the project.

Data collected on macroinvertebrate populations will be in a format which can be used to calculate Q-Value scores (which are the standard EPA scoring system) and ASPT & BMWP Scores (which are the standard scoring systems used in Northern Ireland). This will allow these data to be compared temporally to data collected by the LA and EPA at corresponding sites in the past, facilitating observation of a longer trend in data for the use of CatchmentCARE project objectives.

4.3 Survey Results

A survey programme was developed and subsequently implemented by IFI and LA for the agreed protocols in the three catchments. This programme was also the result of consultations with other CatchmentCARE partners (ABC, AFBI and Geological Survey Ireland-GSI) and with relevant public authorities (DfI Rivers and Office of Public Works-OPW, DAERA fisheries, NIEA and EPA).

The available WFD waterbody classifications and monitoring results by NIEA and the EPA were key in focusing sampling effort to those waterbodies classified as MODERATE status, mainly on the basis of invertebrate data and in reducing sampling effort in waterbodies of POOR or BAD status. It was considered that those waterbodies in MODERATE status would be most likely to respond to hydromorphology measures to improve to GOOD or HIGH status.

Survey work was commenced in August 2018 and completed in July 2019. The agreed protocol approach allowed LA and IFI to operate independently and consistently to compile an evidence base on a large scale and in substantial quantity on elements that had not previously been collected. Thus fish survey locations were nested inside longer channel segments where RHAT surveys were undertaken, giving paired fish and habitat EQRs for channels. Complementary visual field assessment was undertaken on foot and by boat in order to identify sections with similar issues that could be part of proposals for extended channel sections.

4.3.1 Finn Catchment

A total of 55 sites were selected in the Finn catchment, all of which, except one, occur in the Republic of Ireland (Figure 4-5). They cover all waterbodies and some of them are close to EPA monitoring stations:

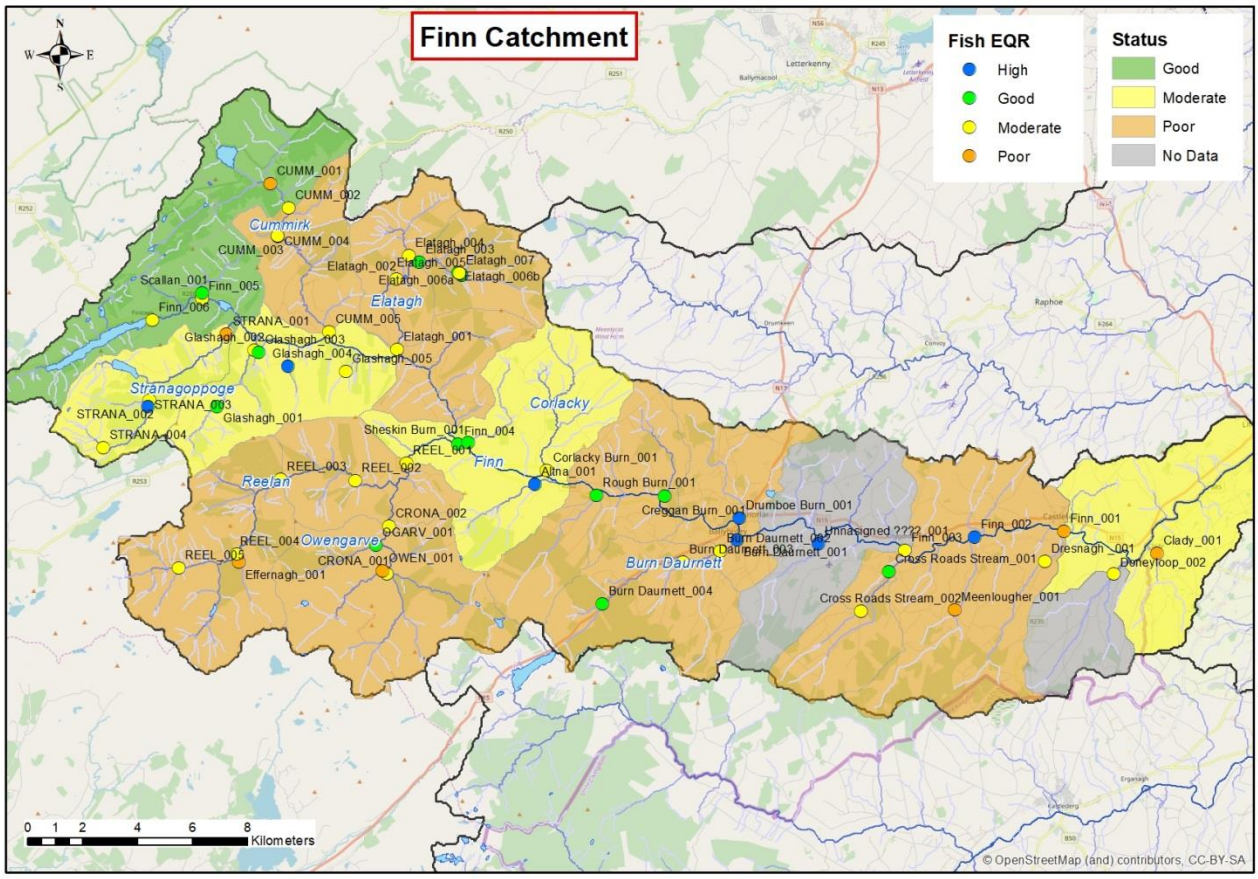

Figure 4-5 Location of fish survey sites in the Finn catchment

All 55 sites were surveyed for fish and EQR's were calculated, with the following results

- High: 8 (14.54%)
- Good: 12 (21.82%)
- Moderate: 28 (50.91%)
- Poor: 7 (12.73%)

As well as electrofishing at these sites, macroinvertebrate samples were taken at each site to compliment the results from the EQR analysis.

Additionally, 22 sites were selected to survey for hydromorphological conditions (RHAT survey).

Those sites covered all waterbodies in Moderate status (Finn(Donegal)_020, Finn(Donegal)_040 and Stranagoppoge_010, as well as the Burn Daurnett_010, Clogher_010, Elatagh_010, Elatagh_020, Finn(Donegal)_030, Finn(Donegal)_050, Finn(Donegal)_060, Finn(Donegal)_080, Reelan_010, Reelan_020, Rough_Burn_010 waterbodies which are in POOR status and the Cummirk_010, Cummirk_020, Crossroads Stream_010 and Finn(Donegal)_010 waterbodies which are in GOOD status.

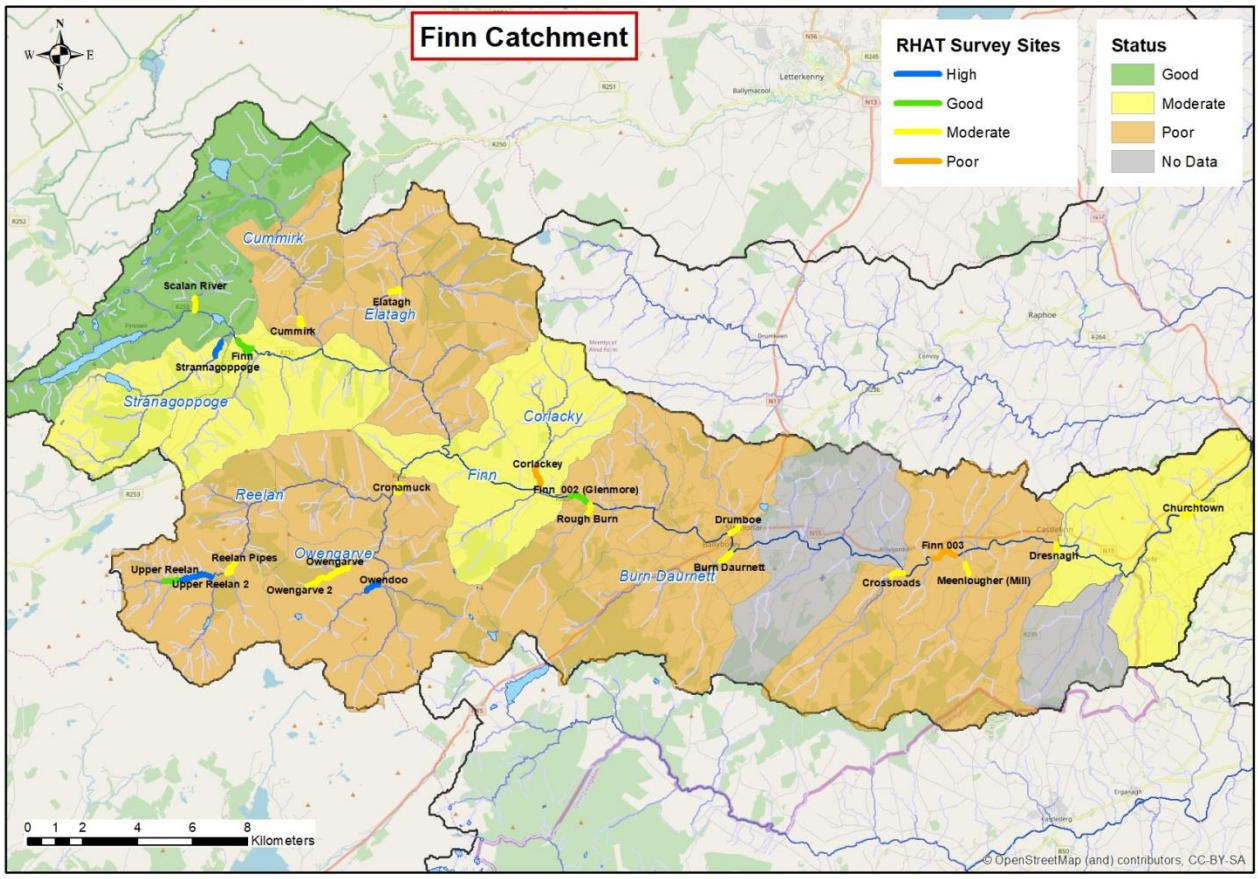

Figure 4-6 Location of RHAT survey sites in the Finn catchment

RHAT surveys were also assessed in terms of EQR's for coherence with fish survey results, showing the following results:

- High: 3 (15%)
- Good: 3 (15%)
- Moderate: 14 (63.64%)
- Poor: 2 (10%)

Table 4-2 Results from L.A. surveys (fish and RHAT) in the Finn catchment

Waterbody Number	Waterbody Name	Status 2018	LA survey sites	Fish EQR	Macro SSRS	Macro Q-Value	RHAT Score
IE_NW_01B020200 (ROI)	BURN DAURNETT_010	Poor	Burn Daurnett_002	Moderate	<6.5	Q3	Moderate
			Burn Daurnett_003	Moderate	<6.5	Q3-4	Moderate
			Burn Daurnett_004	Good	<6.5	Q3	Moderate
IE_NW_01C030100 (ROI)	CUMMIRK_010	Good	CUMM_001	Poor	>7.25	Q3-4	Moderate
			CUMM_002	Moderate	<6.5	Q4-5	Moderate
IE_NW_01C030300 (ROI)	CUMMIRK_020	Poor	CUMM_003	Moderate	>7.25	Q4-5	Moderate
			CUMM_004	Moderate	>7.25	Q4-5	Moderate
			CUMM_005	Moderate	<6.5	Q4	Moderate
IE_NW_01C040500	CROSS	Poor	Cross Roads	Moderate	>6.5	Q4	Moderate

Waterbody Number	Waterbody Name	Status 2018	LA survey sites	Fish EQR	Macro SSRS	Macro Q-Value	RHAT Score
(ROI)	ROADS STREAM_010		Stream_001				
			Cross Roads Stream_002	Moderate	>6.5-7.25	Q4	Moderate
IE_NW_01C060100 (ROI)	CLOGHER (FINN)_010	Poor	Owen_001	Poor	<6.5	Q3	High
			Ogarv_001	Good	>7.25	Q2-3	Moderate
			Crona_001	Moderate	<6.5	Q3	Moderate
			Crona_002	Moderate	>7.25	Q2-3	Moderate
IE_NW_01D150930 (ROI)	DRESNAGH_010	Unassigned	Doneyloop_002		>7.25	Q4	Moderate
			Clady_001	Poor	>7.25	Q4	
IE_NW_01E020100 (ROI)	ELATAGH_010	Poor	Elatagh_005	Good	>6.5-7.25	Q4-5	
			Elatagh_006	Good	<6.5	Q4	
			Elatagh_007	Moderate	>7.25	Q4-5	
IE_NW_01E02300 (ROI)	ELATAGH_020	Poor	Elatagh_001	Moderate	>6.5-7.25	Q4-5	Moderate
			Elatagh_002	Moderate			Moderate
			Elatagh_003	Good	<6.5	Q3-4	
			Elatagh_004	Moderate	<6.5	Q3	
IE_NW_01F010200 (ROI)	FINN(DONEGAL)_010	Good	Finn_006	Moderate	<6.5	Q4	
			Finn_005	Moderate	>7.25	Q4-5	
			Scalan_001	Good	>7.25	Q4	Moderate
IE_NW_01F010350 (ROI)	FINN(DONEGAL)_020	Moderate	Glasagh_001	Good	>6.5-7.25	Q3	Good
			Glasagh_002	Moderate	<6.5	Q2-3	
			Glasagh_003	Good	<6.5	Q3	
			Glasagh_004	High	<6.5	Q1-2	
			Glasagh_005	Moderate	<6.5	Q2-3	
IE_NW_01F010400 (ROI)	FINN(DONEGAL)_030	Poor					
IE_NW_01F010500 (ROI)	FINN(DONEGAL)_040	Moderate	Finn_004	Good	<6.5	Q3	
			Sheskin Burn_001	Moderate	>7.25	Q4-5	
			Altnspaste_001	High	<6.5	Q3	
			Corlackey_001	Moderate	<6.5	Q3-4	Poor
IE_NW_01F010600 (ROI)	FINN(DONEGAL)_050	Poor	Creggan Burn_001	Good	>7.25	Q3-4	Good
IE_NW_01F010800	FINN(DONEGAL)_060	Poor	Burn Daurnett_001	High	<6.5	Q3-4	Moderate
			Drumboe Burn_001	High	<6.5	Q3-4	Moderate
IE_NW_01F010910 (ROI)	FINN(DONEGAL)_070	Unassigned	Unassigned	High	<6.5	Q3	
			Finn_003	Moderate	>6.5-7.25	Q3	
IE_NW_01F011100 (ROI)	FINN(DONEGAL)_080	Poor	Finn_002	High	>6.5-7.25	Q3	

Waterbody Number	Waterbody Name	Status 2018	LA survey sites	Fish EQR	Macro SSRS	Macro Q-Value	RHAT Score
			Meenlougher_001	Poor	<6.5	Q3-4	Moderate
			Dresnagh_001	Moderate	>7.25	Q4	Moderate
			Finn_001	Poor	>6.5-7.25	Q3-4	
IE_NW_01R010200 (R01)	REELIN_010	Poor	Reel_003	Moderate	>6.5-7.25	Q4-5	
			Reel_004	Moderate	>6.5-7.25	Q3	
			Reel_005	Moderate	>7.25	Q4-5	Good
			Effernagh_001	Poor	<6.5	Q3	Moderate
IE_NW_01R010500 (ROI)	REELIN_020	Poor	Reel_002	Moderate	<6.5	Q3	
			Reel_001	Moderate	>7.25	Q4	Moderate
IE_NW_01R020200 (ROI)	ROUGH BURN_010	Poor	Rough Burn_001	Good	>7.25	Q4-5	Moderate
IE_NW_01S020200	STRANAGOP POGE_010	Moderate	Strana_001	Poor	>7.25	Q3-4	High
			Strana_002	Moderate	<6.5	Q4	
			Strana_003	High	>7.25	Q3-4	
			Strana_004	Moderate	>6.5-7.25	Q3-4	

*SSRS

>7.25	>6.5-7.25	<6.5
Probably not at risk	Indeterminate Stream may be at risk	Stream at Risk

*Q Values

Biotic Index	Quality Status	Quality
Q5, 4 - 5, 4	Unpolluted	Class A
Q3 - 4	Slightly polluted	Class B
Q3, 2 - 3	Moderately polluted	Class C
Q2, 1 - 2, 1	Seriously Polluted	Class D

For barriers, following the protocol for barrier survey as previously explained (see section 4.2.3), a total of 447 potential barriers were identified in the Finn (Figure 4-7).

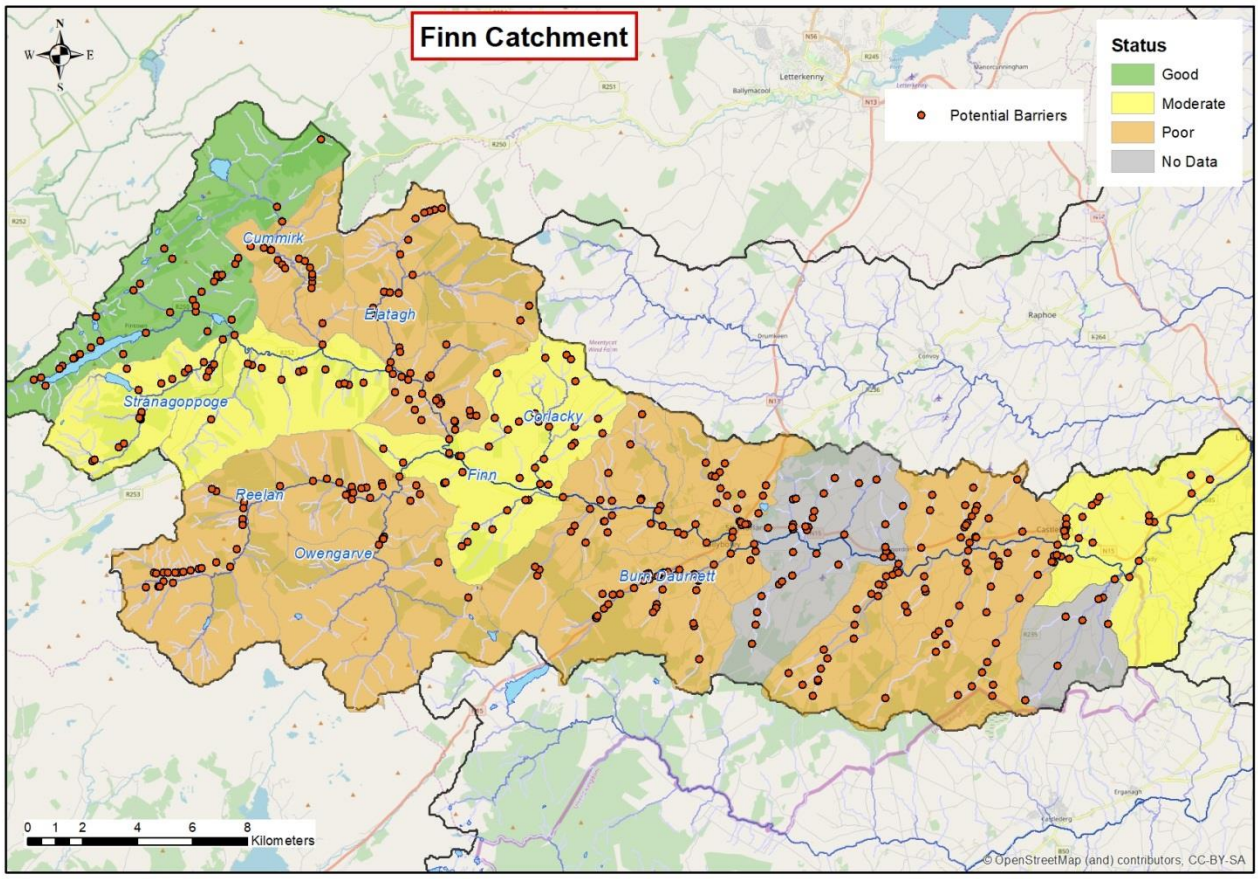

Figure 4-7 Location of potential barriers in the Finn catchment.

Attempts were made to visit all 447 potential barriers highlighted in the Finn Catchment. If a barrier occurred downstream from other potential barriers then the upstream potential barriers were not assessed as the downstream barrier would have inhibited fish passage regardless.

All potential barrier locations visited were assessed for presence/absence of passage issues. Assessments of identified barriers are carried out when a structure is deemed to be a barrier, i.e. drop height over 0.1m, water depth through structure under 0.15m etc.

A total of 133 barriers were identified and assessed within the Finn catchment with 14 barriers prioritised. Four of the prioritised barriers are candidates for in-stream and riparian works (Figure 5-3).

Table 4-3 Identified and candidate barriers in the Finn catchment.

Barriers identified	Barriers prioritised	Number of candidate barriers for mitigation
133	12	4

Table 4-4 Proposed barriers for mitigation in the Finn catchment.

Barrier code	Barrier Structure	Proposal
Rough_Burn	Culvert	Replacement Procedure
Effernagh_001	Culvert	Replacement Procedure
Reelan_pipes	Culvert	Replacement Procedure
Crossroads_001	Rock/Bedrock	Mitigation

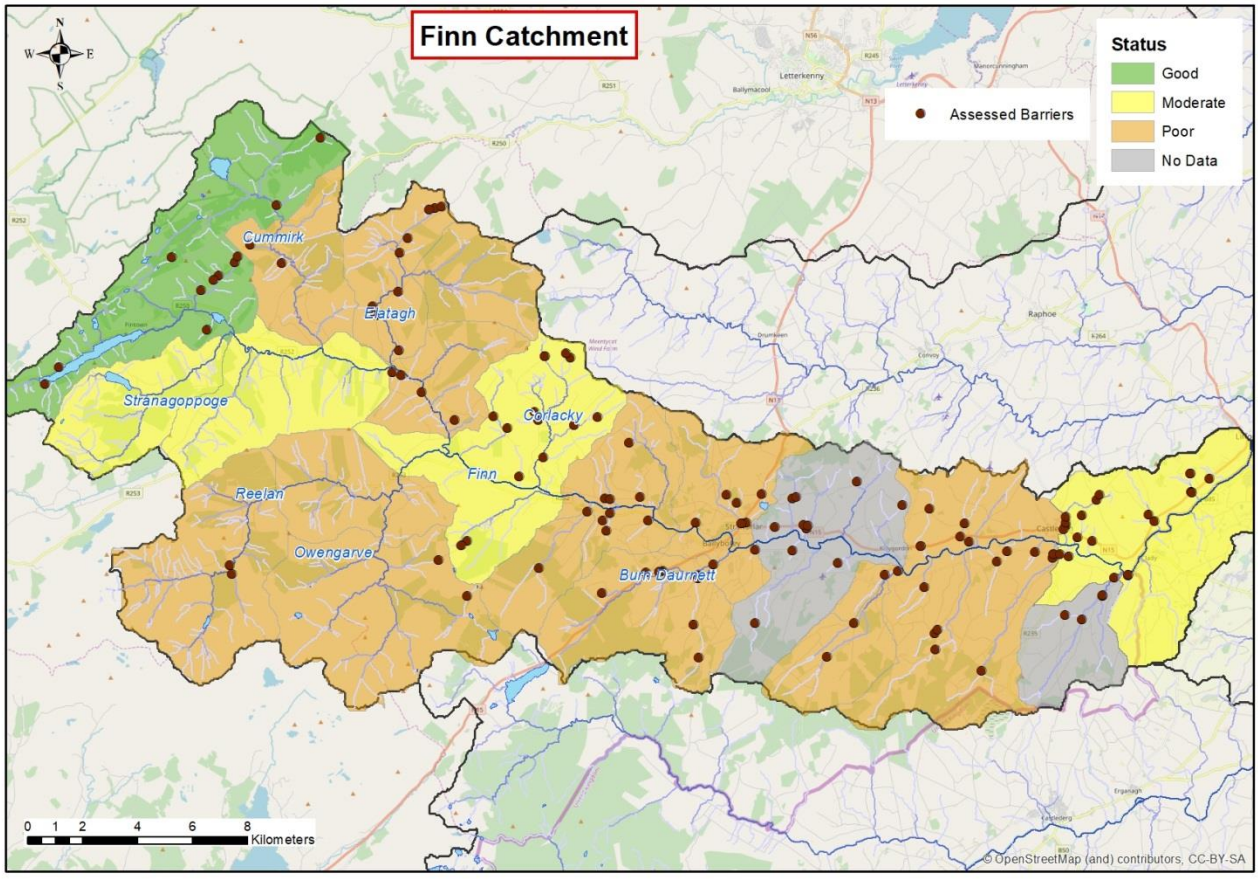

Figure 4-8 Location of identified and assessed barriers in the Finn catchment

A specific report covering the identification, assessment and prioritisation of barriers has been produced for the WP T1 Scoping and Targeting: (see Appendix A: Ranking of Fish Passage Issues).

4.3.2 Arney Catchment

A total of 36 sites were selected in the Arney catchment: 14 sites in the ROI and 22 in NI (Figure 4-9). They cover all waterbodies and some are close to monitoring stations (either from EPA or NIEA monitoring programmes):

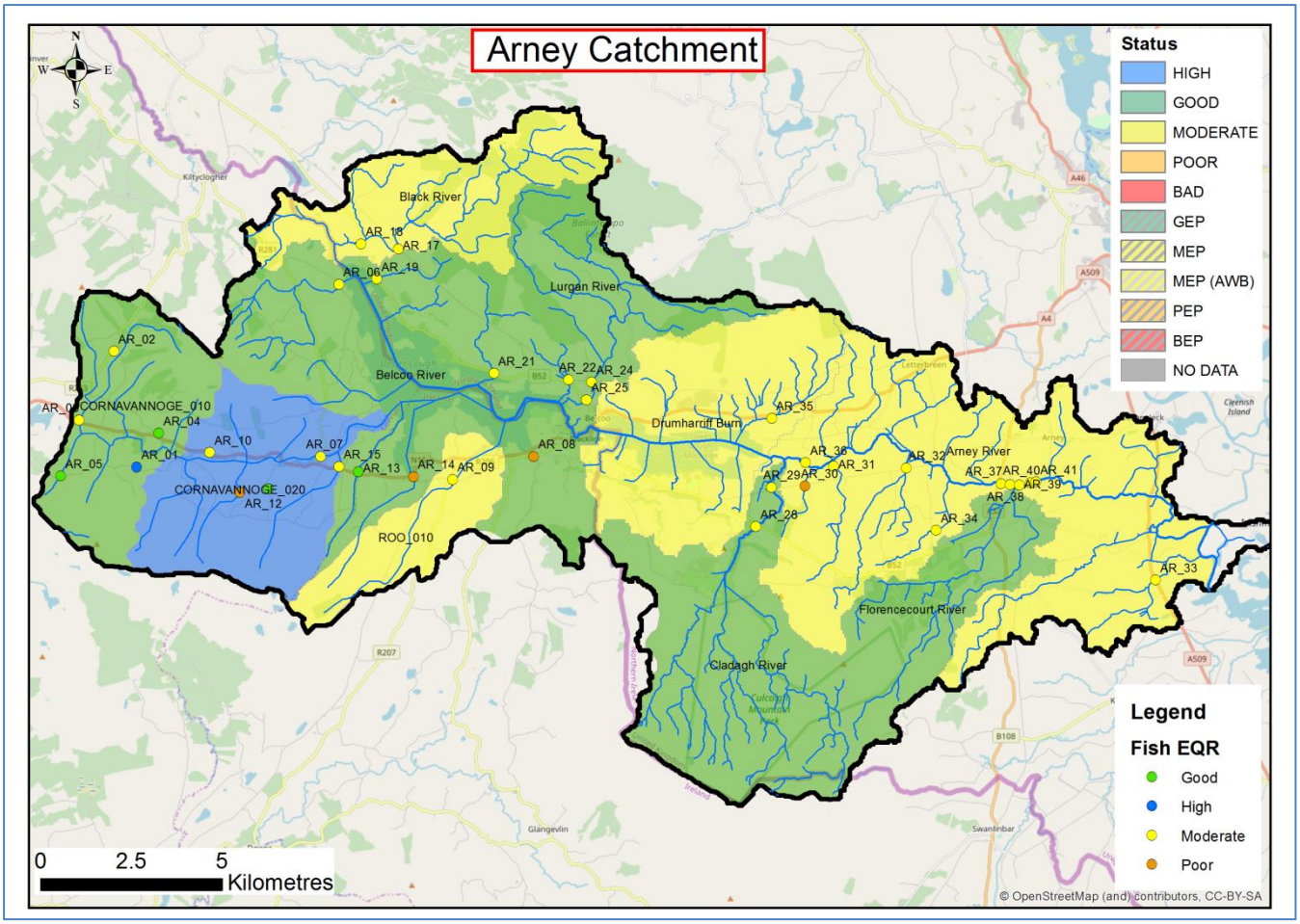

Figure 4-9 Location of fish survey sites in the Arney catchment.

All 36 sites were surveyed for fish and EQR's were calculated, with the following results:

- High: 1 (3%)
- Good: 4 (11%)
- Moderate: 27 (75%)
- Poor: 4 (11%)

From those 36 sites, a total of 13 sites were surveyed for hydromorphological conditions (RHAT survey). Those 13 sites covered waterbodies in MODERATE status (Black River, Drumharriff burn and Arney River), as well as the Cladagh River, which is in GOOD status, to check if the hydromorphological conditions would match the general ecological status. Roo_010 was not surveyed by RHAT due to time constraints and status at time survey season was POOR.

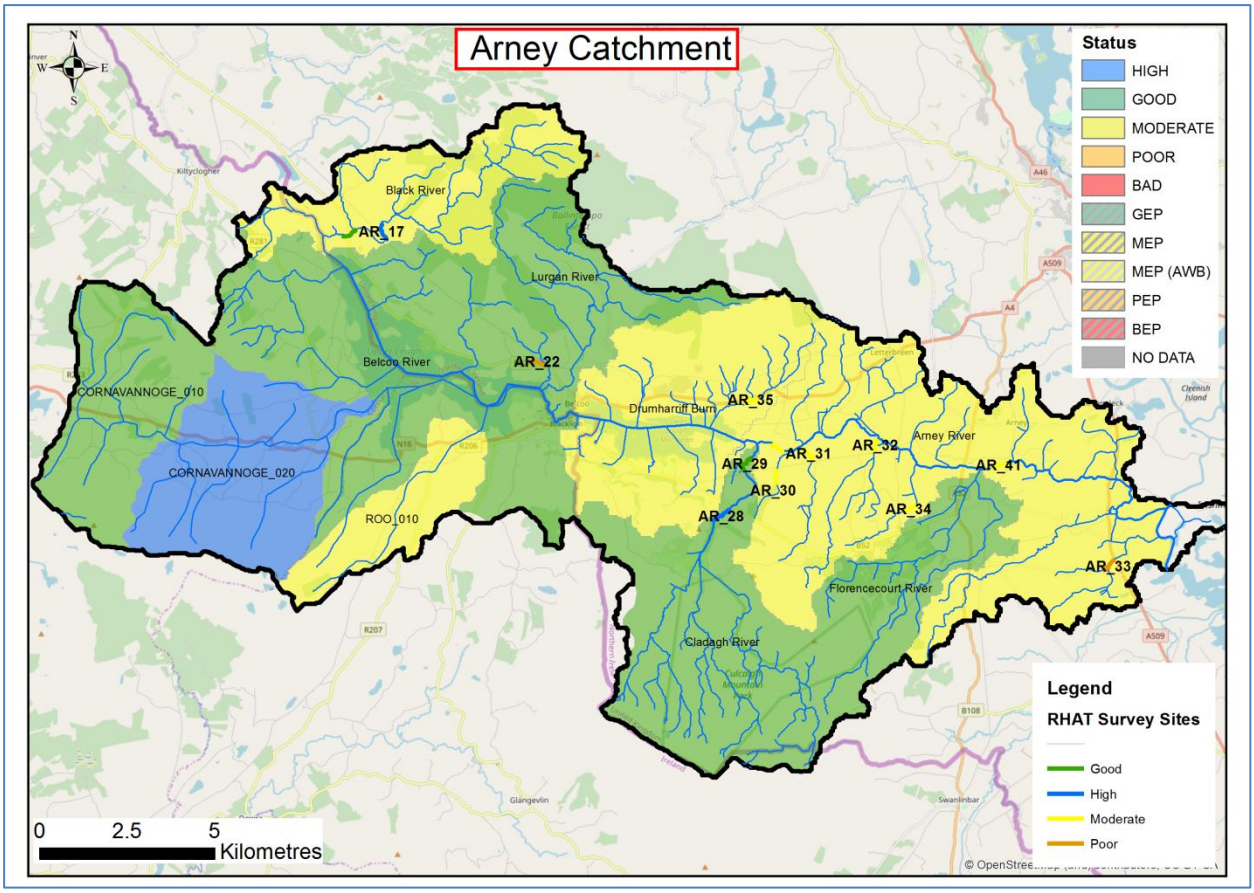

Figure 4-10 Location of RHAT survey sites in the Arney catchment

RHAT surveys were also assessed in terms of EQR's for correspondence with fish survey results, showing the following results:

- High: 2 (15%)
- Good: 2 (15%)
- Moderate: 7 (55%)
- Poor: 2 (15%)

.

Table 4-5 Results of IFI (fish and RHAT) surveys in the Arney catchment.

Waterbody Number	Waterbody Name	Status 2018	IFI survey sites	Fish EQR	RHAT Score
UKGBNI1NW363604059 (NI)	Arney River	MODERATE	AR_36	MODERATE	MODERATE
			AR_37	MODERATE	
			AR_38	MODERATE	
			AR_39	MODERATE	
			AR_40	MODERATE	
			AR_41	MODERATE	MODERATE
			AR_30	POOR	MODERATE
			AR_31	MODERATE	MODERATE
			AR_32	MODERATE	MODERATE
			AR_34	MODERATE	MODERATE
			AR_33	MODERATE	POOR
UKGBNI1NW363601036 (NI)	Black River	MODERATE	AR_17	MODERATE	HIGH
			AR_18	MODERATE	GOOD
UKGBNI1NW363602093 (NI)	Drumharriff Burn	MODERATE	AR_35	MODERATE	MODERATE
UKGBNI1NW363601084 (NI)	Cladagh River	GOOD	AR_28	MODERATE	HIGH
			AR_29	MODERATE	GOOD
UKGBNI1NW363602092 (NI)	Belcoo River	GOOD	AR_06	MODERATE	
			AR_08	POOR	
			AR_13	GOOD	
			AR_14	POOR	
			AR_19	MODERATE	
			AR_21	MODERATE	
			AR_22	MODERATE	POOR
UKGBNI1NW363601007 (NI)	Lurgan River	GOOD	AR_24	MODERATE	
			AR_25	MODERATE	
IE_NW_36C040400 (ROI)	CORNAVANNOGE_010	GOOD	AR_01	HIGH	
			AR_02	MODERATE	
			AR_03	MODERATE	
			AR_04	GOOD	
			AR_05	GOOD	
IE_NW_36C040600 (ROI)	CORNAVANNOGE_020	HIGH	AR_07	MODERATE	
			AR_10	MODERATE	
			AR_11	GOOD	
			AR_12	POOR	
			AR_15	MODERATE	
IE_NW_36R020200 (ROI)	ROO_010	MODERATE	AR_09	MODERATE	

For barriers, following the protocol for barrier survey as previously explained (see section 4.2.3), a total of 274 potential barriers were identified in the Arney (Figure 4-11).

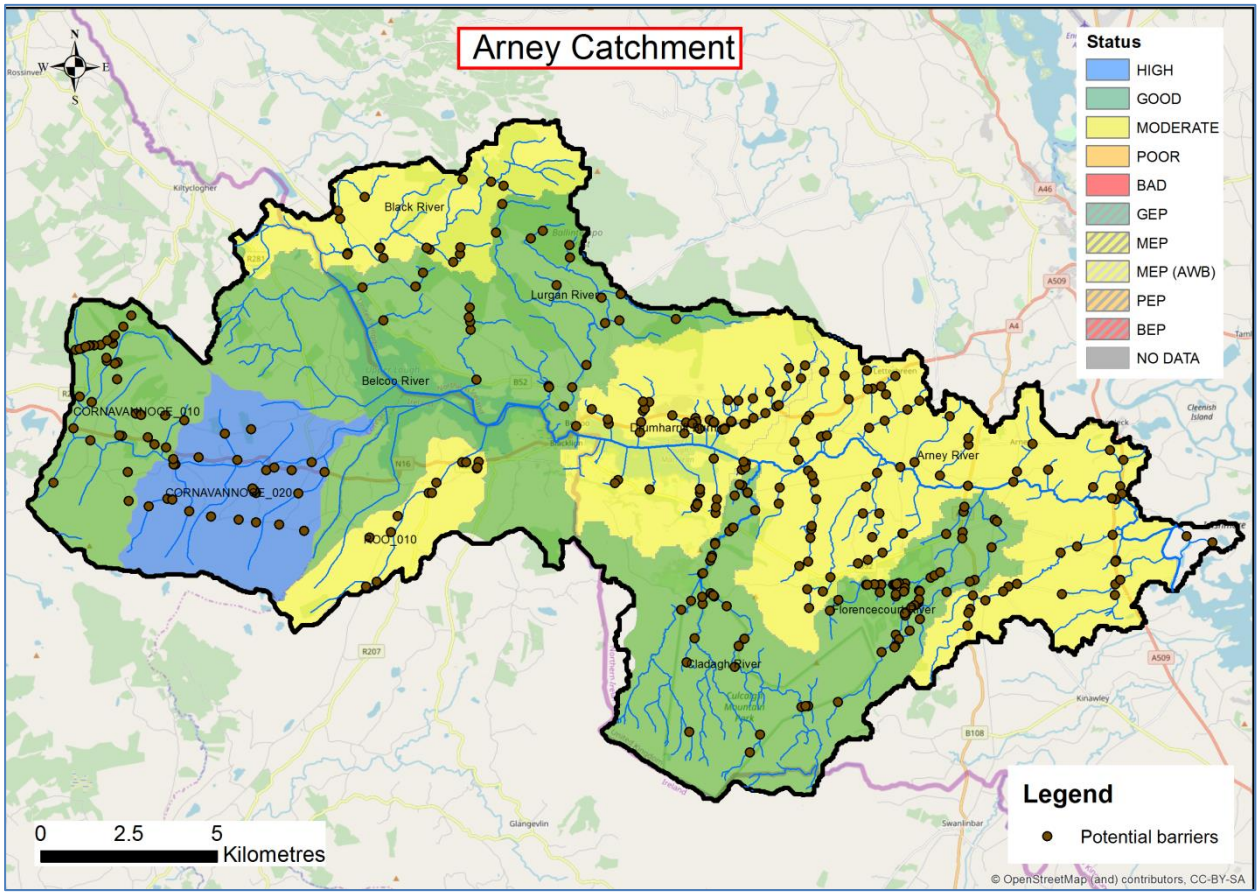

Figure 4-11 Location of potential barriers in the Arney catchment

To rationalise the number of visits to potential barriers, prioritisation was given to catchments with MODERATE or POOR WFD status. Prioritisation was also given to higher impact areas namely the main channels and larger tributaries of waterbodies as barriers in these areas are likely to have an increased effect on the overall system. All potential barrier locations were visited for presence/absence of passage issues. Assessments of identified barriers are carried out when a structure is deemed to be a barrier, i.e. drop height over 0.1m, water depth through structure under 0.15m.

Based on examination and use of the height and depth criteria, a total of 39 barriers were assessed in the Arney catchment (Figure 4-12):

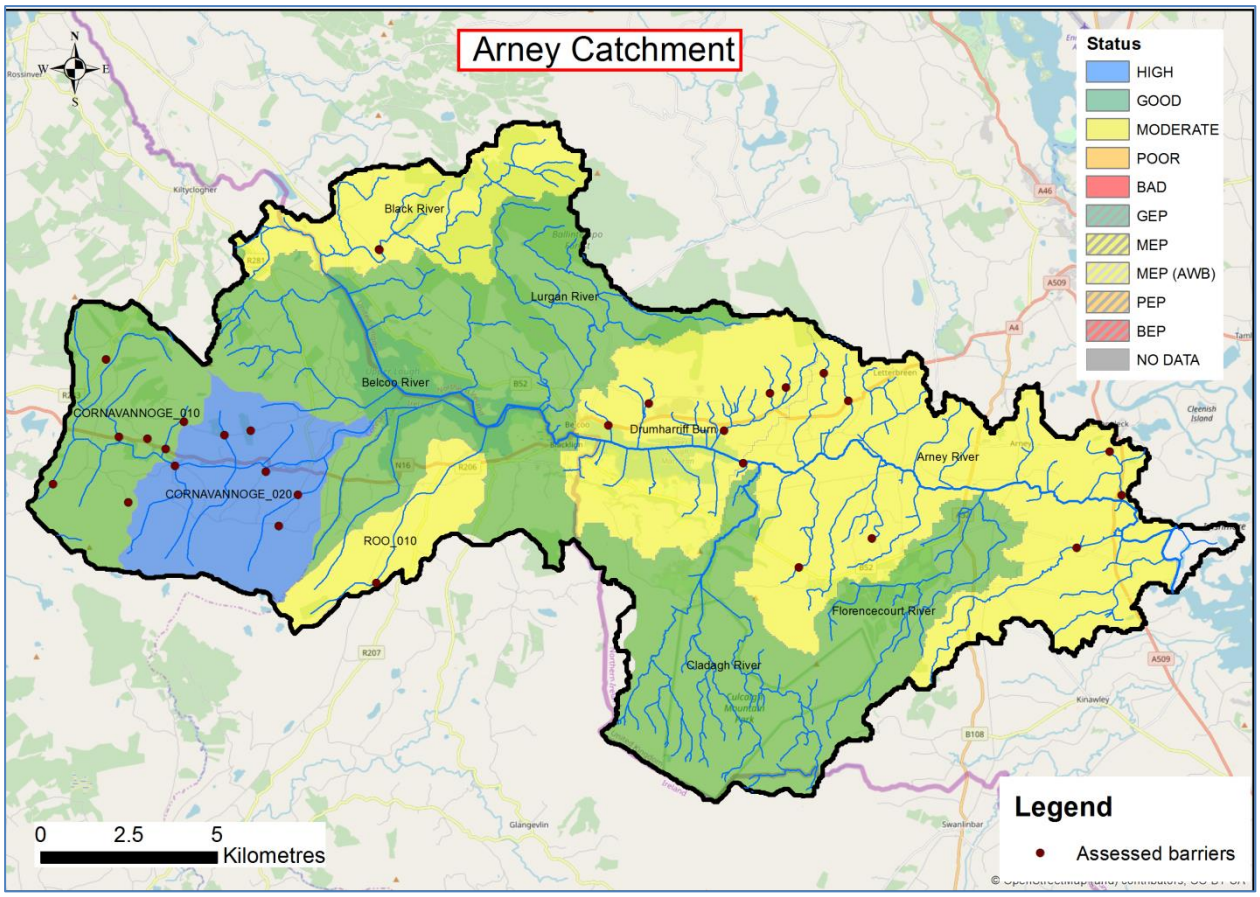

Figure 4-12 Location of identified and assessed barriers in the Arney catchment.

A specific report covering the identification, assessment and prioritisation of barriers has been produced for the WP T1 Scoping and Targeting: (see Appendix A: Ranking of Fish Passage Issues)

4.3.3 Blackwater Catchment

A total of 118 sites were selected in the Blackwater catchment: 57 sites in the RoI and 61 in NI (Figure 4-13). They cover all waterbodies and some of them are close to monitoring stations (either from EPA or NIEA monitoring programmes):

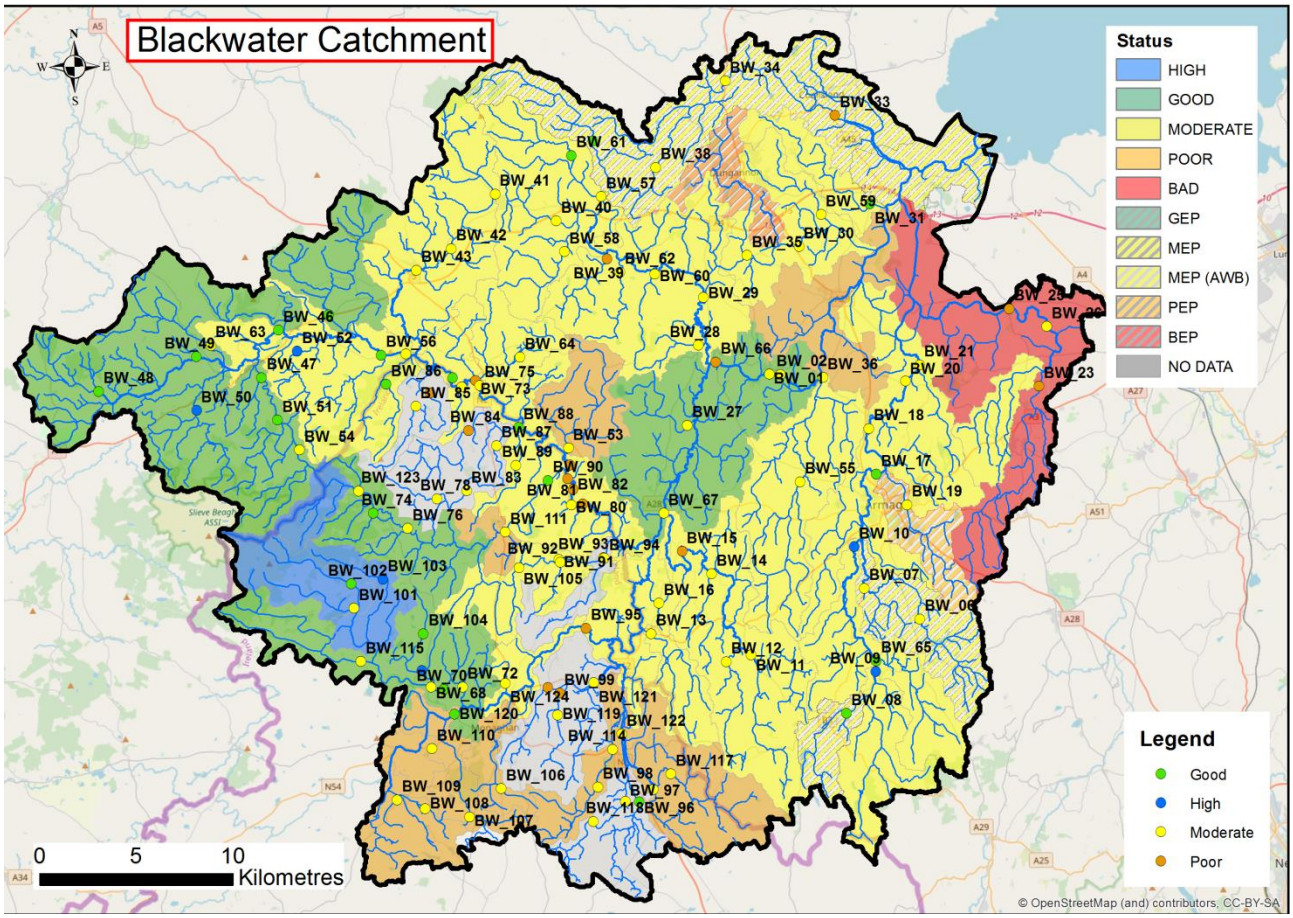

Figure 4-13 Location of fish survey sites in the Blackwater catchment

All 118 sites were surveyed for fish and EQR's were calculated, with the following results :

- High: 6 (5%)
- Good: 23 (19%)
- Moderate: 73 (61%)
- Poor: 16 (14%)

From those 118 sites, a total of 47 sites were surveyed for hydromorphological conditions (RHAT survey). Those 47 sites covered waterbodies predominantly in MODERATE status to check if the hydromorphological conditions would match the general ecological status.

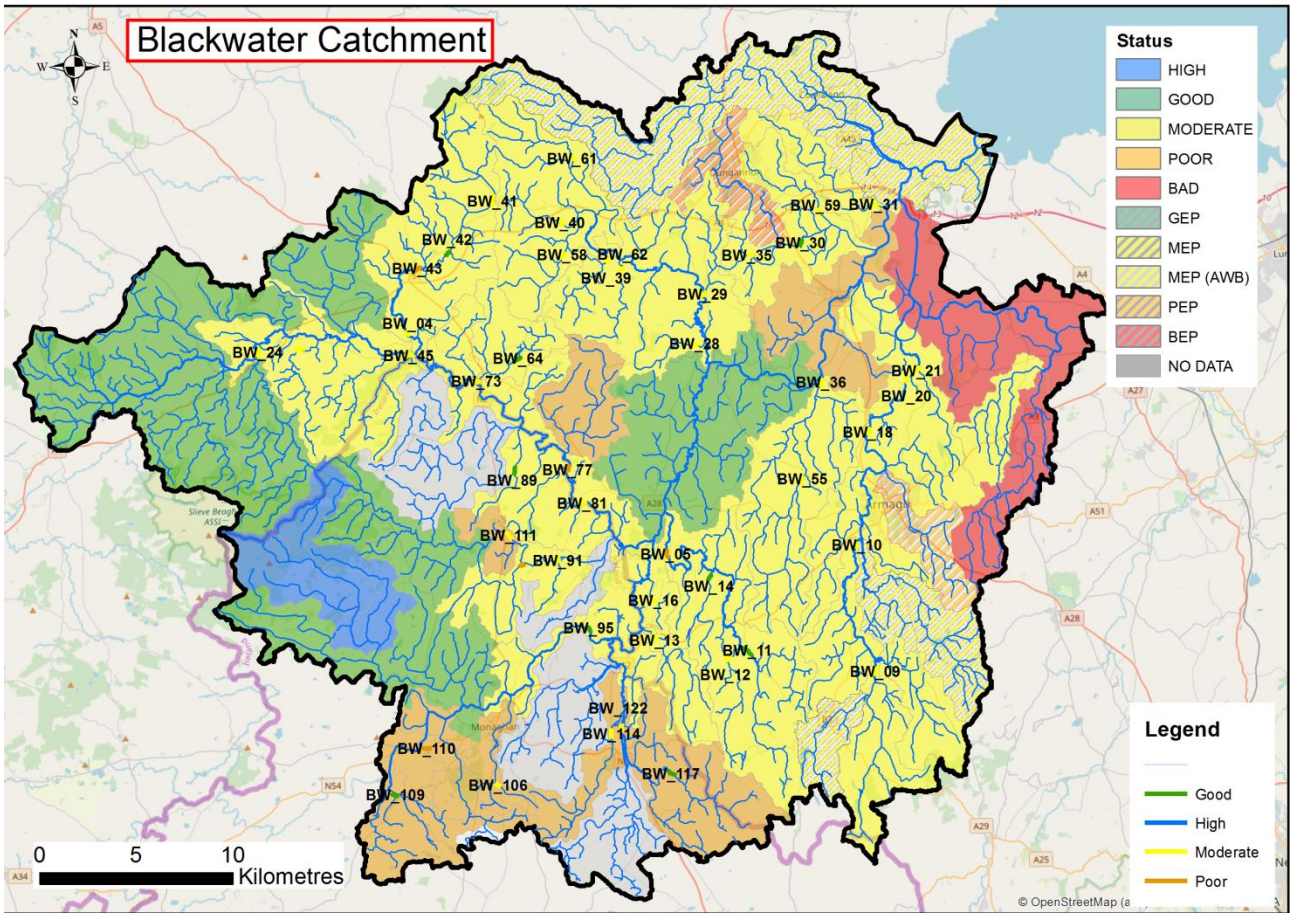

Figure 4-14 Location of RHAT survey sites in the Blackwater catchment

RHAT surveys were also assessed in terms of EQR's for correspondence with fish survey results, showing the following results:

- High: 1 (2%)
- Good: 9 (19%)
- Moderate: 32 (68%)
- Poor: 5 (11%)

Table 4-6 Results from IFI surveys (Fish and RHAT) in the Blackwater catchment.

Waterbody Number	Waterbody Name	Status 2018	IFI survey sites	Fish EQR	RHAT Score
UKGBNI1NB030308223	River Blackwater (Augher)	Moderate	BW_24		Moderate
			BW_46	Good	
			BW_56	Good	
			BW_45	Moderate	Moderate
			BW_52	High	Moderate
UKGBNI1NB030307175	Ballygawley Water	Moderate	BW_04		Moderate
			BW_41	Moderate	Moderate
			BW_42	Moderate	Good
			BW_43	Moderate	Poor
UKGBNI1NB030308201	River Blackwater (Annaghroe)	Moderate	BW_69	Good	
			BW_71	Moderate	
			BW_73	Poor	Moderate
			BW_75	Moderate	

Waterbody Number	Waterbody Name	Status 2018	IFI survey sites	Fish EQR	RHAT Score
			BW_77	Poor	Poor
			BW_79	Poor	
			BW_80	Moderate	
			BW_81	Poor	Moderate
			BW_82	Poor	
			BW_89	Moderate	Good
			BW_90	Good	
UKGBNI1NB030307041	River Blackwater Tributary (Aughnacloy)	Moderate	BW_64	Moderate	Good
UKGBNI1NB030308213	Oona Water (Killymaddy)	Moderate	BW_61	Good	Moderate
			BW_57	Moderate	
			BW_40	Moderate	Moderate
			BW_58	Moderate	Moderate
UKGBNI1NB030308217	Oona Water (Eglish)	Moderate	BW_39	Poor	Moderate
			BW_29	Moderate	Moderate
			BW_62	Moderate	Moderate
			BW_60	Moderate	
			BW_28	Moderate	Moderate
UKGBNI1NB030307036	River Rhone (Dungannon)	Moderate	BW_30	Moderate	Good
			BW_35	Moderate	Moderate
			BW_59	Moderate	Moderate
UKGBNI1NB030307050	Tamnamore Stream	Moderate	BW_31	Good	Moderate
UKGBNI1NB030307096	Cor River Tributary	Moderate	BW_13	Moderate	Moderate
UKGBNI1NB030308245	Cor River	Moderate	BW_16	Moderate	Moderate
			BW_95	Poor	Good
UKGBNI1NB030308236	Tynan River	Moderate	BW_05		Poor
			BW_12	Moderate	Moderate
			BW_15	Poor	
			BW_11	Moderate	Good
			BW_14	Moderate	Good
UKGBNI1NB030307112	Callan River (Tassagh)	Moderate	BW_09	High	Moderate
UKGBNI1NB030307044	Callan River (Milford)	Moderate	BW_10	High	Moderate
UKGBNI1NB030308225	Callan River (Derryscollop)	Moderate	BW_17	Good	
			BW_18	Moderate	Moderate
			BW_20	Moderate	Moderate
			BW_21	Moderate	Moderate
UKGBNI1NB030307111	Ballymacone River	Moderate	BW_65	Good	High
UKGBNI1NB030307045	Ballymartrim Water	Moderate	BW_55	Moderate	Moderate
			BW_36	Moderate	Moderate
UKGBNI1NB030307047	Kilmore Tributary	Moderate	none		
UKGBNI1NB030307242	Knockmany (Blackwater) Burn	Good	none		
IE_NB_03B010130	BLACKWATER (MONAGHAN)_010	Good	BW_115	Moderate	
IE_NB_03B010300	BLACKWATER (MONAGHAN)_020	Good	none		
IE_NB_03B010510	BLACKWATER (MONAGHAN)_030	Good	BW_68	Moderate	
			BW_70	Good	
			BW_72	Moderate	
			BW_104	Good	
			BW_113	High	
IE_NB_03B010800	BLACKWATER (MONAGHAN)_040	Moderate	BW_111	Moderate	Moderate

Waterbody Number	Waterbody Name	Status 2018	IFI survey sites	Fish EQR	RHAT Score
IE_NB_03C011200	CLONTIBRET STREAM_020	Unassigned	BW_96	Good	
			BW_97	Moderate	
			BW_118	Moderate	
IE_NB_03C011400	CLONTIBRET STREAM_030	Poor	BW_98	Moderate	
			BW_114	Moderate	Moderate
			BW_122	Moderate	Moderate
IE_NB_03C021100	CONAWARY (LOWER)_010	Poor	BW_110	Moderate	Poor
IE_NB_03C021300	CONAWARY (LOWER)_020	Poor	BW_107	Moderate	
IE_NB_03L100990	LISAVARGY_010	Unassigned	BW_78	Moderate	
			BW_83	Moderate	
			BW_84	Poor	
			BW_87	Moderate	
IE_NB_03M010200	MOUNTAIN WATER_020	Good	BW_74	Good	
			BW_123	Moderate	
IE_NB_03M010400	MOUNTAIN WATER_030	Good	BW_76	Moderate	
IE_NB_03M010500	MOUNTAIN WATER_040	Poor	BW_111	Moderate	Moderate
IE_NB_03M010650	MOUNTAIN WATER_050	Moderate	BW_91	Moderate	Moderate
			BW_92	Moderate	
			BW_105	Moderate	Poor
IE_NB_03M010700	MOUNTAIN WATER_060	Unassigned	BW_93	Moderate	
			BW_94	Moderate	
IE_NB_03M050960	MULLAMURPHY_010	Unassigned	BW_99	Poor	
			BW_100	Poor	
			BW_119	Moderate	
			BW_121	Moderate	
IE_NB_03S010500	SHAMBLES_010	Poor	BW_106	Moderate	Moderate
IE_NB_03S020500	SCOTSTOWN_020	High	BW_103	High	
IE_NB_03T170930	TIRERAN_010	Unassigned	BW_85	Moderate	
			BW_112	Poor	
IE_NW_36M010150	MAGHERARNEY_010	Poor	BW_109	Moderate	Good
UKGBNI1NB030307025	River Rhone (Moygashel)	BEP	none		
UKGBNI1NB030307042	Crilly Feeder	Poor	BW_53	Moderate	
UKGBNI1NB030307043	River Blackwater (Benburb)	Good	BW_01	Moderate	
			BW_02	Moderate	
			BW_66	Poor	
UKGBNI1NB030307048	Butter Water	MEP	BW_06	Moderate	
			BW_07	Moderate	
UKGBNI1NB030307049	Clay River	MEP	BW_08	Good	
UKGBNI1NB030307109	Killeen Water	PEP	BW_19	Moderate	
UKGBNI1NB030307129	Tall River (Derrycrew)	Bad	BW_25	Poor	
			BW_26	Moderate	
UKGBNI1NB030307180	River Blackwater Tributary (Ballygreenan)	Good	BW_44	Good	
UKGBNI1NB030307196	River Blackwater (Ratory)	Good	BW_48	Good	
			BW_49	Good	
UKGBNI1NB030307238	Fury River	Good	BW_51	Good	
			BW_54	Moderate	
UKGBNI1NB030307239	River Blackwater Tributary (Lisboy)	Good	BW_50	High	
UKGBNI1NB030307242	Knockmany Burn (Blackwater)	Good	none		

Waterbody Number	Waterbody Name	Status 2018	IFI survey sites	Fish EQR	RHAT Score
UKGBNI1NB030307243	River Blackwater Tributary (Killyfaddy)	Good	BW_63	Moderate	
UKGBNI1NB030308202	CLONTIBRET STREAM_010	Poor	BW_116	Moderate	
			BW_117	Moderate	Good
UKGBNI1NB030308203	River Blackwater (Argory)	Poor	none		
UKGBNI1NB030308204	River Blackwater (Caledon)	Good	BW_27	Moderate	
			BW_67	Moderate	
UKGBNI1NB030308222	Torrent River	MEP	BW_33	Poor	
			BW_34	Moderate	
			BW_37	Good	
			BW_38	Moderate	
UKGBNI1NB030308224	Tall River (Rich Hill)	Bad	BW_23	Poor	
UKGBNI1NB030308243	Lough Neagh Peripherals	MEP	none		
UKGBNI1NB030308254	MOUNTAIN WATER_010	High	none		
UKGBNI1NB030308255	SCOTSTOWN_010	High	BW_101	Moderate	
			BW_102	Good	

For barriers, following the protocol for barrier survey as previously explained (see section 4.2.3), a total of 1637 potential barriers were identified in the Blackwater (Figure 4-15).

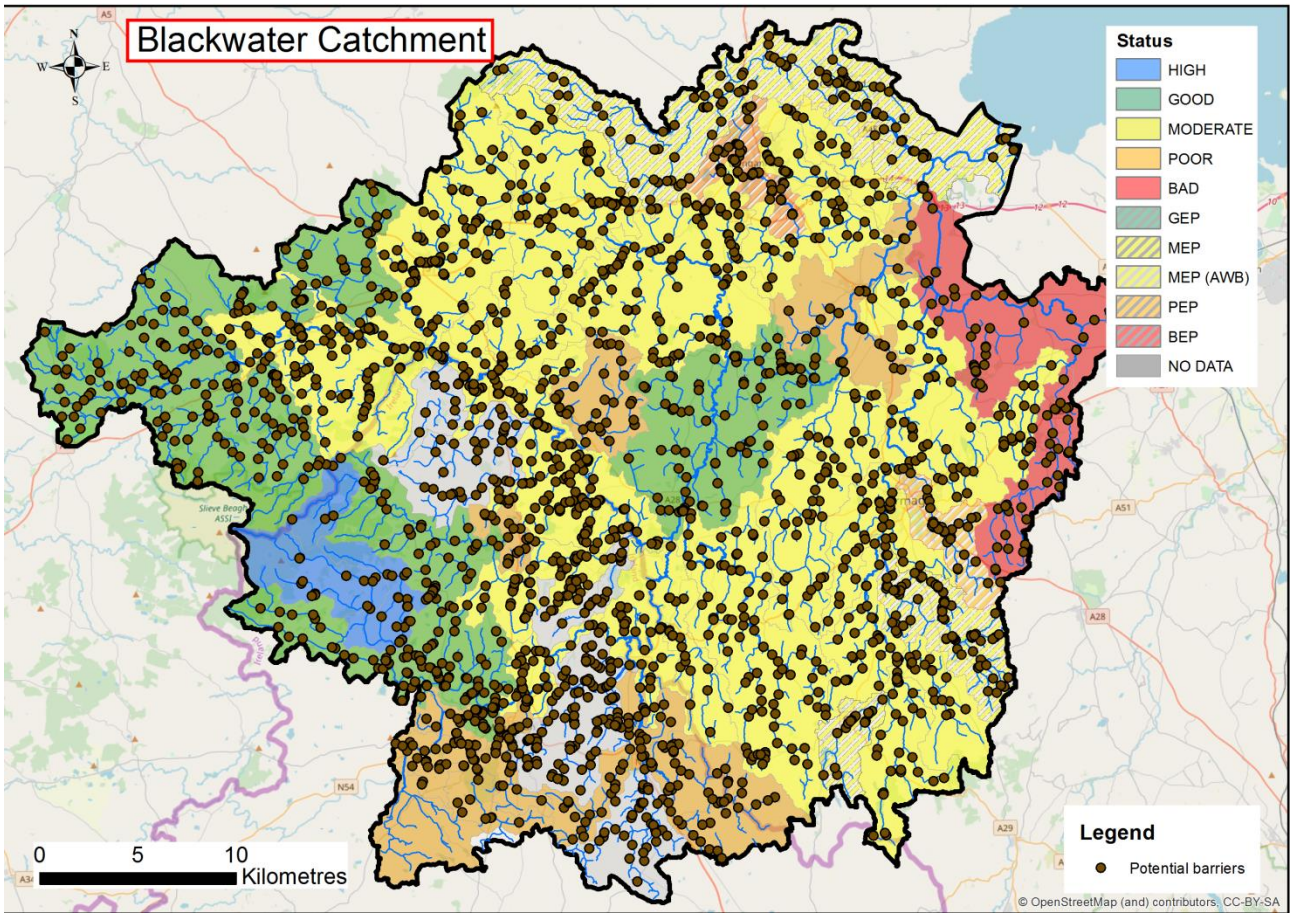

Figure 4-15 Location of potential barriers in the Blackwater catchment

To rationalise the number of visits to potential barriers, prioritisation was given to catchments with MODERATE or POOR WFD status. Prioritisation was also given to higher impact areas namely the

main channels and larger tributaries of water bodies as barriers in these areas are likely to have an increased effect on the overall system. All potential barrier locations were visited for presence/absence of passage issues. Assessments of identified barriers are carried out when a structure is deemed to be a barrier, i.e. drop height over 0.1m, water depth through structure under 0.15m.

Based on examination and use of the height and depth criteria, a total of 115 barriers were assessed in the Blackwater catchment (Figure 4-16).

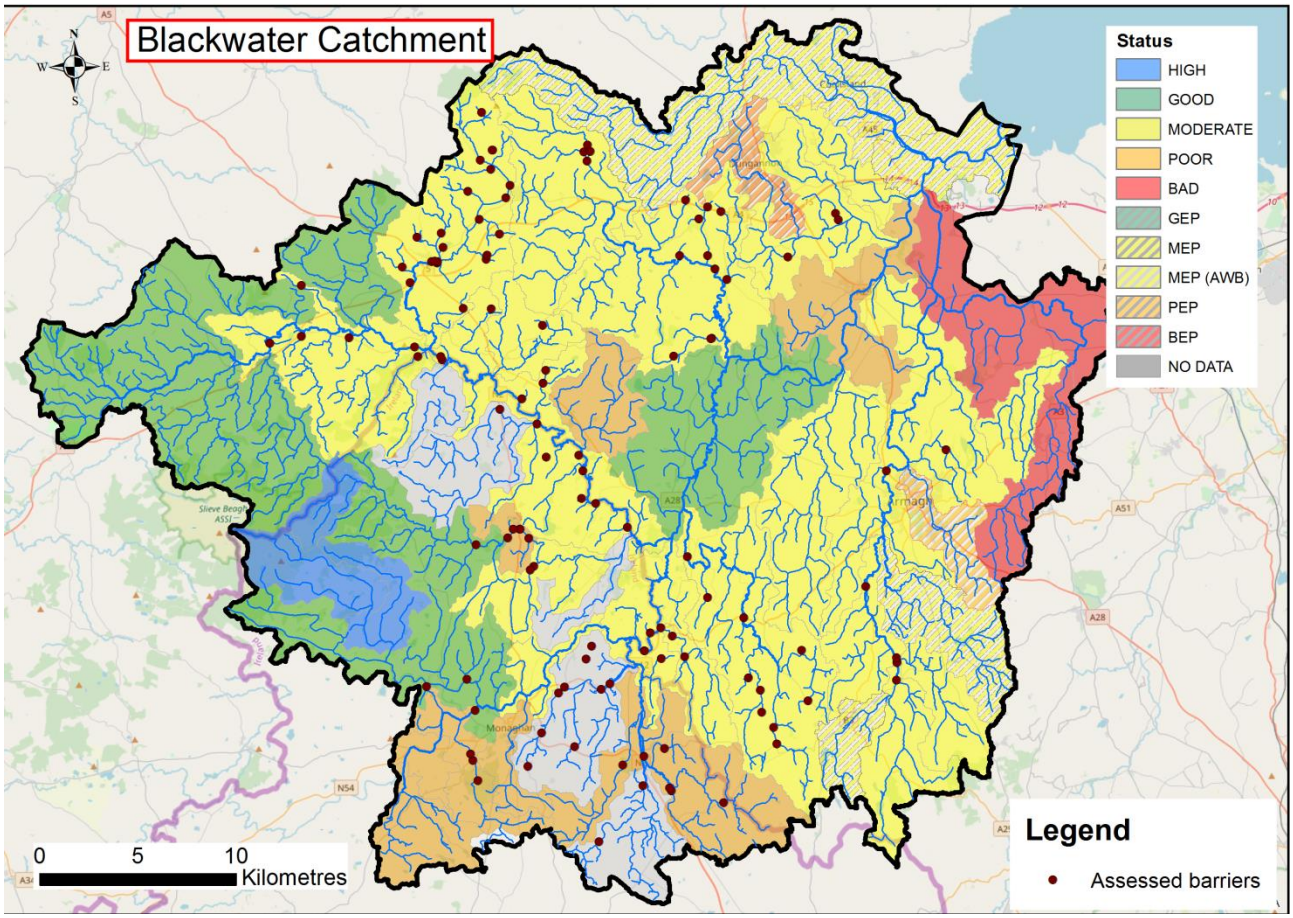

Figure 4-16 Location of assessed barriers in the Blackwater catchment

A specific report covering the identification, assessment and prioritisation of barriers has been produced for the WP T1 Scoping and Targeting (see Appendix A: Ranking of Fish Passage Issues)

5 Priority List of Locations for Hydromorphology Interventions: Candidate River Restoration Sites Based on Scientific Survey Programme

The selection of river restoration sites required the development of a specific, scientifically based methodology (Figure 5-1). This methodology includes the selection of waterbodies in MODERATE status, combined with desk studies (including, among others, the analysis of the historical evolution of the hydromorphology, the current status according to the WFD reporting, and possible national and international designations), as well as complementary field surveys (see previous sections of the present report). Finally, once issues have been identified, proposals will focus on barrier removal/mitigation, in-stream and riparian works.

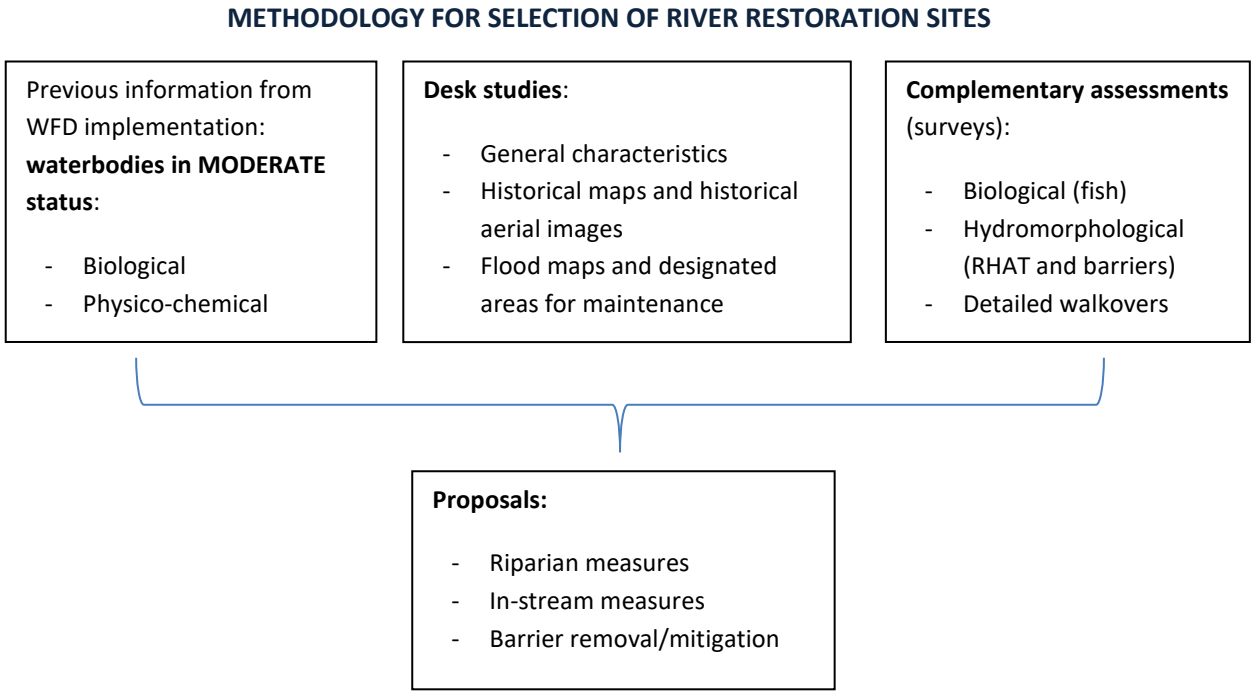

Figure 5-1 Methodology for selection of barrier, instream & riparian proposals

5.1 Finn Catchment

In brief, the candidate list for the Finn catchment includes the Finn(Donegal)_080 waterbody (for more detailed information, see Appendix A & Appendix B). No in-stream or riparian works were considered necessary in the Finn(Donegal_020, Finn(Donegal_040), Finn(Donegal)_050, Finn(Donegal)_060, Finn(Donegal_070, Elatagh_020, Clogher(Finn)_010 waterbodies as no barriers were prioritised and the hydromorphology score was Moderate. For the Finn(Donegal)_080, proposals include one barrier and three sites for in-stream and riparian works. The proposals are located in the Finn(Donegal)_080, RoughBurn_010 and Reelan_010 waterbodies within the tributaries of the main channel. It is expected that in-stream and riparian works will contribute to the overall ecological status classified by those monitoring stations. A candidate list of 21 additional sites for potential works has been selected by formulating a selection matrix from the data collected during the scoping phase of the project. These sites are listed from highest to lowest priority based on Fish EQR, RHAT, Macroinvertebrate SSRS/ Q-Value and EPA Waterbody Status. The next step in conducting works at these sites is to carry out site walkovers and determine specific mitigation

measures to be implemented at each site. Success at a site will be reliant on obtaining permissions from landowners.

Measures are listed below in two categories: riparian and in-stream measures (Table 5-1, Figure 5-2) and barriers

Table 5-2, Figure 5-3) as in most cases the measure will be a mix of riparian and instream.

Table 5-1 Instream and riparian measures for the Finn catchment

Instream and riparian measures				
Waterbody proposal	**Channel length (km)**	**Issues**	**Proposals**	**Justification**
Cummirk_020 (CUMM_001)	0.625 km	Collapsed Bank No/Poor Fencing. No riparian cover. Erosion and channel straightening. Bank reinforcement	Fencing, Tree Planting, In-Stream Works, Other	Walkthrough with CatchmentCARE officer, RHAT assessment, discussion with Loughs Agency Inspectors agreement with landowners
Cummirk_020 (CUMM_002)	0.385 km	No riparian cover, No/ poor fencing, access by livestock	Tree Planting and fencing, Other	Walkthrough with CatchmentCARE officer, RHAT assessment, discussion with Loughs Agency Inspectors agreement with landowners
Finn(Donegal_020(CUMM_003)	0.651 km	No/Poor Fencing. No riparian cover	Fencing, Tree Planting, Other	Walkthrough with CatchmentCARE officer, RHAT assessment, discussion with Loughs Agency Inspectors agreement with landowners
Cummirk_020 (CUMM_004)	0.105 km	Collapsed bank, No/ Poor fencing. No riparian cover	Fencing, Tree planting, Other	Walkthrough with CatchmentCARE officer, RHAT assessment, discussion with Loughs Agency Inspectors agreement with landowners
Cummirk_020 (CUMM_005)	0.125 km	No/ Poor fencing, No riparian cover, Bank Reinforcement, Erosion/	Fencing, Tree Planting, In-Stream Works, Other	Walkthrough with CatchmentCARE

		Deposition		officer, RHAT assessment, discussion with Loughs Agency Inspectors agreement with landowners
Rough Burn_010 (Rough_001)	Single Point	Barrier to fish migration	Removal of barrier, installation of clear span bridge.	Walkthrough with CatchmentCARE officer, RHAT assessment, Barrier Assessment, discussion with Loughs Agency Inspectors agreement with landowners

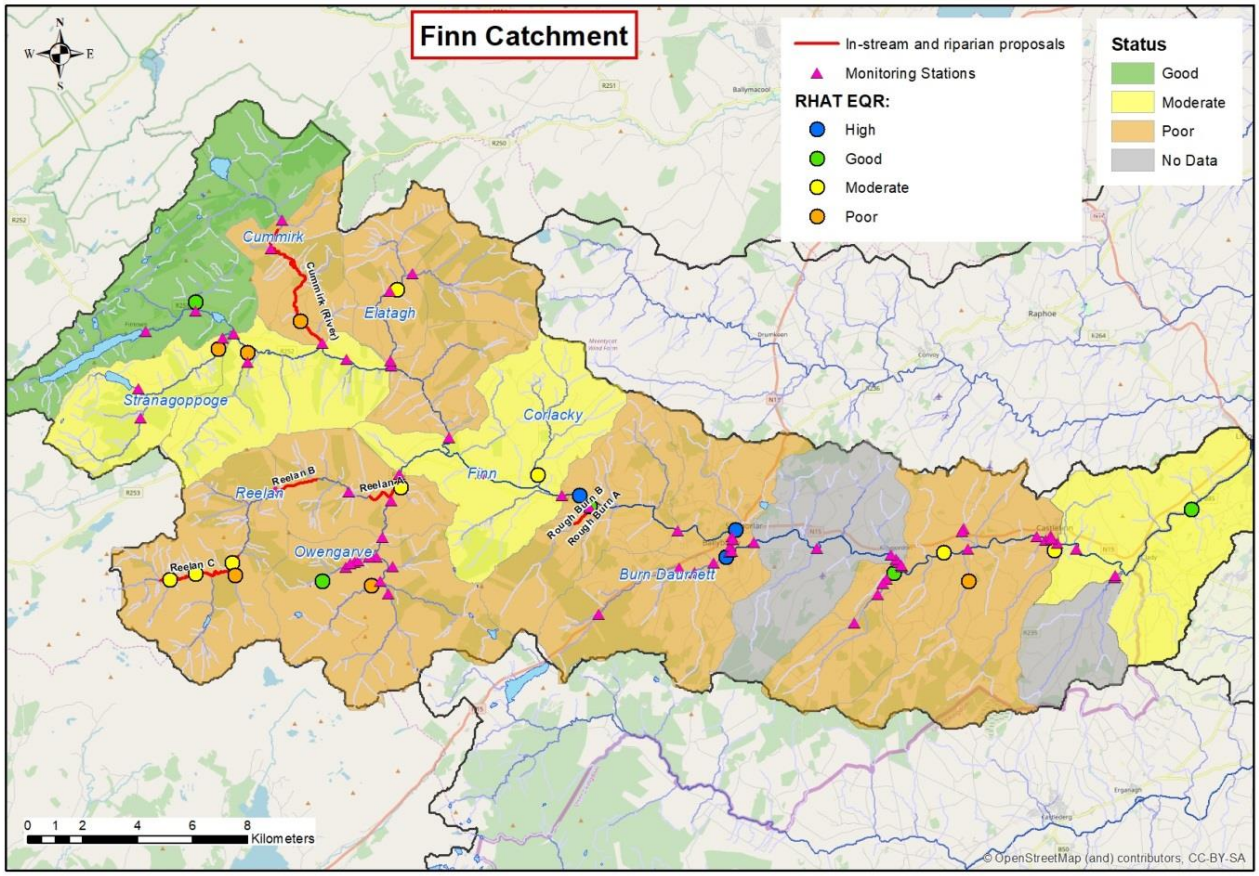

Figure 5-2 Location of instream and riparian measures for the Finn catchment

All in-stream and riparian proposals are located in Republic of Ireland and are not in drainage-designated channels for river maintenance. Therefore, proposed measures do not need to be agreed with OPW (RoI) prior to any works. Measures should, clearly, be agreed with landowner(s) in advance.

Table 5-2 Barrier proposals for the Finn catchment

Barriers			
Water body	**Barrier code**	**Structure**	**Proposal**
Finn(Donegal) _080	Crossroads_001	Rock/Bedrock Obstruction	Mitigation
Reelan_010	Reelan_pipes	Culvert	Replacement Procedure
	Effernagh_001	Culvert	Replacement Procedure
RoughBurn_010	Rough_Burn	Culvert	Replacement Procedure

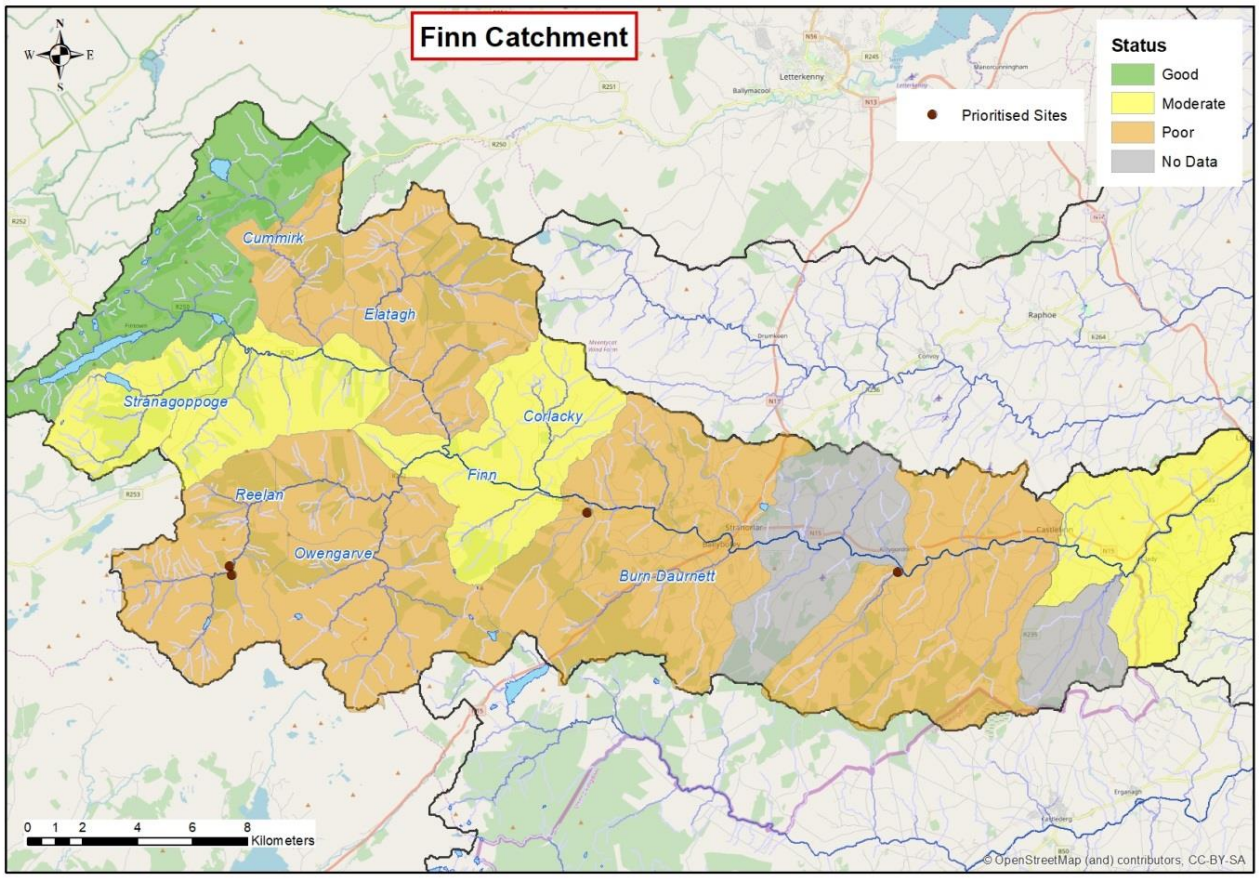

Figure 5-3 Location of barrier proposals for the Finn catchment

5.2 Arney Catchment

In brief, the candidate list for the Arney catchment includes the Drumharriff burn and the Arney River waterbodies (for more detailed information, see Appendix A & Appendix B). No in-stream or riparian works were considered necessary in the Black River water body since no barrier was prioritised (the only barrier identified is a natural barrier) and the hydromorphology scored high and good. For the Drumharrif burn, proposals include two barriers and in-stream and riparian works in the downstream section closer to the NIEA monitoring station. Most proposals are located in the Arney River water body, both in the main channel and tributaries; since some proposals in this water body include NIEA monitoring stations, it is expected that in-stream and riparian works will contribute to the overall ecological status classified by those monitoring stations.

Measures are listed below in two categories: instream and riparian measures (
Table **5-3**,Figure 5-4)and barriers (
Table 5-4,Figure 5-5) since in most cases the measures will be a mix of riparian and instream.

Table 5-3 Instream and riparian proposals in the Arney catchment

In-stream and riparian measures				
Waterbody proposal	**Channel length (km)**	**Issues**	**Proposals**	**Other comments**
Arney River 6 (Main)	1.8	Removal of riparian vegetation; poaching; bank instability; over-deepened; bank reinforcement and re-sectioning	Fencing; riparian planting; cattle drinks; reprofile banks	Survey sites: AR_36
Arney 5 (Main)	5.9	Bank instability; poaching; reinforcement of banks	Fencing; riparian planting; cattle drinks; reprofile bank on RHB	Survey sites: AR_37-41 NIEA station
Arney River 2 (Tributary)	1.3	Lack of riparian vegetation; poaching	Fencing, Riparian tree planting	Survey sites: AR_32
Arney River 1 (Tributary)	2	Lack of riparian vegetation; straightened; over-deepened	Fencing, Riparian tree planting	Survey sites: AR_31
Arney River 7 (Tributary)	2.2	Over-deepening and over-widening; removal of riparian vegetation; poaching; bank instability; poaching	Fencing; riparian planting; cattle drinks; reprofile banks	Survey sites: AR_30
Drumharriff burn	1	Channel straightening and over-deepening; removal of riparian vegetation; poaching; bank instability; bank reinforcement and re-sectioning	Bank reprofiling; fencing; riparian planting; provide cattle drink; substitution of rip-rap by soft engineering	Survey sites: AR_35 NIEA monitoring station
Arney River 4 (Main)	2.1	Over-deepening of channel; removal of riparian vegetation; poaching; bank instability	Fencing; riparian planting; cattle drinks; reprofile banks	
Arney River 8 (Tributary)	1.5	Over-deepening and over-widening; poaching	Fencing; riparian planting; cattle drinks; reprofile banks	Survey sites: AR_33

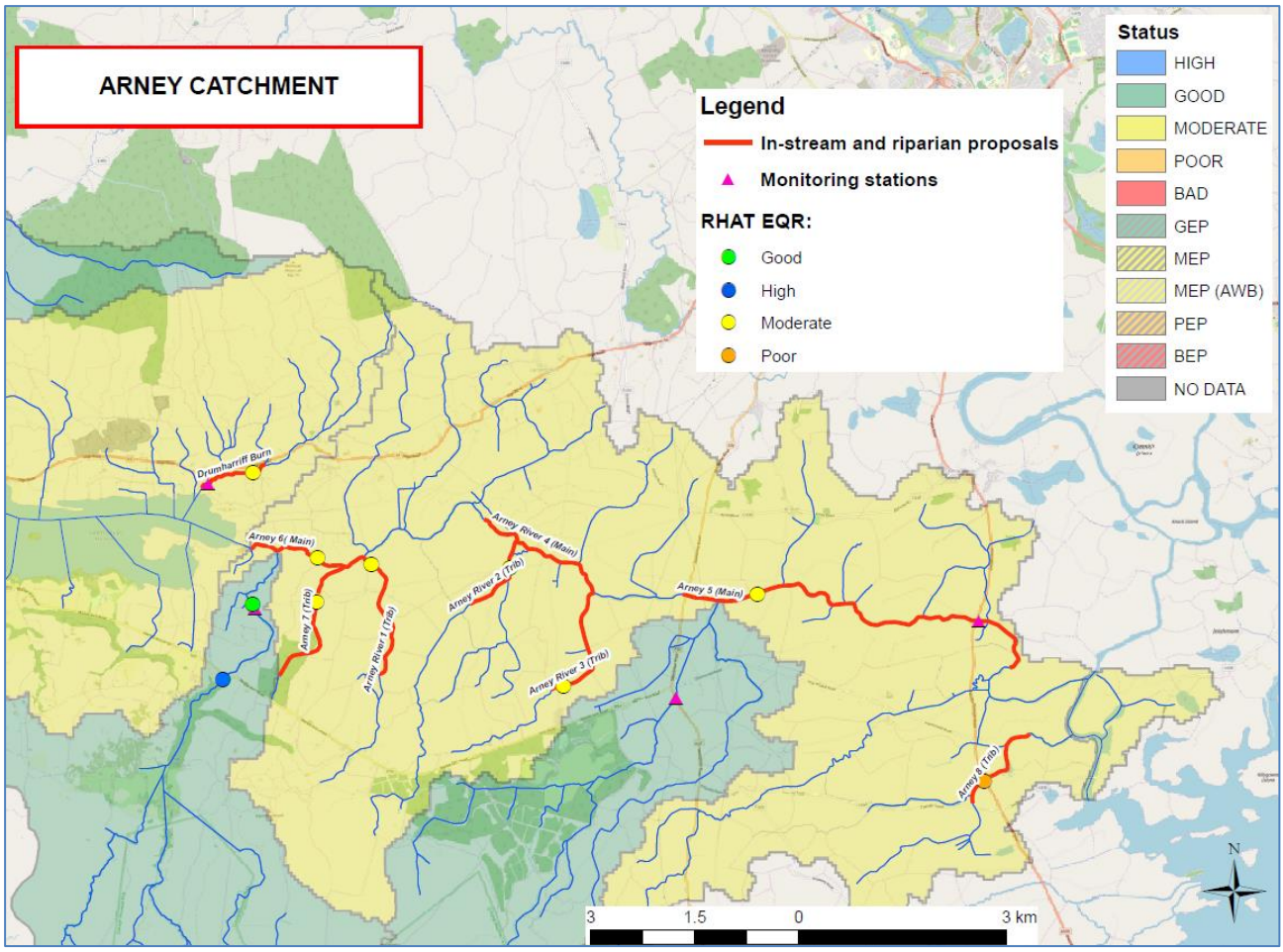

Figure 5-4 Location of instream and riparian proposals in the Arney catchment

All in-stream and riparian proposals are located in Northern Ireland and are in drainage-designated channels for river maintenance by the Department for Infrastructure (DfI Rivers). Therefore, proposed measures need to be agreed with DfI Rivers (NI) prior to any works. Measures should, clearly, be agreed with landowner(s) in advance.

Table 5-4 Barrier proposals in the Arney catchment.

Barriers			
Water body	**Barrier code**	**Structure**	**Proposal**
Drumharriff burn	58_IS_01	Bridge (in disrepair)	Replacement
	58_IS_02	Weir	Mitigation
Arney River	62_RR_46	Bridge apron	Mitigation
	62_RR_6	Culvert	Mitigation
	62_RR_27	Culvert	Mitigation

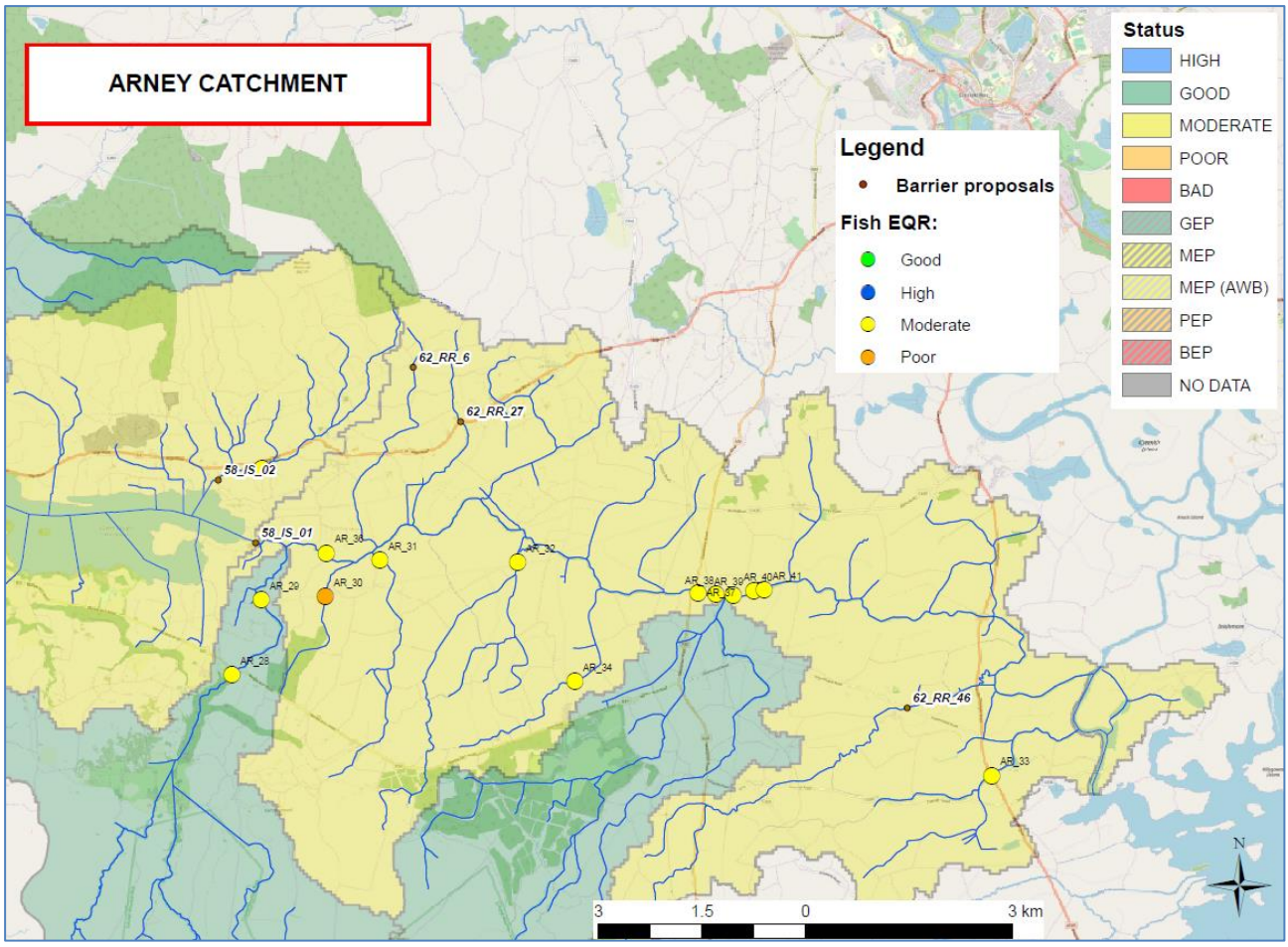

Figure 5-5 Location of barrier proposals in the Arney catchment.

5.3 Blackwater Catchment

The candidate list for the Blackwater catchment includes waterbodies predominantly in Moderate WFD status (for more detailed information, see Appendix A & Appendix B). Measures are listed below in two categories: riparian and habitat improvement measures (Table 5-5, Figure 5-6) since in most cases the measures will be a mix of riparian and in-stream and barriers (Table 5-6, Figure 5-8).

Table 5-5 Instream and riparian proposals (candidate river reaches) for the Blackwater catchment.

Water body proposal	Channel length proposed (km)	Issues	Proposals	Other Comments
Ballymacone	6.9	Re-inforced banks; Bank vegetation.	Fencing; riparian planting; cattle drinks	BW_65
Rhone (Dungannon) 2	4.7	Re-inforced toe; Poaching; Excess Silt.	Fencing; riparian planting; Re-section banks.	BW_35, BW_30
Ballymatrim	7.5	Re-inforced toe, Bank vegetation; Bank Stability	Fencing; riparian planting; cattle drinks. Bank reprofile sections.	BW_36, BW_55
Aughnacloy	3.1	Bank veg; Embankment; Poaching; Re-inforced toe.	Fencing; riparian planting; cattle drinks	BW_64
Tynan 1	6.0	Over-deepened; Narrowed; Re-inforced toe; Poaching.	Fencing; riparian planting.	BW_11, BW_12
Ballygawley 2	3.9	Channel re-aligned; Over-deepened; Embankment; Re-sectioned banks.	Remove Re-inforcements. Bank stabilise.Fencing; riparian planting; cattle drinks.	BW_41, BW_42, BW_43
Augher 2	3.1	Poaching; Channel Vegetation; Riparian Land-use	Fencing; riparian planting; cattle drinks.	BW_52
Mountain Water_050	6.5	Re-sectioned banks; suburban land-use.	Fencing; riparian planting; bank stabilisation.	BW_91, BW_105
Rhone (Dungannon) 1	3.3	Channel re-aligned; Over-deepened, Resectioned banks, Poaching.	Fencing; riparian planting; cattle drinks	BW_59
Oona (Killymaddy) 1	2.8	Channel re-aligned; Re-inforced toe; Poaching	Fencing; riparian planting; cattle drinks.	BW_61
Oona (Killymaddy) 3	2.6	Channel re-aligned; Over-deepened, Resectioned banks, Poaching, Re-inforced toe.	Fencing; riparian planting; cattle drinks, remove hard reinforcements.	BW_40, BW_58
Tynan 2	3.7	Re-sectioned banks; Poaching.	Fencing; riparian planting; cattle drinks.	BW_14

Monaghan Blackwater_040	5.7	Channel re-aligned; Over-deepened; Re-sectioned banks.	Fencing; riparian planting. Soft re-inforcement u/s of meander beside roadway.	BW_95
Cor River 1	2.4	Channel re-aligned; Over-deepened; Re-sectioned banks.	Fencing; riparian planting. Soft re-inforcement.	BW_95
Augher 1	3.5	Channel re-aligned; Over-deepened; Over-widened; Resectioned banks; Poaching.	Fencing; riparian planting and bank stabilisation. Collaboration with DAERA doing in-stream works for fisheries.	BW_24
Callan(Milford)	5.9	Over-deepened; Over-widened; Re-sectioned banks; Embankment.	Fencing; riparian planting; cattle drinks.	BW_10
Annaghroe 2	3.0	Over-deepened; Over-widened; Resectioned banks; Re-inforcements; Poaching	Fencing; riparian planting; cattle drinks	BW_77, BW_81
Callan (Tassagh)	5.6	Over-deepened; Narrowed; Impoundment; Re-sectioned banks; Re-inforced banks.	Fencing; riparian planting; cattle drinks.	BW_09
Cor River 2	2.9	Over-deepened; Over-widened; Embankments.	Fencing; riparian planting. Instream works- sediment traps, experimental?	BW_16
Callan (Derryscollop) 3	3.7	Channel re-aligned; Over-deepened; Over-widened; Re-sectioned banks; Embankment; Poaching	Fencing; riparian planting. Soft engineering bank stablisation.	BW_21
Augher 3	2.2	Over-deepened; Resectioned banks; Private forest felled recently.	Fencing; riparian planting.	BW_45
Callan (Derryscollop) 1	3.2	Over-deepened; Over-widened; Resectioned banks; Re-inforcements; Poaching	Fencing; riparian planting, bank stabilisation.	BW_20
Cor River Tributary	3.4	Re-aligned; Re-inforcement; Resectioned banks.	Fencing; riparian planting; cattle drinks, barrier removal.	BW_13
Ballygawley 1	2.6	Channel re-aligned; Over-deepened; Over-widened; Re-sectioned banks.	Fencing; riparian planting. Bank stabilisation.	BW_04
Callan (Derryscollop) 2	5.9	Channel re-aligned; Over-deepened; Over-widened; Re-sectioned banks; Poaching	Fencing; riparian planting; cattle drinks. Instream works to create variation flow depth.	BW_18
Oona (Eglish)	7.0	Over-deepened; Re-sectioned; Re-inforcements;Embankment; Poaching; Silt/pollution.	Fencing; riparian planting; cattle drinks.	BW_29

Annaghroe 1	7.1	Over-deepened; Impoundment; Re-sectioned banks; Re-inforced toe; Poaching.	Fencing; riparian planting; cattle drinks. Re-profile banks.	BW_73
Tamnnamore Stream	4.6	Channel re-aligned; Over-deepened; Re-sectioned banks.	Fencing; riparian planting; cattle drinks.	BW_31
Tynan 4	7.0	Channel re-aligned; Over-deepened; Over-widened; Resectioned banks; Re-inforcement.	Fencing; riparian planting; cattle drinks. Bank re-sectioning. Meander reconnection. Permission u/s section incl. Estate	BW_05

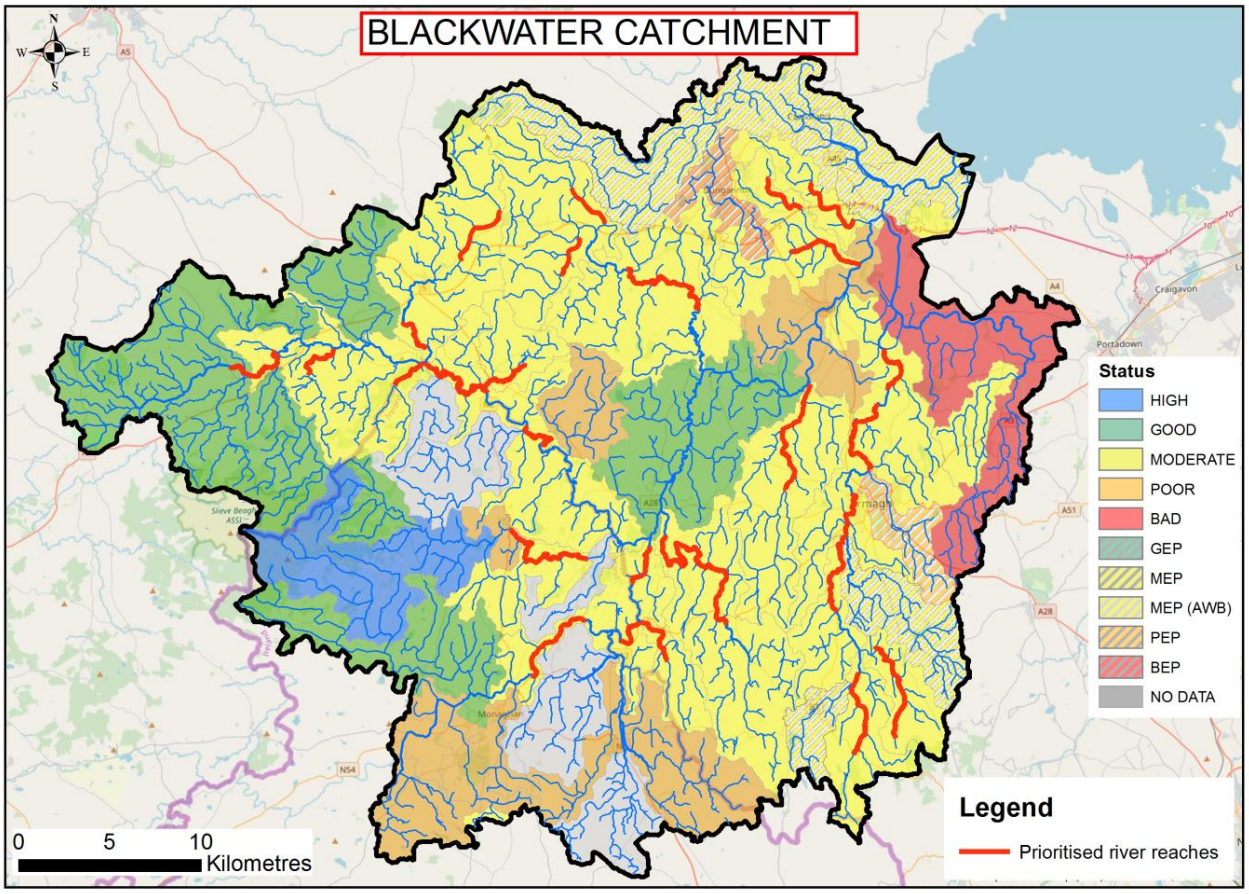

Figure 5-6 Location of instream and riparian proposals (candidate river reaches) in Blackwater catchment.

The majority of in-stream and riparian proposals are located in Northern Ireland and are in drainage-designated channels for river maintenance by the Department for Infrastructure (DfI Rivers). Proposed measures need to be agreed with DfI Rivers (NI) prior to any works. Proposed river reaches for instream and riparian works in the Republic of Ireland are in designated Office of Public Works channels and so proposals need to be agreed with OPW prior to any works. Measures should, clearly, be agreed with landowner(s) in advance.

Final Selection of Reaches in the Blackwater Catchment

Discussion with partners and stakeholders further refined the list of suitable site for works.

Updated data on waterbody status (reassessed from 2018) was available from DAERA. After reviewing the updated data, a number of waterbodies in the Blackwater catchment were excluded from final selection, as their status had changed from Moderate status in 2018.

The candidate waterbodies, where the waterbody status was no longer of Moderate status, were rejected. This included the following tributaries:-

Ballymartrim River

River Rhone (Dungannon)

Cor River

Final prioritisation included consultation with stakeholders, joint works with partners and other CatchmentCARE projects. To maximise the cost-benefit of the restoration joint project work with partners and stakeholders was also considered a priority.

The following rivers within the Blackwater catchment are prioritised for phase 1:

Mountain Water (Mountain Water_30, Mountain Water_40, Mountain Water_50 Mountain Water_60)

LAWPRO has identified the Mountain Water as a priority area in the Catchment and this is included in the works programme.

Ballygawley River (Ballygawley Water)

Joint works are already proceeding with DAERA on the Ballygawley River and they considered this a priority river.

Blackwater between Favor Royal and Aughnacloy (River Blackwater (Annaghroe), River Blackwater (Augher))

A Community Incentive Schemes (CIS) is approved, which would dovetail into the works proposed for the River.

Tynan River (Tynan River)

Opportunities existed on the Tynan to undertake more extensive works than on most of the farmed land. Therefore, several partners had requested that permissions for work should be sought and has been granted by the landowner. This provided the opportunity to scope out a more extensive project using a greater amount of adjoining land.

Callan River (Callan River (Milford), Callan River (Derryscallop), Callan River (Tassagh))

Several CIS projects are approved for the Callan River.

The remaining sections are not included in the initial works and are scheduled for works if any further funding becomes available.

These included:-

Oona (Oona (Killymaddy), Oona (Eglish))

Tamnnamore Stream (Tamnamore Stream)

Ballymacone River (Ballymacone River)

Blackwater between Aughnacloy and Caledon (River Blackwater (Annaghroe))

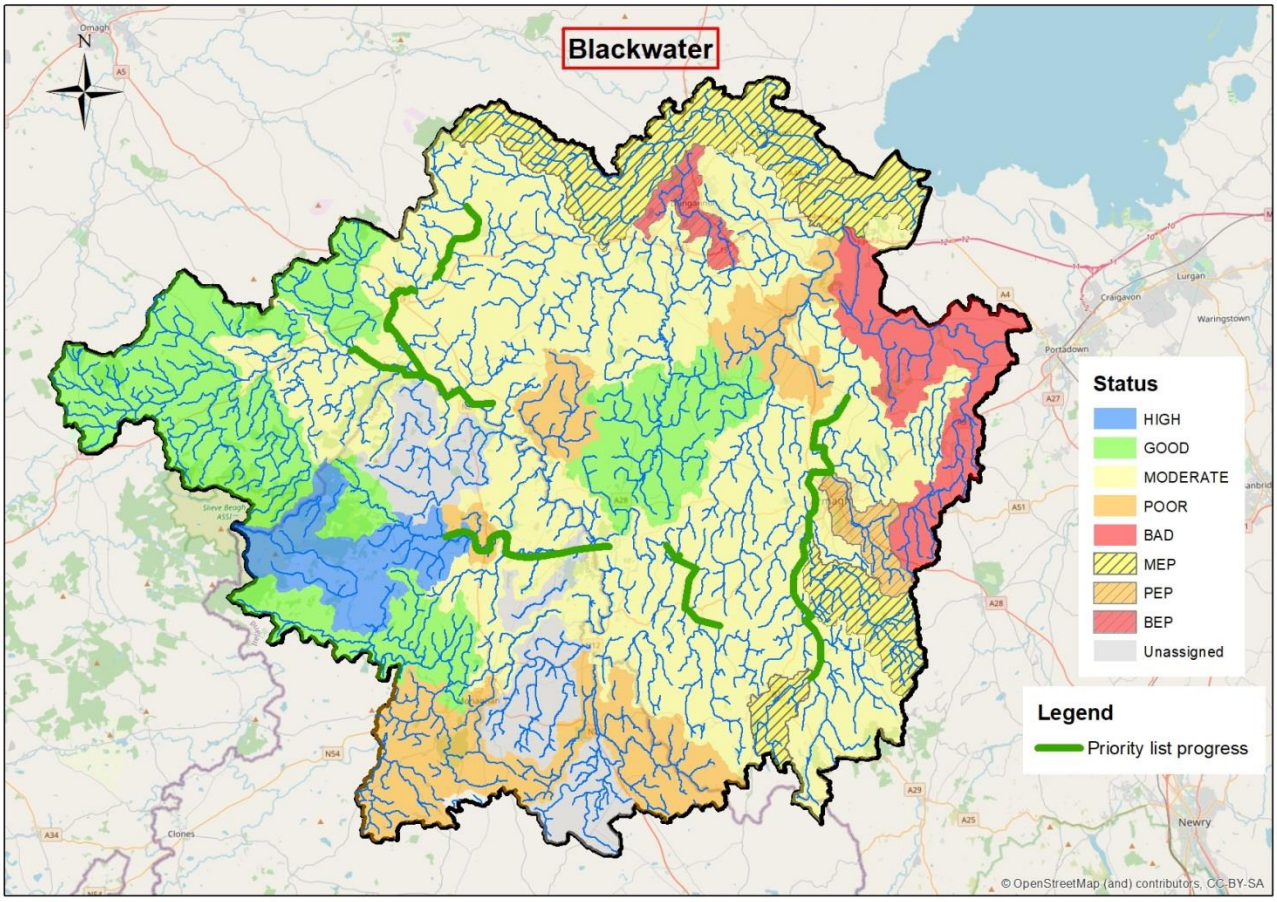

Figure 5-7. Final selection of River reaches in the Blackwater catchment.

Table 5-6 Barrier proposals in the Blackwater catchment.

Barrier code	Water body	Score	Structure	Catchment Status
74_IS_104	Oona Water (Eglish)	3.67	Weir	Moderate
03_425_131	Cor River	3.58	Ford	Moderate
50_IS_85	River Blackwater (Augher)	3.17	Weir	Moderate
48_IS_55	River Blackwater (Annaghroe)	3.08	Weir/ Horseshoe groyne.	Moderate
78_RR_4	Callan River (Derryscollop)	3.08	Weir/ Road bridge.	Moderate
64_IS_77	Ballygawley Water	3.08	Weir	Moderate
74_RR_47	Oona Water (Eglish)	3.08	Culvert	Moderate
64_IS_07	Ballygawley Water	3.00	Weir	Moderate
80_IS_01	Tynan River	2.92	Ford	Moderate
50_IS_71	River Blackwater (Augher)	2.92	Weir	Moderate
64_IS_70	Ballygawley Water	2.75	Weir	Moderate

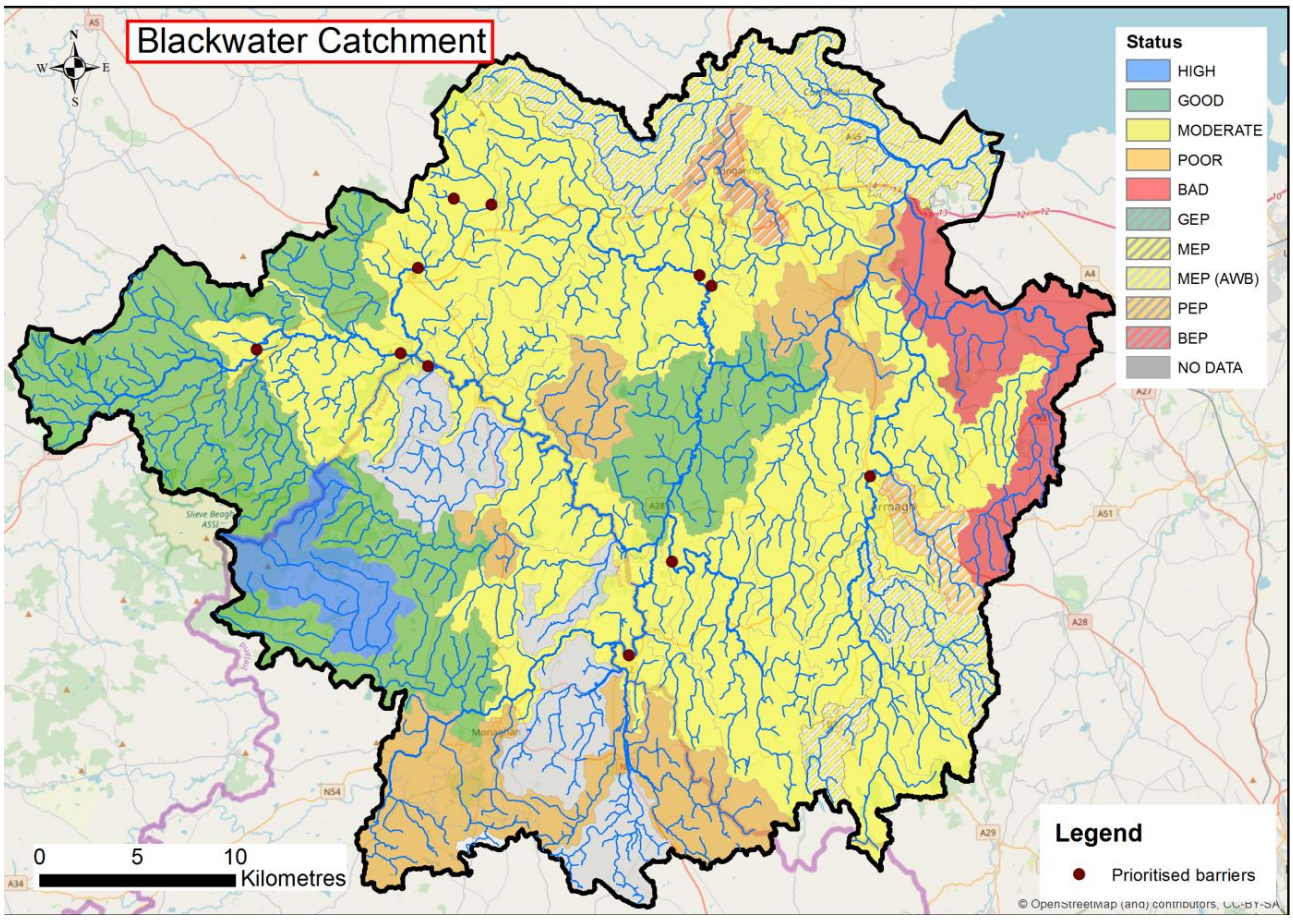

Figure 5-8 Location of barrier proposals in the Blackwater catchment.

6 Post Works Monitoring Programme

This chapter largely encompasses the scientific or investigative facet to the CatchmentCARE project regarding a monitoring strategy to assess the impact of physical works to improve the ecological status of waterbodies, with data collection and development of an evidence base that can be tested before and after any actions.

In that sense, the metrics of success should be based on a before–after-control–impact (BACI) approach, widely applied in literature to assess the effect of a change in an ecosystem (Smith *et al.*, 1993).

It is envisaged that the consistent protocols already presented in this report will be applied before and after the proposed works:

- Assessment through the context of Ecological Quality ratios or EQRs. These are, in essence, a numerical interpretation of status of the various elements examined – the hydromorphology (RHAT scores), the fish (fish EQR), the invertebrates (SSRS/Q-Value) etc.
- Paired comparison (before and after) in those sections where measures will be undertaken. In addition, it is proposed that these metrics should be compared with "undisturbed" sections, i.e. controlled sections with no works undertaken.

Thus outcomes can be examined in the context of EQR scores collected before and after works. These metrics will be an indicator of change, or success, in regard to improving ecological quality.

Taking into account the duration of the CatchmentCARE project (2018-2022), it is expected that works will be ideally carried out in 2020, so metrics can be monitored as part of the project until 2022. Restoration works will usually require a medium to long-term context to show a reliable measure of success. The continuation of the monitoring programme will rely on the relevant state agencies (EPA in the RoI and NIEA in NI) as part of their long-term WFD monitoring programmes.

The current report has identified, with consistent reasoning, waterbodies in MODERATE status (primarily), measures that can be implemented and an indicative costing of works. In order to develop a strong evidence base for impact of any works – be these positive, negative or neutral – a more substantial degree of data collection, covering both the fish community and the physical habitat, is proposed at individual locations.

Fish: Some channel sections where works might be undertaken can exceed 2 – 3 km in length, with some variation in physical habitat over that length. Such lengths permit a comprehensive and extended works programme and are considered to have greater chance of positive impact than a short e.g. 100m section of works. A data collection exercise in a 2 – 3 km location would envisage a series of approximately 5 replicate fishing operations, using the standard 10-minute timed protocol. This would provide a set of 5 data points in regard to fish community composition and allow for calculating five discrete EQR scores. The additional replication would provide a larger data set of fish lengths to examine population structures. A repeat surveying of the 5 sites in the years following works then allows for comparison of a set of 5 data points for each year, as opposed to comparison

of single data points. Such a design is more robust if statistical analysis of trends and outcomes is envisaged.

Physical habitat: A channel length of 2 – 3 km, as described above, would also allow for a degree of replication of data collection for physical habitat variables. The RHAT survey protocol, described previously, gathers data over a 500 m section of channel. An extended channel length would, in many cases, permit a second 500 m segment to be analysed via the RHAT protocol. This would provide 2 data points of EQR scores.

In addition, the RHAT process has its own built-in scope for replicates, insofar as data is summarised at each 50 m channel length walked in the survey, thus providing 10 replicates built in to each 500 m walk.

A further teasing-out of the RHAT score can be undertaken to pinpoint specific issues prior to works. The final RHAT score for a site, providing an EQR value, is a single number but is, in fact, a composite of 8 variables scores individually, and at each 50 m interval. It is possible to have 8 discrete scores, in respect of the individual variables assessed for each RHAT location. This procedure is used in selection and prioritisation of sites for works under T 1.2.3 & T.3.1 – T1.3.4 (see Appendix B)

Control – Experimental site pairings: For any 'experimental' site where works are to be undertaken and where a monitoring programme, with replication, is planned it will be necessary to select a companion control site. Ideally, the control site requires a series of criteria:

- Located upstream of the experimental site to avoid any influence from the 'treated' site
- similar physical and flow characteristics to the 'treated' site
- absence of any tributary channels between the two sites, to ensure the same flow or volume discharge through both sites.

The control site should receive the same level of survey intensity as the 'treatment' site in regard to replicates for fish and for physical habitat. Natural temporal fluctuations can be expected in biological systems. Having a comparator control site allows for tracking of natural fluctuations. It is also important that monitoring be undertaken at same time of year and in same water level and flow conditions, as previous years, in both the control and experimental replicates.

Extent of monitoring programme going forward: The monitoring protocol proposed involves a significant amount of data collection for any particular location selected. Given this, it is envisaged that a small but representative series, only, of locations will be chosen. The choice of locations will be made on the basis of the proposed instream actions and on the character of the river type.

Monitoring programme for Barriers works: In contrast to the 'continuous' nature of proposed instream and riparian issues and works, barriers constitute a discrete item or problem that may be addressed. While the solution to the barrier problem is discrete the impacts of barrier mitigation may be more widespread. Removal of barriers will eliminate the ponding effect in the upstream channel and will also permit downstream movement of sediments, including gravels that can be used for spawning by salmon, brown trout and lamprey species. Any form of mitigation that permits fish passage will permit fish movement both up- and downstream and this may be a positive effect over a considerable distance.

If a barrier mitigation measure is to be pursued a first step is to carry out a more detailed assessment study of the overall structure for fish passability. The SNIFFER coarse resolution protocol (SNIFFER, 2010) is used by IFI for this purpose. The protocol examines any possible passage route or "transversal" across the structure on an individual basis and applies a passability score to each transversal. An overall score is then derived from a review of the individual transversal scores. Scoring is based on four options:
0 = complete barrier
0.3 = high risk of not passing the structure
0.6 = reduced problems in passing the structure
1.0 = not a barrier

A recent study found a strong comparability of outcome for structures In Irish Rivers between the UK-generated SNIFFER score and the French-developed ICE score (Barry et al 2018). Following a mitigation action a SNIFFER passability score can again be generated. The score relates to the situation prevailing at the time of survey. For Health & Safety reasons such surveys are undertaken during conditions of relatively low flow when access onto and adjacent to the structure is considered safe. Such low flow conditions commonly coincide with the migration period of spawning sea lamprey. These conditions will also impact on adult salmon and may require them to seek out downstream resting areas of deeper water and await improved conditions to attempt an ascent past the structure.

In addition to the pre- and post- SNIFFER surveys, a monitoring protocol for assessing impact of barrier mitigation should include an assessment of impact on physical habitat and on one or more of the WFD biological indicators. Surveying may include:

- Topographical survey of channel longitudinal profile (with bed and water surface levelling) to indicate the extent and form of the channel in the upstream impounded area prior to works and the extent to which natural bed form has been restored following barrier removal. This survey is only of relevance in the case of barrier removal.

- RHAT survey of channel in the immediate up- and down- stream vicinity of the barrier. This should show a substantial differential prior to any works and this differential will remain, at least for some of the 8 RHAT attributes scored, if mitigation does not involve breaching of the structure or a lowering of the crest level of the barrier. Where breaching or removal are undertaken this will be strongly reflected in a comparison of pre- and post- RHAT scores particularly in the upstream reaches.

- Fish surveys, using the standard 10-minute timed protocol, should be undertaken in representative areas, as replicates, both up- and downstream of the barrier. Where salmon are present in a channel they can act as valuable indicators of barrier impact. Gargan et al (2011) found that in the case of some barriers there were commonly both 0+ (young-of-the-year) and 1+ salmon downstream of structures. Where either age group was absent upstream of a structure it was considered that the structure was acting as barrier to migration, at least in some years. This disposition of juvenile salmon could be a valuable indicator in the CatchmentCARE study. If salmon are absent or present in low densities

upstream of a structure, relative to downstream locations, then a fish survey procedure would be valuable to indicate the degree of success of any barrier mitigation measure. Any form of upstream dispersal of adult fish, with consequent 0+ and 1+ fish production and survival, may be a consequence of barrier removal or of fish passage easement over the existing structure.

Extent of barrier monitoring programme going forward: The proposed pre- and post- works surveys for barriers may be sufficient to indicate the overall thrust of the barrier modification effect. Follow-up fish and RHAT surveys in the catchment areas upstream of the modified barrier may be appropriate if migratory fish species, such as salmon, were known previously from downstream of the barrier.

The number of barriers that may be modified, particularly those where removal or breaching is proposed, is relatively small within the CatchmentCARE project and it is envisaged that, as a minimum, pre- and post-SNIFFER surveys should be undertaken.

7 References

Barry J, Coghlan B, Cullagh A, Kerr JR, King JJ. (2018) Comparison of coarse-resolution rapid methods for assessing fish passage at riverine barriers: ICE and SNIFFER protocols. *River Res Applic.* 2018; 1–11. https://doi.org/10.1002/rra.3358

Central Statistics Office (2012). Census of Agriculture 2010 Final Results. On-line ISSN 2009-5716.

Clarke, J. https://www.sciencedirect.com/science/article/pii/S0048969715001291 - ! Kelly-Quinn, M., Blacklocke, S., Bruen, M., (2015). The effect of forest windrowing on physico-chemical water quality in Ireland. Science of the Total Environment, Volume 514, 1 May 2015, Pages 155-169.

Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption. [Online]. [Accessed 26 May 2017]. Available from: http://eur-lex.europa.eu/

Council Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy. [Online]. Available from: http://eur-lex.europa.eu/

Department of Arts, Heritage and the Gaeltacht (2014). Site Synopsis River Finn SAC. Version date 06.01.2014. (NPWS, 2014).

Department of Arts, Heritage and the Gaeltacht (2017). River Finn SAC (site code 002301). Conservation objectives supporting document - blanket bogs and associated habitats. NPWS. Version 1, May 2017.

Donegal County Council (2016). The Donegal Local Economic & Community Plan 2016-2022: Appendix 1, The Profile of the County

European Communities (Water Policy) Regulations 2003 (S.I. No. 722 of 2003). [Online]. Available from: http://www.irishstatutebook.ie/

Gargan, P. G., Roche, W. K., Keane, S., King, J. J., Cullagh, A., Mills, P. and O' Keeffe, J. (2011) Comparison of field- and GIS-based assessments of barriers to Atlantic salmon migration: a case study in the Nore Catchment, Republic of Ireland. *J. Appl. Ichthyol.* 27 (Suppl. 3) (2011), 66–72

Hydrometric Data Ireland [Online]. Available from: http://www.epa.ie/water/wm/hydronet/

Hydrometric Data Northern Ireland [Online]. Available from: https://nrfa.ceh.ac.uk/

Kelly-Quinn, M., Bruen, M., Harrison, S., Healy, M., Clarke, J., Feeley, H.B. and Blacklocke, S., (2014). HYDROFOR Project Synthesis Report: Assessment of the Impacts of Forest Operations on the Ecological Quality of Water. Environmental Protection Agency, Johnstown Castle, Ireland.

Loughs Agency of the Foyle Carlingford and Irish Lights Commission Report Ref: LA/CSR/09/11 (2011). 2010 River Finn and Tributaries Catchment Status Report.

Matson R, Delanty K, Shephard S, Coghlan B & Kelly F (2018). Moving from multiple pass depletion to single pass timed electrofishing for fish community assessment in wadeable streams. *Fisheries Research*, Volume 198, February 2018, Pages 99-108.

Murphy, M., & Toland, M. (2012). River hydromorphology assessment technique (RHAT). Training guide. Northern Ireland Environment Agency, Department of the Environment, Version 2.

Neagh Bann river basin management plan 2015 to 2021 (2015). [Online]. Available from: https://www.daera-ni.gov.uk/publications/neagh-bann-river-basin-management-plan-2015-2021

North western river basin management plan 2015 to 2021. [Online]. Available from: https://www.daera-ni.gov.uk/publications/north-western-river-basin-management-plan-2015-2021

River Basin Management Plan 2018-2021. [Online]. Available from: https://www.housing.gov.ie/water/water-quality/river-basin-management-plans/river-basin-management-plan-2018-2021

Smith, E. P., Orvos, D. R., & Cairns Jr, J. (1993). Impact assessment using the before-after-control-impact (BACI) model: concerns and comments. *Canadian Journal of Fisheries and Aquatic Sciences*, 50(3), 627-637.

Water Framework Directive) Regulations (Northern Ireland) 2017. [Online]. Available from: http://www.legislation.gov.uk/nisr/2017/81/made

https://www.epa.ie/water/watmg/wfd/classification/
https://www.loughs-agency.org/wp-content/uploads/2015/05/river-finn-and-tributaries-catchment-status-report-2010.pdf
https://www.npws.ie/sites/default/files/publications/pdf/Lough%20Foyle%20SPA%20(004087)%20Conservation%20objectives%20supporting%20document%20-%20[Version%201].pdf
https://www.epa.ie/pubs/reports/research/water/EPA%20RR%20169%20Essentra%20final%20web.pdf
http://www.wfdireland.ie/wfd-rpa.html

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Appendix A. Ranking of Fish Passage Issues

WP T1: Scoping and Action Targeting

T1.2 Rivers: prioritizing in-stream works

Deliverable T1.2.2:

Ranking of Fish Passage Issues

JULY 2019

A1 Introduction

A1.1 Identification of issues caused by barriers

Longitudinal connectivity is an important factor when considering the ecological health of a river ecosystem. The fragmentation of rivers due to human impacts is a threat to the range of freshwater species inhabiting the rivers. Fish movements and migrations can be effected by different anthropogenic structures in rivers. These structures may include bridge floors, culverts, sluices, dams and weirs. Fish require freedom of movement in order to feed, grow, find shelter and reproduce effectively. Barriers can have negative impacts on reproduction and somatic growth by creating physical, hydrological and behavioural restrictions to these natural imperatives.

Atlantic salmon, sea trout, sea lamprey, river lamprey, and shad and European eel all make long migratory journeys to reproduce, however, a range of other fish, such as pike, brown trout and bream, live entirely in fresh water but make extended movements for feeding or to spawning grounds. Any restrictions to fish migrations may have negative consequences for their reproductive and feeding capacity and could lead to decline in population. Several of the fish species above are listed in the EU Habitats Directive e.g. salmon, the lampreys and the shads, and Ireland has designated Special Areas of Conservation (SACs) on a number of our large river systems where the conservation status of these species is to be of particular concern.

The Water Framework Directive (WFD) views water quality in an all-round sense of ecological quality and uses a number of elements to assess 'water quality' in a given water body. These elements include the fish and invertebrate community and how these communities may differ from natural conditions. Another important quality element in the WFD is that of 'hydromorphology'. This term incorporates the quantity of water (hydrology) and the quality of the physical habitat (morphology and ecology). A component of hydromorphology is that of 'continuity' i.e. the flow of water (fluvial-geomorphology) is undisturbed by obstructions or barriers and fish and other wildlife can pass both upstream and downstream.

An assessment has been carried out of the location and extent of barriers along rivers which may be impacting on a range of fish species, including species protected under the Birds and Habitats Directive, and also on sediment transport processes (an integral element of river hydromorphology). All identified barriers will be ranked according to the risk they pose to fish migration and other important geographical and hydrological variables. Consideration has to be taken as to the type of mitigation carried out on barriers, such as complete removal or easement (i.e. installation of fish pass). Prioritisation of barriers will provide an objective framework for decision-making that hopes to achieve maximum benefit given available resources.

The aims of the project in regard to fish passage issues are as follows:

- Ranking of fish passage with selection of up to 6 locations across the three catchments.
- Modification of barriers to fish and invertebrate passage and to allow natural river bed material transport will create a more natural hydromorphology.

- The works programmes must be compliant with statutory obligations of the Rivers Agency (N.I.) and the Office of Public Works (RoI). Current environmental protocols for channel maintenance implemented by both bodies would be included as actions with this activity. The Scoping exercise will also take into account existing preparatory works.

A2 Methods for Barrier Identification and Assessment

A2.1 Identify locations of potential barriers

An IFI-developed desk study tool was used to identify locations of 'potential barriers'. A significant number of barriers to fish migration are caused by bridge aprons, fords and other river crossings. Using Geographical Information System, locations of road-river interceptions throughout the catchments were identified. Information on the location of weirs, damns and sluices etc. were obtained from a number of sources including IFI's National Barriers Programme, ABC, historical maps and local knowledge. An inventory of potential barriers was produced by merging the data sets. In total, 274 potential barriers were identified in the Arney and 1637 in the Blackwater.

Follow up site surveys were carried out to examine all potential barriers and to measure and record all actual barriers. To rationalise the number of visits to potential barriers, prioritisation was given to waterbodies with moderate or poor WFD status. Prioritisation was also given to higher impact areas namely the main channels and larger tributaries of waterbodies as barriers in these areas are likely to have an increased effect on the overall system. All potential barrier locations are visited for presence/absence of passage issues. Assessments of identified barriers are carried out when a structure is deemed to be a barrier, i.e. drop height over 0.1m, water depth through structure under 0.15m.

A2.2 Assessment of identified barriers

IFI (National Barriers Programme) has developed a field survey barrier assessment form, in line with EU best practice, to capture information on barrier location, type and dimensions in order to assess the risk to fish species. A digitised version of this form is currently used by IFI, loaded onto tablets and mobile phones. This form is used as a Level 1 assessment measure to find, locate and assess barriers.

The barrier measuring followed the IFI-developed survey protocol with geo-referencing of site, photolog, measurement of specific elements and "expert opinion" on passability of the structure for specific fish species, in conditions prevailing at time of survey.

- Georeferencing of site – A waypoint is captured using phones/tablets GPS.
- Photolog – capture a range of photos of barrier structure including a scale reference.
- Type of barrier
    - Barrier type – e.g. Ford, culvert, weir etc.
    - Barrier material – e.g. concrete, masonry, steel etc.
- Measurement of specific elements.
    - Width (m) – the width of barrier across channel.
    - Length (m) – the length of barrier measured longitudinally.

- Hydraulic head/ drop height (m) – the height the water drops from top of barrier.
- Slope (%) – Hydraulic head / Length = Slope(%)
- Depth through structure (m) – Depth of water through barrier structure.
- Plunge pool depth (m) - The depth of the pool directly downstream of the barrier.
- Downstream depth (m) – depth of river downstream beyond the influence of the barrier.
- Downstream width (m) – width of river downstream beyond the influence of the barrier.
- Turbulence (opinion) – Turbulence of water expressed by low, medium or high.
- Standing wave (opinion) – Standing wave expressed by small, medium, and large.
- Length of impoundment (m) – Length of river impounded upstream of structure.

- Expert opinion on passability. – Use values recorded of specific elements to judge the barrier risk for each fish species/group. Barrier risk is categorised as none, low, medium, high and impassable. A 'rule of thumb' guide for barrier risk is used by assessors in the field.

Table 7-1 Showing 'rule of thumb' for expert opinion on barrier risk

Species/Group	Hydraulic head		Water depth		Effective length	
	Barrier	Complete barrier	Barrier	Complete barrier	Barrier	Complete barrier
Adult Salmonids	>0.6m	>1.4m	<0.15m	<0.06m	>10m	>100m
Juvenile Salmonids	>0.1m	>0.35m	<0.08m	<0.03m	>3m	>20m
Cyprinids	>0.1m	>0.25m	<0.1m	<0.05m	>1m	>20m
Lamprey	>0.15m	>0.3m	<0.08m	<0.03m	>3m	>50m

From this dataset, an inventory of barriers has been developed and examined to prioritise barriers for mitigation.

A3 Assess Individually

The process of identification has generated a listing of locations with barrier issues derived from the scoping phase surveys.

The overall initial process has generated data as per Table 7-3,Table 7-3,Table 7-4:

Table 7-2. Barriers identified, surveyed and assessed in the Finn catchment.

Waterbody	Potential barriers surveyed/visited (Overall no. of potential barriers)	Identified barriers to migration
Burn Daurnett_010	*(37)	10
Cummirk_010	*(3)	2
Cummirk_020	*(15)	3
Crossroads Stream_010	*(12)	2
Clogher(Finn)_010	*(4)	2
Dresnagh_010	*(8)	5
Elatagh_010	*(2)	0
Elatagh_020	*(16)	10
Finn(Donegal)_010	*(34)	9
Finn(Donegal_020	*(13)	0
Finn(Donegal)_030	*(23)	4
Finn(Donegal)_040	*(39)	13
Finn(Donegal)_050	*(17)	8
Finn(Donegal_060	*(26)	8
Finn(Donegal)_070	*(37)	11
Finn(Donegal)_080	*(64)	20
Reelan_010	*(25)	2
Reelan_020	*(20)	0
Rough Burn_010	*(6)	2
Stranagoppoge_010	*(21)	0
No Data	*(25)	20

*Technical difficulties meant that it was difficult to ascertain the exact numbers of potential barriers surveyed.

Table 7-3. Showing barriers identified, surveyed and assessed in the Arney catchment.

Waterbody	Potential barriers surveyed/visited (overall no. of potential barriers)	Identified barriers to migration
Arney River	77 (84)	7
Belcoo River	33 (41)	0
Black River	11 (21)	0
Cornavannoge_010	35(35)	7
Cornavannoge_020	26 (26)	5
Drumharriff Burn	55 (55)	6
Roo_010	12 (12)	1

Table 7-4. Showing barriers identified, surveyed and assessed in the Blackwater catchment.

Waterbody	Potential barriers surveyed/ visited (overall no. of potential barriers)	Identified barriers to migration
Ballygawley Water	81 (83)	22
Ballymacone River	2 (20)	1
Ballymatrim	10 (54)	0
Blackwater (Monaghan)_010	0 (23)	0
Blackwater (Monaghan)_020	2 (11)	1
Blackwater (Monaghan)_030	11 (91)	5
Blackwater (Monaghan)_040	21 (50)	6
Callan (Derryscollop)	23 (76)	2
Callan (Milford)	12 (28)	2
Callan (Tassagh)	12 (33)	2
Clontibret Stream_010	26 (39)	5
Clontibret Stream_020	26 (36)	5
Clontibret Stream_030	31 (35)	3
Conawary (Lower)_010	0(22)	0
Conawary (Lower)_020	14 (43)	4
Cor River	24 (24)	3
Cor River Tributary	17 (17)	3
Lisavargy_010	7 (34)	1
Magherarney_010	0 (33)	0
Mountain water_030	2(21)	1
Mountain water_040	5 (20)	5
Mountain water_050	50(70)	3
Mountain water_060	18 (24)	0
Mullamurphy_010	109 (119)	11
Oona (Eglish)	109 (109)	10
Oona (Kilmaddy)	33 (68)	4
River Blackwater (Annaghroe)	75 (156)	12
River Blackwater (Augher)	78 (93)	7
River Blackwater Tributary (Aughnacloy)	24(24)	1
River Rhone (Dungannon)	15 (44)	3
Shambles_010	22 (37)	3
Tamnamore Stream	6 (17)	0
Tynan River	83 (83)	10

A4 Prioritise

Prioritisation helps ensure that the projects with the greatest benefits to fish are addressed first. It weighs the benefits to fish against considerations like project cost and stock status.
The identified barrier sites are weighted by a particular barrier score which gives a list of priority sites to carry out work on.

A4.1 Method for barrier prioritisation

The short-listing aims to identify locations where the greatest hydromorphological impact will occur as a result of the proposed works. Each structure is scored on a scale of 1 (smallest potential benefits following mitigation) to 4 (greatest potential benefits following mitigation).All the parameters were scored on a scale and converted to ratio to ensure that each was given equal weight in the prioritization process.

Prioritisation (*P*) is calculated by:

$$P = O + L + R + S$$

Where O = Stream order expressed as a value between 0 and 1,

L = Length of habitat connectivity expressed as a value between 0 and 1,

R = Risk or passability of barrier expressed as a value between 0 and 1,

S = Presence of Salmonids downstream expressed as a value between 0 and 1.

Score for prioritisation is based on the following parameters:

1. **Stream Order**.
   In order to express the effect a barrier may have on an overall catchment, it is necessary to evaluate the influence of the location of the barrier. Larger rivers such as the main channel and larger tributaries are likely to have a greater impact on fish passage in contrast to smaller headwaters. An appropriate measurement of cross sectional area is Stream Order. The Stream Order is expressed in values 1-6, where 1 (or first-order) indicates a small headwater stream and the largest stream order 6, indicates a main channel in this case.
   Note: Stream order is expressed as 1-5 in the Arney catchment as the largest stream order in that system is classed as a fifth order stream. In the Blackwater stream order ranges from 1-6.

2. **Length of reconnected channel/ Habitat quantity**.
   Prioritisation of mitigation of barriers requires an assessment of the potential benefits gained from removal of barriers. Length of channel to benefit or habitat connectivity is assessed to express the length of undisturbed channel that will remain when a barrier is removed. When measuring habitat connectivity for a barrier, distance to the next upstream barrier and distance to the next downstream barrier is measured and

combined. The measurement intends to express the potential for unimpeded river passage should the barrier be removed.
There are four class boundaries for each catchment and each has been adjusted for the size of the catchment in question.

The Finn Catchment covers an area of approximately 494 km^2, the Arney catchment covers an area of approximately 300 km^2 and the Blackwater catchment comprises an area of approximately 1,500 km^2. The class boundaries have been set out as follows:

Table 7-5 Showing class boundaries for length of habitat reconnection for each catchment

Arney catchment	Blackwater catchment	Finn Catchment	Habitat quantity Score
<1km	<2km	< 1 km	0
1 – 2km	2-4km	1-2 km	1
2 – 3km	4-6km	2-3 km	2
>3km	>6km	>4 km	3

3. **Passability of barrier to fish.**
Barrier passability is assessed by means of 'expert opinion', meaning that a value is given to the risk of the barrier relevant to a range of species and age classes. The values assigned to risk level are as follows; None, Low, Medium, High or Impassable. When assessing possibility a number of factors have to be considered such as depth of water through structure, hydraulic height and length of barrier. For example a barrier may be considered impassable to Cyprinids if the hydraulic height is greater than 0.25m, however it would be classed as no risk to adult Salmonids. Based on the combined risk for fish passage, each barrier has been given a score of 1-4.

Table 7-6. Showing barrier passability score in relation to risk associated to fish passage.

Attribute	Passability Score
Total barrier - A barrier to all species and age classes, heading upstream and downstream.	4
High impact partial barrier - A barrier to all species and age classes heading upstream only.	3
Medium impact partial barrier - A barrier to all species except adult salmonids.	2
Low impact partial barrier - A barrier to all coarse fish and lamprey.	1
No barrier	0

4. **Presence of Salmonids downstream of barrier.**
The presence of Salmonids is an important factor when deciding whether a barrier should be removed. Atlantic Salmon *Salmo salar* (Annex II species) and Trout *Salmo trutta* are indicative of a healthy ecosystem as they are less tolerable to pollution and hydromorphological pressures. Salmon and Sea Trout are diadromous fish which travel

from the sea up to freshwater for spawning, therefore presence of these species should be considered when prioritising barriers. The number of age classes (i.e. fry, parr, adult) is also taken into account as a higher number of age classes indicate a larger range of habitats not only for Salmonids but for other plant and animal species. Using electrofishing data, presence of Salmonids is expressed as 0-2, taking into account the range of age classes present. Presence/absence is measured to the next barrier downstream.

Table 7-7. Showing barrier score in relation to Salmonid age classes.

Attribute	Score
Presence of 2+ age classes.	2
Presence of 1 age class.	1
Absence of salmonid species.	0

Additional factors to take into consideration when making a final decision.

- Opportunities to work with OPW and/or DFI Rivers, where barriers (i.e. culverts) are in disrepair and require maintenance. In such cases, Catchment CARE can advise to benefit fish passage/barriers mitigation.
- Distribution of sites 'politically' and topographically i.e. sites require to be selected in all 3 catchments (Finn, Arney, Blackwater); sites need to be selected in both political jurisdictions; sites need to be selected in a number of waterbodies.
- Presence of Salmonid age classes upstream of a barrier.
- Waterbody status. Areas in moderate WFD status will be prioritised.
- Impoundment. Length of impoundment caused by barrier.
- Water quality- i.e. it is more beneficial to open up a good water quality/habitats to encourage for movement of species.
- Cost – Benefit.
- Mitigation based on a number of consecutive barriers to increase positive results.
- Consideration of high flood risk areas.

Extrapolation from individual or isolated 'Point-locations' of surveying has been undertaken via extended walk-over surveys of relevant partners (e.g. IFI and ABC in Blackwater) and via accessing expert opinion – again leading to extended site explorations

A5 Results

A5.1 Finn

In total, 133 barriers were identified and assessed within the Finn catchment area.

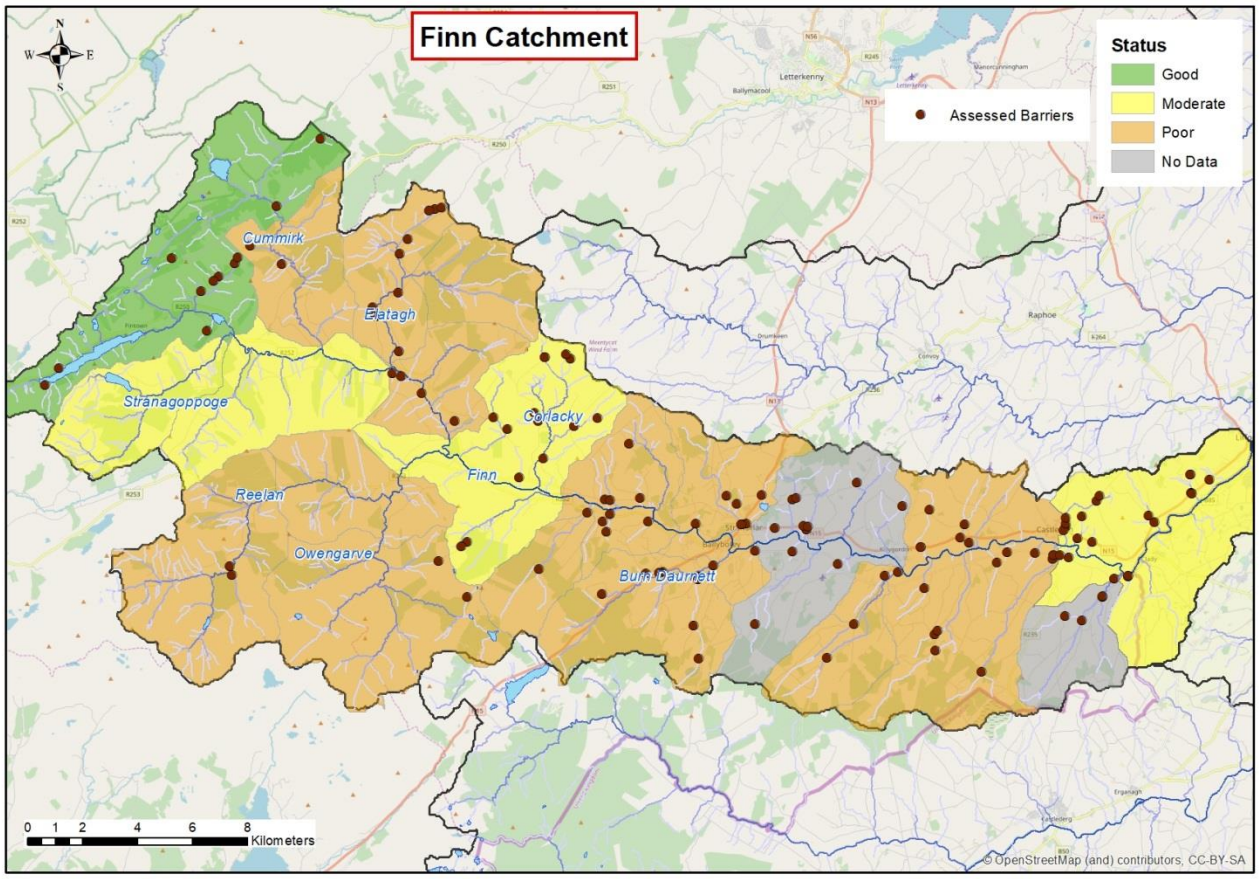


Figure 7-1, Surveyed and assessed barriers in the Finn catchment.

Each barrier was given a prioritisation score ranging from 0 to 4 after considering four criteria which included Stream order, length of reconnection, possibility and presence of salmonids downstream. After calculating the potential impact of barriers assessed, the highest scoring 10% of barriers were shortlisted for further investigation to determine the practicality of removal/mitigation. For the Finn catchment area there were 12 priority sites identified for investigation for barrier removal or mitigation procedures.

Table 7-8, Top 10% priority assessed barriers for improvement works.

Barrier Code	Waterbody	Structure	Score
01_1002_214	Finn(Donegal)_070	Rock/Bedrock barrier	3.17
Rough Burn	Rough Burn_010	Culvert	2.83
01_1183_0	Finn(Donegal)_040	Culvert	2.50
01_818_10	Finn(Donegal)_060	Road (T-Junction)	2.50
01_633_52	Unassigned	Culvert	2.33
Crossroads_001	Finn(Donegal)_080	Weir	2.33

Barrier Code	Waterbody	Structure	Score
01_1185_7	Finn(Donegal)_040	Culvert	2.25
Reelan_Pipes	Reelan_010	Culvert	1.92
01_038_193	Finn(Donegal)_080	Rock/Bedrock	1.67
01_1403_21	Finn(Donegal)_030	Culvert	1.42
01_1788	Finn(Donegal)_080	Rock/Bedrock	1.42
Effernagh_001	Reelan_010	Culvert	1.33

Follow up investigations of the sites listed in Table 7-8 resulted in a shortlist of four barriers which are considered prime candidates for removal or mitigation procedures. These sites are listed in

Table 7-9. The Rough Burn has been selected for site improvement works based on the Lough's Agency historical knowledge of the site, conversations with Loughs Agency fishery inspectors and conversations with the landowner. This site was selected as one of the 'win-win' options (also selected was an area of the Cummirk River for riparian and instream works) prior to carrying out the scoping phase of the project. Further investigations of the site resulted in a moderate RHAT score due to poor riparian land use on both banks due to anthropogenic influences. The target barrier is comprised of a concrete pipe culvert which is collapsing under the weight of boulders above it, which were placed as a makeshift crossing of the river. The culvert has a significant drop height on the downstream side and acts as a sediment and debris trap on the upstream side, particularly during periods of high flow. The significant narrowing of the stream at the pipe culvert has also led to the river breaking its banks and cutting a path around the structure during times of high flow.

Crossroads_001 was identified for potential mitigation due to its priority score of 2.33 in combination with a catchment status of moderate. The RHAT score for this site gave further justification for selecting this site for potential mitigation measures. The site had a moderate RHAT score and conditions highlighted during the survey included; overgrown riparian vegetation on both banks (including substantial amounts of invasive species), significant amounts of silt within the area and a significant barrier which seemed to be the remnants of an old ford. In combination, the above mentioned data strengthens the decision to implement improvements within Crossroads_001.

2018 WFD Ecological Status lists both the Reelin_Pipes (Reelin_010) and Reelin_020 as 'Poor' in quality. It is believed this is partially due to the discontinuity created by the Reelan pipes structure which is a barrier to migrating fish. Works in this area will aid in the improvement of the habitat suitability and availability for the Reelin_020 sub-catchment and will have a positive effect on its WFD ecological status. This site also achieved a moderate RHAT score as it is a significant barrier in low flow whilst also causing the retention of sediment on the upstream side of the structure. These factors led to the identification of this side as in need for removal/ mitigation works.

Similarly, the Effernagh_001 is also situated above the Reelan Pipes and the area holds a 'Poor' catchment status designation. Removal/ mitigation of this site will further increase habitat suitability for the Reelan_020 area and will help improve its WFD ecological status of poor. This site is upstream from the Reelan_Pipes and therefore improvement works in this area will open up further habitat connectivity of the Reelan River within the Finn catchment area.

Table 7-9, Top four barrier sites for removal/mitigation procedures

Barrier Code	Water body	Structure	Score
Rough Burn	Rough Burn_010	Culvert	2.83
Crossroads_001	Finn(Donegal)_080	Weir	2.33
Reelan_Pipes	Reelan_010	Culvert	1.92
Effernagh_001	Reelan_010	Culvert	1.33

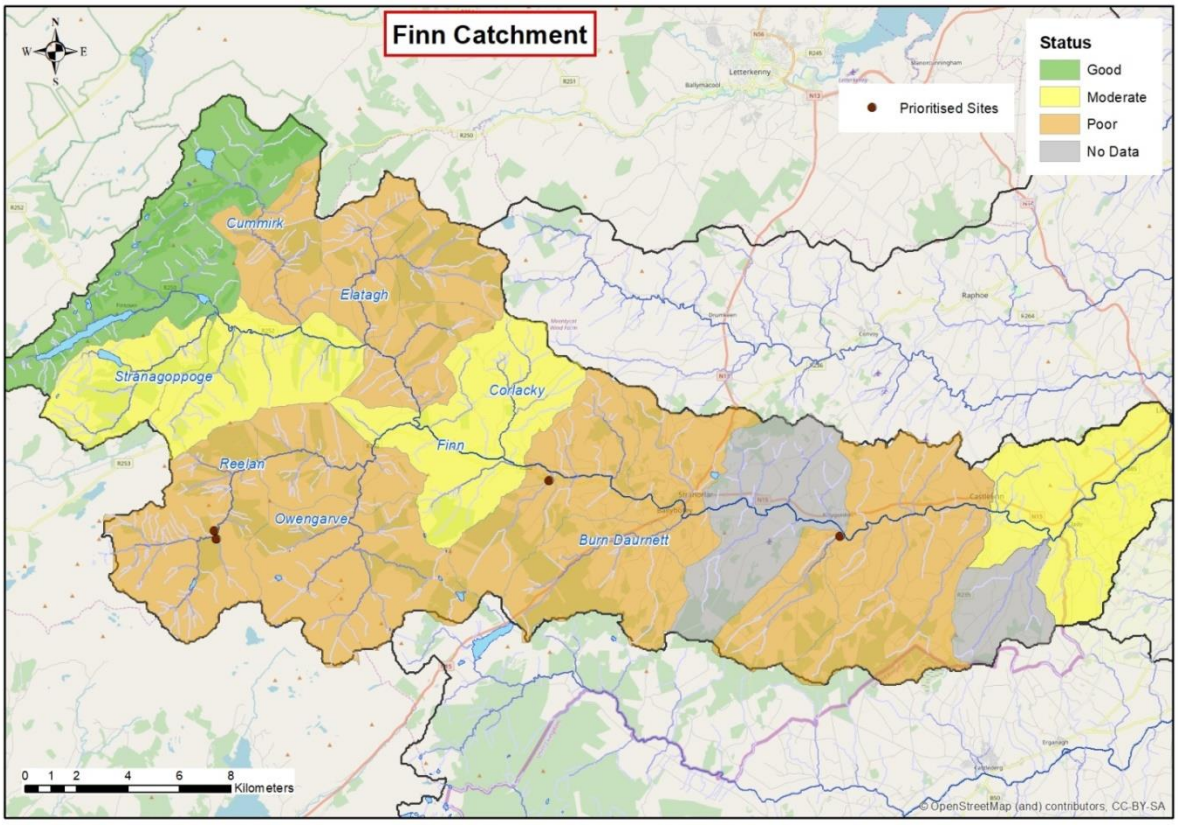


Figure 7-2: Location of prioritised barriers in the Finn Catchment

A5.1.1 Finn prioritised barriers

Barrier Code	Crossroads Stream_001
Easting	34452
Northing	558702
Barrier Issue	This is a significant barrier in low flow. During survey it was preventing the movement of fish up or downstream. Formerly a crossing ford.
Proposal	Creating either a fish pass or a staggered step pool system for fish movement upstream.

Barrier Code	Rough Burn_001
Easting	23824
Northing	561795
Barrier Issue	This pipe culvert is collapsing in three places. It will eventually cave in. The structure regularly creates a debris dam forcing the burn to cut a new path through the field on the right hand bank looking upstream, depositing boulders, cobbles and gravels which would be prime fish habitat which the Rough Burn is sorely lacking.
Proposal	Removal of current structure and replacing with a clear span bridge. Riparian fencing and some in-stream works are possible to ensure livestock do not have access to the burn.

Barrier Code	Reelan_Pipes
Easting	10673
Northing	560970
Barrier Issue	A barrier in low flow which restricts the movement of salmonids upstream and prevents the movement of gravels and spawning materials downstream. It is a wide open area which allows for predation.
Proposal	Replace barrier with double or triple box culvert. Plant native broadleaf trees and install livestock and flood proof fencing.

Barrier Code	Effernagh_001
Easting	10725
Northing	560650
Barrier Issue	A smaller version of the Reelan pipes. This small stretch of the Effernagh has significant hard engineering on the left hand bank looking upstream with a small pipe culvert used as a crossing to the forestry. This is a barrier in low flow.
Proposal	Replace the barrier with a box culvert and regrade the river and potentially replace the hard engineering on the left hand bank looking upstream.

A5.2 Arney

In total, 29 barriers were identified and assessed in the Arney catchment.

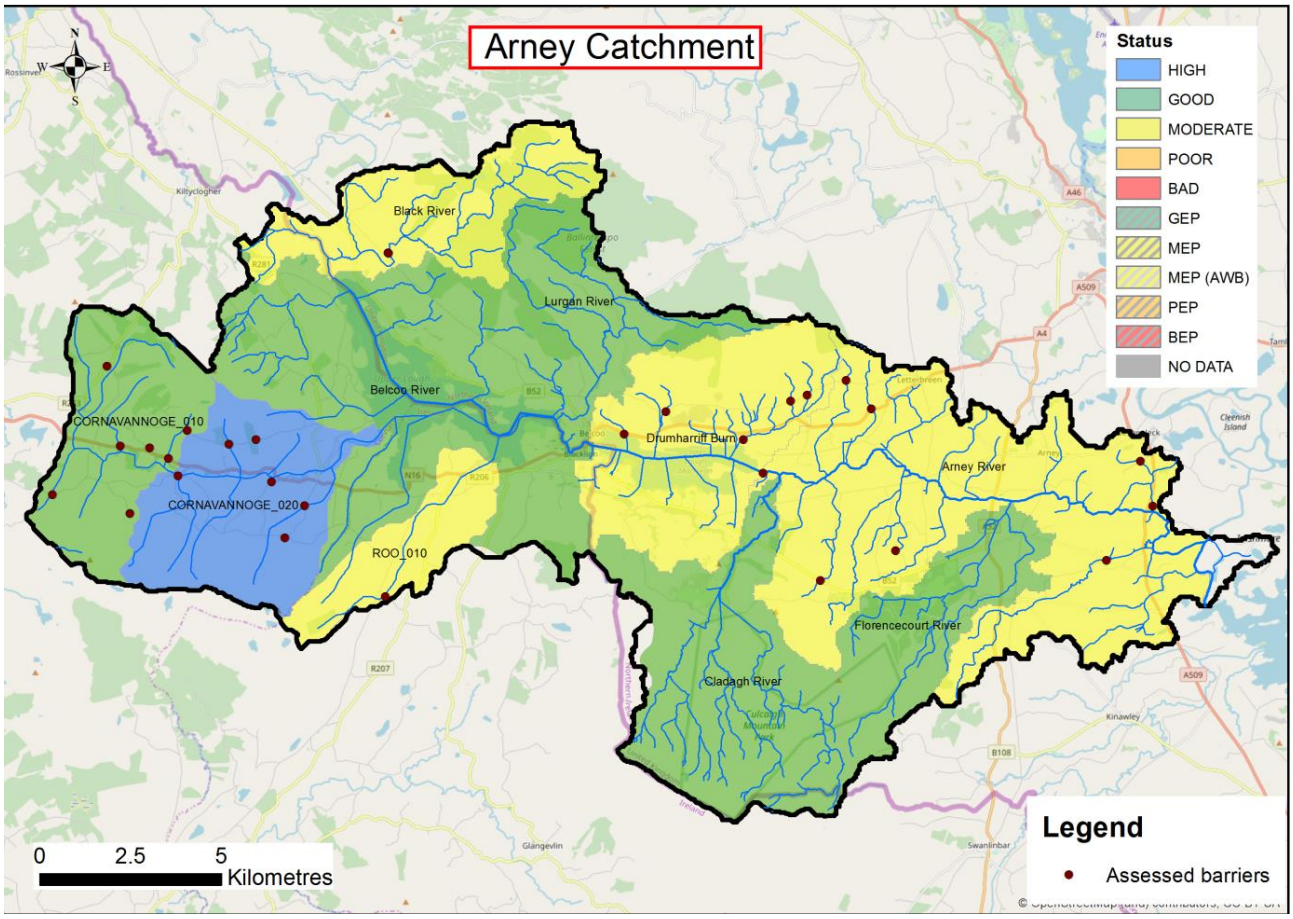


Figure 7-3. Assessed barriers in the Arney catchment.

Each barrier was given a 'prioritisation score' considering four criteria (Stream order, length of reconnection, possibility, presence of salmonids downstream). Barriers located in High and Good WFD status sub-catchments were removed as works will be focused on Moderate or Poor Status sub- catchments. After applying scores to represent the impact of the barrier, the highest scoring 10% of assessed barriers have been chosen to investigate further and to assess the feasibility of removal/mitigation.

Table 7-10. List of prioritised barriers.

Barrier code	Waterbody	Structure	Score
58_IS_01	Drumharriff Burn	Bridge	3.3
62_RR_46	Arney River	Bridge apron	1.9
62_RR_6	Arney River	Culvert	1.7
62_RR_27	Arney River	Culvert	1.7
58_IS_02	Drumharriff Burn	Weir	1.4

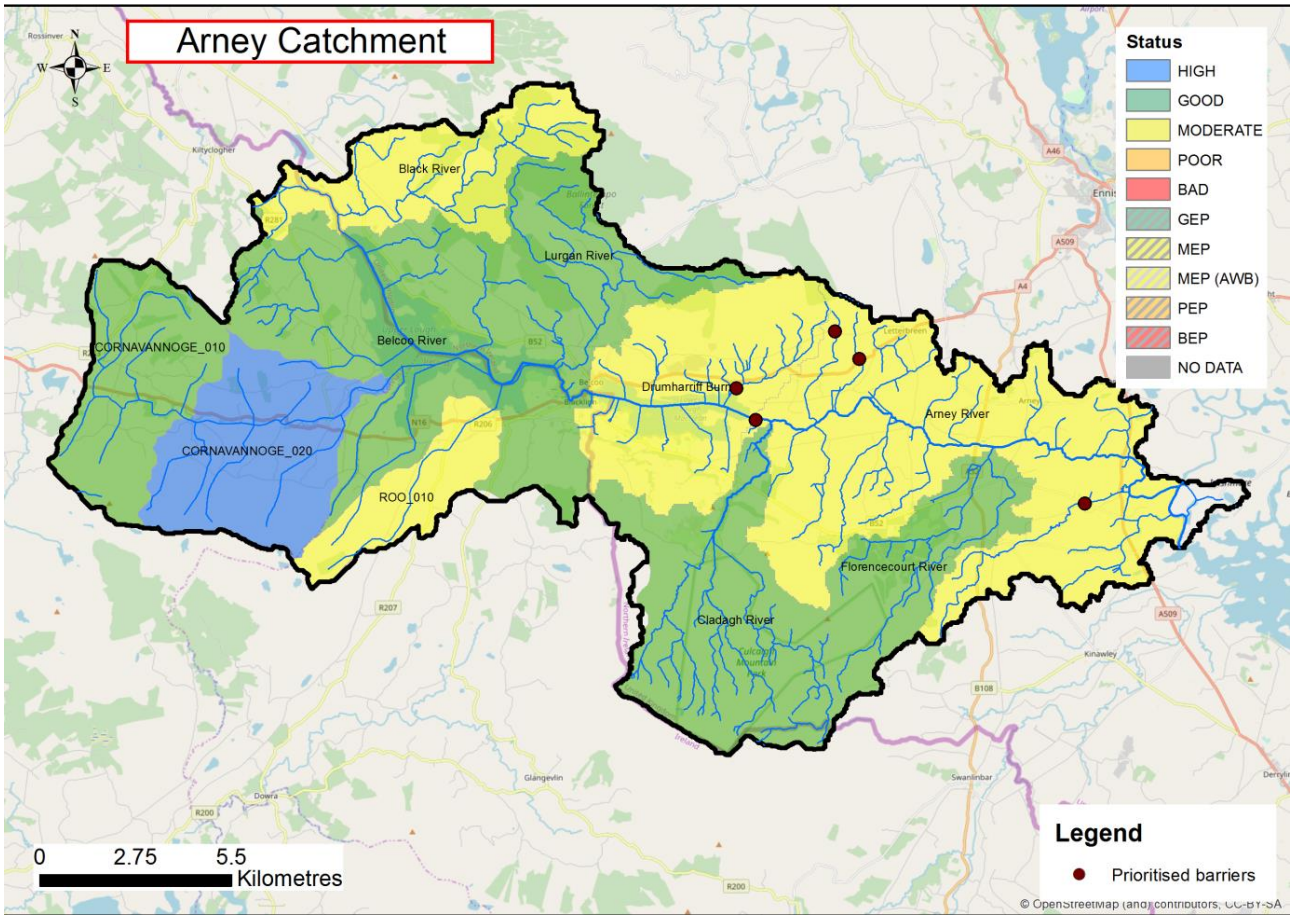
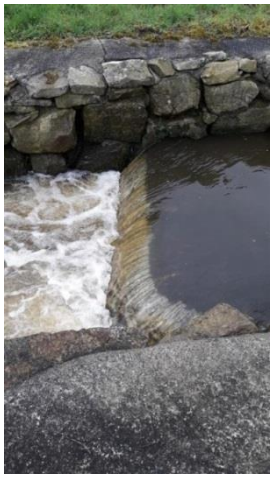


Figure 7-4. Locations of prioritised barriers in the Arney catchment.

A5.2.1 Arney prioritised barriers

Barrier code	**58_IS_01**
Easting	612960
Northing	837702
Barrier issue	Barrier located on Arney main channel at outflow of Lower Lough Macnean, therefore having a high influence on fish passage to the upper part of the catchment.
Proposal	Replace in-stream structure with a clear-span bridge crossing.

Barrier code	**58_IS_02**
Easting	612521
Northing	838487
Barrier issue	Hydraulic head/drop height 0.25m making it a barrier for cyprinids.
Proposal	



Barrier code	**62_RR_46**
Easting	622505
Northing	835178
Barrier issue	Hydraulic head/ drop height over 0.15m. A barrier to cyprinids. Located in tributary.
Proposal	Cut notches in bridge apron and downstream barrier.

Barrier code	**62_RR_6**
Easting	615361
Northing	840122
Barrier issue	Extremely high hydraulic head. Located far up a tributary meaning a lower priority.
Proposal	

Barrier code	**62_RR_27**
Easting	616046
Northing	839330
Barrier issue	Hydraulic head / drop height 0.2m making it a barrier for cyprinids.
Proposal	

A5.3 Blackwater

In total, 115 barriers have been identified and assessed in the Blackwater catchment.

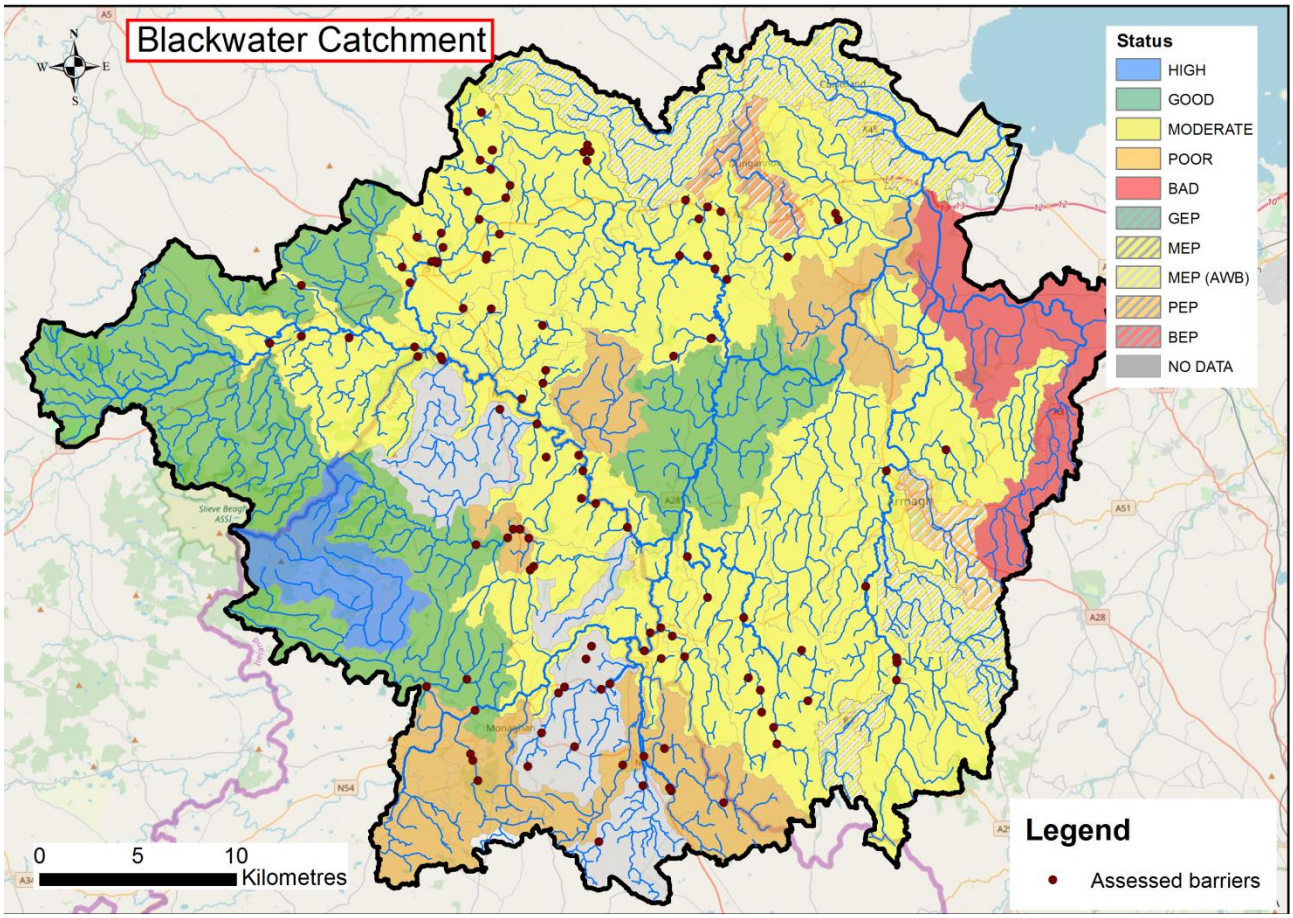


Figure 7-5. Locations of assessed barriers in the Blackwater catchment.

After applying scores to represent the impact of the barrier, the highest scoring 10% of assessed barriers have been chosen to investigate further and to assess the feasibility of removal/mitigation.

Table 7-11. List of prioritised barriers in the Blackwater catchment.

Barrier code	Water body	Structure	Score
74_IS_104	Oona Water (Eglish)	Weir	3.67
03_425_131	Cor River	Ford	3.58
50_IS_85	River Blackwater (Augher)	Weir	3.17
48_IS_55	River Blackwater (Annaghroe)	Weir/ Horseshoe groyne.	3.08
78_RR_4	Callan River (Derryscollop)	Weir/ Road bridge.	3.08
64_IS_77	Ballygawley Water	Weir	3.08
74_RR_47	Oona Water (Eglish)	Culvert	3.08
64_IS_07	Ballygawley Water	Weir	3.00
80_IS_01	Tynan River	Ford	2.92
50_IS_71	River Blackwater (Augher)	Weir	2.92
64_IS_70	Ballygawley Water	Weir	2.75

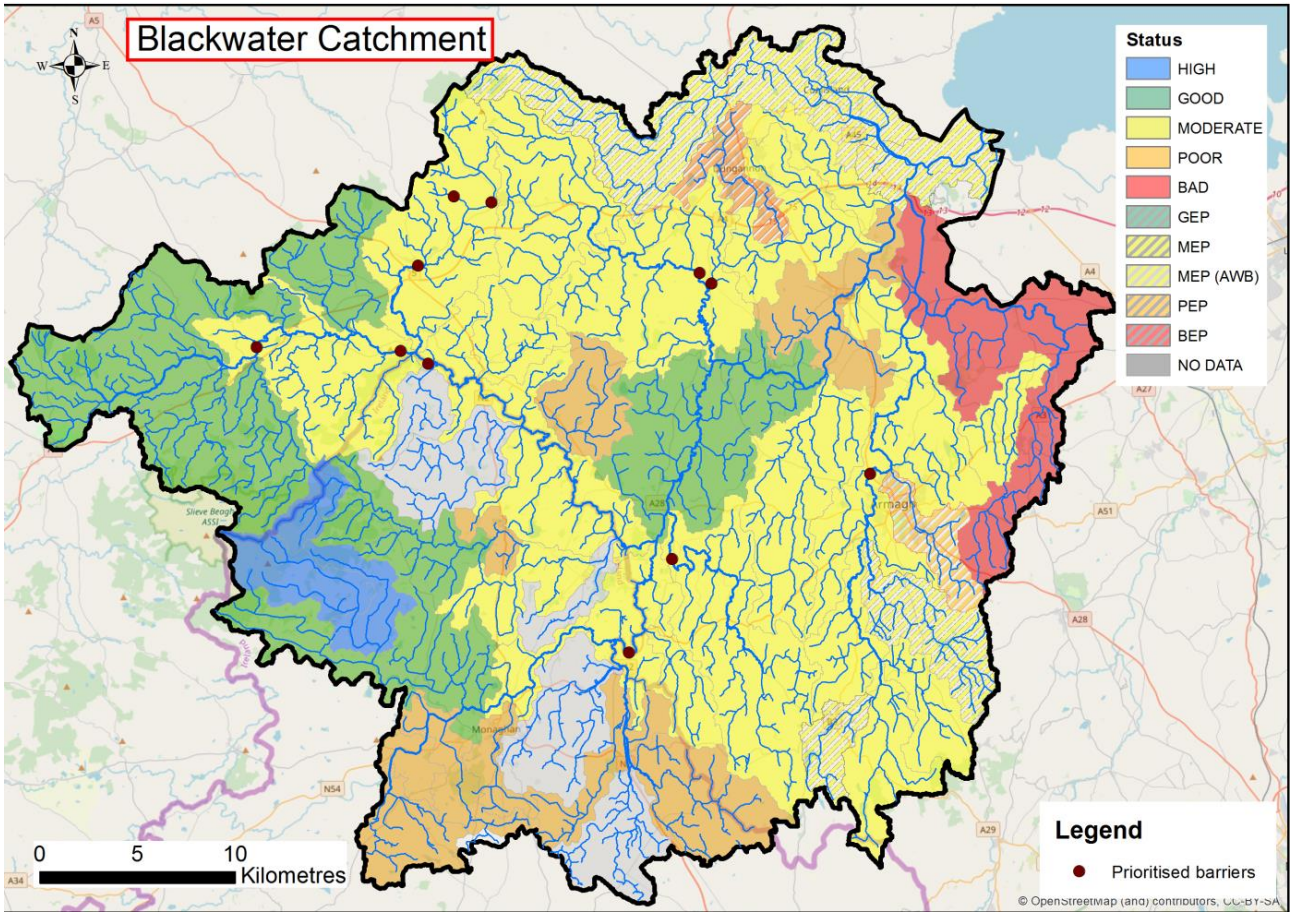


Figure 7-6. Locations of prioritised barriers in the Blackwater catchment.

A5.3.1 Blackwater prioritised barriers

Barrier code	**74_IS_104**
Easting	677588
Northing	857038
Barrier issue	An old disused weir which is a barrier for height and is impassable by all species heading upstream except elver.
Proposal	

Barrier code	**03_425_131 (51_IS_01)**
Easting	673988
Northing	837599
Barrier issue	A ford on the main channel of the Cor which is a barrier for height and water through structure.
Proposal	Replace ford with a clear span bridge.

Barrier code	**50_IS_85**
Easting	654904
Northing	853246
Barrier issue	A disused weir which is a barrier to most fish except adult salmonids and elvers. This weir has a large length of impoundment upstream.
Proposal	Remove completely.

Barrier code	**48_IS_55**
Easting	663684
Northing	852398
Barrier issue	A minor barrier for hydraulic height, however it is located on the main channel of the blackwater giving it a greater influence on species richness.
Proposal	Cut notches in weir.

Barrier code	**78_RR_4**
Easting	686317
Northing	846757
Barrier issue	A minor barrier for hydraulic height, however it is located on the main channel of the Callan river giving it a greater influence on species richness.
Proposal	Cut notches in weir/ bridge apron. However, any works may have adverse effect on road bridge.

Barrier code	**64_IS_77**
Easting	664985
Northing	860977
Barrier issue	A barrier for extremely high hydraulic head. A large amount of impoundment is noticeable upstream of barrier.
Proposal	

Barrier code	**74_RR_47**
Easting	670190
Northing	856502
Barrier issue	This barrier is considered impassable to all species due to it's length of 250m. The barrier extends across the main road in Eglish town.
Proposal	

Barrier code	**64_IS_07**
Easting	666915
Northing	860668
Barrier issue	A barrier for height on the main channel of the Ballygawley water. A clear span farm bridge is directly upstream of this barrier. Coincidently an area that has also been historically straightened.
Proposal	Remove barrier completely .

Barrier code	**64_IS_70**
Easting	
Northing	
Barrier issue	
Proposal	

Appendix B. Ranking of Riverine Reaches for Habitat Improvement and Riparian Works.

WP T1: Scoping and Action Targeting

T1.2 Rivers: prioritizing habitat improvement

Deliverables T1.2.3 & T1.3.1 – T1.3.4: Ranking of Riverine Reaches for Habitat Improvement & Ranking of Riverine Reaches for Riparian Works

JULY 2019

B1 Introduction

Rivers are among the most important environments in the UK and Republic of Ireland and they support a high diversity of habitats and wildlife. River habitat includes in-stream and terrestrial riparian areas, and can often change over short distances and timescales. The dynamics and diversity of rivers mean that they are of high conservation value and have been protected by national and international laws such as the EU Water Framework Directive.

Human interference and influence has negatively affected rivers and their habitats, especially in recent years. The intensification of industry and alteration of river courses has homogenised river habitats resulting in uniform, less resilient ecosystems. River habitats are subject to a range of pressures such as pollution, invasive species and physical alteration. Physical alterations such as dredging, channelization, flood embankment and alteration of flows are now recognized as having a significant impact on river habitats and therefore water quality (Addy *et al.*, 2016).

Conservation and restoration of river habitats is paramount for maintaining natural processes of rivers. Restoration actions aim to restore river biodiversity and conserve ecosystem services such as the provision of clean drinking water and the natural management of flood risk. Current river restoration principals promote the idea of encouraging natural processes to create characteristic, self-sustaining, dynamic physical habitat that induces biological recovery (Brookes *et al*., 1996).

The aim of the Catchment CARE INTERREG project is to establish 3 water quality improvement projects in 3 cross-border catchments between the Republic of Ireland and Northern Ireland: the Arney, Blackwater and Finn Catchments. As specified in the CatchmentCARE project description, this task **T1.2 Ranking of Riverine Reaches for Habitat Improvement** is integrally linked to task **T1.3 Ranking of Riverine Reaches for Riparian Works.**

B1.1 Identification of habitat degradation issues.

B1.1.1 In-stream

To implement effective hydromorphology measures it is necessary to have some understanding of both the biological and morphological (physical) conditions in any river or stream. In their hydromorphology role for prioritising in-stream and riparian works within the CatchmentCARE project, Inland Fisheries Ireland and the Loughs Agency developed a knowledge base of both the biological and physical elements of the three catchments. Typical issues which effect in-stream habitats include channelisation and drainage of rivers.

Channelisation involves straightening and deepening of rivers to aid navigation and improve drainage of agricultural land. These rivers have uniform shapes and lack the diversity of flows and depths needed to sustain varied habitat for flora and fauna. Channelisation also results in disconnect of rivers from their floodplains reducing the exchange of water, nutrients and matter between water and land. Straightened and deepened channels therefore retain most of the water in the channel which increases flow and often results in flooding downstream.

Dredging of rivers has an immediate impact on rivers by removing adequate substrate and altering habitat for plant, invertebrate and fish communities. Destabilised river beds often increase fine sediment loads resulting in siltation of substrates downstream which covers spawning habitats for fish and deprives invertebrate communities of oxygen.

To address the issues, the aims of the CatchmentCARE project are as follows:

- Ranking of riverine reaches for habitat improvement, based on hydromorphology criteria (RHAT data).
- Identification of an appropriate monitoring strategy to assess water body status improvement.
- Agreed environmental protocol for maintenance work to be developed with Office of Public Works (Republic of Ireland) and Department for Infrastructure Rivers (Northern Ireland) for general implementation during river maintenance works.

B1.1.2 Riparian

The physical form (morphology) of the river includes both the in-stream components and the condition of the riparian zone and they both are integral parts of the river corridor. The riparian zone consists of the bank slope, bank top or bankfull level and the immediate floodplain area adjoining the top of the bank. This zone is dry in medium to low flows and can carry growth of tall emergent plants, terrestrial vegetation as well as bushes and trees.

The different stratums of the vegetation cover (herbs, shrubs, trees) help to stabilise the bank and provide a range of habitats used by river corridor birds and mammals (bats and otters). The riparian vegetation provides potential for a buffer zone to prevent excessive input of nutrients into the river from agricultural land as well as trapping carbon, providing leaf litter as a carbon source to in-stream animals for food, canopy providing shading and temperature control for in-stream organism, impending growth of excessive in-stream vegetation.

The bank condition can be damaged by poor land management practises – cultivating soil right up to the edge of the bank, allowing livestock ingress with trampling of banks. These practises can lead to the loss of riparian vegetation and bank instability, as well as substantial silt and nutrient inputs from runoff and direct faecal contamination (nutrients and pathogens) of the watercourse.

Management practises such as fencing and off-line drinker provision for livestock, development of tree lines, buffer strips and the addressing of man-made bank erosion situations can all safeguard good riparian condition and contribute to improved water body status.

The aims of the project in regard to issues in the riparian zone are as follows :

- Ranking of riparian habitat for bank stabilisation strategies based on hydromorphology criteria.
- Identification and ranking of cattle access points per catchment – to develop strategy for exclusion and installation of off-line drinkers.

- Ranking of riparian habitat for buffer strips based on the River Hydromorphology Assessment Technique (RHAT).
- Identification of areas for management of problem riparian tree/scrub cover.
- Identification of an appropriate monitoring strategy to assess water body status improvement.
- Agreed environmental protocol for maintenance work to be developed with Office of Public Works (Republic of Ireland) and Department for Infrastructure Rivers (Northern Ireland) for general implementation during river maintenance works.

B1.2 Potential improvement measures

B1.2.1 In-stream

There are many variations of habitat improvement measures and each should be appropriate to the river in question. Restoration techniques that encourage natural processes and help rivers to recover by themselves are recommended.

It must be also pointed out that actions under the “in-stream works” task are likely to be undertaken in tandem with actions under the “riparian works” task.

Habitat Improvement (Instream) measures:

- Removal of bank reinforcements – allows river to move laterally.
- Riffle pool sequence recovery – allow processes to occur naturally. Less likely in areas with low water velocities and high sediment. On certain occasions, trigger the process to start by digging a small pool/ placing deflectors to encourage diversity of water depth and velocities.
- Meander reconnection – allows connection to water, sediment, organic material and biota between river and floodplain. Reduces velocity of water and controls erosion downstream. Increases river length, longer retention time leads to less flooding downstream.
- Re-profile beds to more natural shape – create a two stage channel for low/high flows, excavate pools for variation of flows and depths.

It is considered prudent that all of the measures listed be undertaken in an appropriate setting i.e. no works should be undertaken that may impact buildings or infrastructure, as a general rule. Measures also need to be considered, in drainage-designated channels, in the context of conveyance/flood risk management and all measures in channels managed by DFI Rivers (NI) and by OPW (RoI) should be agreed with the relevant statutory body prior to any works. Measures should, clearly, be agreed with landowner(s) in advance. In some cases the measure will be a mix of riparian and instream works.

B1.2.2 Riparian

There are several measures that are relevant in regard to the improvement of hydromorphological conditions of the riparian zone; they have to be particularly appropriate for each channel section being examined – a one-size-fits-all approach is not appropriate, although many measures will find widespread use.

It must be also pointed out that actions under the "riparian works" task are likely to be undertaken in tandem with actions under the "instream" task.

One of the key views identified in the CatchmentCARE project is the complete exclusion of livestock from the channel. Therefore, the instream and riparian works (as composite 'packages') in the three catchments will include locations where livestock exclusion from channels is required. This implies complete fencing and provision of off-line water supply where excluding fencing has been installed. It is expected that this would eliminate the practise of cattle entering the water, even to a limited degree at the water's edge, and would require provision of alternative drinking facilities for livestock in the fields isolated from the river.

In areas where significant bank erosion is occurring, commonly as a result of previous channel straightening, bank modification can be undertaken to permit a degree of re-naturalisation, particularly where re-linkage to old meander locations has been identified. Measures to mitigate bank stability problems include elements of re-profiling, fencing and buffer strip planting of native deciduous tree cover.

Bank vegetation contributes to river habitat and bank stability. Tree cover is also considered to be valuable as a climate change measure in mitigating against river water temperature increase. The shading provided by tree cover combines with the value of trees in stabilising bank slopes and in provision of organics to the instream for food webs etc. to flag a major value of trees along water courses.

Tree planting and provision of buffer strips are measures that can be combined with other measures. Creation of buffer zones between fencing and top of bank can help with mitigation of nutrients entering water courses.

Riparian measures:

- Fencing for total exclusion of livestock from river and streams.
- Provision of off-line water supply where excluding fencing has been installed.
- Zero provision or agreement to cattle access points – exception for ford crossings where specific measures would be required on a site-by-site basis.
- Provision of buffer zones between fencing and top of bank –width to depend on agreement with landowner. In drainage-designated channel sections agreement MUST be reached with OPW (RoI) and DFI Rivers (NI) in regard to buffer width in order to allow for channel maintenance machinery to track the bank and access the channel.
- Riparian planting – use of native broadleaf trees, to include (a) planting of 'specimen' species e.g. oak, (b) planting of hawthorn in dense stands, (c) to allow for use of willow slips/stakes

for self-setting, (d) alder and birch planting as these are wet-adapted species and (e) allowing fenced sites to 'self-seed' with native trees.

- Riparian planting to be undertaken in a manner that provides optimal cover to the channel to permit thermal buffering i.e. trees planted to provide shade over the channel, from one bank only in drained and maintained channels.
- Management of tree cover to provide other benefits – thinning tree cover where this is substantial and use of the cut material for (a) bank protection (use of alder, willow, NOT hawthorn) and (b) to create low-level instream structures that would deflect low level flows, trap silt and permit natural river processes in impacted channels (use of alder, ash and other hardwoods or conifers, NOT willow or hawthorn).
- Bank re-profiling to create more natural and stable slopes.
- Removal of hard bank protection materials and replacement with fencing/planting and/or undertake 'soft-engineering' bank protection measures.
- Isolated use of 'hard –engineering' to protect banks in short channel sections should be an exception and NOT a norm – to view on a case-by-case basis.
- Where appropriately-sized side drains are entering a channel, and clearly draining a large area of the adjoining field, it may be an option to create a small 'constructed wetland' area to intercept nutrient and slow water release to the river, without impairing the drainage aspect of the side channel. Fencing of the 'wetland' and suitable planting regime to be undertaken, all with landowner agreement.

It is considered prudent that all of the measures listed be undertaken in an 'agricultural' setting i.e. no works should be undertaken adjacent to buildings or infrastructure, as a general rule. Measures also need to be considered, in drainage-designated channels, in the context of conveyance/flood risk management and all measures in channels managed by DFI Rivers (NI) and by OPW (RoI) should be developed in writing and agreed with the relevant statutory body prior to any works. Measures should, clearly, be agreed with landowner(s) in advance. In some cases the measure will be a mix of riparian and instream.

B2 Methods

The selection of river restoration sites required the development of a specific scientifically based methodology (Figure 7-7). This methodology implies the selection of water bodies in MODERATE status, combined with desk studies (including, among others, the analysis of the historical evolution of the hydromorphology, the current status according to the WFD reporting, and possible national and international designations), as well as complementary field surveys. Finally, once issues have been identified, proposals will focus on barrier removal/mitigation, in-stream and riparian works.

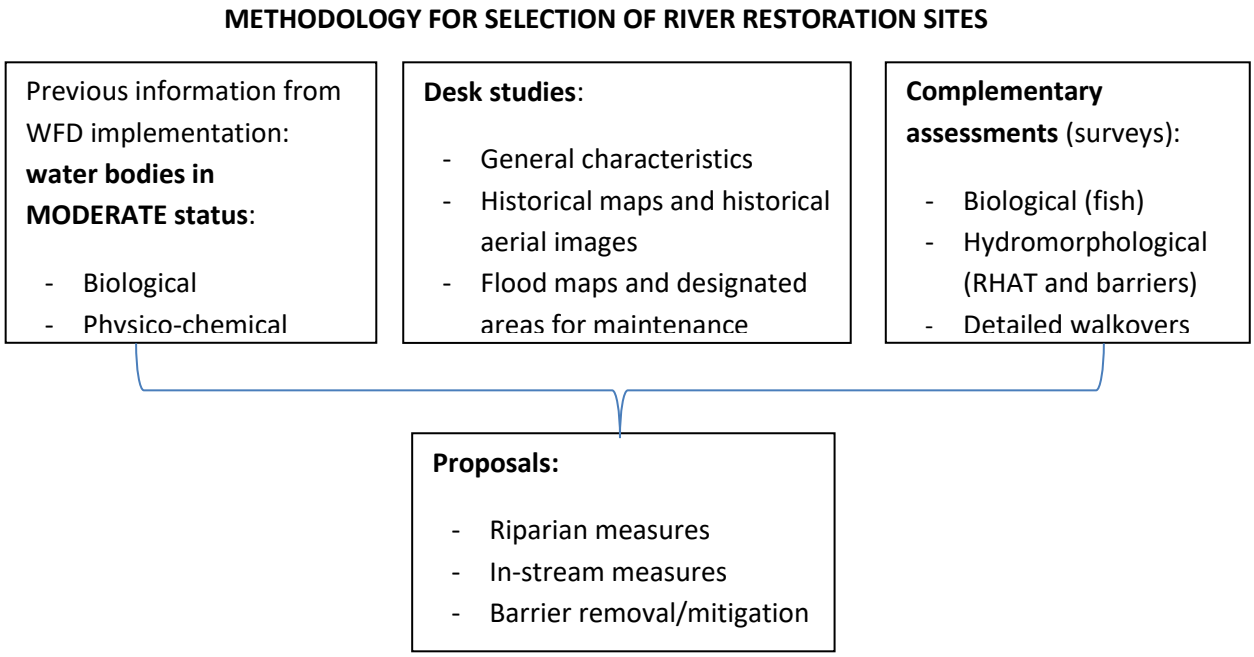


Figure 7-7Methodology for selection of instream, riparian and barrier proposals.

B2.1 Selection of areas to assess.

Areas were chosen to coincide with electrofishing sites to compliment data. Fishing sites were chosen by selecting at least one site in each waterbody and adding extra sites as a waterbody increased in area. Fishing sites were spread evenly throughout the catchment to obtain a representative dataset. Sites were often located beside bridges/roads for ease of access.

B2.2 Assessment of riverine reaches.

The River Hydromorphological Assessment Technique (RHAT) is a survey developed by NIEA specifically for the Water Framework Directive (Murphy and Toland, 2012). Hydromorphology describes the physical habitat of a river constituted by the physical form (abiotic and biotic) and flow of the river.

RHAT is designed to be a holistic visual assessment and can be used to assess individual sites. This generates data for 8 relevant variables of habitat quality within 10 sub-sections of a 500m length of channel. Key elements include the flow, sediment type, channel and floodplain dimensions, topography and substratum, continuity and connectivity of a river. Anthropogenic features such as

bank protection works, artificial barriers (weirs, dams) and modifications to processes are also included. It is assumed that natural systems support ecology better than modified systems. Hence the RHAT method classifies river hydromorphology based on a departure from naturalness. It assigns a morphological classification directly related to that of the WFD: High, Good, Moderate, Poor and Bad, based on semi-qualitative and quantitative criteria.

More detailed information can be found in the RHAT guidance handbook: https://www.daera-ni.gov.uk/sites/default/files/publications/doe/Surface%20water%20alteration%20handbook%20-%20updated%202017%20version.pdf

B2.2.1 In-stream

RHAT surveys are useful for determining areas of in-stream habitat degradation.
Attributes used to indicate in-stream issues are;

1) **Channel Modifications**. This attribute evaluates the form of the river and its deviation from natural including the plan form, cross-section, natural bed forms, flow types and obstructions.

2) **Channel Vegetation**. This attribute relates to the presence, diversity and habitat potential of any vegetation, including woody habitat (WH), leaf litter and tree roots occurring within the channel.

3) **Substrate condition**. This attribute evaluates the type, quantity and diversity of substrate present in the river. The dominant substrate depends on the river type and geology. The score will reflect the heterogeneity of the substrate present.

4) **Barriers to continuity**. This attribute relates to in stream barriers which affect both the variation in velocity across the channel and the longitudinal continuity of the river. The score will indicate the impacts on downstream transport of water, sediment and organic matter, and up and downstream migration of fish (salmon, trout, eel and lamprey).

Each attribute is scored on a scale of 0-4, where 0= Bad, 1=Poor, 2=Moderate, 3=Good and 4=High. Corresponding with WFD status, attributes are considered 'passing' when ≥3 and 'failing' when ≤2.

B2.2.2 Riparian

RHAT surveys are useful for determining areas of degradation of both in-stream and riparian habitats. In particular, attributes to indicate issues regarding riparian habitats are (as numbered in the RHAT survey form):

5) **Bank Structure and Stability.** This attribute assesses the shape and stability of the banks of the river. The score relates to both the degree of bank engineering and the effect of riparian or channel use on the stability of the banks, by evaluating bank material, bank modifications (e.g. reinforcements, embankments) and bank features (e.g. eroding cliff, stable cliff).

6) **Bank Vegetation.** This attribute assesses the types, continuity and canopy layers of the bank vegetation. The score will reflect the amount and extent of vegetation cover, by evaluating bank top and bank face vegetation structure, the extent and variety of trees and habitat structure features (e.g. channel shading).

7) **Riparian Land Cover.** This attribute relates to land cover within the zone adjacent to the river (1 – 20 m from the bank top). The score will reflect the amount and type of vegetation and the human use of the floodplain, by evaluating bank top land use and resource use.

8) **Floodplain Connectivity.** This attribute concerns with the degree of lateral connectivity between the channel and the floodplain. The score will reflect the degree to which channel and bank alterations have affected flow regimes.

Each attribute is split into Left hand bank and Right hand bank and scored accordingly. Each bank is scored on a scale of 0-2 for each attribute where 0= Bad, 0.5=Poor, 1=Moderate, 1.5=Good and 2=High. Corresponding with WFD status, attributes (by bank) are considered 'passing' when ≥1.5 and 'failing' when ≤1.

B2.3 Prioritisation of riverine reaches for habitat improvement.

B2.3.1 In-stream

The aim of prioritising is to select sites with the highest cost-benefit. There is no incentive to focus on sites with High/Good RHAT attribute scores as these areas will not benefit significantly from hydromorphological measures. It is also less efficient to focus on sites that are scoring poorly on many attributes as the cost of works will outweigh the benefit. It is therefore more efficient to focus on areas that are only failing (RHAT Score ≤ Moderate) on one attribute rather than all four.

Prioritisation criteria:

- Remove sites that are in water bodies with Bad, Poor, Good and High WFD status.
- Prioritise sites that are failing on one, two or three attributes (see example Table 7-12).
- Prioritise sites that have attribute scores 2 (moderate) rather than 1 (poor) or 0 (poor).

Note: Sites that score Good (3)/High (4) on all selected attributes (Channel form, Channel vegetation, Substrate condition, Barriers to continuity) will be allocated a rank score of zero. These sites will only become priority when combined with riparian works ranks scores.

Table 7-12 Combination of RHAT attribute scores for ranking sites- instream

Rank Score	Ratio				
1	0.0294118	2	3	3	3
2	0.0588235	1	3	3	3
3	0.0882353	0	3	3	3
4	0.1176471	2	2	3	3
5	0.1470588	2	1	3	3
6	0.1764706	2	0	3	3
7	0.2058824	1	1	3	3
8	0.2352941	1	0	3	3
9	0.2647059	0	0	3	3
10	0.2941176	2	2	2	3
11	0.3235294	2	2	1	3
12	0.3529412	2	2	0	3
13	0.3823529	2	1	1	3
14	0.4117647	2	1	0	3
15	0.4411765	2	0	0	3
16	0.4705882	1	1	1	3
17	0.5	1	1	0	3
18	0.5294118	1	0	0	3
19	0.5588235	0	0	0	3
20	0.5882353	2	2	2	2
21	0.6176471	2	2	2	1
22	0.6470588	2	2	2	0
23	0.6764706	2	2	1	1
24	0.7058824	2	2	1	0
25	0.7352941	2	2	0	0
26	0.7647059	2	1	1	1
27	0.7941176	2	1	1	0
28	0.8235294	2	1	0	0
29	0.8529412	2	0	0	0
30	0.8823529	1	1	1	1
31	0.9117647	1	1	1	0
32	0.9411765	1	1	0	0
33	0.9705882	1	0	0	0
34	1	0	0	0	0

B2.3.2 Riparian

The aim of prioritising is to select sites with the highest cost-benefit. There is no incentive to focus on sites with High/Good RHAT attribute scores as these areas will not benefit significantly from hydromorphological measures. It is also less efficient to focus on sites that are scoring poorly on many attributes as cost of works will outweigh the benefit. It is therefore more efficient to focus on areas that are only failing (Score ≤1) on one attribute rather than all four or eight in this case as each attribute has a score for each bank.

Prioritisation criteria:

- Remove sites that are in water bodies with Bad, Poor, Good and High WFD status.
- Prioritise sites that are failing on one, two or three attributes.
- Prioritise sites that have attributes by bank scores 1 (moderate) rather than 0.5 (poor) or 0 (poor).

Note: Sites that score Good(1.5)/High(2) on all selected attributes (Bank Structure & Stability, Bank Vegetation, Riparian Land Cover, Floodplain Connectivity) will be allocated a rank score of zero. These sites will only become priority when combined with habitat improvement ranks scores

B2.4 Selection of Measures for Habitat Improvement

B2.4.1 In-stream

A table has been created of suggested measures to improve habitat based on typical pressures associated with RHAT attributes.

Table 7-13 Suggested measures to improve score of RHAT attribute for instream

Attribute	Typical pressures	Measures
Channel form and Flow type	Channelisation, straightening or deepening. Bank and Bed reinforcements. Impounding, abstraction and flow regulation.	Remove hard reinforcements. Allow naturalisation by removing any artificial structure effecting hydromorphology. Recovery of pool-riffle-glide sequence.
Channel vegetation	Vegetation management/removal, Reduced channel shading, Dredging/ deepening of channel.	Increase diversity of habitat by creating pool riffle glide sequences in appropriate areas. Create habitat for marginal vegetation.
Substrate condition	Dredging, modified sediment regime i.e. barrier upstream, in-channel structures causing scouring, cattle poaching, over-grazing, tilled land, conifer forestry. Removal of substrate.	Increase diversity of substrate in-channel by introducing different types of substrate that may be lacking (i.e. gravel/ cobble boulder)

Attribute	Typical pressures	Measures
Barriers to continuity	Artificial in-channel features (weirs, dams), Diversions (e.g. Mill race), Impounding, Abstraction and flow regulation. Widening/straightening of channel where water speed may cause difficulties for upstream fish migration.	Remove artificial barrier. Allow naturalisation of altered channels by removing artificial structures.

Use additional information from 1) WFD Status, 2) RHAT Attribute Comments, 3) RHAT Sweep-up, 4) Electrofishing, 5) NIEA RHAT surveys 6) Distance to EPA/NIEA monitoring station, 7)Designated maintenance channel 8) Cost of proposed works and 9)Permission from landowner to aid decision on proposals for habitat improvement.

1) WFD Status. Determine what element/elements the waterbody is failing on. This will give an area to focus on for habitat improvement.
2) Comments are entered during RHAT surveys to highlight why attributes are given a particular score. This will help highlight issues that need to be addressed.
3) RHAT Sweep- ups contain a lot of information about features of the survey site. This will help highlight issues that need to be addressed.
   Extract information from RHAT Sweep-up;
   F. Channel Modifications
   J. Habitat Structure Features.
   K. Bank and Channel Features
4) IFI electrofishing surveys contain information about channel features and fish communities present of the survey site.
5) Comments from NIEA staff may indicate issues observed or recommendations for habitat improvement.
6) The location of EPA/NIEA monitoring station will indicate a stretch of riverine habitat that may be influencing the WFD status. The location of proposed works in relation to monitoring stations will therefore have an influence on the overall WFD status.
7) Designated for maintenance by Department of Infrastructure/Office of Public Works. This will indicate area where works may be carried out in conjunction with government departments to be more cost efficient.
8) The cost of works will indicate areas with the highest cost benefit.
9) Permission from landowners will indicate which proposals will be feasibly carried out.

B2.4.2 Riparian

A table has been created of suggested measures to improve riparian areas based on typical pressures associated with RHAT attributes

Table 7-14 Suggested measures to improve score of RHAT attribute for riparian

Attribute	Typical pressures	Proposals
Bank Structure and Stability	Channelisation, bank straightening or steepening. Embankments. Bank reinforcements. Poaching.	Remove artificial structures constraining natural meander progression. Bank reprofiling for a stable slope. Fencing for total exclusion of livestock, provision of off-line water supply
Bank Vegetation	Vegetation management/removal, Reduced channel shading.	Riparian planting which stabilises banks and creates habitat for marginal vegetation.
Riparian Land Cover	Reduced cover of native vegetation, agriculture, forestry, urban development.	Fencing off livestock, provision of buffer zones between fencing and top of bank
Floodplain Connectivity	Embankment, over-deepening, over-widening, channelization, bank reinforcement	Remove artificial structures that prevent floodplain interaction. Re-profile bank for a stable slope.

As for instream measures use additional information from 1) WFD Status, 2) RHAT Attribute Comments, 3) RHAT Sweep-up, 4) Electrofishing, 5) NIEA RHAT surveys 6) Distance to EPA/NIEA monitoring station, 7)Designated maintenance channel 8) Cost of proposed works and 9)Permission from landowner to aid decision on proposals for riparian works.

B3 Results

B3.1 Finn Catchment

In total, 22 sites have been surveyed using the River Hydromorphology Assessment Technique (RHAT). The RHAT surveys took place in 4 different waterbodies. Locations of RHAT surveys were coincident with electrofishing sites on all occasions.

Four RHAT attribute scores were expressed for each survey site (Channel form, Channel vegetation, Substrate condition and Barriers to continuity). These four attributes best represent the condition of in-stream habitat.

Prioritisation criteria were applied to all sites in the Finn catchment resulting in a ranked table.

Table 7-15 Instream rank score for Finn catchment

Site	Water Body	Water Body Status	RHAT	Channel form and flow type	Channel Vegetation	Substrate Condition	Barriers to continuity	Rank Score
ODO_1	Clogher(Finn)_010	Poor	High	4	3	4	4	0
STRA_1	Stranagoppog_010	Moderate	High	4	4	4	4	0
UPPER REEL_2	Reelan_010	Poor	High	3	3	4	4	0
BD_1	Burn_Daurnett_010	Poor	Moderate	3	3	2	3	1
CRO_1	Clogher(Finn)_010	Poor	Moderate	3	2	4	4	1
DRE_1	Dresnagh_010	No data	Moderate	3	4	3	2	1
FINN_2	Finn(Donegal)_080	Poor	Good	3	3	2	3	1
CRK_1	Cummirk_010	Good	Moderate	3	1	3	4	2
UPPER REEL_1	Reelan_010	Poor	Good	4	1	4	4	2
DRU_1	Finn(Donegal)_060	Poor	Moderate	3	2	3	2	4
EFE_1	Rough_Burn_010	Poor	Moderate	3	2	3	2	4
FINN_1	Finn(Donegal)_080	Poor	Good	2	3	2	4	4
MNL_1	Finn(Donegal)_080	Poor	Moderate	3	3	2	2	4
ELA_1	Elatagh_010	Poor	Moderate	2	1	3	3	5
CROS_1	Crossroads_Stream_010	Poor	Moderate	3	2	2	2	10
SCA_1	Finn(Donegal)_010	Good	Moderate	2	3	2	2	10
FINN_3	Finn(Donegal)_070	No data	Poor	1	2	2	3	11
FINN_4/	Finn(Donegal)_040	Moderate	Moderate	1	2	2	4	11
RB_1	Rough_Burn_010	Poor	Moderate	2	3	2	1	11
REEL PIPES_	Reelan_010	Poor	Moderate	2	1	4	1	13
COR_1	Finn(Donegal)_010	Poor	Poor	0	0	4	1	18
OGV_1	Clogher(Finn)_010	Good	Moderate	2	2	1	2	21

Four RHAT attribute scores were expressed for each survey site (Bank Structure and Stability, Bank Vegetation, Riparian Land Cover, Floodplain Connectivity). These four attributes best represent the condition of in-stream habitat.

Prioritisation criteria were applied to all sites in the Finn catchment resulting in a ranked table.

Table 7-16 Riparian rank score for Finn catchment

Site Code	Water Body	Water Body Status	RHAT	Bank Structure & Stability		Bank Vegetation		Riparian Land Cover		Floodplain Connectivity		Rank Score
				LHB	RHB	LHB	RHB	LHB	RHB	LHB	RHB	
UPPER Reel_2	Reelan _010	Poor	High	2	1.5	1	1.5	1.5	1.5	1.5	1.5	1
STRA_1	Stranagoppoge _010	Moderate	High	1.5	2	1.5	1	1.5	1.5	2	2	1
ODO_1	Clogher (Finn)_010	Poor	High	2	2	1	1	1.5	1.5	2	2	4
FINN_1	Finn(Donegal)_ 080	Good	Good	1.5	2	1.5	1.5	0.5	0.5	1.5	2	7
SCA_1	Finn(Donegal)_ 010	Good	Moderate	1	1.5	1	1.5	1	0	1.5	1.5	22
OGV_1	Clogher (Finn)_010	Poor	Moderate	0.5	1	1.5	1.5	0.5	1	1	1.5	38
UPPER Reel_1	Reelan _010	Poor	Good	1	1.5	0.5	0.5	1	0.5	2	2	41
DRU_1	Finn(Donegal)_ 060	Poor	Moderate	1.5	1	0	0	0.5	0.5	1.5	1.5	47
FINN_2	Finn(Donegal)_ 080	Poor	Good	1	1	1	1	1	1	1.5	1.5	55
MNL_1	Finn(Donegal)_ 080	Poor	Moderate	1	1	1.5	1.5	0.5	0.5	1	1	58
BD_1	Burn_Daurnett _010	Poor	Moderate	0.5	1	1.5	1.5	0	1	1	1	59
REEL PIPES_	Reelan _010	Poor	Moderate	1	1	0.5	0.5	1	0.5	1.5	1.5	61
FINN/C TOWN	Finn(Donegal)_ 040	Moderate	Moderate	2	2	0.5	0.5	0.5	0.5	1	1	65
ELA_1	Elatagh _010	Poor	Moderate	0.5	0.5	0.5	0.5	1	1	2	2	65
DRE_1	Dresnagh _010	No data	Moderate	1	0.5	1.5	1.5	0.5	0.5	0.5	0.5	70
CRK_1	Cummirk _010	Good	Moderate	0.5	0.5	0.5	0.5	0	0	2	2	78
COR_1	Finn(Donegal)_ 010	Moderate	Poor	1	1.5	0.5	0.5	1	1	0.5	0.5	93
RB_1	Rough _Burn_010	Poor	Moderate	1	1	1	1	1	1	1	1	119
EFE_1	Rough _Burn_010	Poor	Moderate	1	1	0.5	0.5	0	1	1	1	126
CROS_ 1	Crossroads Stream010	Poor	Moderate	1	1	0.5	0.5	0.5	0.5	1	1	129
CRO_1	Clogher(Finn) _010	Poor	Moderate	0.5	0.5	0.5	0.5	0.5	0.5	1	1	140

Site Code	Water Body	Water Body Status	RHAT	Bank Structure & Stability		Bank Vegetation		Riparian Land Cover		Floodplain Connectivity		Rank Score
				LHB	RHB	LHB	RHB	LHB	RHB	LHB	RHB	
FINN_3	Finn(Donegal)_070	Poor	Poor	0.5	0.5	0.5	0.5	0.5	1	0.5	0.5	147

To improve cost-benefit of the project, actions under the “instream works” task are likely to be undertaken in tandem with actions under the “riparian works” task. Therefore it is reasonable to combine the ranking score of instream and riparian works to produce a ranking score for river stretches. Rank scores are expressed on differing scales and need to be ‘normalised’ to ensure that each was given equal weight in the prioritization process. The normalised score or ratio is a value between 0 and 1, calculated by dividing the score by the highest value in the scale.

Table 7-17 Combined scores expressed in order of rank for the Finn catchment

Site	Water Body	Water Body Status	RHAT	Ratio Habitat Improvement	Ratio Riparian	Ratio Combined (0-2)
STRA_1	Stranagoppoge_010	Moderate	High	0	0.006	0.006
UPPER REEL_2	Reelan_010	Poor	High	0	0.006	0.006
ODO_1	Clogher(Finn)_010	Poor	High	0	0.025	0.025
FINN_1	Finn(Donegal)_080	Poor	Good	0.117647	0.043	0.160647
UPPER REEL_1	Reelan_010	Poor	Good	0.058824	0.252	0.310824
FINN_2	Finn(Donegal)_080	Poor	Good	0.029412	0.337	0.366412
BD_1	Burn_Daurnett_010	Poor	Moderate	0.029412	0.362	0.391412
DRU_1	Finn(Donegal)_060	Poor	Moderate	0.117647	0.288	0.405647
SCA_1	Finn(Donegal)_010	Good	Moderate	0.294118	0.135	0.429118
DRE_1	Dresnagh_010	No data	Moderate	0.029412	0.429	0.458412
MNL_1	Finn(Donegal)_080	Poor	Moderate	0.117647	0.356	0.473647
CRK_1	Cummirk_010	Good	Moderate	0.058824	0.479	0.537824
ELA_1	Elatagh_010	Poor	Moderate	0.147059	0.399	0.546059
FINN_4/ CTOWN	Finn(Donegal)_040	Moderate	Moderate	0.323529	0.399	0.722529
REEL PIPES_1	Reelan_010	Poor	Moderate	0.382353	0.374	0.756353
OGV_1	Clogher(Finn)_010	Poor	Moderate	0.617647	0.233	0.850647
CRO_1	Clogher(Finn)_010	Poor	Moderate	0.029412	0.859	0.888412
EFE_1	Reelan_010	Poor	Moderate	0.117647	0.773	0.890647
RB_1	Rough_Burn_010	Poor	Moderate	0.323529	0.730	1.053529
CROS_1	Crossroads_Stream_010	Poor	Moderate	0.294118	0.791	1.085118
COR_1	Finn(Donegal)_040	Moderate	Poor	0.529412	0.571	1.100412
FINN_3	Finn(Donegal)_070	No data	Poor	0.323529	0.902	1.225529

B3.1.1. Candidate River reaches Finn Catchment

The prioritisation process for habitat improvement focused on factors such as the catchment status, RHAT Score, Fish EQR and the macroinvertebrate score, the sites with the lowest scores are to be considered of highest importance for works. The suggested method is to investigate the highest ranking sampling site and its corresponding candidate river reach to evaluate the feasibility of carrying out measures for improvement. Each area will be assessed in more detail using additional information. If it is concluded that it is not feasible to carry out improvement works or the potential benefit is deemed insignificant then the next site on the list will be assessed. The table below highlights sites which have been assessed and feasible for beneficial improvement works within the Finn Catchment Area.

Table 7-18 Candidate River reach for Finn catchment

Candidate River Reach	Channel Length (km)	Issues	Proposals	Other Comments
Cummirk	30.6	Poaching; Channel & Bank Vegetation; Riparian Land-use; Re-sectioned banks; Reinforcements; Narrowed	Fencing; riparian planting; cattle drinks	Site Code: CRK_1 EPA Monitoring Station
Reelan (Reel Pipes)	0.5	Significant pipe culverted bridge - barrier in low flow & barrier to sediment; Re-sectioned banks; Reinforcements; Narrowed; Embankments; Bank Vegetation; Riparian Land-use	Instream works on barrier (Reel Pipes); fencing; riparian planting; cattle drinks	Site Code: REELPIPES_1 3279m upstream of EPA monitoring site.
Reelan (Other)	20.6	Reinforcements; Embankment; Bank Vegetation; Riparian Land-use; Poaching	Fencing; riparian planting; cattle drinks	Site Code: UPPERREEL_1-2 4950m upstream of EPA monitoring site
Rough Burn	1.1	Culverted ford is gradually collapsing, which will eventually become an impassible barrier to fish	Replace ford with a small clear span bridge	Site Code: RB_1 100m upstream of EPA Monitoring Site

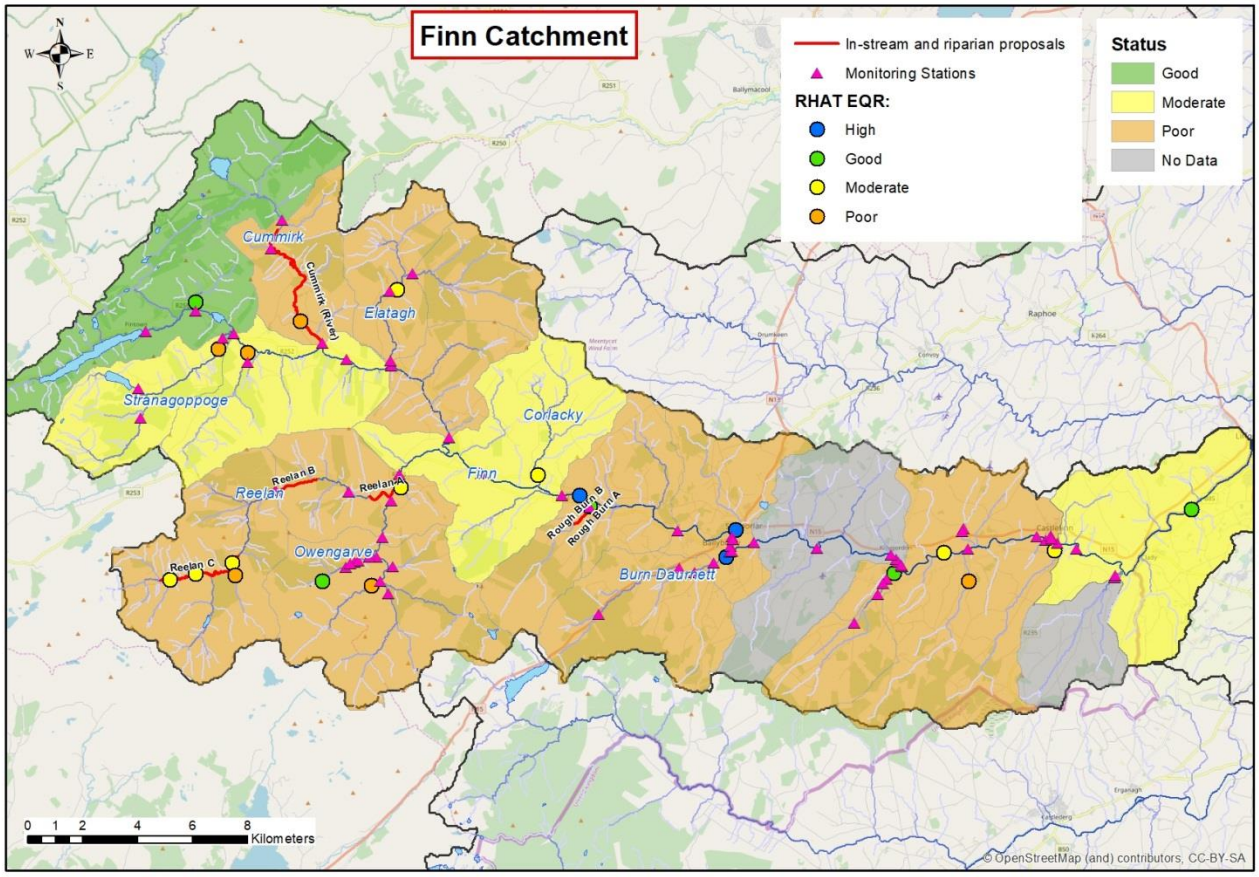


Figure 7-8 Location of candidate river reaches for instream and riparian proposals

B3.2 Arney Catchment

In total, 13 sites have been surveyed by the River Hydromorphological Assessment Technique (RHAT). The RHAT surveys took place in 4 different waterbodies, namely the Arney River, Belcoo River, Black River and Drumharriff Burn. Locations of RHAT surveys were coincident with electrofishing sites on the majority of occasions.

Four RHAT attribute scores were expressed for each survey site (Channel form, Channel vegetation, Substrate condition and Barriers to continuity). These four attributes best represent the condition of in-stream habitat.

Prioritisation criteria were applied to all sites in the Arney catchment resulting in the Ranked table below.

Table 7-19 Instream rank score for the Arney catchment

Site	Water body	Water body status	RHAT	Channel form and flow type	Channel vegetation	Substrate condition	Barriers to continuity	Rank Score
AR17	Black River	Moderate	High	4	4	4	4	0
AR18	Black River	Moderate	Good	3	4	4	3	0
AR41	Arney River	Moderate	Moderate	3	2	3	4	1
AR35	Drumhariff Burn	Moderate	Moderate	1	3	3	3	2
AR36	Arney River	Moderate	Moderate	4	2	2	4	4
AR31	Arney River	Moderate	Moderate	2	2	2	3	10
AR32	Arney River	Moderate	Moderate	2	2	2	1	21
AR30	Arney River	Moderate	Moderate	1	2	2	1	23
AR33	Arney River	Moderate	Poor	1	2	2	1	23
AR34	Arney River	Moderate	Moderate	1	1	2	2	23

Four RHAT attribute scores were expressed for each survey site (Bank Structure and Stability, Bank Vegetation, Riparian Land Cover, Floodplain Connectivity). These four attributes best represent the condition of riparian habitat.

Prioritisation criteria were applied to all sites in the Arney catchment resulting in the Ranked table below.

Table 7-20 Riparian rank score for the Arney catchment.

Site	Water body	Water body status	RHAT	Bank Structure & Stability		Bank Vegetation		Riparian Land Cover		Floodplain Connectivity		Rank Score
				LHB	RHB	LHB	RHB	LHB	RHB	LHB	RHB	
AR17	Black River	Moderate	High	2	2	2	1.5	1.5	1	2	2	1
AR18	Black River	Moderate	Good	1.5	1.5	1	1.5	1	1	1.5	1.5	10
AR32	Arney River	Moderate	Moderate	1	0.5	1	0.5	1	1	1.5	1.5	58
AR34	Arney River	Moderate	Moderate	0.5	1.5	0.5	1.5	1	1	0.5	1	61
AR36	Arney River	Moderate	Moderate	1	1	1.5	1	0.5	0.5	1	1	86
AR30	Arney River	Moderate	Moderate	1	1	1	1	1	1	0.5	0.5	122
AR41	Arney River	Moderate	Moderate	1	1	1	1	1	1	0.5	0.5	122
AR35	Drumhariff Burn	Moderate	Moderate	1	1	0.5	1	0.5	1	0.5	0.5	129
AR31	Arney River	Moderate	Moderate	1	1	0.5	0.5	0.5	0.5	0.5	0.5	140
AR33	Arney River	Moderate	Poor	1	1	0.5	0.5	0.5	0.5	0.5	0.5	140

To improve cost-benefit of the project, actions under the “instream works” task are likely to be undertaken in tandem with actions under the “riparian works” task. Therefore it is reasonable to combine the ranking score of instream and riparian works to produce a ranking score for river stretches. Rank scores are expressed on differing scales and need to be ‘normalised’ to ensure that each was given equal weight in the prioritization process. The normalised score or ratio is a value between 0 and 1, calculated by dividing the score by the highest value in the scale.

Table 7-21 Combined scores expressed in order of rank for the Arney catchment

Site code	Water body	Water body status	RHAT	Ratio Habitat Improvement	Ratio Riparian	Ratio Combined (0-2)
AR17	Black River	Moderate	High	0	0.006	0.006
AR18	Black River	Moderate	Good	0	0.061	0.061
AR36	Arney River	Moderate	Moderate	0.118	0.527	0.645
AR41	Arney River	Moderate	Moderate	0.029	0.748	0.777
AR32	Arney River	Moderate	Moderate	0.618	0.355	0.973
AR34	Arney River	Moderate	Moderate	0.676	0.374	1.050
AR31	Arney River	Moderate	Moderate	0.294	0.859	1.153
AR35	Drumhariff Burn	Moderate	Moderate	0.059	0.791	1.381
AR30	Arney River	Moderate	Moderate	0.676	0.748	1.424
AR33	Arney River	Moderate	Poor	0.676	0.859	1.535

B3.2.1 Candidate River Reaches Arney Catchment

Taking into account reports on "Ranking of riverine reaches for habitat improvement" and discussion with project partners, a summary of candidate river reaches have been compiled and are listed below. The suggested method is to investigate the highest ranking sampling site and its corresponding candidate river reach to evaluate the feasibility of carrying out measures for improvement. Each area will be assessed in more detail using additional information. If it is concluded that it is not feasible to carry out improvement works or the potential benefit is deemed insignificant then the next site on the list will be assessed.

Table 7-22 Candidate river reaches for the Arney catchment

Candidate River Reach	Channel length (km)	Issues	Proposals	Other comments
Arney River 6 (Main)	1.8	Removal of riparian vegetation; poaching; bank instability; over-deepened; bank reinforcement and re-sectioning	Fencing; riparian planting; cattle drinks; reprofile banks	Survey sites: AR_36
Arney 5 (Main)	5.9	Bank instability; poaching; reinforcement of banks	Fencing; riparian planting; cattle drinks; reprofile bank on RHB	Survey sites: AR_37-41 NIEA

Candidate River Reach	Channel length (km)	Issues	Proposals	Other comments
				monitoring station
Arney River 2 (Tributary)	1.3	Lack of riparian vegetation; poaching	Fencing, Riparian tree planting	Survey sites: AR_32
Arney River 1 (Tributary)	2	Lack of riparian vegetation; straightened; over-deepened	Fencing, Riparian tree planting	Survey sites: AR_31
Arney River 7 (Tributary)	2.2	Over-deepening and over-widening; removal of riparian vegetation; poaching; bank instability; poaching	Fencing; riparian planting; cattle drinks; reprofile banks	Survey sites: AR_30
Drumharriff burn	1	Channel straightening and over-deepening; removal of riparian vegetation; poaching; bank instability; bank reinforcement and re-sectioning	Bank reprofiling to allow lateral mobility and channel-floodplain connection; fencing; riparian planting; provide cattle drink; substitution of rip-rap by soft engineering	Survey sites: AR_35 NIEA monitoring station
Arney River 4 (Main)	2.1	Over-deepening of channel; removal of riparian vegetation; poaching; bank instability	Fencing; riparian planting; cattle drinks; reprofile banks	
Arney River 8 (Tributary)	1.5	Over-deepening and over-widening; removal of riparian vegetation; poaching; bank instability; poaching	Fencing; riparian planting; cattle drinks; reprofile banks	Survey sites: AR_33

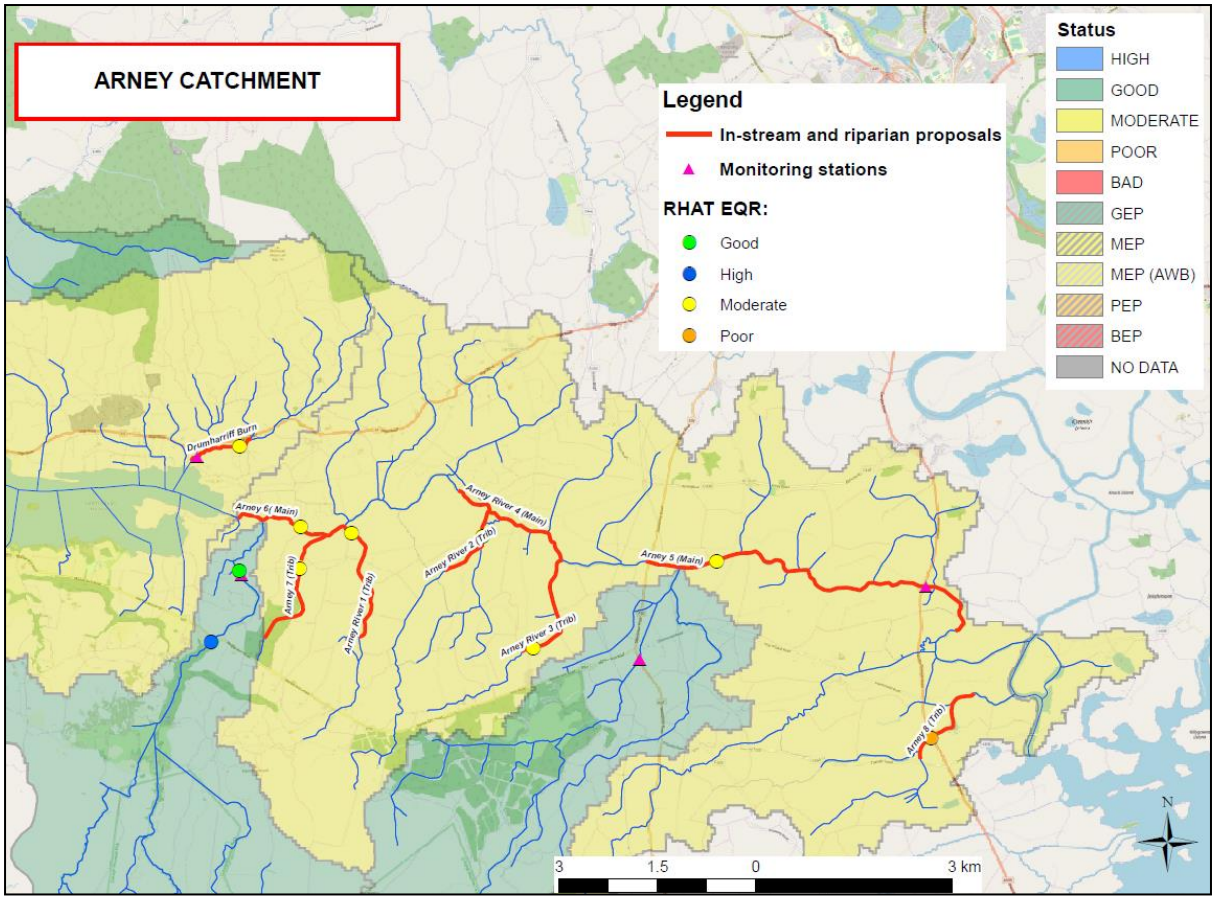


Figure 7-9 Location of candidate river reaches in the Arney catchment

Measures have not been proposed for the Black River as it is thought that the potential benefit from works will not have a significant effect on the water quality status. The overall RHAT scores in the Black River water body are Good and High. Examination of the attributes of the RHAT surveys indicate there are very few pressures on this channel (i.e. Riparian Land Use, Bank vegetation) therefore there are very few hydromorphological measures that can be implemented to have a significant impact on water quality. The WFD failing element for the Black River is fish EQR. There seems to be ample habitat for fish along this river, therefore there may be a fish passage issue further downstream or through the lakes in the Arney catchment.

All in-stream and riparian proposals are located in Northern Ireland and are in drainage-designated channels for river maintenance by the Department for Infrastructure (DfI Rivers). Therefore, proposed measures need to be agreed with DfI Rivers (NI) prior to any works. Measures should, clearly, be agreed with landowner(s) in advance.

B3.3 Blackwater Catchment

In total, 47 sites have been surveyed using the River Hydromorphology Assessment Technique (RHAT). The RHAT surveys took place in 24 different waterbodies. Locations of RHAT surveys were coincident with electrofishing sites on the majority occasions.

Four RHAT attribute scores were expressed for each survey site (Channel form, Channel vegetation, Substrate condition and Barriers to continuity). These four attributes best represent the condition of in-stream habitat. Prioritisation criteria were applied to all sites in the Blackwater catchment resulting in a ranked table.

Table 7-23 Instream rank score for the Blackwater catchment

Site	Water body	Water body status	RHAT	Channel form and flow type	Channel vegetation	Substrate condition	Barriers to continuity	Rank score
BW11	Tynan River	Moderate	Good	3	3	3	3	0
BW30	River Rhone (Dungannon)	Moderate	Good	4	3	3	4	0
BW35	Rhone (Dungannon)	Moderate	Moderate	3	3	3	3	0
BW42	Ballygawley Water	Moderate	Good	4	3	3	4	0
BW64	R. Blackwater (Aughnacloy)	Moderate	Good	4	3	3	4	0
BW65	Ballymacone River	Moderate	High	4	4	4	4	0
BW91	Mountain Water_050	Moderate	Moderate	3	2	3	3	1
BW09	Callan River (Tassagh)	Moderate	Moderate	2	3	3	3	1
BW36	Ballymartrim Water	Moderate	Moderate	3	3	2	3	1
BW55	Ballymartrim Water	Moderate	Moderate	4	2	3	3	1
BW59	River Rhone (Dungannon)	Moderate	Moderate	2	3	3	3	1
BW89	R. Blackwater (Annaghroe)	Moderate	Good	4	3	2	3	1
BW95	Cor River	Moderate	Good	2	4	4	3	1
BW62	Oona Water (Eglish)	Moderate	Moderate	3	3	1	4	2
BW04	Ballygawley Water	Moderate	Moderate	2	3	2	3	4
BW40	Oona Water (Killymaddy)	Moderate	Moderate	2	2	3	3	4
BW45	R. Blackwater (Augher)	Moderate	Moderate	3	2	2	4	4
BW52	R. Blackwater (Augher)	Moderate	Moderate	4	2	2	4	4

Site	Water body	Water body status	RHAT	Channel form and flow type	Channel vegetation	Substrate condition	Barriers to continuity	Rank score
BW81	R. Blackwater (Annaghroe)	Moderate	Moderate	3	2	2	3	4
BW14	Tynan River	Moderate	Good	3	1	2	4	5
BW18	Callan River (Derryscollop)	Moderate	Moderate	1	3	3	2	5
BW21	Callan River (Derryscollop)	Moderate	Moderate	1	3	2	3	5
BW41	Ballygawley Water	Moderate	Moderate	1	3	3	2	5
BW10	Callan River (Milford)	Moderate	Moderate	2	2	3	2	10
BW39	Oona Water (Eglish)	Moderate	Moderate	2	2	2	3	10
BW73	River Blackwater	Moderate	Moderate	2	2	3	2	10
BW29	Oona Water (Eglish)	Moderate	Moderate	2	2	3	1	11
BW61	Oona Water (Killymaddy)	Moderate	Moderate	2	2	3	1	11
BW24	R. Blackwater (Augher)	Moderate	Moderate	3	2	2	0	12
BW16	Cor River	Moderate	Moderate	1	1	2	3	13
BW58	Oona Water (Killymaddy)	Moderate	Moderate	1	1	2	3	13
BW105	Mountain Water_050	Moderate	Poor	1	0	0	3	18
BW12	Tynan River	Moderate	Moderate	2	2	2	2	20
BW13	Cor River Tributary	Moderate	Moderate	2	2	2	2	20
BW20	Callan River (Derryscollop)	Moderate	Moderate	2	2	2	2	20
BW28	Oona Water (Eglish)	Moderate	Moderate	2	2	2	2	20
BW77	R. Blackwater (Annaghroe)	Moderate	Poor	0	2	2	2	22
BW31	Tamnamore Stream	Moderate	Moderate	1	1	2	2	23
BW43	Ballygawley Water	Moderate	Poor	2	2	1	0	24
BW05	Tynan River	Moderate	Poor	1	1	1	1	30

Four RHAT attribute scores were expressed for each survey site (Bank Structure and Stability, Bank Vegetation, Riparian Land Cover, Floodplain Connectivity). These four attributes best represent the condition of riparian zones. Prioritisation criteria were applied to all sites in the Blackwater catchment resulting in a ranked table.

Table 7-24 Riparian rank score for Blackwater catchment

Site	Water body	Water body status	RHAT	Bank Structure & Stability		Bank Vegetation		Riparian Land Cover		Floodplain Connectivity		Rank Score
				LHB	RHB	LHB	RHB	LHB	RHB	LHB	RHB	
BW65	Ballymacone River	Moderate	High	1.5	2	1	1.5	1.5	2	1.5	2	1
BW30	River Rhone (Dungannon)	Moderate	High	2	2	1	1	1.5	1.5	2	2	4
BW62	Oona Water (Eglish)	Moderate	Good	1.5	1.5	1	1	1.5	1	2	1.5	10
BW35	Rhone (Dungannon)	Moderate	Good	1.5	1	1	1	1	1	2	2	20
BW89	R. Blackwater (Annaghroe)	Moderate	Good	1	2	1.5	1.5	1	1.5	1	1	20
BW55	Ballymartrim Water	Moderate	Good	2	1.5	1	0.5	1	1	2	2	21
BW61	Oona Water (Killymaddy)	Moderate	Moderate	1.5	1.5	1	1	0	1	1.5	1.5	22
BW12	Tynan River	Moderate	Moderate	1	1.5	0	1.5	1	1	2	2	22
BW41	Ballygawley Water	Moderate	Moderate	1	0.5	1.5	1.5	1.5	0.5	1.5	0.5	26
BW36	Ballymartrim Water	Moderate	Good	1	1	1	1	1	1	1.5	1.5	35
BW52	R. Blackwater (Augher)	Moderate	Good	1	1.5	1	1	0.5	1	2	2	36
BW64	R. Blackwater (Aughnacloy)	Moderate	Good	1	1.5	1	1	0.5	1	1.5	2	36
BW24	R. Blackwater (Augher)	Moderate	Moderate	1	1.5	1	1	0.5	0.5	1.5	1.5	38
BW11	Tynan River	Moderate	Good	1	1	1.5	1	0.5	0.5	1.5	1.5	38
BW10	Callan River (Milford)	Moderate	Moderate	0.5	1.5	0.5	1.5	0.5	0.5	0.5	1.5	50
BW28	Oona Water (Eglish)	Moderate	Moderate	1	1	1	1	1	1	1.5	1.5	55
BW42	Ballygawley Water	Moderate	Good	1	1	1.5	1.5	1	1	1	1	55
BW14	Tynan River	Moderate	Good	1	1	1	1	0.5	1	2	2	56
BW91	Mountain Water_050	Moderate	Poor	1.5	1	1	1	1	0	1.5	1	57
BW20	Callan River (Derryscollop)	Moderate	Moderate	0.5	1	1	1.5	0.5	1.5	1	1	58
BW40	Oona Water (Killymaddy)	Moderate	Moderate	1	1	1	1	0.5	0.5	1.5	1.5	58
BW59	River Rhone (Dungannon)	Moderate	Moderate	1	1	0.5	0.5	1	1	1.5	1.5	58
BW13	Cor River Tributary	Moderate	Moderate	1	1	0.5	0.5	1	0.5	1.5	1.5	61
BW91	Mountain Water_050	Moderate	Poor	1.5	1	1	1	1	0	1.5	1	57

Site	Water body	Water body status	RHAT	Bank Structure & Stability		Bank Vegetation		Riparian Land Cover		Floodplain Connectivity		Rank Score
				LHB	RHB	LHB	RHB	LHB	RHB	LHB	RHB	
BW58	Oona Water (Killymaddy)	Moderate	Moderate	1	1	0.5	0.5	0.5	0.5	1.5	1.5	65
BW77	R. Blackwater (Annaghroe)	Moderate	Poor	1	1	1.5	1.5	0.5	0.5	0	0	67
BW16	Cor River	Moderate	Moderate	1	1	2	0.5	1	1	1	1	84
BW81	R. Blackwater (Annaghroe)	Moderate	Moderate	1	1	1.5	1	1	1	0.5	0.5	86
BW95	Cor River	Moderate	Good	1	1	1.5	1	0.5	0.5	1	1	86
BW43	Ballygawley Water	Moderate	Poor	1	0.5	1	1	0.5	0	1.5	0.5	94
BW29	Oona Water (Eglish)	Moderate	Moderate	1	1	1	1	1	1	1	1	119
BW39	Oona Water (Eglish)	Moderate	Moderate	1	1	0.5	1	1	1	1	1	120
BW09	Callan River (Tassagh)	Moderate	Moderate	0.5	0.5	0.5	1	0.5	1	0.5	0.5	122
BW31	Tamnamore Stream	Moderate	Moderate	1	0.5	1	1	1	1	1	0.5	122
BW73	R. Blackwater (Annaghroe)	Moderate	Moderate	1	1	0.5	1	1	1	0.5	0.5	125
BW05	Tynan River	Moderate	Poor	1	1	1	1	0.5	0.5	0.5	0.5	129
BW21	Callan River (Derryscollop)	Moderate	Moderate	1	1	1	1	0.5	0.5	0.5	0.5	129
BW45	R. Blackwater (Augher)	Moderate	Moderate	1	1	1	0.5	0.5	0.5	0.5	0.5	134
BW04	Ballygawley Water	Moderate	Moderate	1	1	0.5	0.5	0.5	0.5	0.5	0.5	140
BW18	Callan River (Derryscollop)	Moderate	Moderate	1	0.5	1	0	0.5	0.5	0.5	0.5	141

To improve cost-benefit of the project, actions under the “instream works” task are likely to be undertaken in tandem with actions under the “riparian works” task. Therefore it is reasonable to combine the ranking score of instream and riparian works to produce a ranking score for river stretches. Rank scores are expressed on differing scales and need to be ‘normalised’ to ensure that each was given equal weight in the prioritization process. The normalised score or ratio is a value between 0 and 1, calculated by dividing the score by the highest value in the scale.

Table 7-25 Combined scores expressed in order of rank for the Blackwater catchment

Site	Water body	Water body status	RHAT	Ratio Habitat Improvement	Ratio Riparian Works	Ratio combined(0-2)
BW65	Ballymacone River	Moderate	High	0	0.006	0.006
BW30	River Rhone (Dungannon)	Moderate	Good	0	0.025	0.025
BW62	Oona Water (Eglish)	Moderate	Moderate	0.059	0.061	0.120
BW35	River Rhone (Dungannon)	Moderate	Moderate	0	0.123	0.123
BW89	River Blackwater (Annaghroe)	Moderate	Good	0.029	0.123	0.152
BW55	Ballymartrim Water	Moderate	Moderate	0.029	0.129	0.158
BW64	Blackwater (Aughnacloy)	Moderate	Good	0	0.221	0.221
BW11	Tynan River	Moderate	Good	0	0.233	0.233
BW36	Ballymartrim Water	Moderate	Moderate	0.029	0.215	0.244
BW41	Ballygawley Water	Moderate	Moderate	0.147	0.160	0.307
BW42	Ballygawley Water	Moderate	Good	0	0.337	0.337
BW52	River Blackwater (Augher)	Moderate	Moderate	0.118	0.221	0.339
BW59	River Rhone (Dungannon)	Moderate	Moderate	0.029	0.356	0.385
BW91	Mountain Water 050	Moderate	Moderate	0.029	0.350	0.379
BW61	Oona Water (Killymaddy)	Moderate	Moderate	0.324	0.135	0.458
BW40	Oona Water (Killymaddy)	Moderate	Moderate	0.118	0.356	0.473
BW14	Tynan River	Moderate	Good	0.147	0.344	0.490
BW95	Cor River	Moderate	Good	0.029	0.528	0.557
BW24	R. Blackwater (Augher)	Moderate	Moderate	0.353	0.233	0.586
BW10	Callan River (Milford)	Moderate	Moderate	0.294	0.307	0.601
BW81	R. Blackwater (Annaghroe)	Moderate	Moderate	0.118	0.528	0.645
BW12	Tynan River	Moderate	Moderate	0.588	0.135	0.723
BW09	Callan River (Tassagh)	Moderate	Moderate	0.029	0.748	0.777
BW58	Oona Water (Killymaddy)	Moderate	Moderate	0.382	0.399	0.781

Site	Water body	Water body status	RHAT	Ratio Habitat Improvement	Ratio Riparian Works	Ratio combined(0-2)
BW16	Cor River	Moderate	Moderate	0.382	0.515	0.898
BW28	Oona Water (Eglish)	Moderate	Moderate	0.588	0.337	0.926
BW95	Mountain Water 050	Moderate	Poor	0.529	0.399	0.928
BW21	Callan River (Derryscollop)	Moderate	Moderate	0.147	0.791	0.938
BW45	R. Blackwater (Augher)	Moderate	Moderate	0.118	0.822	0.939
BW20	Callan River (Derryscollop)	Moderate	Moderate	0.588	0.356	0.944
BW13	Cor River Tributary	Moderate	Moderate	0.588	0.374	0.962
BW04	Ballygawley Water	Moderate	Moderate	0.118	0.859	0.977
BW18	Callan River (Derryscollop)	Moderate	Moderate	0.147	0.865	1.012
BW39	Oona Water (Eglish)	Moderate	Moderate	0.294	0.736	1.030
BW29	Oona Water (Eglish)	Moderate	Moderate	0.324	0.730	1.053
BW77	R. Blackwater (Annaghroe)	Moderate	Poor	0.647	0.411	1.058
BW73	R. Blackwater (Annaghroe)	Moderate	Moderate	0.294	0.767	1.061
BW43	Ballygawley Water	Moderate	Poor	0.706	0.577	1.283
BW31	Tamnamore Stream	Moderate	Moderate	0.676	0.748	1.425
BW05	Tynan River	Moderate	Poor	0.882	0.791	1.674

B3.3.1 Candidate River Reaches Blackwater Catchment

Taking into account reports on “Ranking of riverine reaches for habitat improvement” and discussion with project partners, a summary of candidate river reaches have been compiled and are listed below. The suggested method is to investigate the highest ranking sampling site and its corresponding candidate river reach to evaluate the feasibility of carrying out measures for improvement. Each area will be assessed in more detail using additional information. If it is concluded that it is not feasible to carry out improvement works or the potential benefit is deemed insignificant then the next site on the list will be assessed.

Table 7-26 Candidate river reaches for works in the Blackwater catchment

Candidate River Reach	Channel length proposed (km)	Issues	Proposals	Other Comments
Ballymacone	6.9	Re-inforced banks; Bank vegetation.	Fencing; riparian planting; cattle drinks	BW_65
Rhone (Dungannon) 2	4.7	Re-inforced toe; Poaching; Excess Silt.	Fencing; riparian planting; Re-section banks.	BW_35, BW_30
Ballymatrim	7.5	Re-inforced toe, Bank vegetation; Bank Stability	Fencing; riparian planting; cattle drinks. Bank reprofile sections.	BW_36, BW_55
Aughnacloy	3.1	Bank veg; Embankment; Poaching; Re-inforced toe.	Fencing; riparian planting; cattle drinks	BW_64
Tynan 1	6.0	Over-deepened; Narrowed; Re-inforced toe; Poaching.	Fencing; riparian planting.	BW_11, BW_12
Ballygawley 2	3.9	Channel re-aligned; Over-deepened; Embankment; Re-sectioned banks.	Remove Re-inforcements. Bank stabilise.Fencing; riparian planting; cattle drinks.	BW_41, BW_42, BW_43
Augher 2	3.1	Poaching; Channel Vegetation; Riparian Land-	Fencing; riparian planting; cattle drinks.	BW_52
Mountain Water_050	6.5	Re-sectioned banks; suburban land-use.	Fencing; riparian planting; bank stabilisation.	BW_91, BW_105
Rhone (Dungannon) 1	3.3	Channel re-aligned; Over-deepened, Resectioned banks, Poaching.	Fencing; riparian planting; cattle drinks	BW_59
Oona (Killymaddy) 1	2.8	Channel re-aligned; Re-inforced toe; Poaching	Fencing; riparian planting; cattle drinks.	BW_61
Oona (Killymaddy) 3	2.6	Channel re-aligned; Over-deepened, Resectioned banks, Poaching, Re-inforced toe.	Fencing; riparian planting; cattle drinks, remove hard reinforcements.	BW_40, BW_58
Tynan 2	3.7	Re-sectioned banks; Poaching.	Fencing; riparian planting; cattle drinks.	BW_14
Monaghan Blackwater_040	5.7	Channel re-aligned; Over-deepened; Re-sectioned banks.	Fencing; riparian planting. Soft re-inforcement u/s of meander beside roadway.	BW_95
Cor River 1	2.4	Channel re-aligned; Over-deepened; Re-sectioned	Fencing; riparian planting. Soft re-inforcement.	BW_95
Augher 1	3.5	Channel re-aligned; Over-deepened; Over-widened; Resectioned banks; Poaching.	Fencing; riparian planting and bank stabilisation. Collaboration with DAERA doing in-stream works for fisheries.	BW_24
Callan(Milford)	5.9	Over-deepened; Over-widened; Re-sectioned banks; Embankment.	Fencing; riparian planting; cattle drinks.	BW_10
Annaghroe 2	3.0	Over-deepened; Over-widened; Resectioned banks; Re-inforcements; Poaching	Fencing; riparian planting; cattle drinks	BW_77, BW_81

Candidate River Reach	Channel length proposed (km)	Issues	Proposals	Other Comments
Callan (Tassagh)	5.6	Over-deepened; Narrowed; Impoundment; Re-sectioned banks; Re-inforced banks.	Fencing; riparian planting; cattle drinks.	BW_09
Cor River 2	2.9	Over-deepened; Over-widened; Embankments.	Fencing; riparian planting. Instream works- sediment traps, experimental?	BW_16
Callan (Derryscollop) 3	3.7	Channel re-aligned; Over-deepened; Over-widened; Re-sectioned banks; Embankment; Poaching	Fencing; riparian planting. Soft engineering bank stablisation.	BW_21
Augher 3	2.2	Over-deepened; Resectioned banks; Private forest felled recently.	Fencing; riparian planting.	BW_45
Callan (Derryscollop) 1	3.2	Over-deepened; Over-widened; Resectioned banks; Re-inforcements; Poaching	Fencing; riparian planting, bank stabilisation.	BW_20
Cor River Tributary	3.4	Re-aligned; Re-inforcement; Resectioned banks.	Fencing; riparian planting; cattle drinks, barrier removal.	BW_13
Ballygawley 1	2.6	Channel re-aligned; Over-deepened; Over-widened; Re-sectioned banks.	Fencing; riparian planting. Bank stabilisation.	BW_04
Callan (Derryscollop) 2	5.9	Channel re-aligned; Over-deepened; Over-widened; Re-sectioned banks; Poaching	Fencing; riparian planting; cattle drinks. Instream works to create variation flow depth.	BW_18
Oona (Eglish)	7.0	Over-deepened; Re-sectioned; Re-inforcements;Embankment; Poaching; Silt/pollution.	Fencing; riparian planting; cattle drinks.	BW_29
Annaghroe 1	7.1	Over-deepened; Impoundment; Re-sectioned banks; Re-inforced toe; Poaching.	Fencing; riparian planting; cattle drinks. Re-profile banks.	BW_73
Tamnnamore Stream	4.6	Channel re-aligned; Over-deepened; Re-sectioned	Fencing; riparian planting; cattle drinks.	BW_31
Tynan 4	7.0	Channel re-aligned; Over-deepened; Over-widened; Resectioned banks; Re-inforcement.	Fencing; riparian planting; cattle drinks. Bank re-sectioning. Meander reconnection. Permission u/s section incl. Estate	BW_05

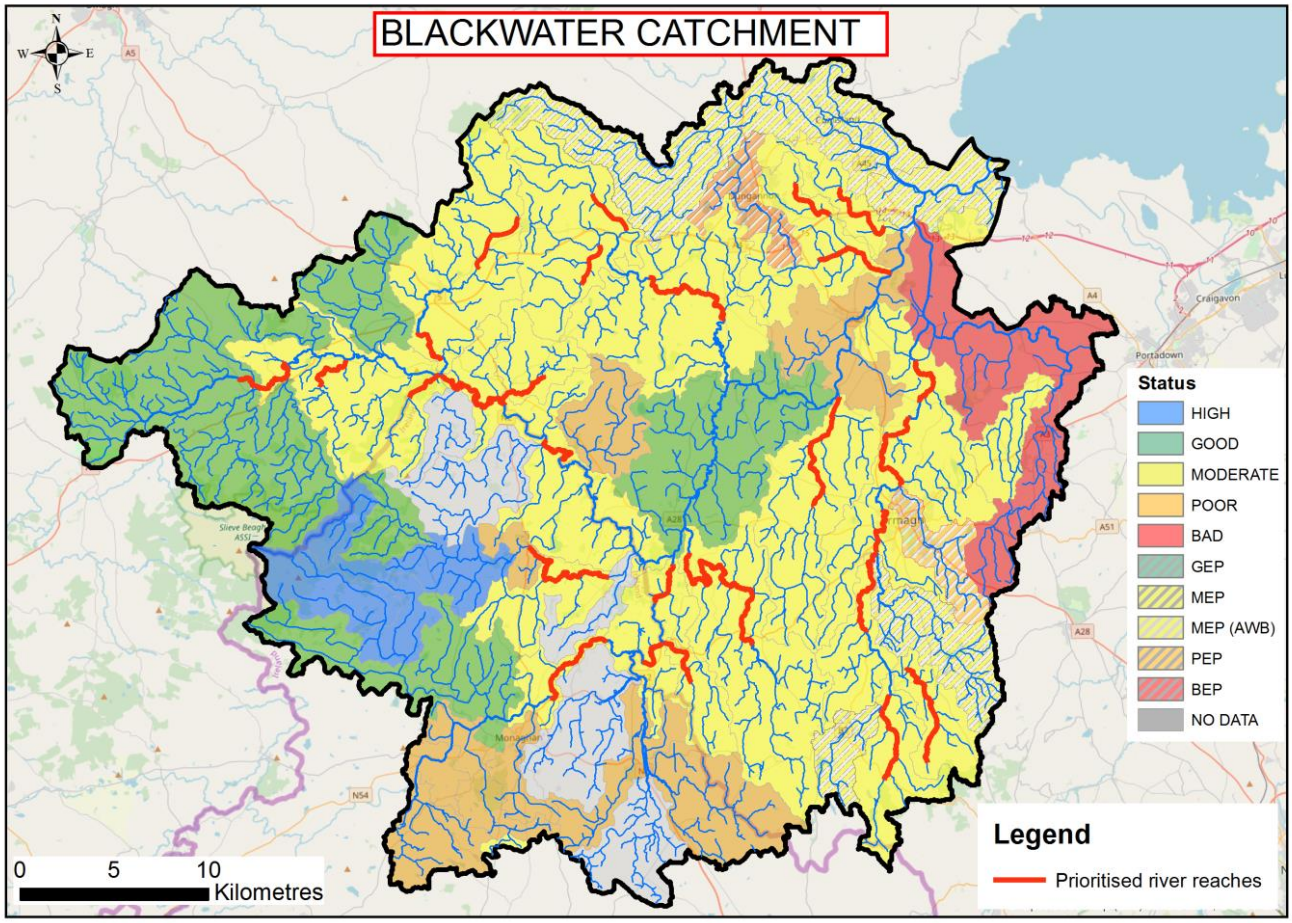


Figure 7-10 Location of candidate river reaches for works in the Blackwater catchment.

Final Selection of Reaches in the Blackwater Catchment

Discussion with partners and stakeholders further refined the list of suitable site for works.

Updated data on waterbody status (reassessed from 2018) was available from DAERA. After reviewing the updated data, a number of waterbodies in the Blackwater catchment were excluded from final selection, as their status had changed from Moderate status in 2018.

The candidate waterbodies, where the waterbody status was no longer of Moderate status, were rejected. This included the following tributaries:-

Ballymartrim River

River Rhone (Dungannon)

Cor River

Final prioritisation included consultation with stakeholders, joint works with partners and other CatchmentCARE projects. To maximise the cost-benefit of the restoration joint project work with partners and stakeholders was also considered a priority

The following rivers within the Blackwater catchment are prioritised for phase 1:

Mountain Water (Mountain Water_30, Mountain Water_40, Mountain Water_50 Mountain Water_60)

LAWPRO has identified the Mountain Water as a priority area in the Catchment and this is included in the works programme.

Ballygawley River (Ballygawley Water)

Joint works are already proceeding with DAERA on the Ballygawley River and they considered this a priority river

Blackwater between Favor Royal and Aughnacloy (River Blackwater (Annaghroe), River Blackwater (Augher))

A Community Incentive Schemes (CIS) is approved, which would dovetail into the works proposed for the River.

Tynan River (Tynan River)

Opportunities existed on the Tynan to undertake more extensive works than on most of the farmed land. Therefore, several partners had requested that permissions for work should be sought and has been granted by the landowner. This provided the opportunity to scope out a more extensive project using a greater amount of adjoining land.

Callan River (Callan River (Milford), Callan River (Derryscallop), Callan River (Tassagh))

Several CIS projects are approved for the Callan River.

The remaining sections are not included in the initial works and are scheduled for works if any further funding becomes available.

These included:-

Oona (Oona (Killymaddy), Oona (Eglish))

Tamnnamore Stream (Tamnamore Stream)

Ballymacone River (Ballymacone River)

Blackwater between Aughnacloy and Caledon (River Blackwater (Annaghroe))

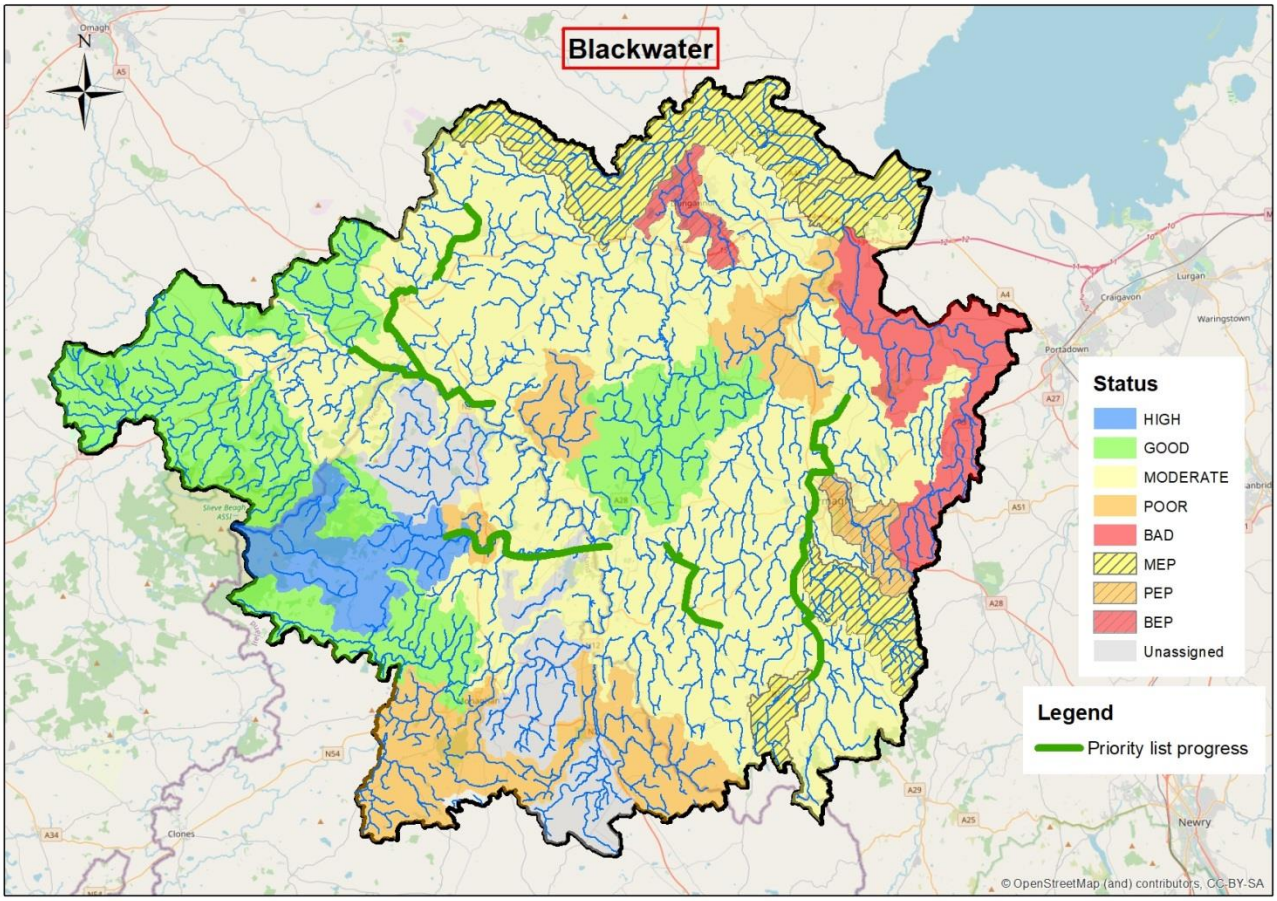


Figure 7-11. Finalised selection of river reaches for the Blackwater catchment.

B4 References

Addy, S., Cooksley, S., Dodd, N.,Waylen, K., Stockan, J., Byg, A., Holstead, K. (2016) River Restoration and Biodiversity: Nature-based solutions for restoring rivers in the UK and Republic of Ireland. *CREW reference: CRW2014/10*

Brookes, A. and Shields, F.D. (1996). River Channel Restoration: Guiding Principles for Sustainable Projects, Chichester, UK, Wiley.

Murphy, M., & Toland, M. (2012). River hydromorphology assessment technique (RHAT). Training guide. Northern Ireland Environment Agency, Department of the Environment, Version 2.