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Galloway Rivers Trust / Peatland Action annual water quality monitoring report 2025/2026 – Tannylaggie Flow and River Dee Catchment

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Summary

Annual water quality monitoring report on behalf of Peatland Action – Tannylaggie Flow and River Dee Catchment

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Keywords

Peat; Peatland Restoration; EXO1 Sonde; Brown trout; Atlantic salmon; River Dee; Kirkcudbrightshire Dee; Black Water of Dee; Water Quality, pH; acidification

Galloway Rivers Trust (GRT) have been actively involved with encouraging and supporting peatland restoration in South-west Scotland. GRT's main interest in this work is associated with the potential water quality benefits from peatland restoration, particularly to help address acidification impacts and restore degraded fish populations. Starting in November 2019, and continuing over subsequent years, Peatland Action (PA) has funded an annual water quality monitoring program within the Galloway region under the guidance of Emily Taylor, Galloway's local PA Peatland Officer. For the last five years water quality monitoring has centred around monitoring the Dargoal Burn at Tannylaggie Flow (River Bladnoch Catchment) to assess the impact of the Tannylaggie Flow peatland restoration and a catchment wide water quality assessment of a Galloway river catchment. The Kirkcudbrightshire Dee was the river covered during winter 2025/2026.

The Tannylaggie Flow peatland lies within the headwaters of the River Bladnoch in South-west Galloway. Historically the Bladnoch headwaters have been converted to commercial forestry (primarily Sitka spruce), with Tannylaggie Flow having been extensively drained and afforested. **As a result of the relationship between deep peat drainage and increased acidity the Dargoal Burn has become the most acidified watercourses in Galloway**. To help restore water quality in the headwaters of the River Bladnoch Forestry and Land Scotland (FLS) agreed to restore most of the Tannylaggie Flow peatland. The restoration work is at an early stage but is currently ongoing.

The River Dee is one of the largest rivers in Galloway, it is over 60 km long and has a catchment area that covers over 1,000 km^2. The river catchment contains considerable deposits of peat with over 50% of the catchment containing peat or peaty soils. Within this is 214 km^2 containing deep peat (nearly 20% of the catchment). Both peatlands and water quality are under considerable pressure within the Dee catchment. Commercial (Sitka spruce dominated) forestry covers a large percentage of the upland areas within the Dee catchment and coincides with most of the peatlands. Where forestry has been planted on peat this has typically required significant drainage damaging the peatlands and potentially impacting water quality. The headwaters of the Dee have also been subject to renewable energy developments, with multiple wind farms having been built within a relatively small section of the catchment. Over 141 wind turbines are located within the Dee catchment with most being constructed in the area which contains most of the deep Dystrophic Blanket Peat. This has resulted in significant areas of peat being dug up/disturbed to build roads and turbine bases. The Dee also contains an extensive hydro-electric scheme with multiple dams of varying size

covering the whole river system and even moving water between neighbouring river catchments. In addition to submerging several named peatlands below reservoir water the hydro-electric scheme has greatly altered hydrology and geomorphology causing significant impacts on water quality, quantity, plant and animal habitats and generally damaging aquatic ecosystems. **As a result of the various pressures within the Dee catchment Scottish Environment Protection Agency (SEPA) rates the river system as "Poor" or "Bad" for Overall Status, Overall, Ecology, Fish and Fish Ecology.**

The results from the Dargoal Burn water quality monitoring suggest that, to date, if the FLS peatland restoration at Tannylaggie is having any impact it is not yet obvious enough to detect as monitoring has not been undertaken for long enough post restoration. In addition, only a small section of the restoration project has been completed at the time of writing (estimated at under 5%). There being no obvious change in water quality to date is not unexpected given these factors. Peatland restoration at Tannylaggie Flow should be scaled up from winter 2026/2027.

Although most of the Kirkcudbrightshire Dee catchment generally has good water quality (based on pH levels), the results from this report show one sub-catchment, the Black Water of Dee, to be heavily acidified. Most of the Black Water of Dee catchment lies on top of two large areas of granite bedrock. The resulting low acid neutralising capacity has made the watercourses in these areas very susceptible to acidification resulting from anthropogenic changes within catchments. Due to the uniformity of the bedrock and the acid susceptibility the sampled watercourses flowing over granite within the Black Water of Dee provided an opportunity to look at several variables and how they impact pH levels/water quality. **From the variables that were available the granite sites low pH results tie in strongly with levels of fDOM (dissolved organic carbon) and upstream catchment mean altitude**. There was also a lesser correlation with slope. Whilst altitude clearly relates to dissolved organic carbon and pH levels it is also possible that the restored peatland at Silver Flowe on the upper Black Water of Dee is having a positive impact on water quality. An additional consideration is that there is a higher percentage of commercial forestry, and therefore drainage, within the lower Black Water of Dee, where water quality is poorer. One additional consideration relating to acidification within the Black Water of Dee is the impact of the Galloway Hydro-electric Scheme. During sampling (both continual monitoring and spot sampling) there was no water being released from Clatteringshaws Dam, although there was a small amount of leakage through the dam. As the pH levels from the upper Black Water of Dee are less acidic than the lower river the water from the upper catchment would have a diluting effect on the acidified water coming in from the burns in the lower catchment. However, this is lost as much of the flow from the upper river is diverted to the Water of Ken for power generation. **The water quality monitoring results indicate that the lower half of the Black Water of Dee catchment should be the priority for peatland restoration. As there appears to be no peatland in good condition within the lower catchment, and potentially a higher percentage of commercial forestry, restoration would also make sense from this perspective as well. From the peat, forestry and bedrock maps it has been possibly to identify priority locations for peatland restoration.**

While the upper Black Water of Dee is less acidified than the lower river, the upper catchment would still appear to be experiencing some degree of reduced water quality. Any opportunity to extend the peatland restoration at Silver Flowe would help address any ongoing issues and add to the favourability of an important SSSI/RAMSAR site.

Main findings/recommendations

- There are no recorded improvements in water quality within the Dargoal Burn at this early stage of the Tannylaggie Flow peatland restoration. Long-term monitoring is required at Tannylaggie Flow/the Dargoal Burn if the full restoration benefits are to be recorded.

- Due to the relationship between pH, fDOM and upstream catchment mean altitude the lower half of the Black Water of Dee catchment is a priority for peatland restoration aimed at reducing the input of dissolved organic carbon from the surrounding landscape. From the peat, forestry and bedrock maps shown within this report the obvious priority locations for peatland restoration would be:

    1) The area of dystrophic blanket peat adjacent to the North-west shore of Loch Grannoch (NX54096 71368, referred to as Blood Moss on OS maps)

    2) The area of dystrophic blanket peat which covers the lower Pullhaugh Burn and the headwaters of the Green Burn (NX54963 73540, referred to as Kaugh Moss on OS maps)

    3) The dystrophic blanket and basin peat covering much of the Glengainoch Burn catchment (NX61529 71160, referred to as Barney Water Flow on OS maps)

- While restoration of the highlighted peatlands will help resolve some of the worst water quality issues, the poor water quality is common across the lower Black Water of Dee catchment and any additional opportunities to restore peatlands should be seized if the opportunity arises.

- Any opportunity to extend the peatland restoration at Silver Flowe would help address any ongoing issues within the upper Black Water of Dee catchment. At present the peatland is afforested below the Cornarroch Burn and above the Saugh Burn, with most of the peat to the East of Silver Flowe (on the opposite side of the Black Water of Dee) also being afforested.

- Any potential water quality benefits from the peatland restoration at Silver Flowe are not reaching the lower Black Water of Dee due to the water management at Clatteringshaws Dam. Managed releases of water from the dam could potentially help reduce pH levels in the lower river during key times in salmonid egg development.

- The Black Water of Dee requires more detailed investigations into the impact of peatland type and condition and commercial forestry on water quality and aquatic ecosystems. A larger spot sampling network and laboratory dissolved organic carbon testing should be combined with more detailed mapping of peat and forestry cover to look in detail at the exact nature of the relationship between degraded peatlands, dissolved organic carbon and pH/water quality.

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1 INTRODUCTION

1.1 Acidification in Galloway, peatlands and native fish species

The Galloway region of South-west Scotland has been well documented in being subject to the effects of acidification. Atmospheric acid deposition from the burning of fossil fuels in areas of base-poor geology has resulted in soils exceeding their capacity to buffer against acid inputs, leading to artificially lowered pH within soils and waterbodies in these areas. Where large scale conifer plantations are present (in particular Sitka spruce) the impacts of acidification are often greater, with several authors finding a direct link between plantations and lowered pH (e.g. Harriman & Morrison, 1982) resulting from increased rates of wet and dry deposition of acidic pollutants. The Galloway region is one of the most afforested areas in the UK (Yang. A, 2020) with most plantations typically consisting of Sitka spruce (*Picea sitkensis*). Much of the planting was historically carried out in the “lower-value”, base-poor upland areas that are more susceptible to acidification. Acidification resulted in widespread artificially lowered pH levels in many upland areas within the Galloway region, with many upland lochs being reported as fishless by the late 1980’s (Maitland et al., 1987). In more recent times improvements in air quality resulting from reductions in the burning of fossil fuels has seen recovery form acidification in some areas, but others remain heavily impacted (Ferrier et al,. 2001; Helliwell et al., 2001).

The two main native fish species within upland acidified areas in Galloway are Brown trout (*Salmo trutta*) and Atlantic salmon (*Salmo salar*). Low pH can have significant impacts to both trout and salmon at critical stages within their lifecycle. At the time of hatching pH below 4.5 can block the action of the hatching enzyme chorionase leading to mortalities in Atlantic salmon (Waiwood & Haya, 1983). One of the main impacts of lowered pH is the association with increased levels of labile Aluminium (Driscoll, 1985), which can be toxic to trout and salmon. Mobilised Aluminium in soils can form complexes with water molecules, enabling them to bind to fish gills at low pH levels resulting in both ionoregulatory and respiratory impacts (Gensemer & Playle, 1999), whilst the physiological transformations that Atlantic salmon smolts undergo to cope with changes in salinity levels makes them particularly sensitive to Aluminium levels and has been associated with mortalities (Kroglund et al., 2008). Due to the complex interactions between pH and the environment and the subsequent impacts on fish Crisp (2000) summarises the general levels of concern of low pH for trout and salmon as being harmful at values below five and lethal at values below four. As a result of reduced pH levels within watercourses one of the major impacts within the Galloway region was the reduction, and in many cases complete loss, of Brown trout and Atlantic salmon populations. Maitland et al., in their 1987 publication *Acidification and Fish in Scottish Lochs* reported that in eleven lochs studied in the Galloway region that were known to once hold fish, six were now fishless whilst others showed impacts consistent with increased acidity. Since the late 1980’s improvements in air quality, liming, forestry restructuring and changes in land use have resulted in some improvements to fish populations with recovery of trout populations in some areas. However, recovery appears slow in some areas where improvements have been made, whilst other areas remain at pH levels that severely impact fish populations (Ferrier et al., 2001, Battarbee et al., 2011, Brown et al., 1998, Shilland et al., 2009). Electrofishing surveys carried out by Galloway Rivers Trust still routinely record low or absent trout and salmon numbers from upland areas that once held either or both.

Peatlands are extensive within many of the acidified areas within the Galloway region, with Dumfries and Galloway holding some of the largest areas of peat within Scotland (Chapman et al., 2009). The importance of Peatlands cannot be understated. Their role as a carbon store is gaining increasing exposure in the public eye given the importance being placed upon acting on climate change. However, they also carry out several other ecological services including water purification, improving climate resilience, flood control and act as unique habitats for flora and fauna (Harenda et al., 2018). Their occurrence on waterlogged, often nutrient poor "low value" uplands has resulted in the degradation of many peat bogs within Dumfries and Galloway, primarily from draining for agriculture and forestry (Peacock et al., 2018). Draining peatlands lowers the water table and exposes the peat to aerobic decomposition, resulting in the stored carbon being released into the atmosphere (Martin-Ortega et al., 2014). In addition to the release of carbon, drained peatlands can have impacts on waterbodies with increases in the quantity of Fine Particulate Organic Matter, metal concentrations, dissolved organic carbon (DOC), water turbidity and lowered pH (Martin-Ortega et al., 2014). In areas where conifer plantations have been planted on drained peat the resulting changes can be very damaging. Drainage and loss of vegetation, combined with the increased scavenging of atmospheric acidic pollutants associated with conifers, can result in the amplification of acidification issues within watercourses beyond that experienced within degraded peatlands or conifer plantations alone. Conifer plantations planted on peat can result in an additional lowering of pH, an increase in toxic metals, an increase in ammonia, an increase in DOC and an increase in turbidity (Harrison et al., 2014; Puhr et al., 2000). This has clearly been shown on the Cardoon Burn in the headwaters of the Water of Fleet where Peatland Action sponsored water quality monitoring carried out by Galloway Rivers Trust showed significantly different pH levels between heavily drained/afforested and restored sections of the same area of peatland (Galt, 2022).

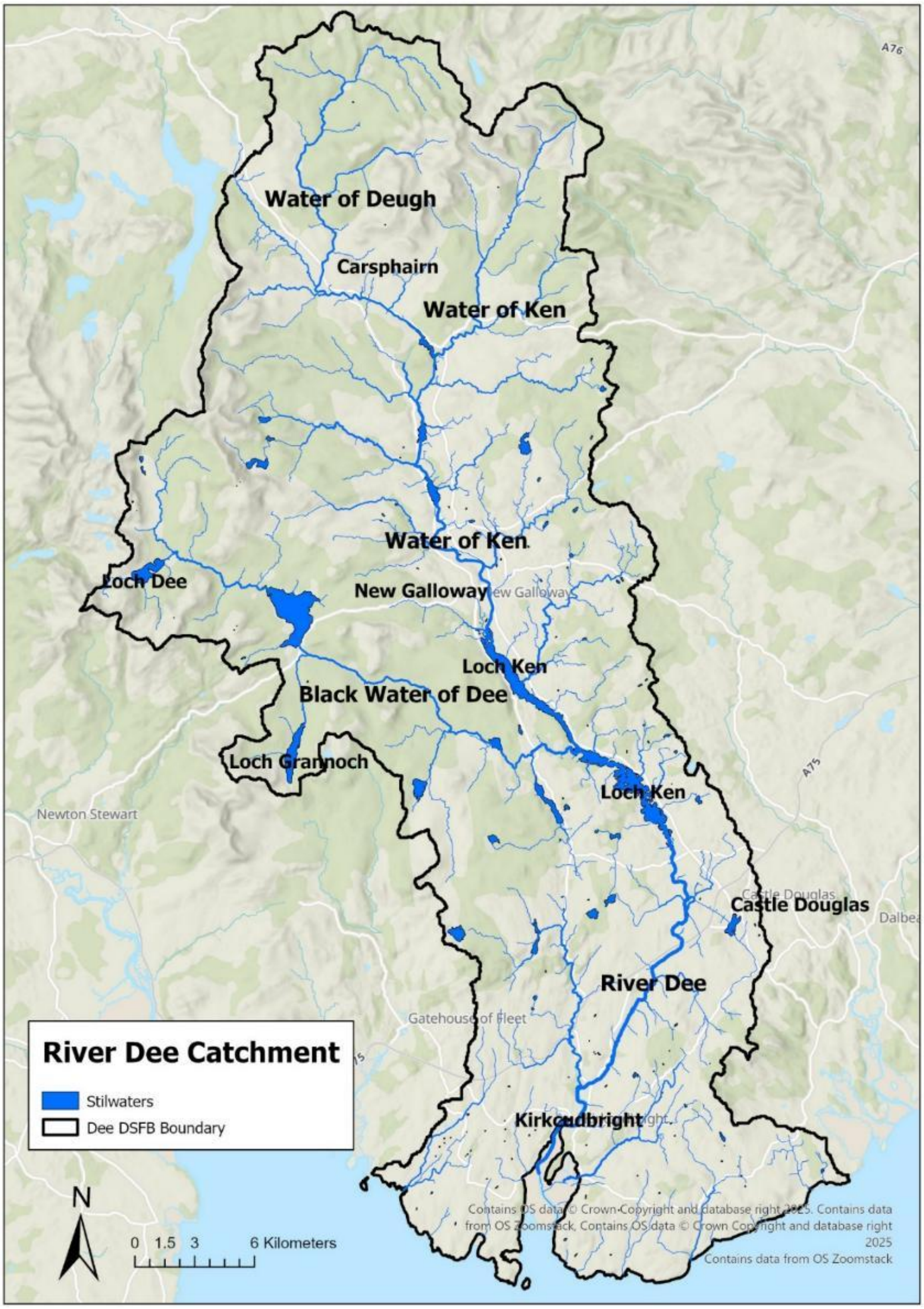
The identification of areas where acidification impacts fish populations, and working to address, mitigate or inform land management practice, forms a large part of the work carried out by GRT. Within this the identification of areas of degraded peatlands (and areas where conifers are planted on deep peat) that are causing significant water quality issues forms a key component of this work. Where land use results in degraded peatlands that are impacting fish populations there may be the opportunity for multiparty work towards peatland restoration that fulfils several environmental and climatic goals, such as carbon storage, repopulating unique peatland flora and fauna and improved water quality with resulting benefits for fish populations. For that purpose, GRT has been working in partnership with Peatland Action (PA) and the Crichton Carbon Centre (CCC) since 2019 to monitor water quality in sections of Galloway rivers that are impacted by acidification resulting from damaged/degraded peatlands. The project/partnership aims to monitor the impacts of peatland restoration on water quality (particularly in relation to salmonids), assess water quality across upland sections of rivers where degraded peat is present and to use the information gathered to raise awareness, prioritise areas where peatland restoration will result in the biggest improvements to water quality and to provide data to feed into land management plans. The collaboration between GRT, CCC and PA is funded by NatureScot (NS) with funding being secured in the autumn of 2024 to monitor water quality at a the Tannylaggie Flow peatland restoration site and within the River Dee catchment over winter 2025/26 (winter being the period when rainfall is typically highest resulting in more frequent acid flushes into watercourses).

1.2 River Dee catchment summary

1.2.1 Introduction

The Kirkcudbrightshire Dee is located within West Galloway and is one of the larger rivers in Dumfries and Galloway. At over 60 km long it has over 750 km of channel length and has a catchment area of over 1,000 km^2. At its furthest point from the sea the river forms in Millaneoch Hill near Windy Standard on the Kirkcudbrightshire and East Ayrshire boundary. Over most of its course the river generally flows southwards before entering the Solway via Kirkcudbright Bay. The river undergoes several name changes throughout its course, with only the lower 17 km below Loch Ken being known as the River Dee. Loch Ken is a natural widening within the river around two thirds of the way down the catchment, it is fed by two main sources the Black Water of Dee, which flows into the middle reaches of the Loch, and the larger Water of Ken, which flows in at the northern (upstream) end of the loch. The Water of Ken has a large tributary known as the Water of Deugh which joins the upper Ken, with the

Deugh being larger than the Water of Ken at joining of the two rivers (the headwaters of the Deugh form the source of the river based on the furthest point from the sea). Like most of its neighbouring rivers the Dee has a relatively uncrowded catchment with a low human population density. The largest settlements within the catchment are St John's Town of Dalry, Castle Douglas and Kirkcudbright with populations of around 1,000, 4,000 and 3,350 respectively. Other notable settlements include New Galloway, Carsphairn, Crossmichael and Twynholm. All have a population under 500, except for New Galloway for which figures cannot be found online (but is more similar in size to Dalry).



Map 1: Catchment map for the River Dee

Picture 1 – the River Dee between Loch Ken and Kirkcudbright, flows in this section are regulated by the Galloway Hydro-electric Scheme

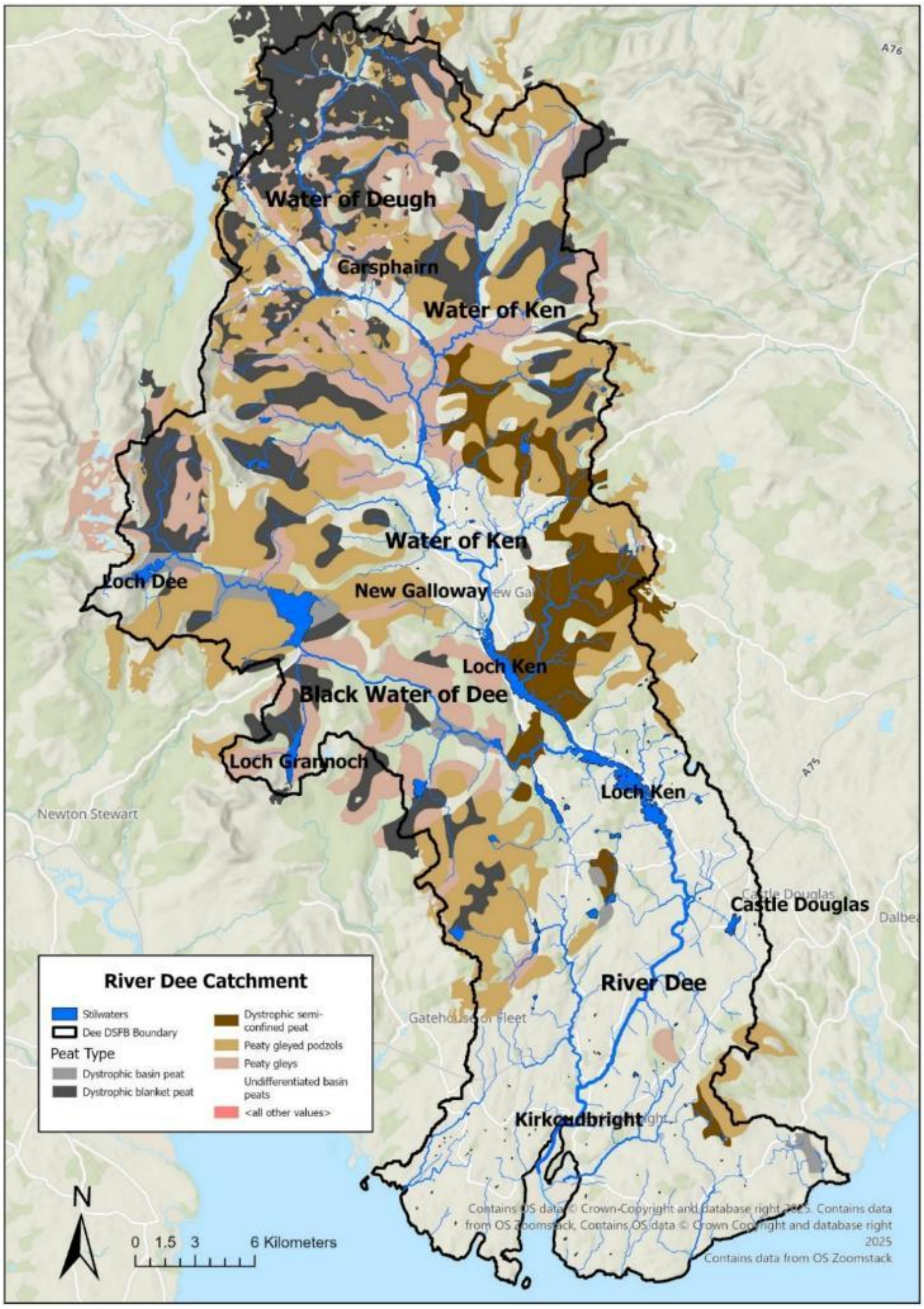
Picture 2 – the Water of Ken above New Galloway, flows in this section are regulated by the Galloway Hydro-electric Scheme with this picture having been taken when there is no power being generated within this section

Picture 3 – the lower Black Water of Dee, flows within this section of river are impacted by Clatteringshaws Dam which forms part of the Galloway Hydro-electric Scheme

Picture 4 – the Water of Deugh in the Dee headwaters, like the upper Water of Ken the Deugh is inaccessible to migratory fish because of dams which form part of the Galloway Hydro-electric Scheme

1.2.2 Dee Catchment Peatland Condition and Extent

Like many of the rivers in South-west Scotland, much of the upper Dee catchments consist of nutrient poor moorland and heathland with significant areas of deep and shallow peat present (including the two peatland SSSI's described previously). Map 2 shows the peat map for the Dee catchment. Whilst the exact locations, areas and depths of all peatlands within the Dee catchment have not been accurately recorded, Map 2 clearly shows there are significant areas of blanket/basin peat (which typically describe large areas of deep peat), semi-confined peat and peaty gleys. Analysis of the National Soil Map of Scotland[1] shows that peatlands make up a significant proportion of the soils in the catchment (Table 1).



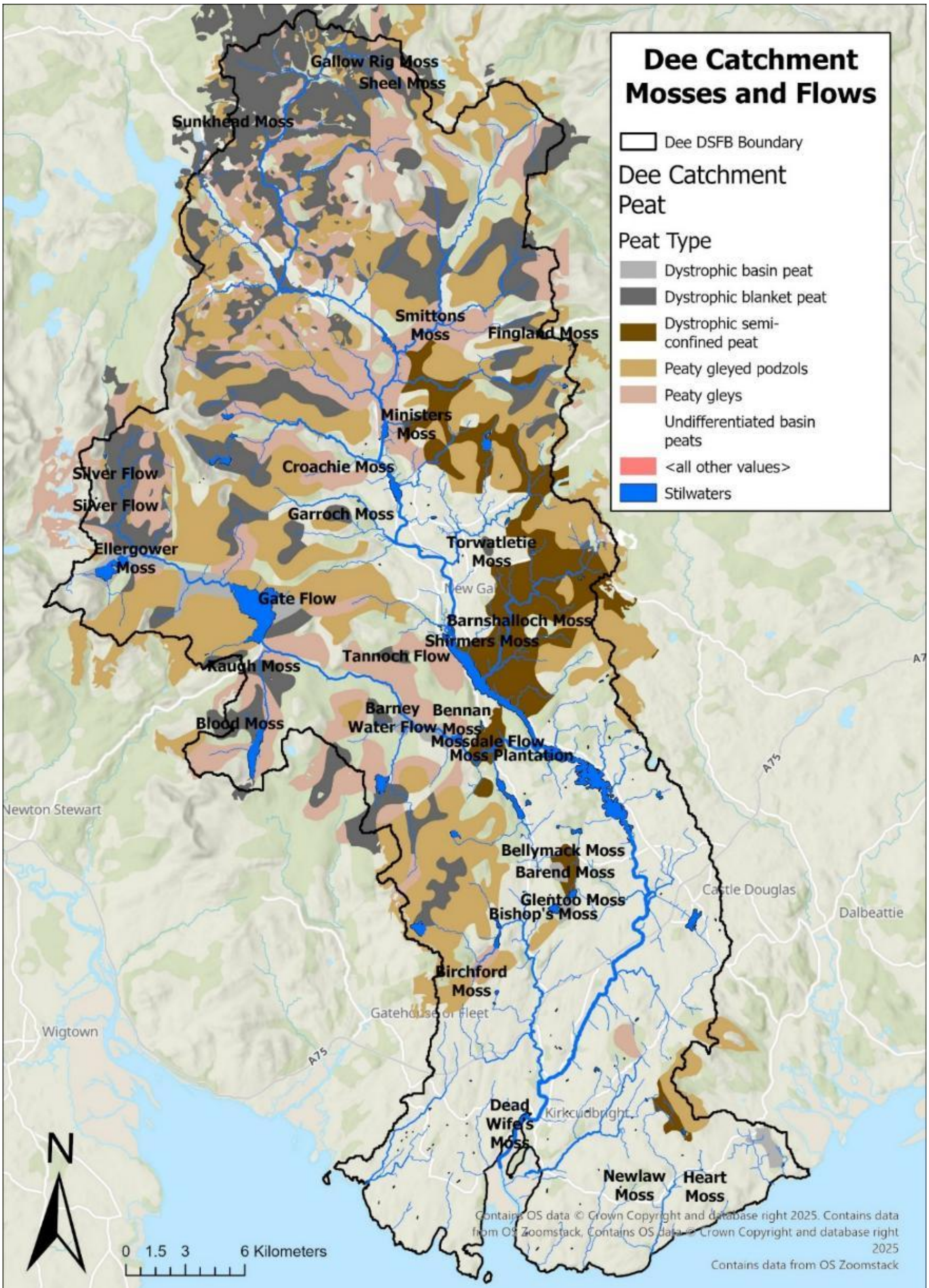
Map 2: Catchment map for the River Dee showing peat distribution and type, map provided by the Crichton Carbon Centre

[1] Soil Survey of Scotland Staff (1981). Soil maps of Scotland at a scale of 1:250 000. Macaulay Institute for Soil Research, Aberdeen. DOI: 10.5281/zenodo.4646891'

Table 1: Peatland soils in the Dee catchment[1]

Soil Type	*Area (km^2)*	*% of Catchment*	*Deep/Shallow Peat*
Dystrophic basin peat	*22.43*	*2.0%*	Deep
Dystrophic blanket peat	*93.61*	*8.3%*	Deep
Dystrophic blanket peat with peaty gleys	*39.68*	*3.5%*	Deep
Dystrophic semi-confined peat with brown earths	*30.40*	*2.7%*	Deep (but likely variable)
Dystrophic semi-confined peat with peaty gleyed podzols with peaty gleys	*19.44*	*1.7%*	Deep
Dystrophic semi-confined peat with peaty rankers	*8.05*	*0.7%*	Deep (could be variable with rankers)
Peaty gleys with dystrophic blanket peat	*32.19*	*2.8%*	Shallow / peaty soils
Peaty gleys with dystrophic semi-confined peat	*18.07*	*1.6%*	Shallow / peaty soils
Peaty gleys with dystrophic semi-confined peat with brown earths with peaty gleyed podzols	*54.57*	*4.9%*	Shallow / peaty soils
Peaty gleys with peaty gleyed podzols with dystrophic blanket peat	*22.48*	*2.0%*	Shallow / peaty soils
Peaty gleyed podzols with peaty gleys with dystrophic blanket peat	*39.47*	*3.5%*	Shallow / peaty soils
Peaty gleys with dystrophic semi-confined peat with peaty gleyed podzols	*1.55*	*0.1%*	Shallow / peaty soils
Peaty gleyed podzols	*30.08*	*2.7%*	Shallow / peaty soils
Peaty gleyed podzols with peaty rankers	*5.87*	*0.5%*	Shallow / peaty soils
Peaty gleyed podzols with peaty gleys	*149.23*	*13.3%*	Shallow / peaty soils
Peaty rankers	*4.53*	*0.4%*	Shallow / peaty soils (very shallow)
Brown earths with dystrophic basin peat with peaty alluvial soils	*7.18*	*0.6%*	Shallow / mineral soils (highly mixed)
Humus-iron podzols with peaty gleyed podzols	*35.75*	*3.2%*	Shallow / mineral soils
Noncalcareous gleys with peaty gleys	*8.08*	*0.7%*	Shallow / mineral soils
Total	*622.66 km^2*	*55.2%*	

It is also interesting to note that Ordnance Survey maps highlight numerous areas within the Dee catchment that are named as Moss or Flow, old names typically used for waterlogged peatlands. These include Silver Flowe, Gate Flow, Tannoch Flow, Barney Water Flow, Mossdale Flow and numerous additional locations described as being Mosses. Map 3 shows the location of named mosses and flows within the Dee catchment. Not displayed on the map are Craigwell Flow, Darnaw Flow and Moss Raploch. All three were found on old maps stored on the National Library of Scotland website (https://maps.nls.uk/geo/find/marker/) and are now submerged under water above Clatteringshaws Dam on the Black Water of Dee. The maps indicate that a large area of deep peat is submerged under the reservoir, with peat depths of up to 8 m having been recorded immediately above the reservoir by the Crichton Carbon Centre.

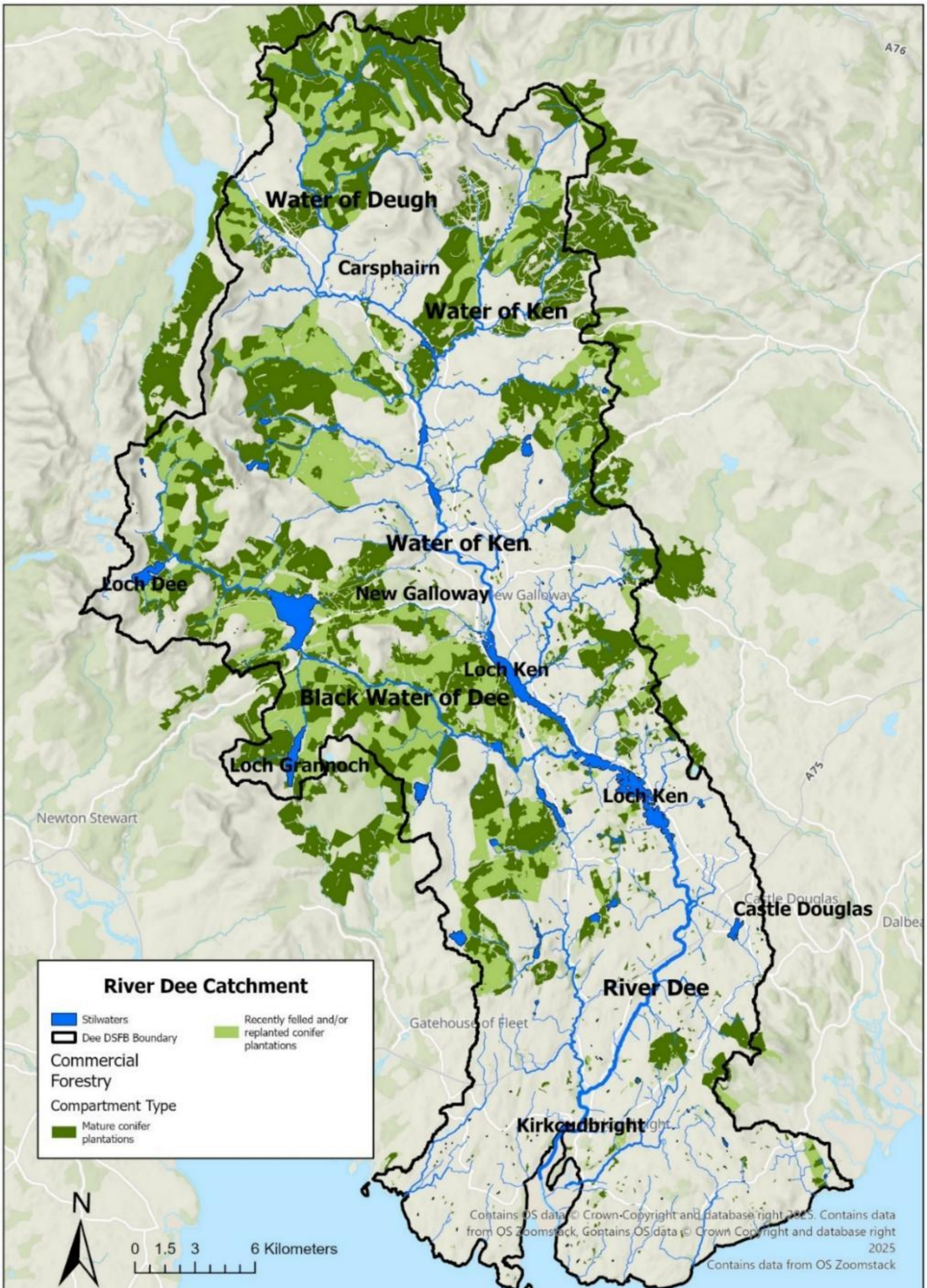


Map 3: The location of named mosses and flows within the Dee catchment, shown on the Dee catchment peat map

1.2.3 Dee Catchment Commercial Forestry

Due to the low cost and productivity of the land, a large proportion of the uplands within the Dee catchment were historically bought up and converted to commercial forestry (typically between the 1950's and the 1970's), with this land use largely continuing to the present day. Map 4 shows the extent of the commercial forestry (primarily Sitka spruce) within the Dee catchment, with many areas of deep peat being drained and afforested. Where deep peat was historically prepared for commercial forestry extensive, deep drainage networks were often required to drain the land for planting, resulting in considerable damage to the peatland. Whilst little information is available regarding the nature and extent of commercial forestry drainage within areas of deep peat, it is likely that a significant proportion of afforested peatlands and peaty soils have been drained extensively. As can be seen by comparing the forestry map with the peat map there is considerable overlap between commercial forestry and peat within the Dee catchment.

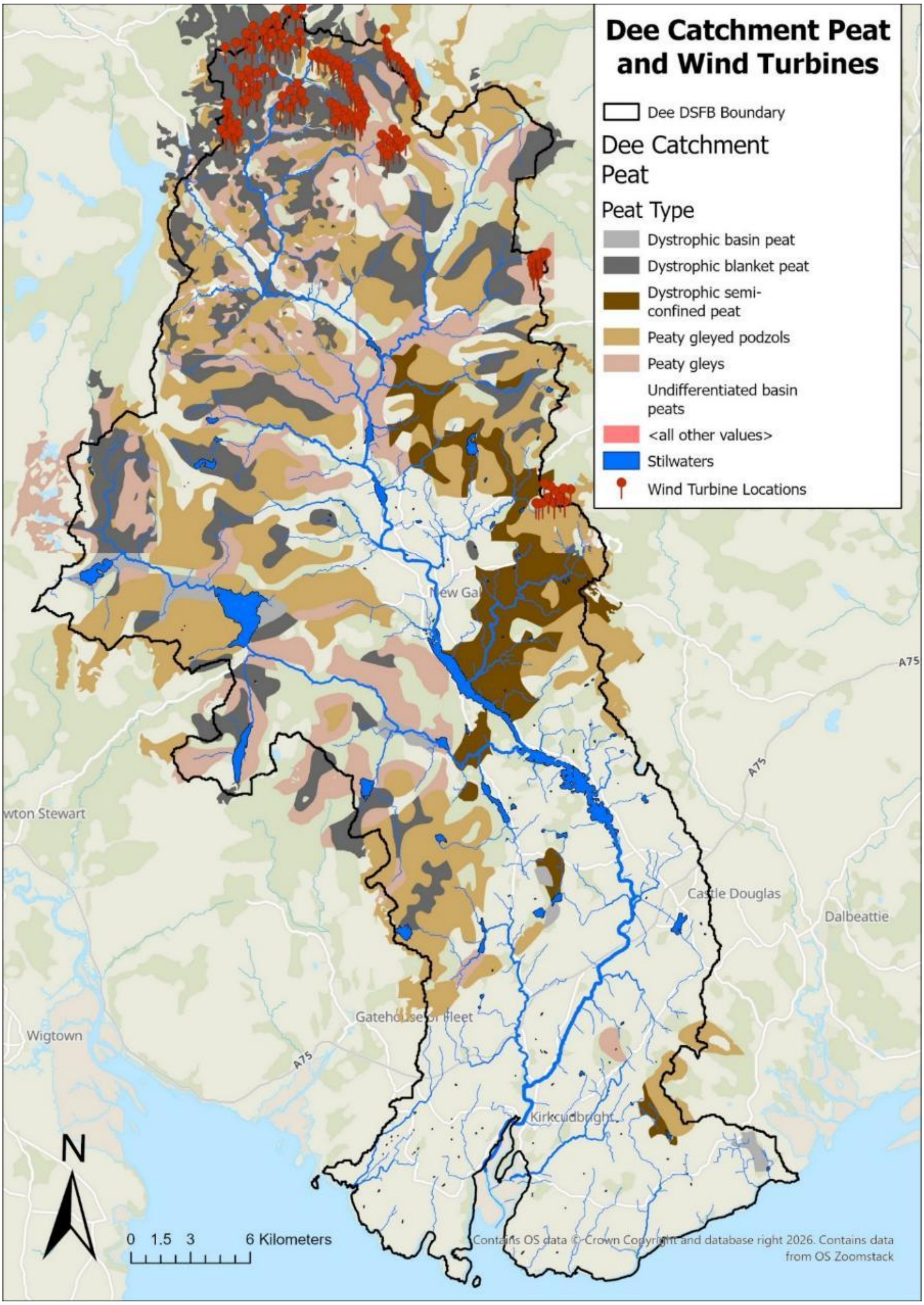
To date peatland restoration has been very limited in the catchment with small scale schemes completed such as the Forestry and Land Scotland "South Dee" forest to bog project, approximately 15 ha in size, and the Silver Flowe ditch blocking project completed in 2012.



Map 4: The distribution of commercial forestry within the Dee catchment

1.2.4 Dee Catchment Renewable Energy Developments

A more modern potential impact on peatlands within the Dee catchment (and throughout Scotland in general) is renewable energy developments, primarily in the form of wind farms. Map 5 shows the locations of wind turbines within the Dee catchment.



Map 5: The distribution of wind turbines and peat within the Dee catchment

The locations were identified from Grid Reference Finder which uses Apple Maps aerial imagery. There is no date of image capture on Apple Maps aerial imagery but given the turbines at Benbrack Wind Farm were fully constructed at the time of image capture, and that deciduous trees are in full leaf, this would indicate the images were likely taken during summer 2025. There are 141 wind turbines recorded within Map 5, while additional wind farms/turbines are currently under construction. The Scottish Government reports that as of 2022 there are 850 wind turbines in Southern Scotland. Given that there has been multiple wind farms constructed since 2022 the figure as of March 2026 is likely to be far higher (Scottish Renewables reports that there are approximately 4,200 wind turbines within all of Scotland as of early 2026). The map only shows turbines within the Dee catchment. As several of the wind farms are located on the boundary between the Dee and its neighbouring catchments this excludes a significant number of turbines from which form part of some of the wind farms. Map 5 shows that most of the wind farm developments within the Dee catchment are located within the headwaters of the Water of Deugh sub-catchment. As can also be seen from the map the turbines have been constructed on one of the largest/most significant areas of Dystrophic blanket peat within the Dee catchment. As such wind farm developments within the Dee catchment are primarily located in areas containing blanket peat. Whilst efforts will likely have been made to avoid peat were possible, it would be impossible to construct the number of turbines currently in operation without significant damage to peat. Where peat is present large areas will have been dug up to create space for roads and turbine bases. An example of this was captured by Apple Map imagery on Grid Reference Finder on a new Wind Farm construction on the boundary between the Dee and Nith catchments and is shown in Picture 5.

Picture 5: Apple Map aerial imagery (thought to be from summer 2025) showing diggers actively draining and removing peat to build roads as part of a Wind Farm development on the boundary between the Kirkcudbrightshire Dee and Nith catchments

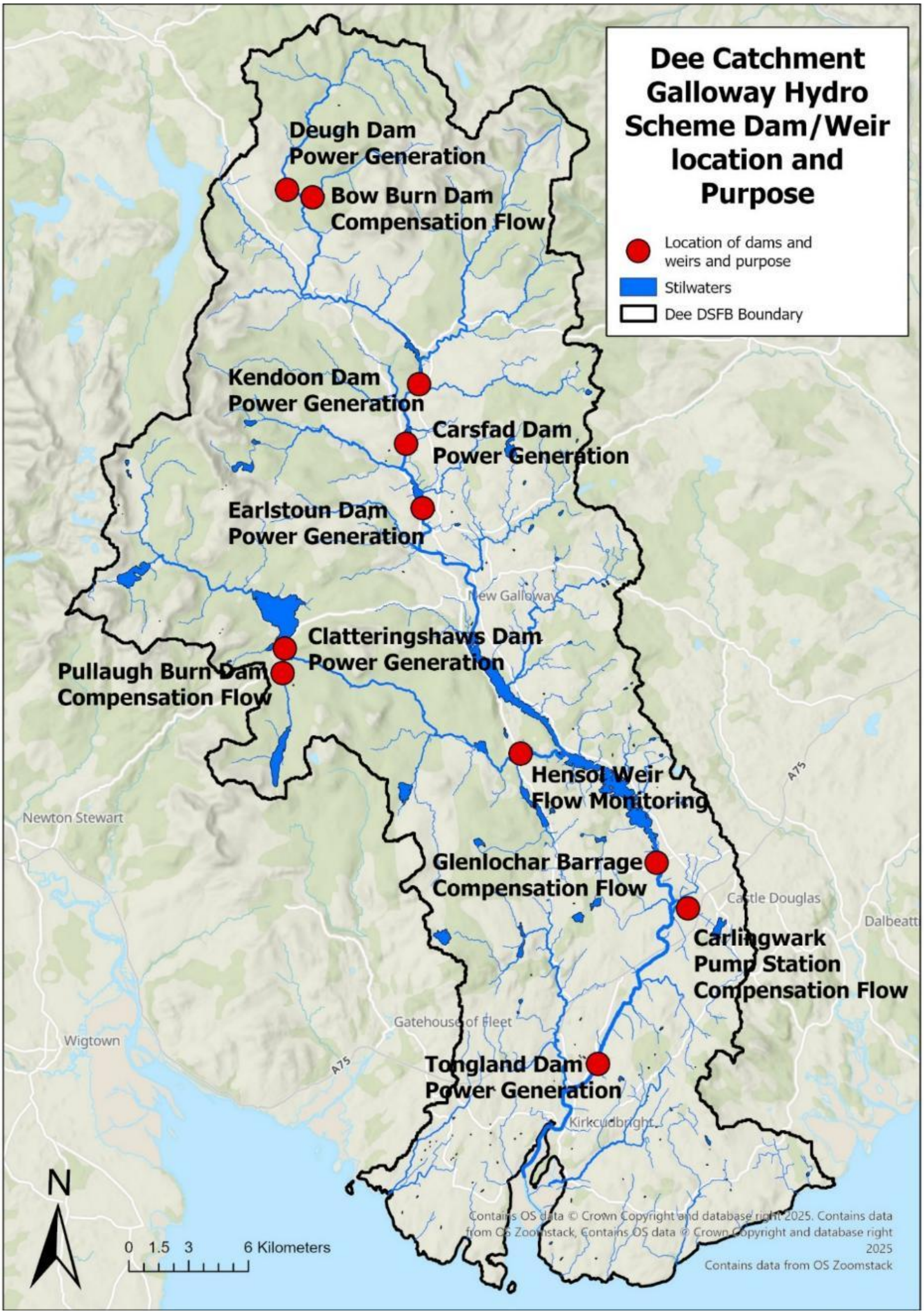
The impacts on peatlands, water quality and acidification resulting from wind farm developments are only just starting to be understood, however, any disturbance caused by developments poses a potential threat to water quality with some studies having shown a link between Wind Farm developments and acidification within acid sensitive catchments (e.g. Millidine et al., 2015). Wind Farm developments on areas containing peat are not restricted to just the Dee catchment within Galloway, with most rivers having seen wind farm development in some shape or form. Both the Water of Luce and River Bladnoch contain a large proportion of peat within their catchments and are acid sensitive. Both rivers have been subject to significant wind farm development in areas containing peat.

Picture 6: Apple Map aerial imagery (thought to be from winter 2024/2025) showing diggers actively draining and removing peat to build roads and turbine bases as part of a Wind Farm development within the Water of Luce catchment

Although out with the scope of this report there is clear evidence to indicate that wind farm developments are being prioritised ahead of peatland protection and/or restoration targets.

1.2.5 Galloway Hydro-electric Power Scheme

The Dee catchment contains the Galloway Hydro-electric Scheme, a network of dams, weirs, barrages and hydro-electric power stations spanning much of the course of the River Dee and its major tributaries. The scheme also draws water from Loch Doon, which forms the source of the neighbouring River Doon, which in turn receives compensation flows from the Water of Deugh. As a result, a considerable volume of water is moved between adjacent river catchments. Galloway Hydro-electric Scheme was built between 1930 and 1936 and unlike many of the hydro-electric schemes within Scottish rivers the Scheme encompasses the whole river system, with the furthest downstream dam (Tongland) being located just above the rivers tidal limit. As a result of dams associated with the scheme the headwaters of the Water of Ken, Black Water of Dee and the entire Water of Deugh are cut off from migratory fish. This encompasses a catchment area of just over 250 km^2, or roughly one quarter of the entire catchment. However, the impact of the hydro-electric dams goes far beyond just fish access, as significant areas of salmon and trout spawning have been lost in the areas flooded by the reservoirs, whilst the dams have also stopped the natural movement of gravels/substrate down the river system. Since the installation of the dams the substrate/gravel below has been washed downstream during floods, with no natural replacement coming down from above. In addition to providing spawning substrate for fish river gravel/substrate also provides habitat for aquatic plants and freshwater invertebrates and its absence can have dramatic impacts on aquatic life. Its absence has a significant impact on aquatic ecosystems. The high energy Black Water of Dee has been particularly badly impacted by gravel/substrate loss within the river. The hydro scheme also manipulates flows within the river by holding up water behind dams then releasing it downstream during periods of power generation. This can lead to varying extremes of high and low flows and rapid rises and falls over very short periods of time. License reviews are currently underway to assess what impact this may be having on fish migrations and fish populations in general. Whilst salmonid populations can often provide a useful gauge of water quality, the impacts of the Galloway Hydro-electric Scheme on fish populations within the Dee catchment make this type of assessment much more difficult. For Atlantic salmon within the Dee catchment loss of habitat, alteration of flows, impacts on fish passage at dams and complete exclusion of fish from some parts of the catchment have had a significant impact on fish numbers. This combined with modern sea survival rates has resulted in the Atlantic salmon numbers within the Dee catchment being well below historic levels, and well below expected densities across much of the river. This makes it almost impossible to assess water quality using numbers of Atlantic salmon (at any life stage) as factors other than water quality are most likely having the biggest impact on salmon numbers across most, if not all, of the catchment. Brown trout (including their anadromous form Sea trout) are also impacted by the hydro scheme, for many of the same reasons, but to a lesser extent than salmon. This is because Brown trout can complete their life cycle without the need for marine migrations and primarily spawn within burns, which are less impacted by dams and regulated flows (there are some hydro-electric dams within a small number of burns within the Dee catchment, but most burns are relatively free from man-made obstructions). However, Brown trout still likely use the larger channels impacted by the hydro-electric scheme as adults. As a result, Brown trout can be used as an indicator of water quality, but with several caveats based on the individual circumstances within different parts of the catchment. As a result of Tongland dam European eels (*Anguilla anguilla*) and Sea lamprey (*Petromyzon marinus*) are absent from almost all the river system. Map 6 shows the location of Galloway Hydro Scheme dams and barrages, and their purpose.



Map 6: Catchment map for the River Dee highlighting the locations and purposes of the Galloway Hydroelectric Scheme dams and weirs. Drumjohn Power Station has been omitted from the map as it lies within the River Doon catchment however, water from the power station flows into the Dee catchment. Several dams on small burns (providing compensation flows for hydro dams) have also been omitted due to their size.

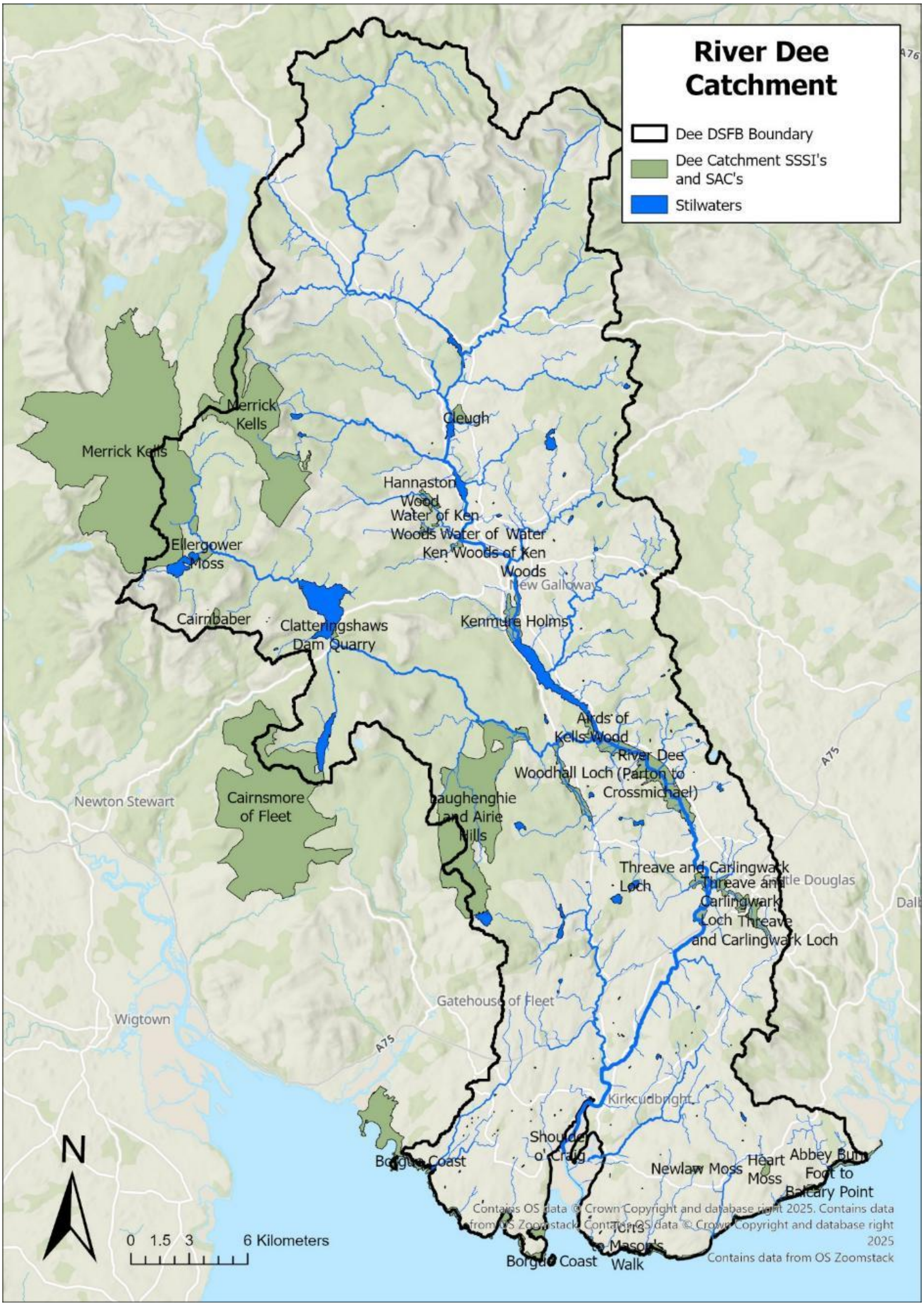
1.2.6 Non-native Invasive Species

Historically many non-native fish species have been introduced to the Rive Dee system. They include species such as Northern pike (*Esox lucius*), European perch (*Perca fluviatilis*), Common roach (*Rutilus rutilus*), Common bream (Abramis brama), Common dace (*Leuciscus leuciscus)* and Ruffe (*Gymnocephalus cernua*). As a result of the exclusion of fish species such as European eels and Sea lamprey there are currently more non-native fish species within the Dee system than there are native fish species, with the hydro-electric dams and the raising of the height of Loch Ken (Glenlochar barrage) providing additional habitat suitable for many of the non-native species. In addition to non-native fish species invasive North American signal crayfish have been introduced to the Dee catchment. They currently cover much of the river system and are particularly abundant within Loch Ken. The impacts of non-native species are well known with all the species noted above having some degree of impact on native fish and invertebrate populations.

1.2.7 Dee Catchment SSSI's and SAC's

The River Dee catchment contains several important areas classed as Sites of Special Scientific Interest (SSSI) or as Special Areas of Conservation (SAC). The headwaters of the Black Water of Dee form part of the Merrick Kells SSSI and SAC, which is protected as an example upland habitat in Southwest Scotland. It is noted for its water body, bog, heath, alpine grassland and sub alpine grassland habitats and for its geology. Located within the Merrick Kells and the Black Water of Dee catchment is Silver Flowe, 620 ha of restored dystrophic blanket peat. It is one of the least disturbed patterned blanket bogs in the UK and as such is recognised as a RAMSAR site. A short distance downstream from Silver Flowe is Ellergower Moss SSSI, a much smaller area of protected peatland (35 ha) immediately downstream from Loch Dee and sandwiched between commercial forestry in all other directions. Cairnbaber SSSI is also located in the upper Black Water of Dee catchment, it is protected as an example of upland (notably cliff) habitat. A small percentage of the Cairnsmore of Fleet SSSI is also located within the Black Water of Dee catchment. It is another example of upland habitats. Most of the Laughenghie and Airie Hill SSSI is also located within the Black Water of Dee catchment, it is noted as being the best remaining area of unplanted moorland in the Stewartry District and for its breeding bird species. At the bottom of the Black Water of Dee catchment, just above the confluence with Loch Ken, is Woodhall Loch SSSI. The Loch represents a transition between a peaty upland and a richer lowland loch. There are a wide range of habitats, with good examples of both fen and mire.

Whilst the Black Water of Dee sub-catchment has the highest number of SSSI's within the Dee catchment there are several other located within other locations. They include Cleugh SSSI (grassland), Water of Ken Woods SSSI (woodlands), Kenmure Holms SSSI (fen meadow), Airs of Kells Wood SSSI (oak woodland), River Dee (Parton to Crossmichael) SSSI (open water transitional fen) and Threave and Carlingwark Loch SSSI (complex and diverse wetland sites).



Map 7: Catchment map for the River Dee showing the location of SSSI's and SAC's

1.3 SEPA water hub Dee catchment water quality data

Given the known water quality and water management issues within the Dee and their impacts on fish populations some information on current River Dee water quality and ecological status is available through the Scottish Environment Protection Agency (SEPA) water hub (https://www.sepa.org.uk/data-visualisation/water-classification-hub/). The hub summarises SEPA's own monitoring data. The hub splits the Dee catchment into several sub-catchments. All parameters are scored based on a "High" (Blue), "Good" (Green), "Moderate" (Yellow), "Poor" (Amber) and "Bad" (Red) scoring system. Screenshots from the SEPA hub for overall status, overall ecology, overall hydrology, water quality, acidity, pH, morphology, hydrology (low flows), hydrology (moderate/high flows), fish, fish ecology, fish barriers, macroinvertebrates (acid) and macroinvertebrates (RICT/WHTP) are shown below. These parameters have been selected from the large number of parameters available due their link (either direct or indirect) to water quality (specifically pH) and hydrology (hydro-electric energy generation) and their potential impacts on fish and invertebrates.

Figure 1: SEPA Condition Classification Scores

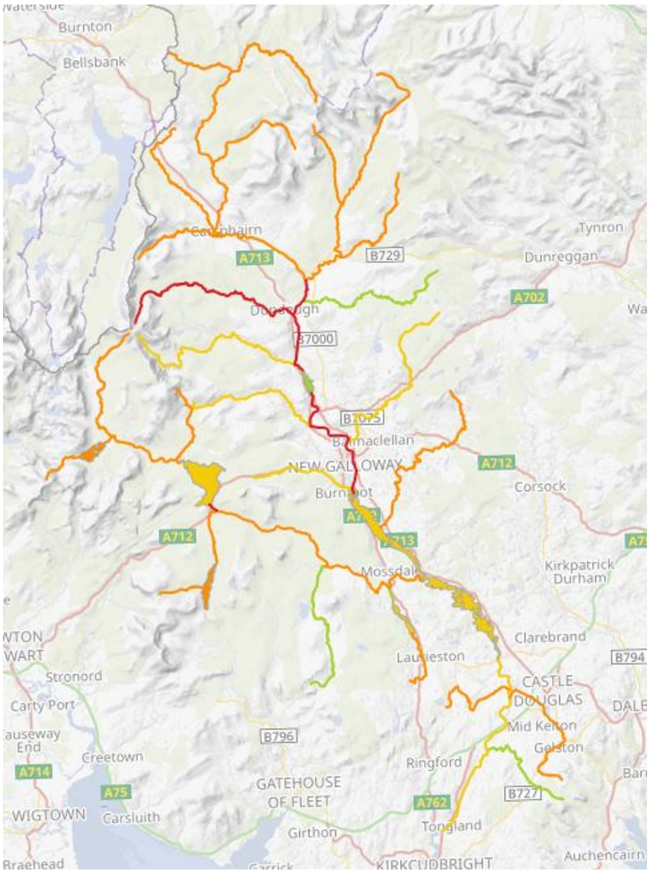


Figure 2: SEPA water hub River Dee classification: Overall Status

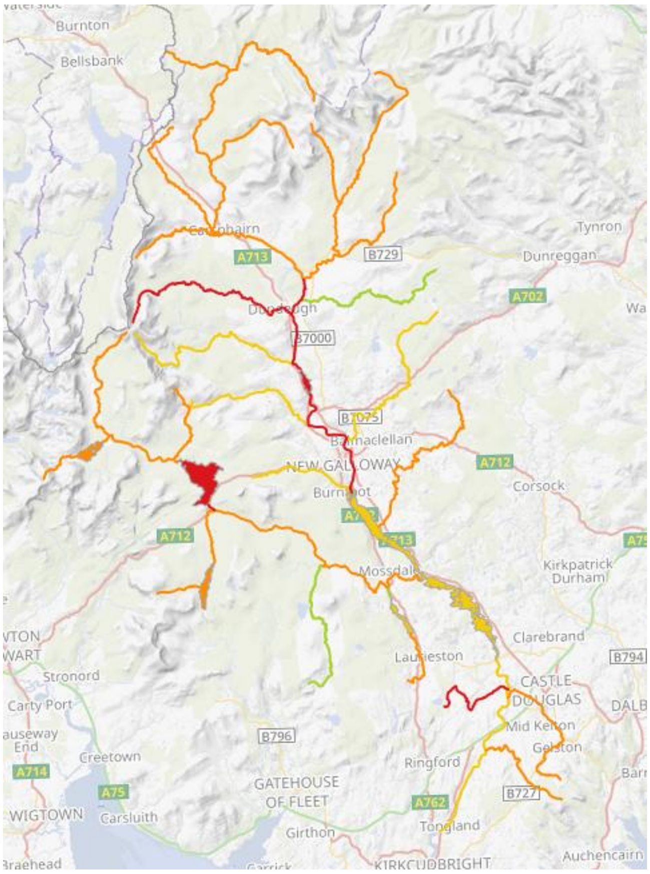


Figure 3: SEPA water hub River Dee classification: Overall Ecology

Figure 4: SEPA water hub River Dee classification: Overall Hydrology

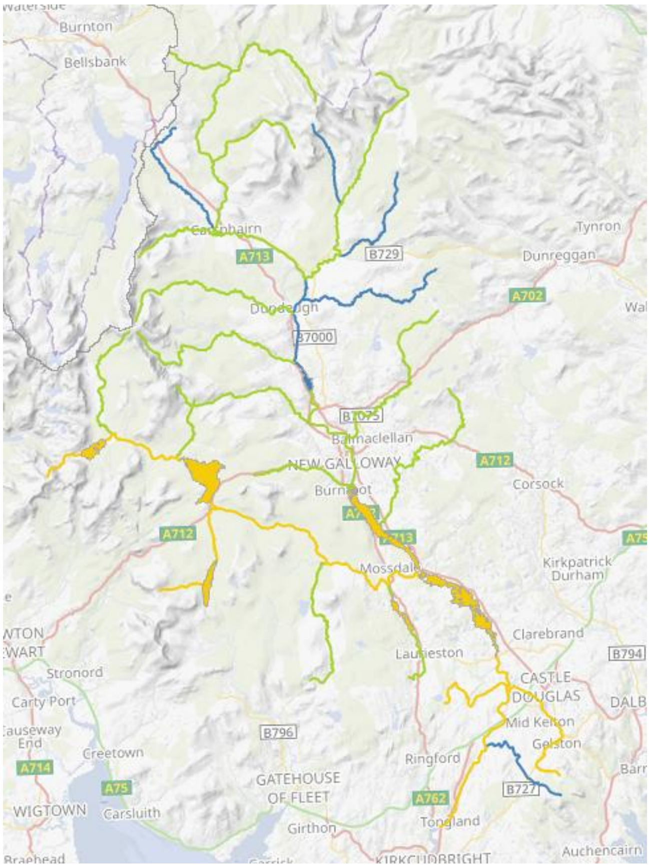


Figure 5: SEPA water hub River Dee classification: Water Quality

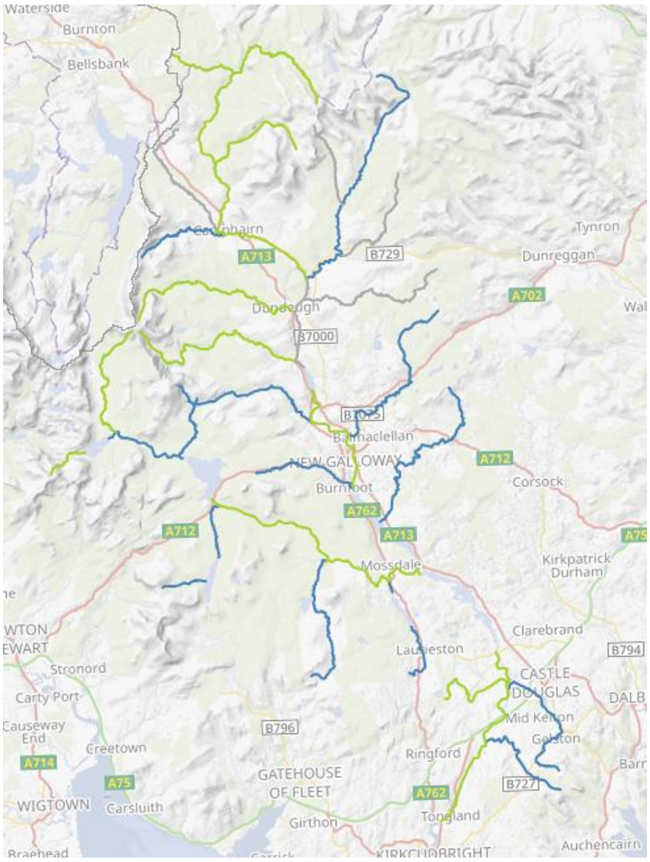


Figure 6: SEPA water hub River Dee classification: Acidity

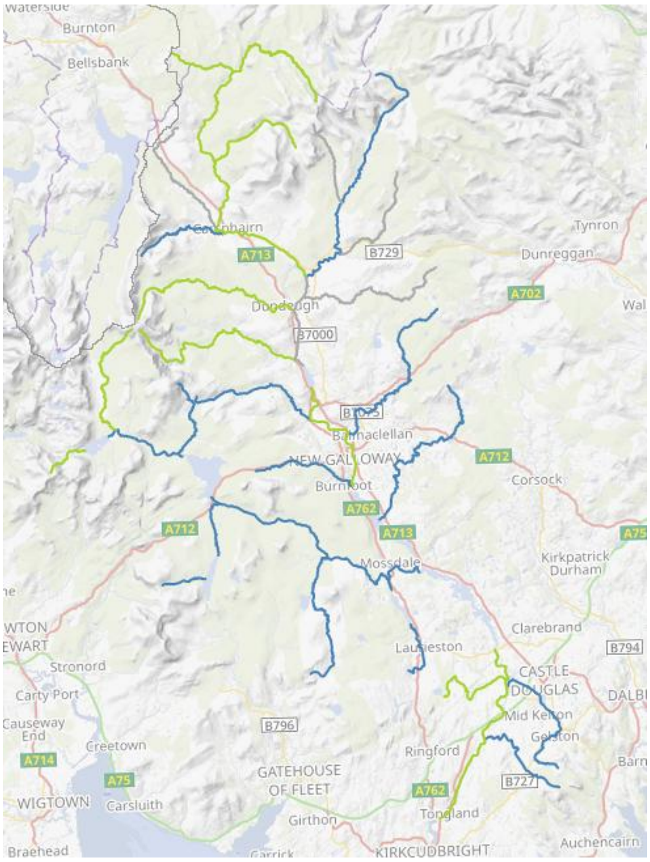


Figure 7: SEPA water hub River Dee classification: pH

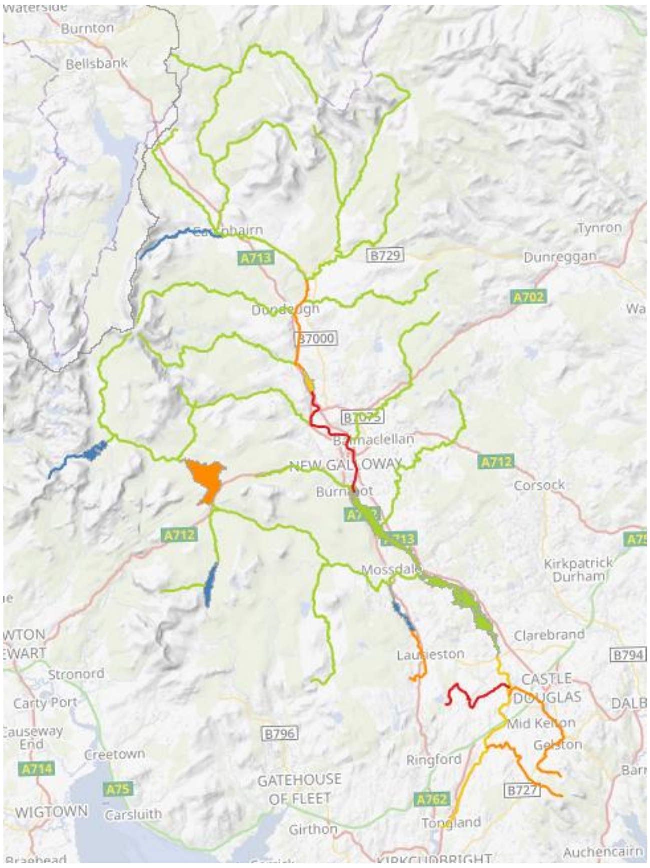


Figure 8: SEPA water hub River Dee classification: Morphology

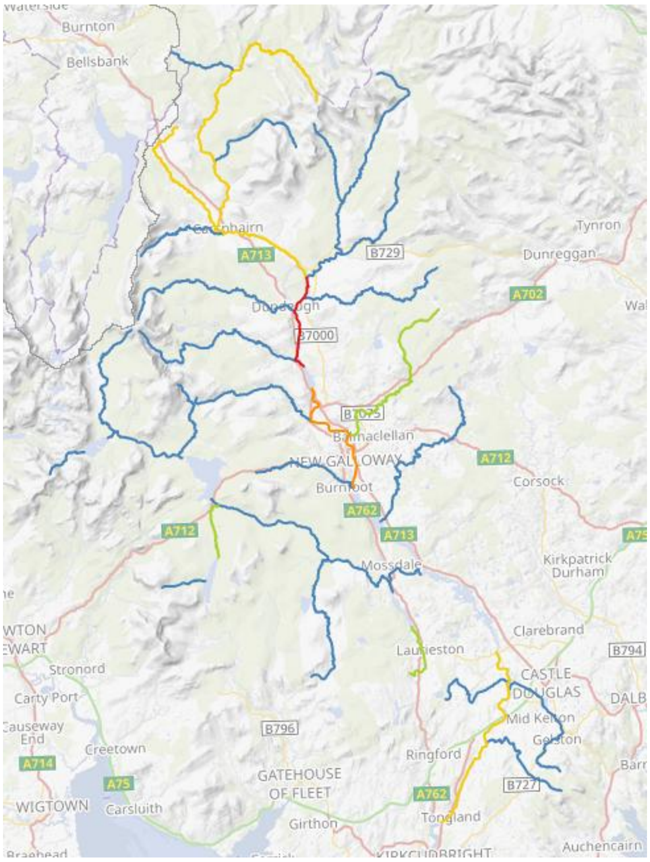


Figure 9: SEPA water hub River Dee classification: Hydrology (low flows)

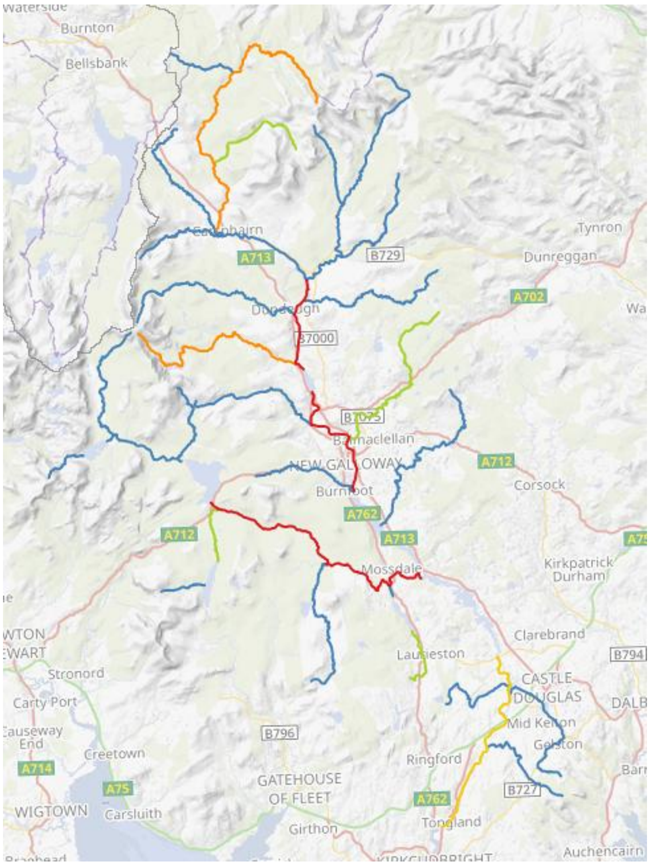


Figure 10: SEPA water hub River Dee classification: Hydrology (medium/high flows)

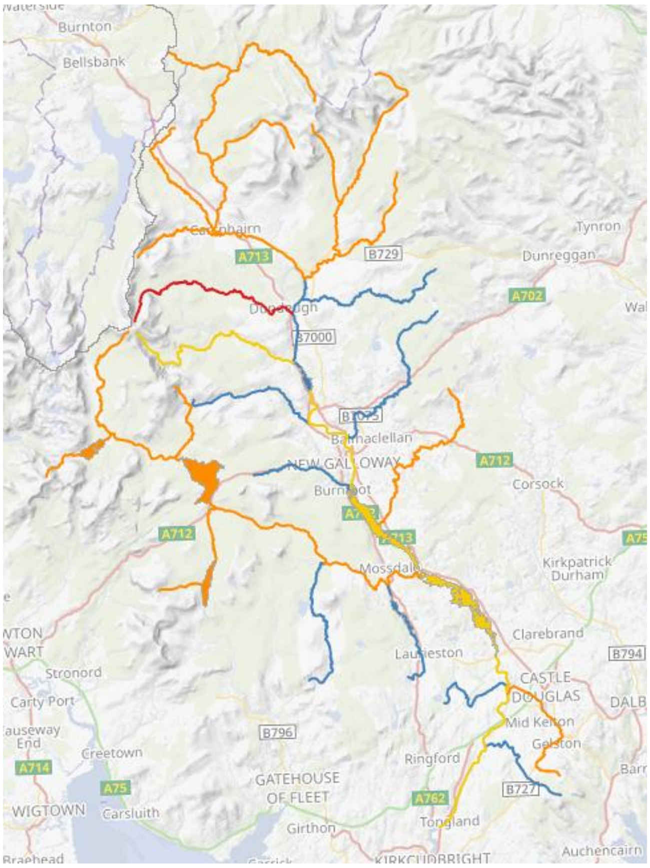


Figure 11: SEPA water hub River Dee classification: Fish

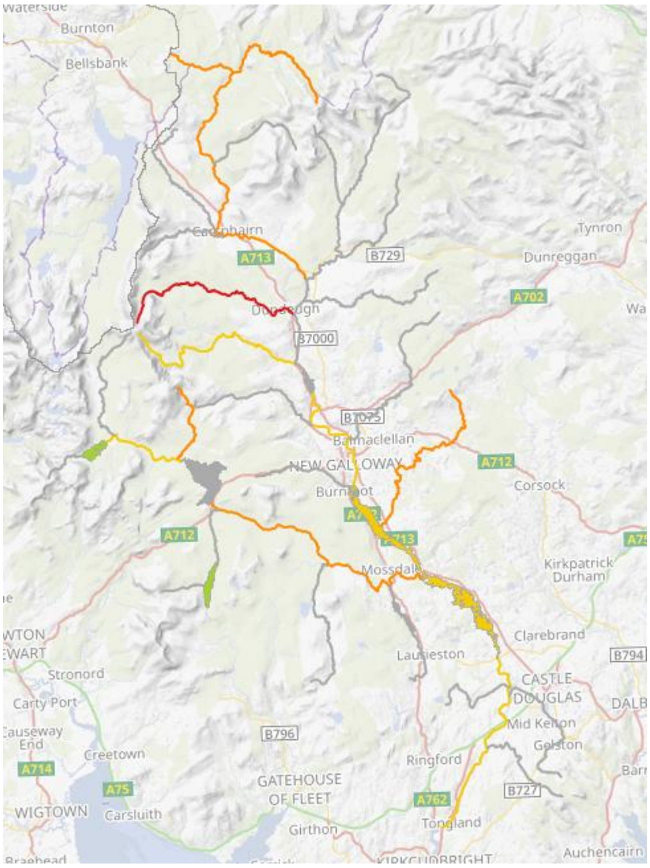


Figure 12: SEPA water hub River Dee classification: Fish Ecology

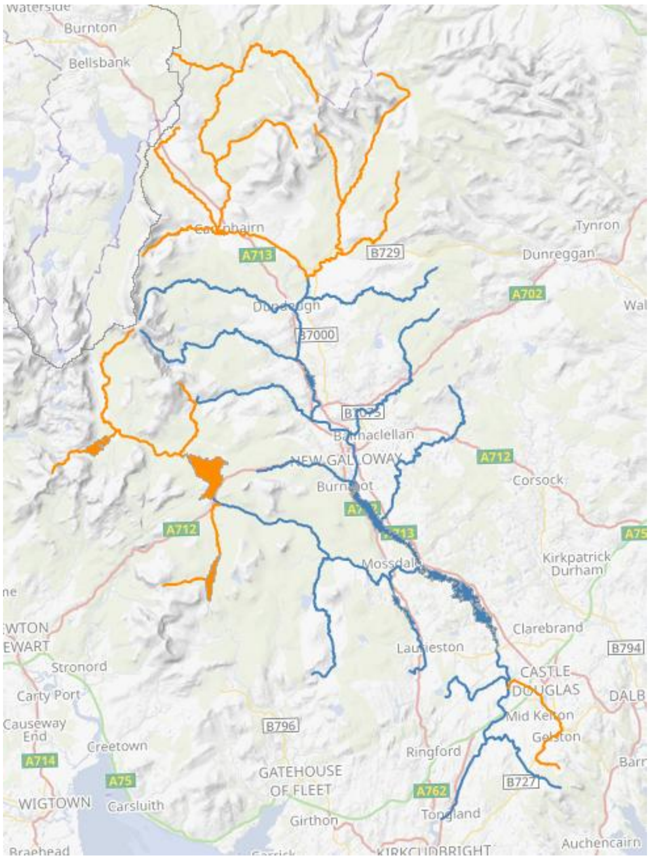


Figure 13: SEPA water hub River Dee classification: Fish Barriers

Figure 14: SEPA water hub River Dee classification: Freshwater Macroinvertebrates Acid

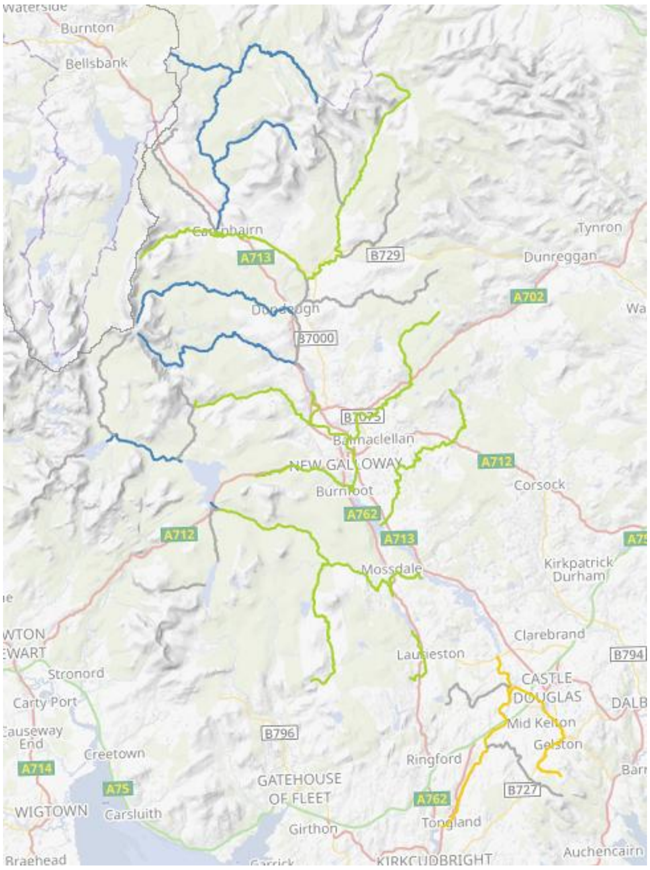
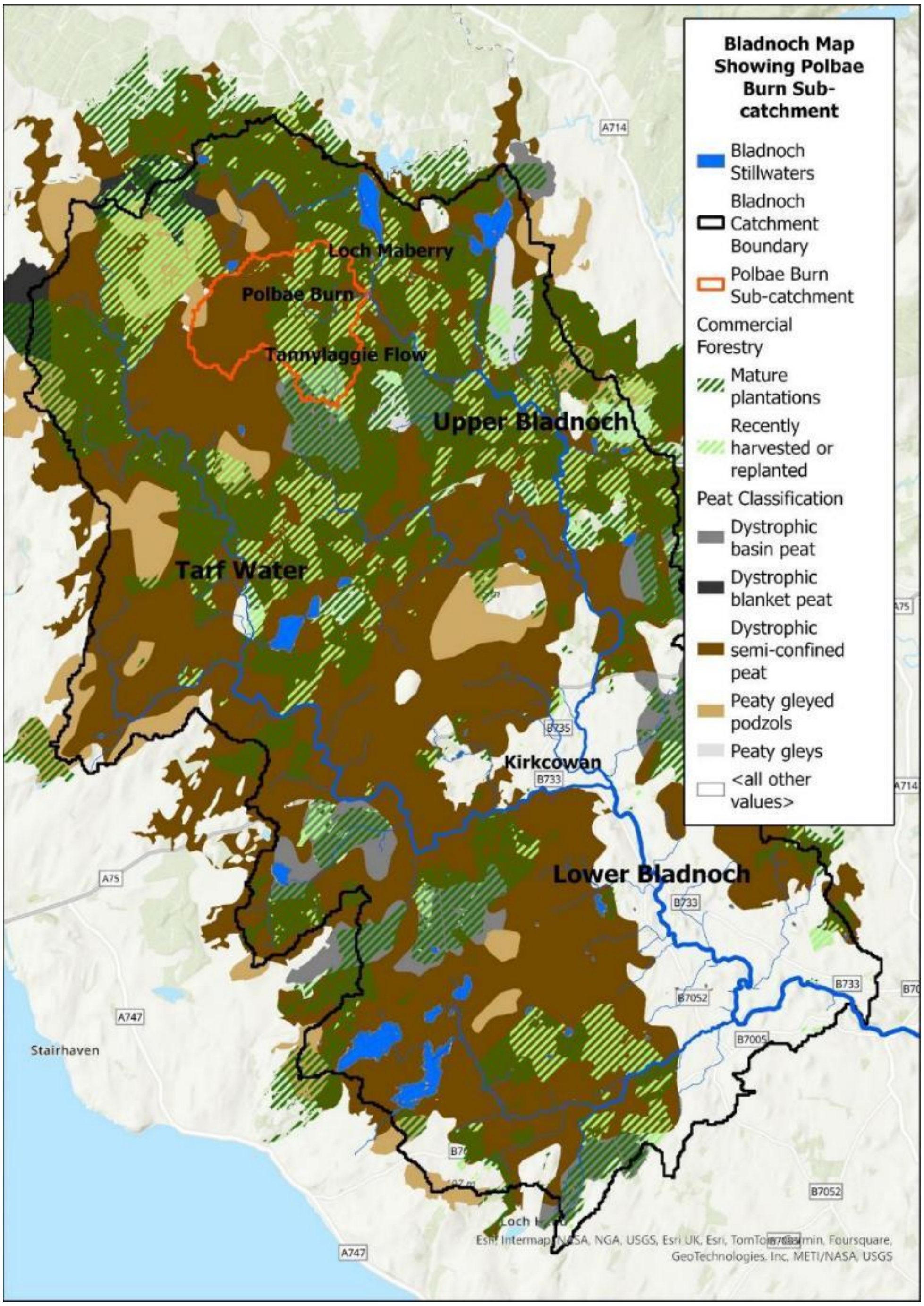


Figure 15: SEPA water hub River Dee classification: Freshwater Macroinvertebrates River Invertebrate Classification Tool

As can be seen from the SEPA classifications, the results for some parameters vary between maps, and often vary from the results shown later in this report. This is highlighted by the Black Water of Dee which is classed as “High” for pH, “Good” for Acidity, “Moderate” for Macroinvertebrate Acid and “Moderate” for overall water quality. As is shown later in this report, the Black Water of Dee is shown as being acidified based on direct water quality measurements. This inconsistency in the classifications may be because of limited SEPA sampling within a section of river, or from results from a small number of locations being considered representative of a much larger area with localised impacts being missed. Whilst the SEPA water quality results appear variable between different form of measurement, the SEPA results for classifications relating to river morphology and flows all point to a heavily impacted river system. **As a result of the overall modifications to the river system the classifications for Overall Status, Overall, Ecology, Fish and Fish Ecology show most of the catchment to be in “Poor” or “Bad” status.**

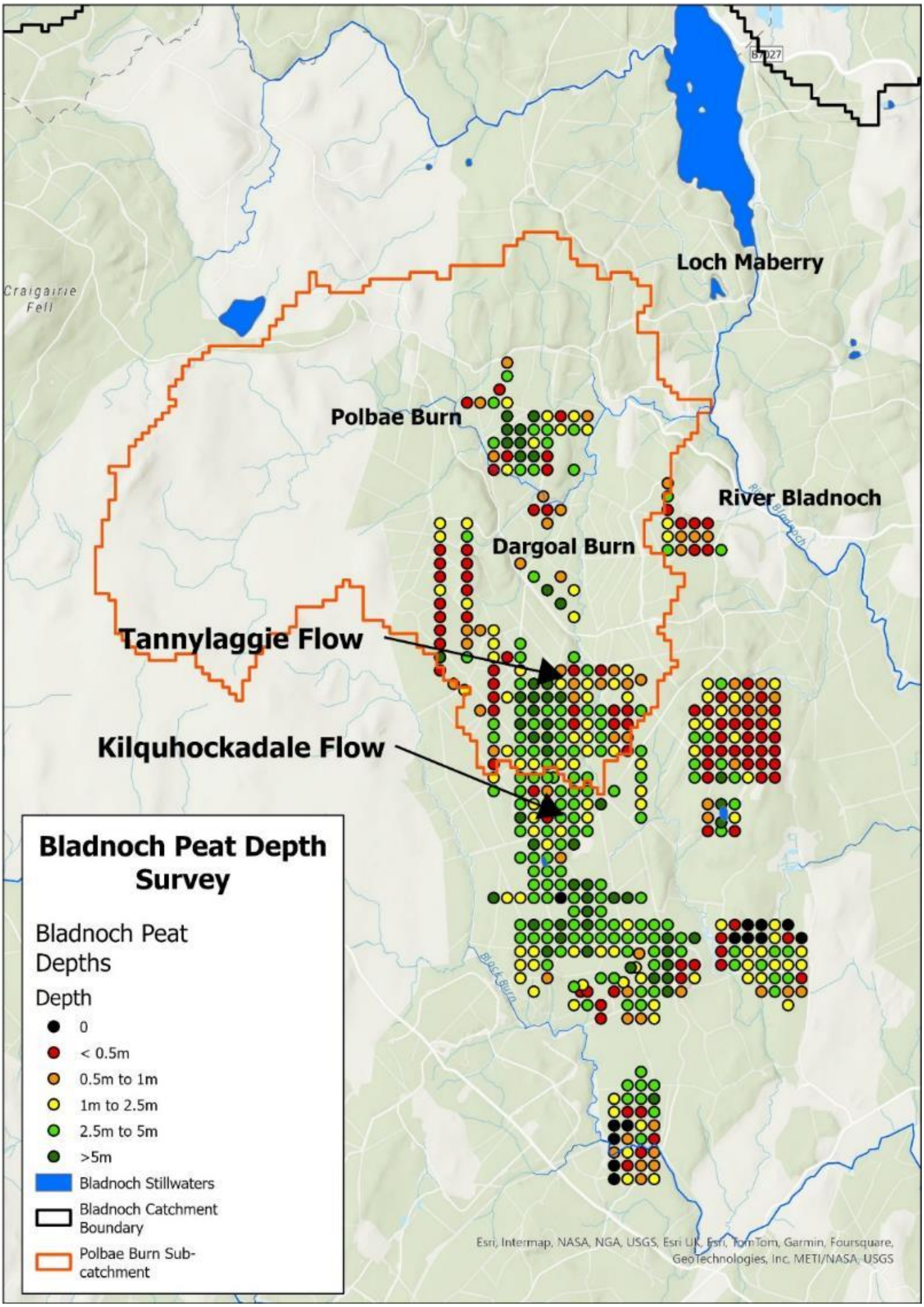
1.4 GRT Peatland Action water quality monitoring winter 2025/2026

GRT PA funded monitoring includes monitoring water quality within the Dargaol Burn which within the FLS peatland restoration site at Tannylaggie Flow. Tannylaggie Flow is an area of deep basin peat within the upper River Bladnoch. It lies within the Polbae Burn sub-catchment near waterside as shown on Map 8.

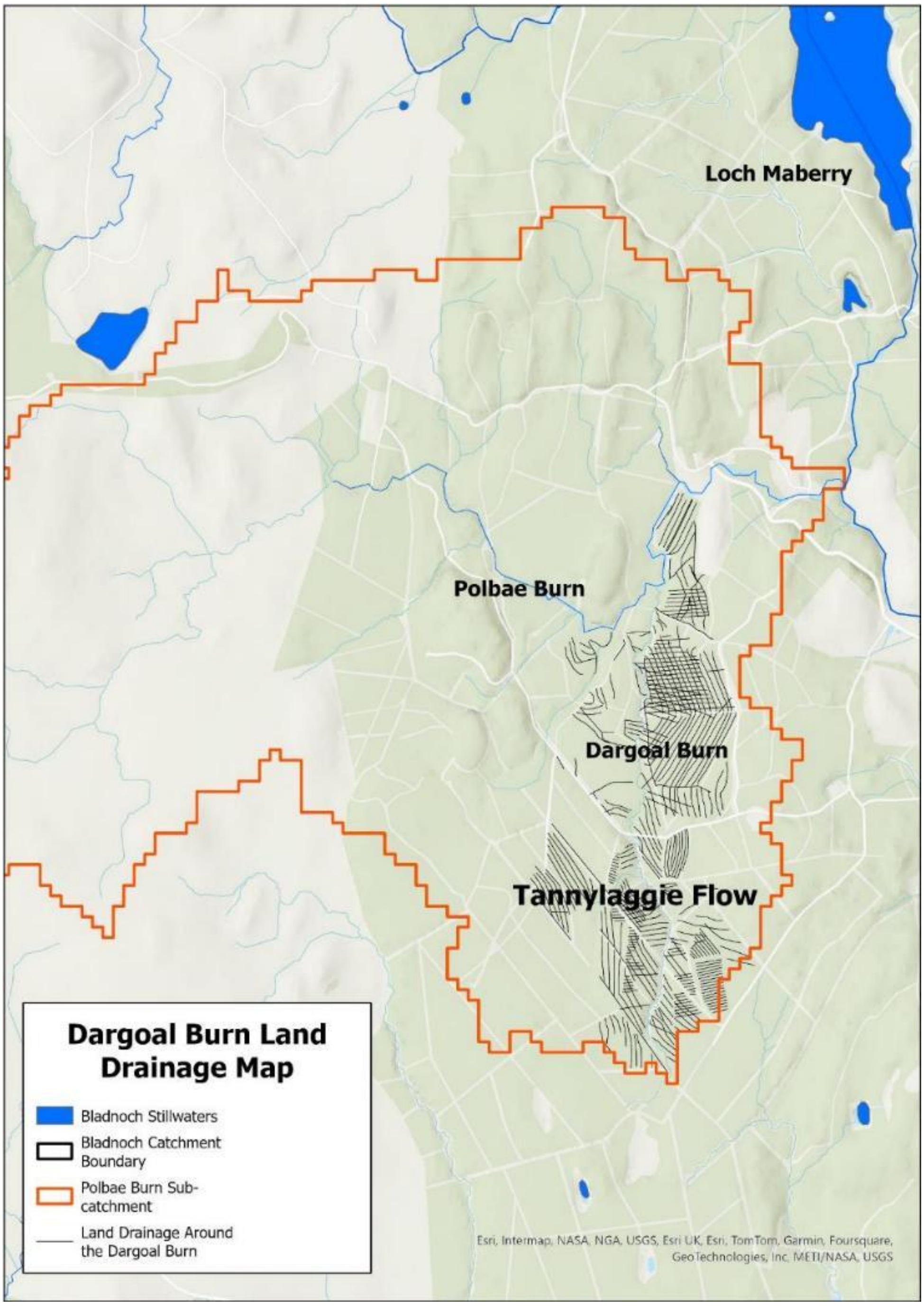


Map 8: Catchment map for the River Bladnoch showing the location of the Polbae Burn sub-catchment, peat type and forestry cover

A large percentage (well over half) of the Polbae Burn sub-catchment was purchased by the UK government in the mid to late 20th century and converted to commercial forestry, dominated by Sitka spruce. This area covered almost the entirety of the Tannylaggie Flow area of deep basin peatland. To allow for the growth of commercial trees the peatland was extensively drained to prepare the land for planting. The combination of drainage and planting caused considerable damage to the peatland. Map 9 shows peat depths recorded by GRT in and around Tannylaggie Flow showing he extent of peat depths, whilst Map 10 shows a sub-section of the drainage channels along the Dargoal Burn as mapped by the Crichton Carbon Centre. This gives an indication of the extent of the drainage network.



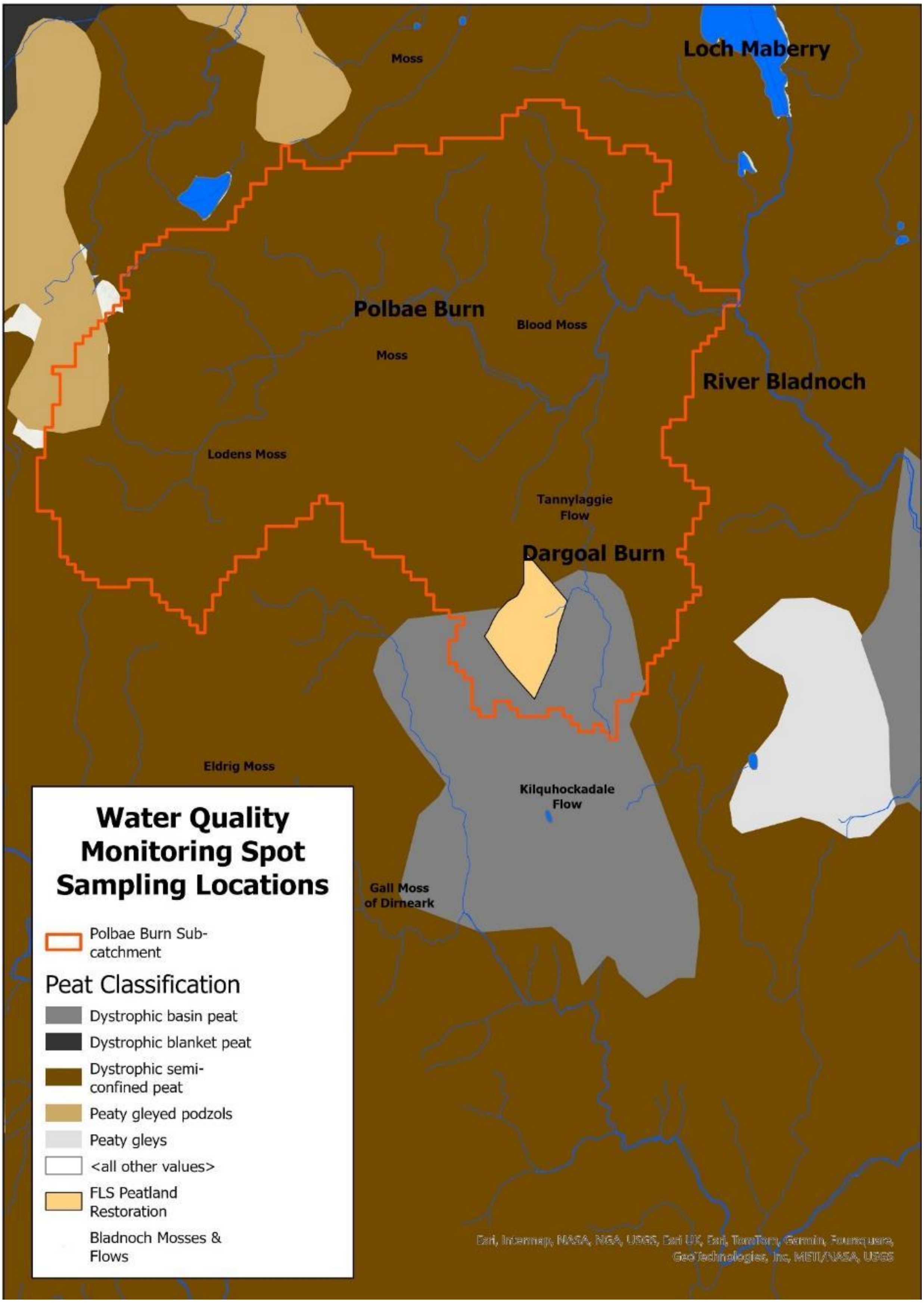
Map 9: Peat depths recorded around Tannylaggie and Kilquhockadale Flow (deep peat is classed as peat at a depth of 0.5 m or over)



Map 10: Some of the forestry drainage network around the Dargoal Burn as mapped by the Crichton Carbon Centre

The Dargoal Burn flows north through Tannylaggie Flow and is the destination for much of the forestry drainage network. Given the extent of the drainage and the current size of the burn it is unclear just how natural it is in its present form. The author has observed that the banks are eroding bare peat in many sections of the burn which has artificially widened the channel width in many areas. This may be because of the artificially high flows caused by the extensive drainage following periods of prolonged heavy rainfall. Given the extent of the bankside peat erosion (on both banks) around the upper burn, and the depth of the eroding peat, it is hard to imagine that the peat could have built up to this extent if the current high flow levels are natural. The Dargoal Burn flows into the Polbae Burn, itself a major headwater tributary of the upper River Bladnoch and part of the River Bladnoch SAC. As a result of historic acidic pollutants in the atmosphere, industrial scale deep peat drainage and dense conifer planting

the Dargoal Burn has become one of the most acidified watercourses within Galloway and frequently experiences pH levels that are lethal to fish (regularly sitting just above and below pH 4 during winter flows), as previously shown by GRT/PA water quality monitoring). As a result of low pH levels within the Dargoal Burn, and in the general area surrounding the upper Polbae Burn, water quality (low pH) is impacted in the middle and lower Polbae Burn, with low pH persisting downstream to the confluence with the River Bladnoch. This has resulted in reduced water quality (low pH) within the River Bladnoch for a significant distance downstream of the Bladnoch/Polbae Burn confluence. The knock-on effect is that the acidification from the Dargoal Burn and greater Polbae Burn sub-catchments is having a significant impact on the River Bladnoch SAC. The commercial forestry within the Dargoal Burn and greater Polbae Burn sub-catchment is primarily owned/managed by Forestry and Land Scotland, the government agency responsible for managing state owned forestry. As part of the latest plan for the management of Tannylaggie Forest (the name for the large section of commercial forestry surrounding the section of the upper Bladnoch catchment containing the Dargoal and Polbae Burns) large areas of deep peat at Tannylaggie Flow and Kilquhockadale Flow (both are parts of the same peat unit but draining in opposite directions) have been highlighted for peatland restoration. As the felling of mature conifer plantations is staggered over multiple years some sections of Tannylaggie Flow are still covered in mature conifers and will not be considered for restoration until the trees are removed. However, large areas have been felled and are ready for peatland restoration. After several delays peatland restoration commenced in a section of land adjacent to the Dargoal Burn in early 2023. Restoration techniques included stump flipping, ground smoothing and ditch blocking. Map 11 shows an estimation of the area that has been restored to date. Further large-scale tree felling took place during 2025 with further; significant restoration planned for 2026 and beyond. Due to the restoration only beginning in early 2023 water quality monitoring to up to that date was pre-restoration data collection, with monitoring over winter 2023/2024, 2024/2025 and 2025/2026 recording data during the early stages of restoration. The restoration to date (estimated at roughly 20-25 ha) represents a relatively modest percentage of the total area intended for peatland restoration, and of the Dargoal Burn sub-catchment, but it is hoped that restoration will recommence at pace as of winter 2026/2027.



Map 11: The approximate area of FLS peatland restoration at Tannylaggie Flow

The FLS Tannylaggie Forest Land Management Plan 2016 – 2026 is available from the link below.

https://forestryandland.gov.scot/media/1zrhbgzr/tannylaggie-land-management-plan-2016-26.pdf

In addition to the Tannylaggie Flow peatland restoration monitoring the PA funded GRT 2025/2026 water quality monitoring included a catchment wide review of water quality within the River Dee (Kirkcudbrightshire) catchment. The first part of this was analysis of electrofishing data held by GRT to assess the current impacts of water quality on fish populations across the Dee catchment, and to ascertain any long-term trends. Given the sensitivity of salmon and trout to low pH during some periods of development the aim of the review was to look at the current distribution and density of trout and salmon, to see if there were any areas where fish numbers showed signs of being impacted by poor water quality, and to see if there were any changes in fish numbers over time that would indicate improving or declining conditions. GRT has been carrying out electrofishing surveys to record juvenile salmonid densities in the Dee river system since the early 2000's and has amassed a significant amount of data from over 300 separate survey sites. However, sampling was undertaken for a wide variety of reasons, in a wide variety of locations and at irregular intervals so the amount of long-term data from individual sampling sites is limited.

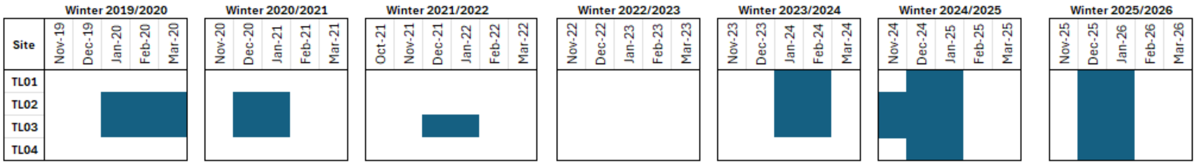
The second part of the Dee catchment wide water quality review was to collect a general record of catchment wide water quality across the whole River catchment. The aim was to look at variation in water quality (primarily pH) across the whole river system and to highlight areas of poorer water quality for targeted peatland restoration and/or further gathering of information. It is hoped that once the areas with the poorest water quality have been identified more data can be collected and that this can be directly linked to the current land use land use and/or the current state of any peatlands present.

2 METHOD

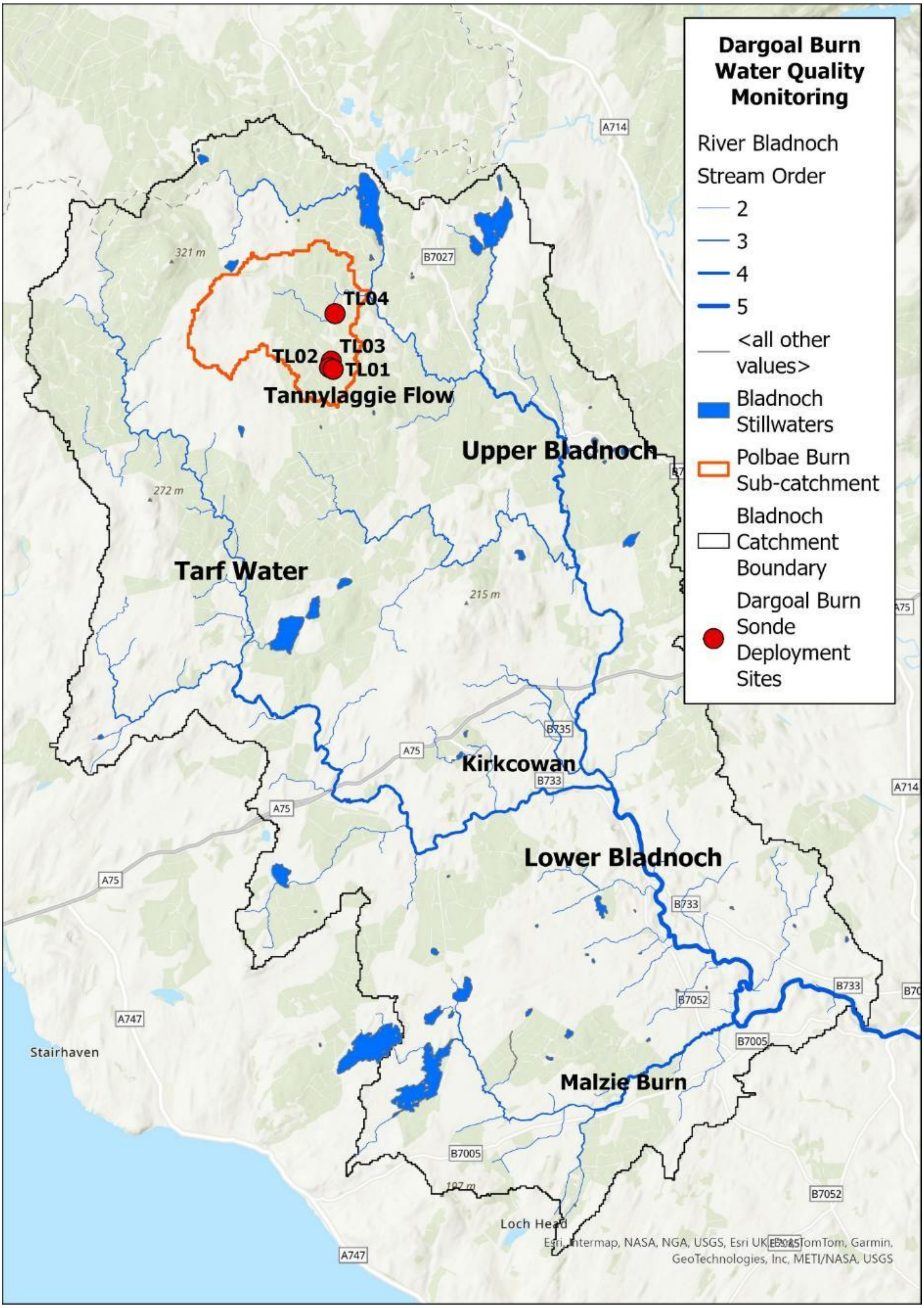
2.1 Tannylaggie peatland restoration water quality data collection

Tannylaggie peatland pre-restoration water quality recording began in winter 2019/2020, with additional pre-restoration data being collected during winter 2020/2021 and winter 2021/2022. No monitoring took place during winter 2022/2023 as the upper Water of Luce was monitored instead due to the possibility of peatland restoration taking place, but monitoring re-commenced in winter 2023/2024 and continued during winters 2024/2025 and 2025/2026. The long-term monitoring sites in the Dargoal Burn centre around a small tributary/large forestry drain within Tannylaggie Flow which appears to drain the area where the first section of peatland restoration took place, and into which several large forestry ditches drain. Sites are located above the tributary (TL01), within the tributary itself (TL02) and below the tributary (TL03). An additional site at the bottom of the burn just upstream of its confluence with the Polbae Burn was added in winter 2024/2025 because of an additional sonde being available. During the initial three years of monitoring two Sondes were available for data collection but as of 2023/2024 three Sondes were available with four Sondes being available from 2024/2025 onwards. The peatland restoration carried out to date lies upstream of the tributary, but it is unclear at this stage exactly how much of the area drains directly into it.

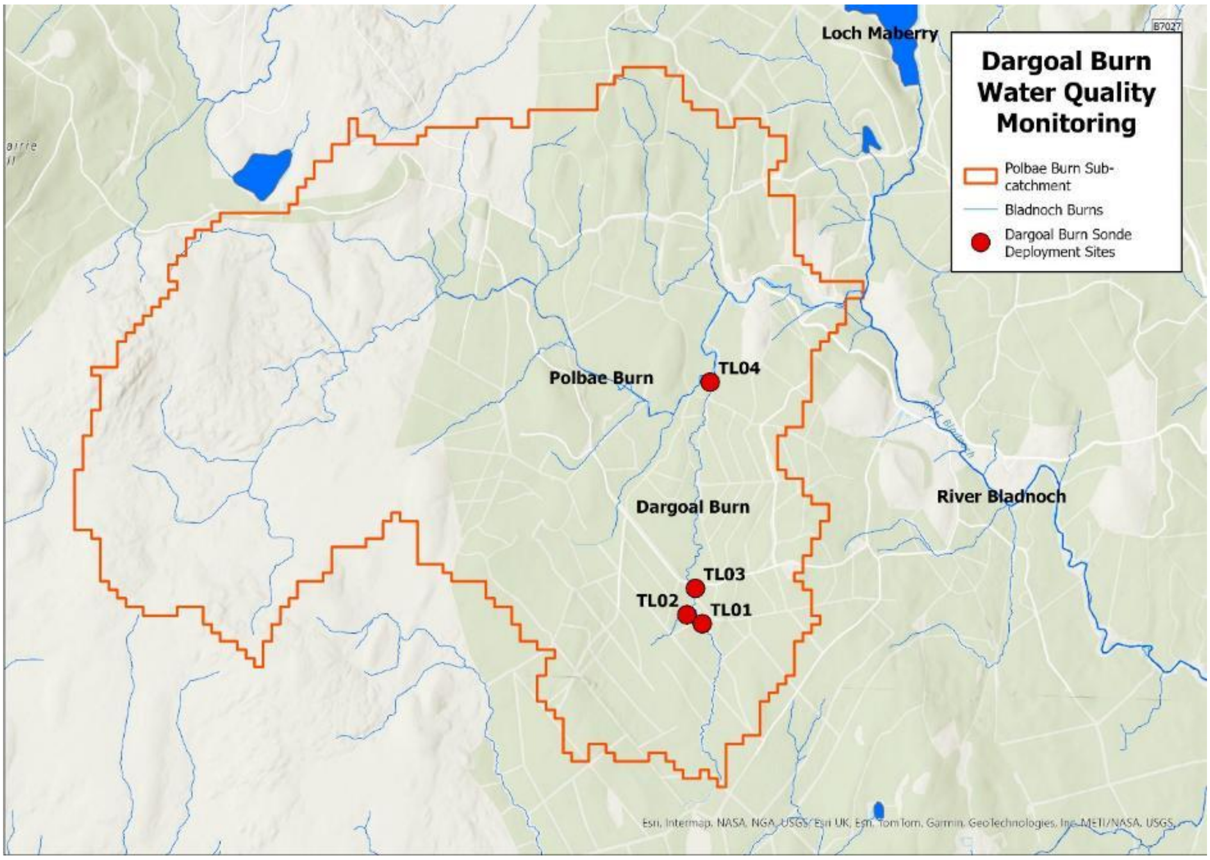
Chart 1: Tannylaggie Peatland Restoration Water Quality Monitoring Approximate Timeline



The sites were chosen to show the overall condition of the Dargoal Burn, localised variations coming from the tributary and to show if the water from the tributary is having any significant impact on water quality. Map 12 shows the locations of the sample sites within the greater Bladnoch catchment whilst Map 13 shows the sites at a local level. Tree felling within the Tannylaggie Flow restoration area was well underway by the time the pre-restoration monitoring began, with additional large-scale tree felling and conifer regeneration removal taking place during 2025. During deployment here have been some issues with calibrations and sensor faults which explains any gaps seen within the recorded data within the results section of this report.



Map 12: Tannylaggie peatland restoration water quality monitoring Sonde deployment sites within the greater Bladnoch catchment



Map 13: Tannylaggie peatland restoration water quality monitoring Sonde deployment sites within the Polbae Burn sub-catchment

The first phase/section of peatland restoration was completed during early 2023 and data was collected from all three sites during January/February 2024 (but with the TL01 Sonde moved upstream approximately 10 m as previously stated). Monitoring in winter 2024/2025 commenced in mid-November and finished in mid-January. Due to issues with equipment servicing and the availability of calibration chemicals only two Sondes were deployed at sites TL02 and TL03 (the most important sites in terms of data collection). However, four Sondes were available for the second month of recording and as a result all three sites were monitored along with a new site at the bottom of the Dargoal Burn (shown in Maps 10 and 11). During winter 2025/2026 Sondes were deployed at all four sites between 25/11/2025 and 21/01/2026 (for TL01 to TL03) and 20/11/2025 and 21/01/2026 (TL04), except for a period between 18/12/2025 and 22/12/2025 when the Sondes where retrieved, re-calibrated and re-deployed.

EXO1 Sondes recorded water quality parameters at 15-minute intervals after deployment. At each site pH, Dissolved Organic Matter (DOM), Dissolved Oxygen (DO), conductivity, and depth were recorded. Of the sensors available from the manufacturer each parameter was chosen for the following reason:

- **pH** – acidification of upland waterbodies on base-poor geology is a significant problem within the Galloway region. Several scientific papers have linked degraded peat with increased acidification in watercourses.
- **Dissolved Organic Matter (DOM)** – as extensive drainage is often the primary cause of damage to Peatlands and as the drainage results in the peat eroding around the drains and entering watercourses DOM represents a direct measure of the levels of suspended solids within watercourses.
- **Dissolved Oxygen** – as peat is partly decomposed organic matter decomposition is likely to continue (but at a faster oxidised rate) when it enters rivers/burns through

bacterial action. The increase in bacteria associated with increased volumes of organic matter increases Biological Oxygen Demand and can lead to reduced oxygen levels within watercourses.

- **Conductivity** – the ease at which an electric current can pass through water is directly related to the level of particulate matter in the watercourse. As such conductivity represents another method of recording the volume of suspended solids resulting from Peatland erosion.
- **Depth** – to give an indication of flow so it can be used to assess impacts of changes in flow/rainfall.

All Sondes are calibrated before being deployed and are held in place submerged within monitoring sites using frames constructed out of drainpipe and supported by wooden posts, as shown in Picture 7.

Picture 7: Example of GRT frame designed for the support of EXO1 Sondes

The Sondes are located within the lower, submerged sections of pipe, with the submerged section of pipe being perforated to allow water to pass through.

The parameters measured, the calibration interval (approximately one month) and the method of deployment are standard for all GRT PA funded continual water quality monitoring sites.

2.2 River Dee electrofishing data review

GRT has been carrying out electrofishing surveys to assess juvenile salmonid populations on the River Dee since the early 2000's. However, most of the data was recorded between 2010 and 2025. Dee electrofishing sites have been chosen and/or visited for several purposes. These include general monitoring of fish populations, assessing spatial distribution, directly monitoring habitat works, consultancy work and investigative work (e.g. investigating the impacts of barriers or acidification on fish populations). The period within which each site was visited, and the number of times each site has been repeated, varies greatly between electrofishing sites. As the purpose of this electrofishing review is to look at the areas impacted, or potentially impacted, by acidification, the review focuses on sites within areas of base-poor geology. However, most electrofishing sites have been included regardless of geology to look at the overall picture.

The electrofishing sampling methodology adopted for the electrofishing sites included within the review is one to three run area delineated sampling following the Scottish Fisheries Co-ordination Centre (SFCC) methodology (Scottish Fisheries Co-ordination Centre, 2021). This gives quantitative or semi-quantitative results based on the number of runs completed and gives, at the very least, a minimum estimate of fish density per 100 m^2 for each site (single run). It allows, at the very least, for the first run fish density to be compared between sites, with electrofishing efficiency likely to be relatively similar between sites. Due to the practical limitations of electrofishing the fish habitat sampled is typically shallow riffle and run habitat which is typically dominated by juvenile salmon and trout, with salmon and trout being both the target species and the main native fish species present within watercourses. Sites are normally visited during July, August, or September, and to a lesser extent, October. This is when fry (juveniles in the first year of their life) have grown large enough to be influenced by the electrofishing process and to be identified. In all cases within this review the results are given as a minimum density per 100 m^2 of water, based on a single electrofishing run. Whilst this does not give the actual density and underrepresents the fish numbers present, it does allow a comparison between equal sampling effort for all sites regardless of the numbers of runs completed. The results given in this report are primarily for the fry (0-year-old "young-of-the-year"), however parr (one year old and over juveniles) are also shown in some cases. Fry are primarily chosen as their movements from the areas in which they were spawned are more limited than older life stages (Hesthagen, 1988) and therefore give the most accurate indication of whether the eggs of salmon or trout can develop and hatch (the stage most susceptible to the impacts of acidification). As such, fry give the best indication of any potential impacts on fish populations caused by acidification. Where electrofishing sites have been visited on six or more occasions the results for these sites are shown individually to show long term trends in numbers. Only a relatively small number of sites have enough data to show the long-term trends for individual sites. Therefore, for the remaining data, to allow some sort of comparison that can be used to assess whether there have been changes over time, the results have been assigned into two roughly equal time periods – 2010 to 2017 and 2018 to 2025. Where a site has had more than one visit during a given period the results have been averaged. It should also be noted that salmon and trout tend to segregate at spawning time with salmon spawning in larger, wider channels (rivers) and trout in smaller, narrower channels (burns). The exact channel width at which salmon spawning changes to trout spawning varies from location to location and both can overlap but, for the most part, shallow riffles and runs within burns under 2 - 3 m average width should be dominated by trout fry (with salmon fry often absent), with larger channels dominated by salmon fry. This has been considered within the data analysis with salmon fry results shown for larger channels, trout fry results shown for burns and both being shown where salmon and trout fry overlap. To aid with data analysis a scoring/rating system for salmon and trout fry densities was developed by Godfrey (2006) using data collected from 1,638 Scottish electrofishing survey sites covering the period 1997 to 2002. From this, regional figures were created to allow more accurate local 'density ranges' with the Solway region scorings/ratings shown in Table 2. Colour coding has been added to help visualize results shown on maps.

Table 2: Minimum density per 100 m^2 ranges for juvenile trout and salmon fry based on one-run electrofishing events, calculated on densities > 0 over 291 sites in the Solway Statistical Region

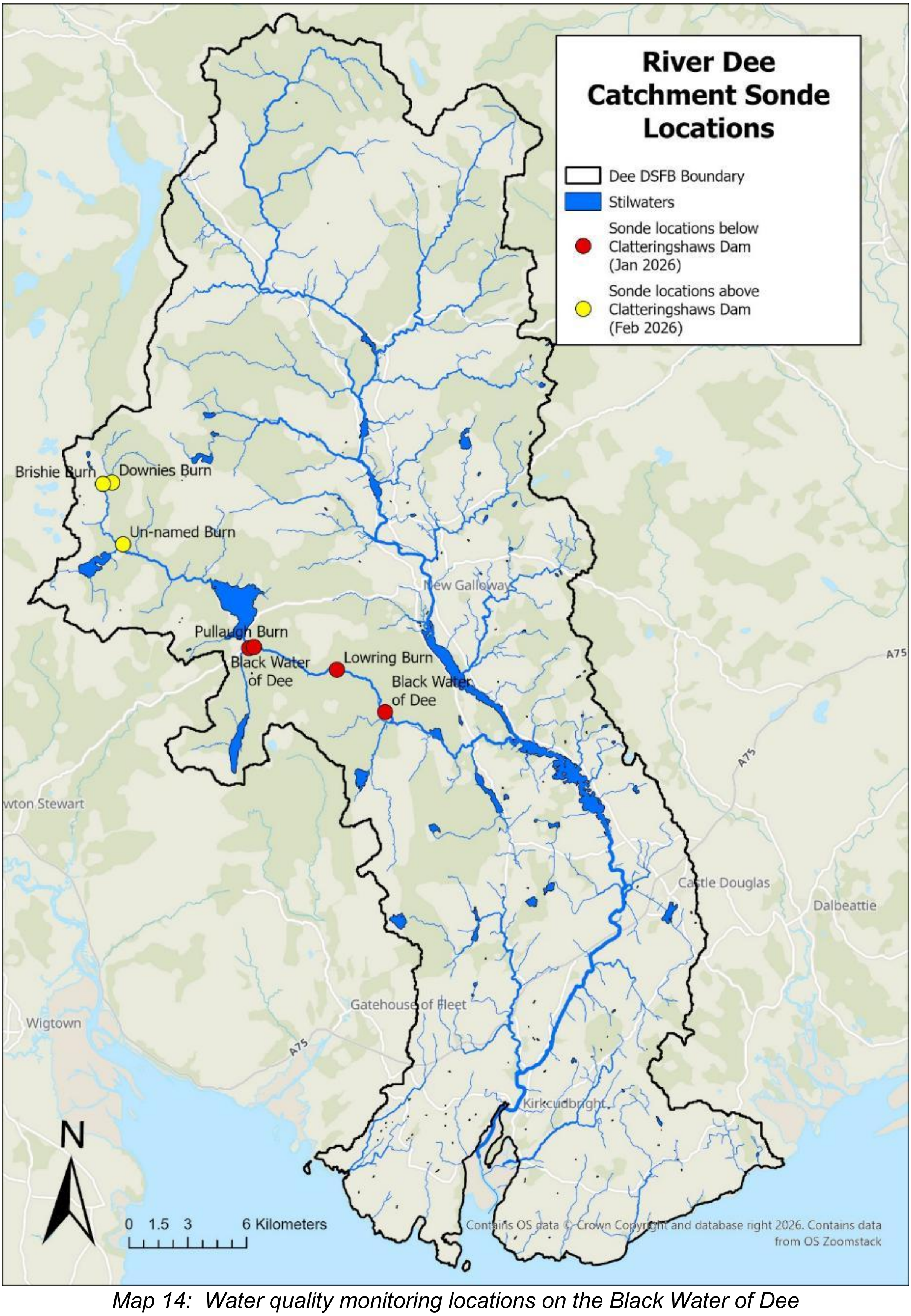
Fry Density Rating	Trout Fry Density (per 100 m^2) Range
Absent	**0**
Very Low	**0.01 to 4.13**
Low	**4.14 to 12.08**
Moderate	**12.09 to 26.62**
High	**26.63 to 56.48**
Very High	**56.49 +**

2.3 River Dee water quality overview

To gain an overview of water quality across the River Dee catchment EXO1 Sondes were deployed at seven locations on the Black Water of Dee to gather data at 15-minute intervals. Due to limitations on the number of Sondes available (four in January/February and three in March) four Sondes were deployed from late January to late February before being retrieved. Three of the Sondes were then calibrated and redeployed between late February and late March. Table 3 provides a summary of the deployment details whilst Map 14 shows the deployment locations. Site locations focused on the Black Water of Dee sub-catchment as it was thought to be the area most impacted by low pH (later confirmed during spot sampling). Individual sites were chosen based on collecting a spread of data across the whole sub-catchment, combined with sampling based on land use and peat type. The latter was more evident in the sites within the upper Black Water of Dee where sites were chosen to include the restored peatland at Silver Flowe. The water quality parameters recorded are the same as those for the Tannylaggie peatland restoration monitoring, for the same reasons.

Table 3: River Dee Water Quality Monitoring Sonde deployment summary

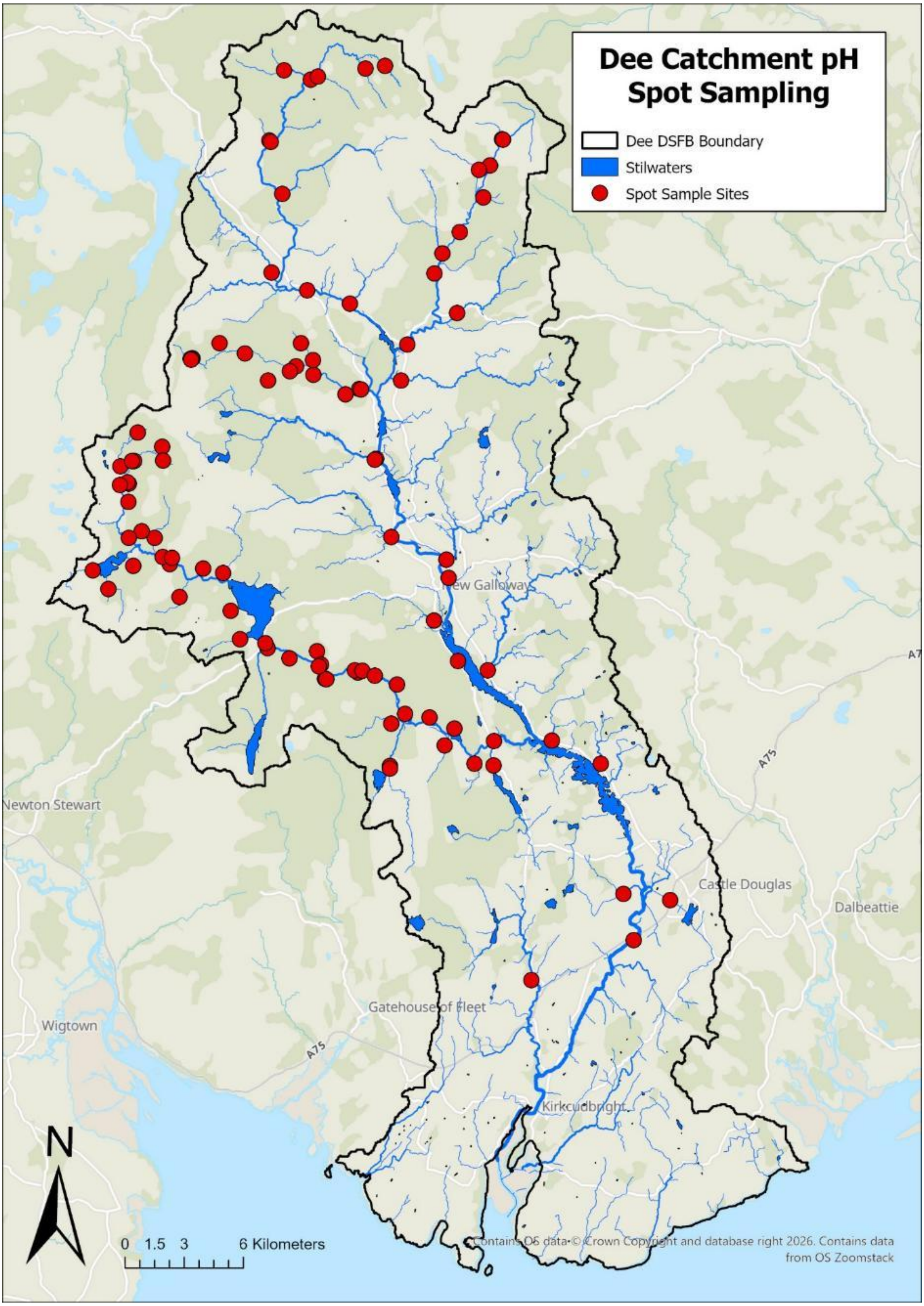
ID	Easting	Northing	Watercourse	Location	Deployment
De01	255059	574855	Black Water of Dee	650 m below Clatteringshaws Dam	23/01/2026 to 23/02/2026
De02	254819	574795	Pullhaugh Burn	250 m above confluence with Black Water of Dee	23/01/2026 to 23/02/2026
De03	259302	573693	Lowring Burn	150 m above confluence with Black Water of Dee	23/01/2026 to 24/02/2026
De04	261761	571520	Black Water of Dee	150 m above forestry road bridge	23/01/2026 to 24/02/2026
De05	248369	580101	Un-named Burn	75 m above confluence with Black Water of Dee	25/02/2026 to 26/03/2026
De06	247810	583257	Downies Burn	50 m above Cooran's Lane access point	25/02/2026 to 26/03/2026
De07	247355	583169	Brishie Burn	150 m above confluence with Downies Burn	25/02/2026 to 26/03/2026



Map 14: Water quality monitoring locations on the Black Water of Dee

In addition to the deployment of the EXO1 Sondes spot sampling was carried out across the whole Dee catchment. Spot sampling involves collecting water samples from chosen locations within watercourses after periods of high flows to catch pH at, or near, its lowest level. Once collected water samples are taken back to the GRT office and water quality parameters are recorded using an EXO1 Sonde retained within the office. The same parameters are recorded as with the Sondes that are deployed in the field. Spot sampling sites were spread across the whole catchment to assist in gaining a water quality overview for the river system. Whilst Sondes deployed in the field provide detailed information on trends in water quality their cost limits the number of locations from which data can be collected at any one time. Although only one reading is collected from a single point in time, spot sampling allows data to be collected from many sites and flows in a relatively short period of time, allowing any spatial relationships to be investigated and allowing areas to be highlighted for more detailed investigation.

Map 15 shows the spot sampling sites within the Dee catchment. Due to the number of sites involved it was not possible to survey all sites at once, with sampling being split into different areas. For each we sampled once during high flows and once during relatively low winter flows. Due to known water quality issues sampling intensity was higher within the Black Water of Dee than throughout most of the river system, except for the Polmaddy Burn which also had a greater sampling intensity to tie in with ongoing environmental improvement/restoration works between GRT and FLS. Spot sampling was carried out on 15/01/2026 (lower Water of Ken, Lock Ken Burns and River Dee), 22/01/2026 (Black Water of Dee), 05/02/2026 (Water of Ken, Loch Ken Burns and River Dee), 02/03/2026 (upper Water of Ken), 06/03/2026 (Black Water of Dee), 18/03/2026 (Polmaddy Burn), 20/03/2026 (Water of Deugh and lowest Black Water of Dee sites) and 25/03/2026 (Polmaddy Burn and Water of Deugh). Sampling also took place on 12/02/2026 on the Black Water of Dee but the results were omitted after an issue with the Sonde calibration was identified. High and low flow sampling (relative to the time of year) was used to give an indication of low pH levels (high flows), high pH levels (low flows) and the average between low and high flows was used to give an indication of pH persistence. As such the extent of the acidification (lowest pH) and an indication of pH persistence (average pH) are shown for each spot sample site. The pH scoring system used in this report is based on salmonid pH tolerance, with salmonids acting as a good barometer of water quality and low pH impacts on aquatic ecosystems. February and March 2026 rain was common with totals around average for the time of year. However, the rainfall was relatively frequent intense downpours were relatively scarce, with small floods being common and larger floods being relatively rare. While all attempts were made to sample different parts of the catchment at similar levels of high or low flows the high flows during recording on the Polmaddy Burn and Water of Deugh were lower than the high flows recording for other parts of the catchment, and this should be considered when interoperating the results.



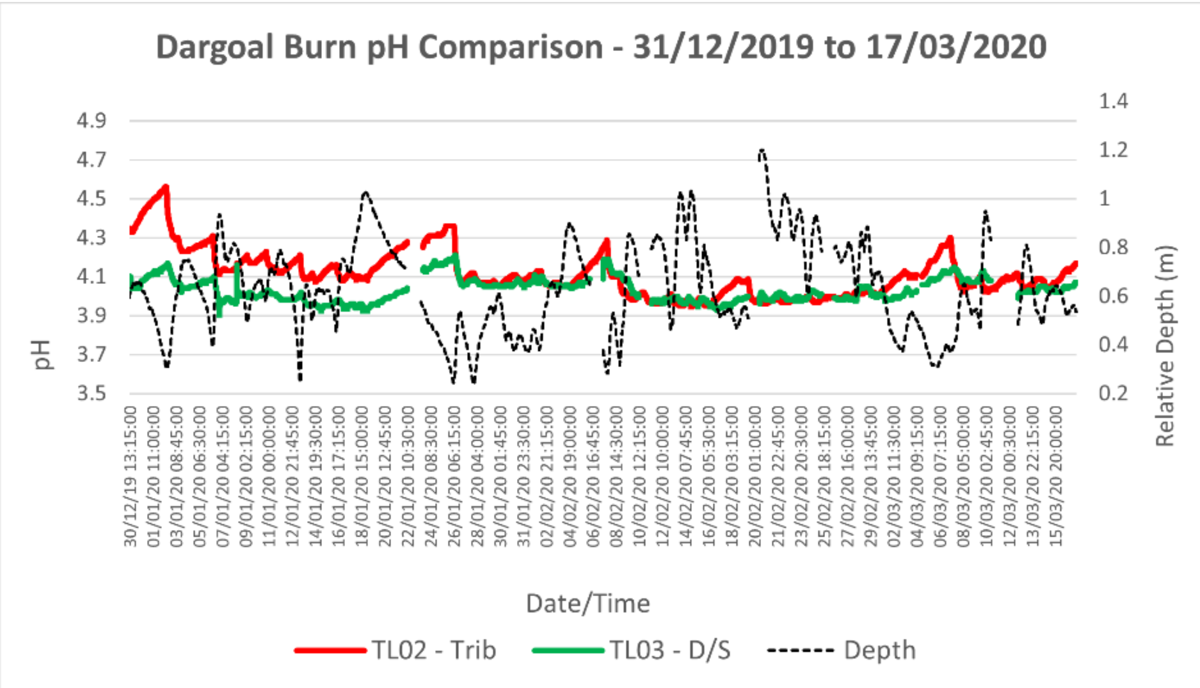
Map 15: Water quality monitoring spot sampling sites within the Dee catchment

3 RESULTS

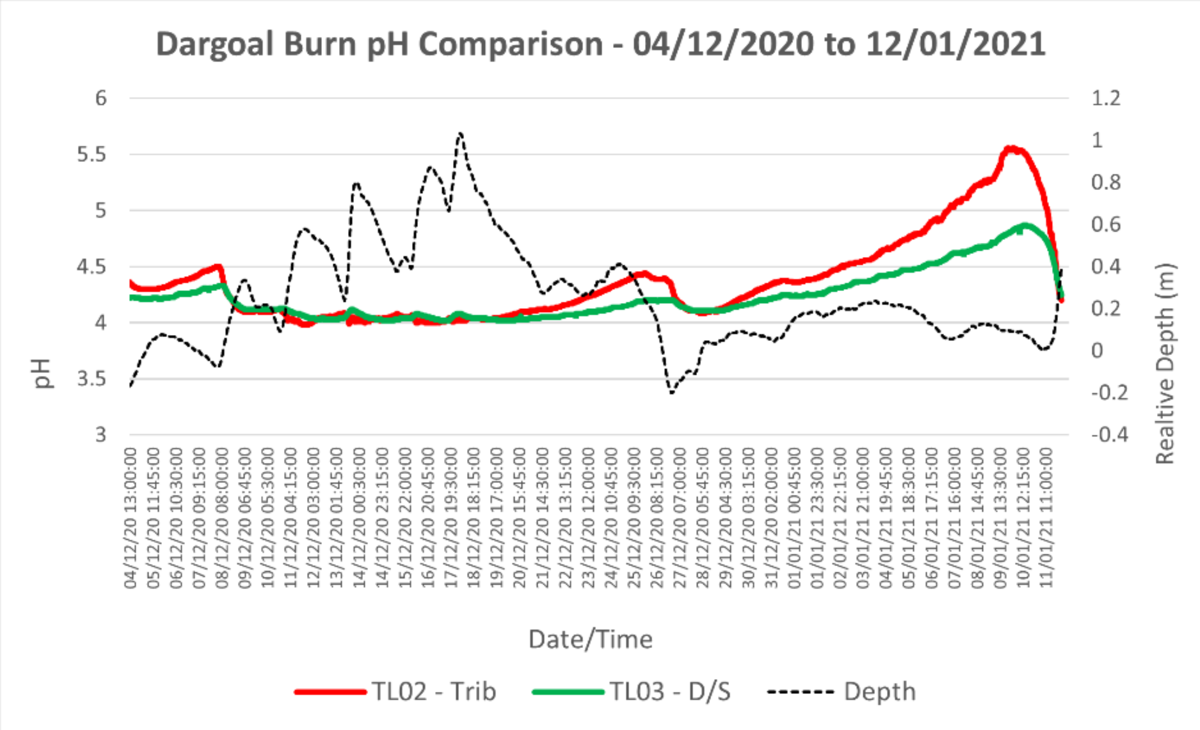
3.1 Tannylaggie peatland restoration water quality data collection

The water quality monitoring results from the Dargoal Burn during winters 2019/2020, 2020/2021, 2021/2022, 2023/2024, 2024/2025 and 2025/2026 are shown below in Graphs 1 to 21. The results for pH, fDOM and Dissolved Oxygen are shown. Conductivity was also recorded but fDOM is a better indication of suspended peat resulting from peatland erosion. The averages from each period are also listed in Tables 4 to 6. The monitoring site above the tributary (TL01) has proven problematic during monitoring and readings were thought to have been impacted by periodic exposure to air during low flows. As a result, and due to only two water quality monitoring Sondes being available at the time, this site was not monitored during winter 2020/2021. It was redeployed during winter 2021/2022 with the Sonde placed in deeper water. However, the issues persisted revealing that water stagnating at the monitoring site was the likely factor impacting results. The site was moved upstream approximately 10 m into an area of swifter flow during winter 2023/2024 which appears to have solved the issue. Therefore, the only reliable data for this site is from winter 2023/2024 onwards and all other data from this site has been largely disregarded. The pH results from winter 2020/2021 have been included to highlight the issues experienced within the data. The data gaps clearly seen in some graphs are the periods in which Sondes were taken out, recalibrated and then re-deployed (as the recommended re-calibration period for the pH sensors is one month).

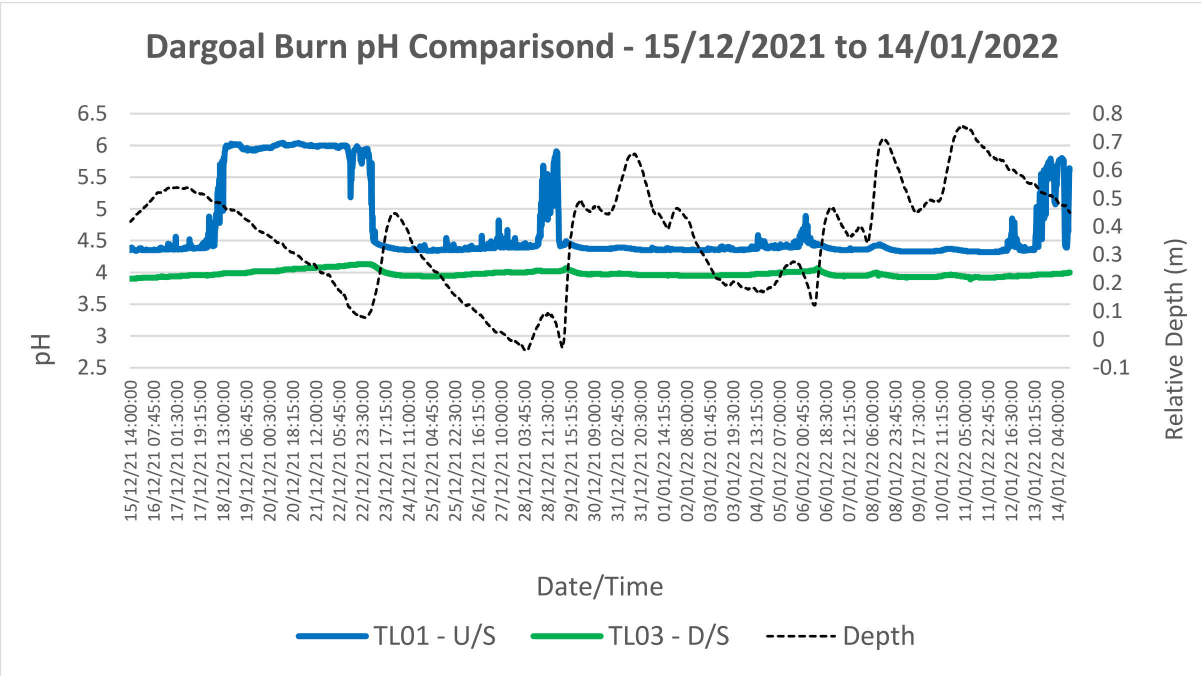
As FLS peatland restoration at Tannylaggie will be ongoing over the next few years the data prior to 2023 should be considered “pre-restoration” and the winter 2023/2024 data should be considered as “during restoration” data. There has been no additional restoration since 2023 so the data from 2024 to the present should be considered as a pause within the “during restoration” period. Even though the first stage of restoration has been completed a significant area of additional restoration is still in planning. There was significant felling of mature conifers within the Dargoal Burn catchment upstream of the monitoring sites during 2025 and the potential impacts from the disturbance should be considered within the results.



Graph 1: Comparison between pH and relative water depth (m) at TL02 (tributary) and TL03 (downstream) on the Dargoal Burn during winter 2019/2020

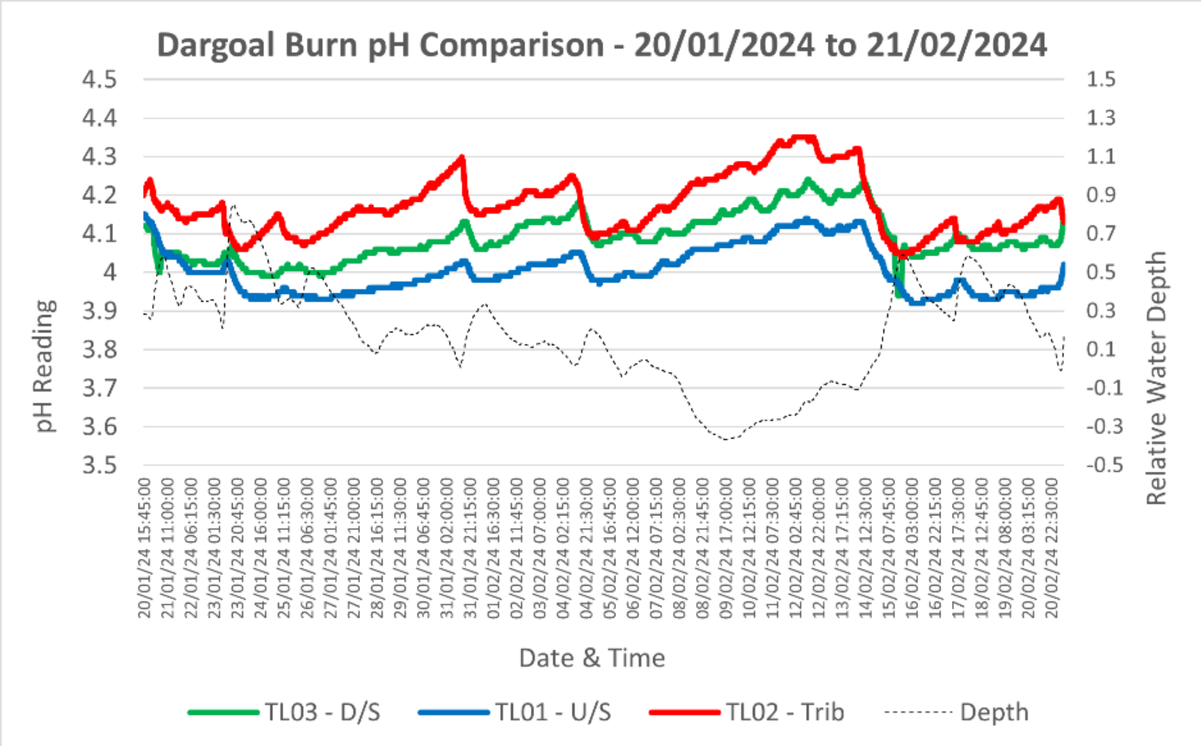


Graph 2: Comparison between pH and relative water depth (m) at TL02 (tributary) and TL03 (downstream) on the Dargoal Burn during winter 2020/2021

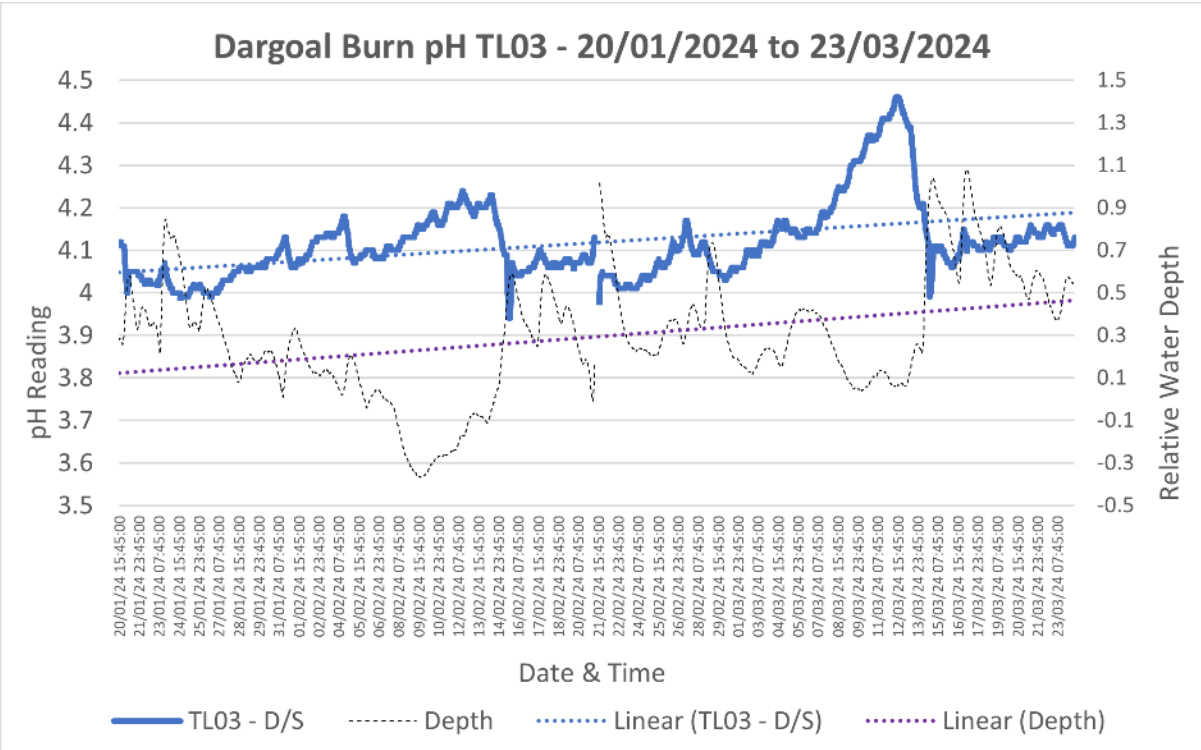


Graph 3: Comparison between pH and relative water depth (m) at TL01 (upstream) and TL03 (downstream) on the Dargoal Burn during winter 2021/2022

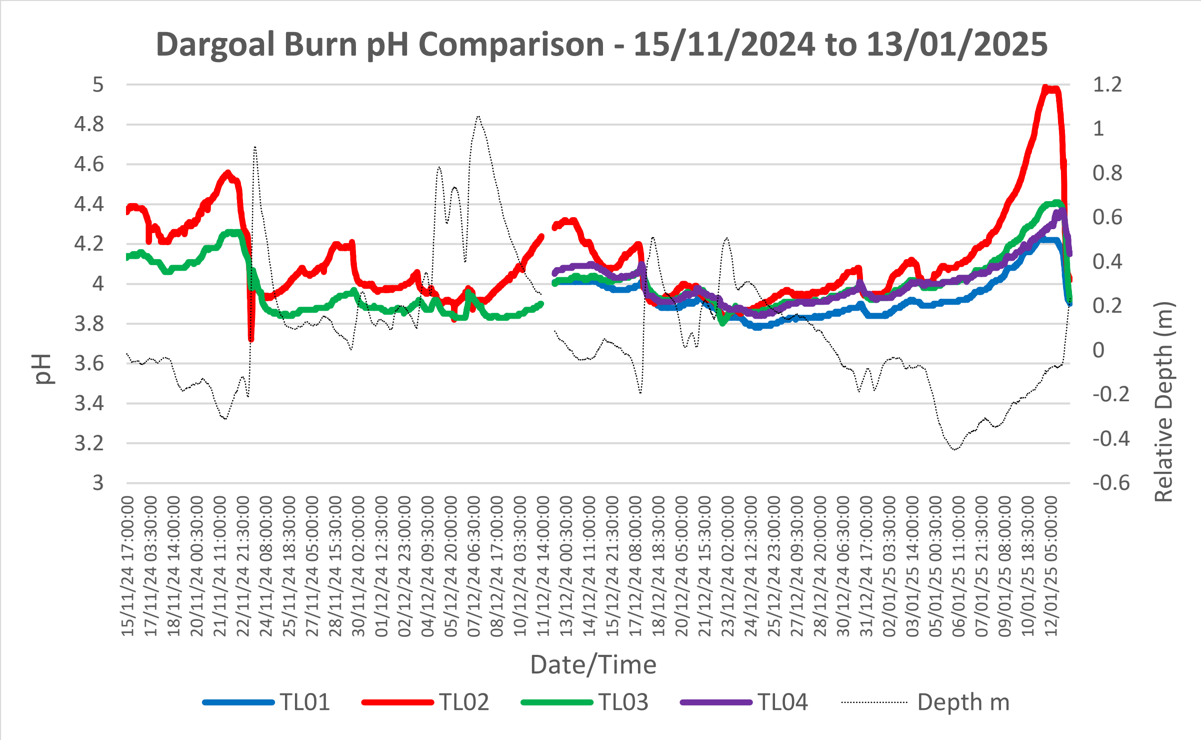
Graph 3 highlights the stagnation issues at site TL01 (before being re-sited) and the impact on pH readings.



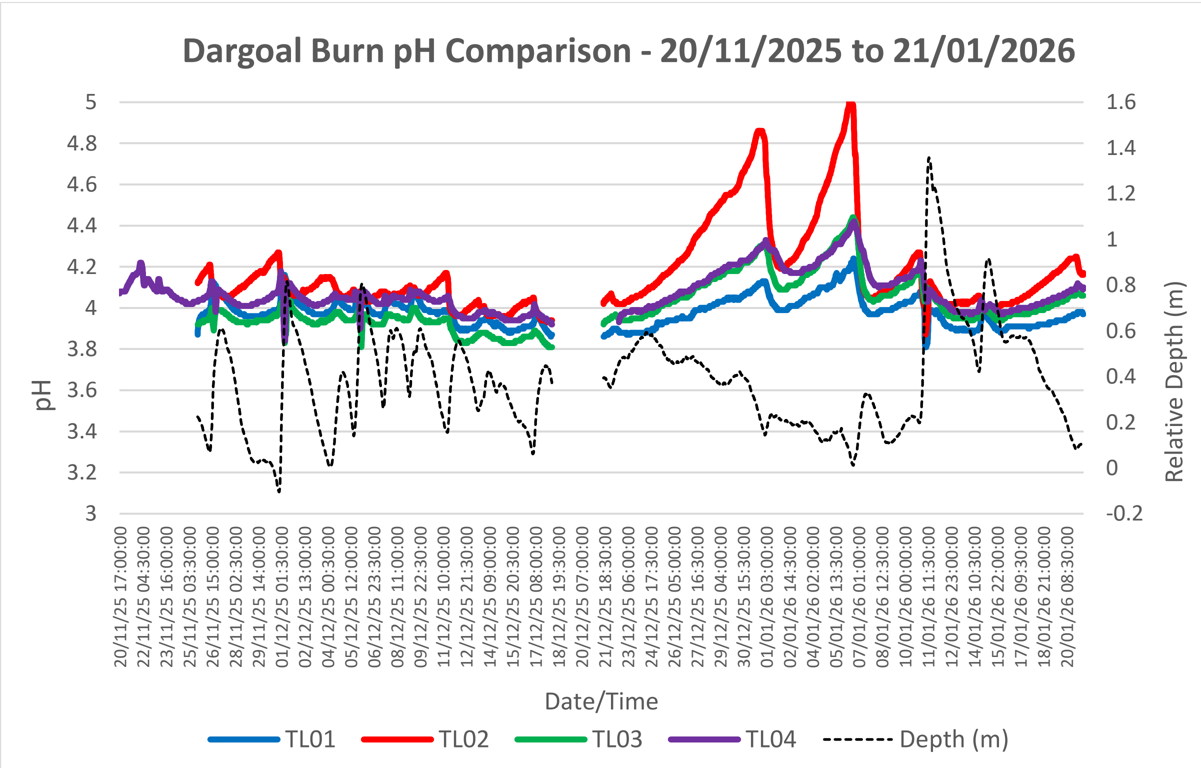
Graph 4: Comparison between pH and relative water depth (m) at TL01 (upstream), TL02 (tributary) and TL03 (downstream) on the Dargoal Burn during winter 2023/2024



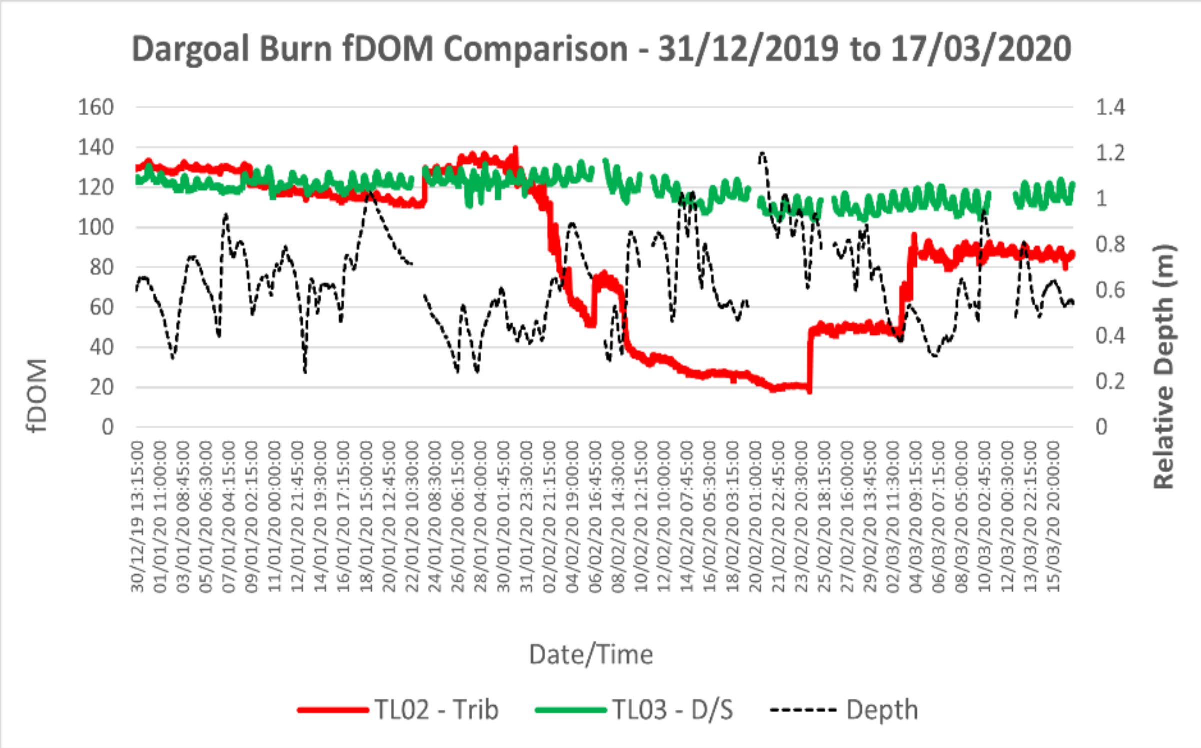
Graph 5: pH readings against relative depth for extended monitoring of Site TL03 (downstream) during winter 2023/2024



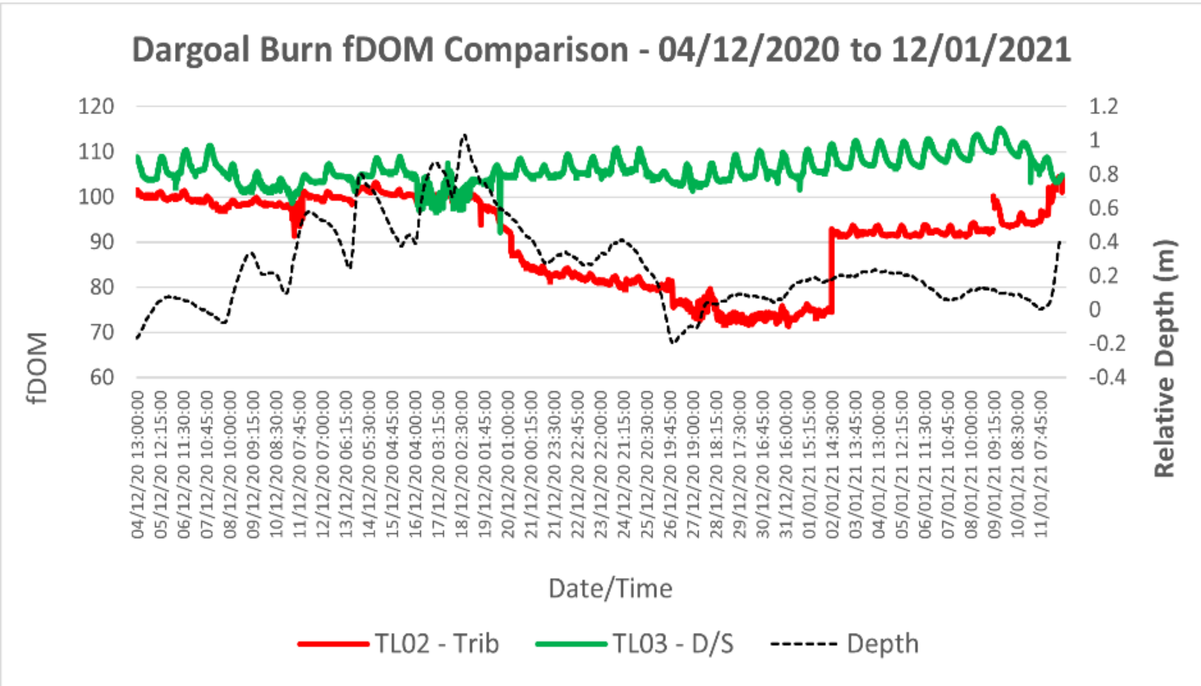
Graph 6: Comparison between pH and relative water depth (m) at TL01 (upstream), TL02 (tributary) and TL03 (downstream) and TL04 (Lower Burn) on the Dargoal Burn during winter 2024/2025



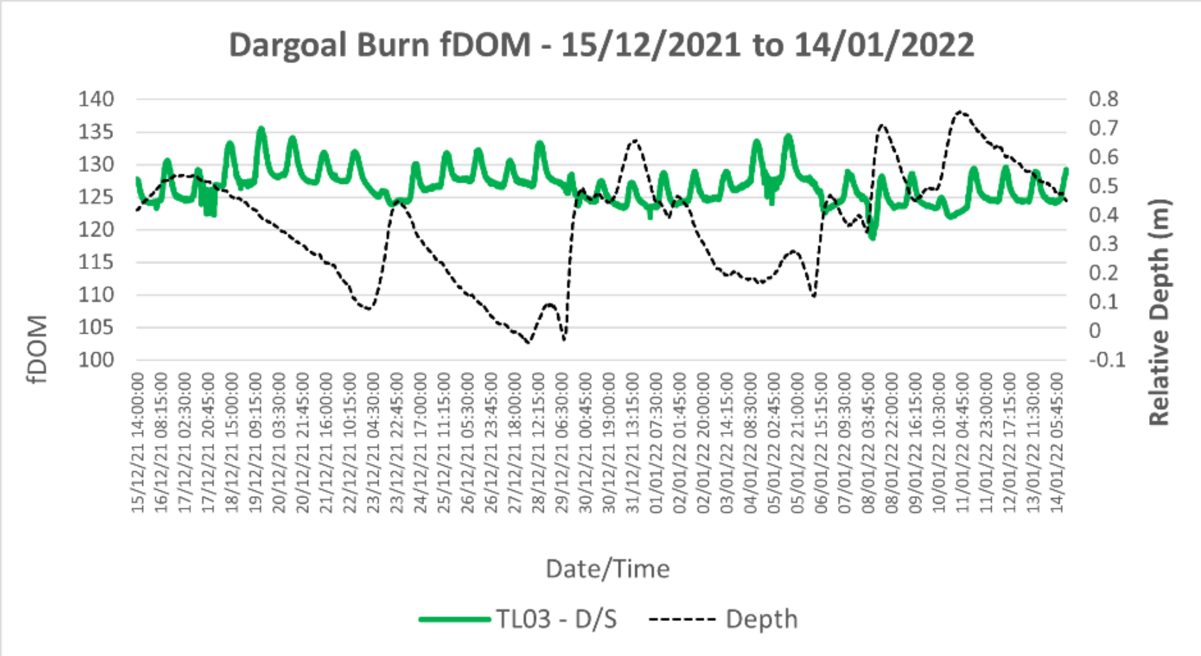
Graph 7: Comparison between pH and relative water depth (m) at TL01 (upstream), TL02 (tributary) and TL03 (downstream) and TL04 (Lower Burn) on the Dargoal Burn during winter 2025/2026



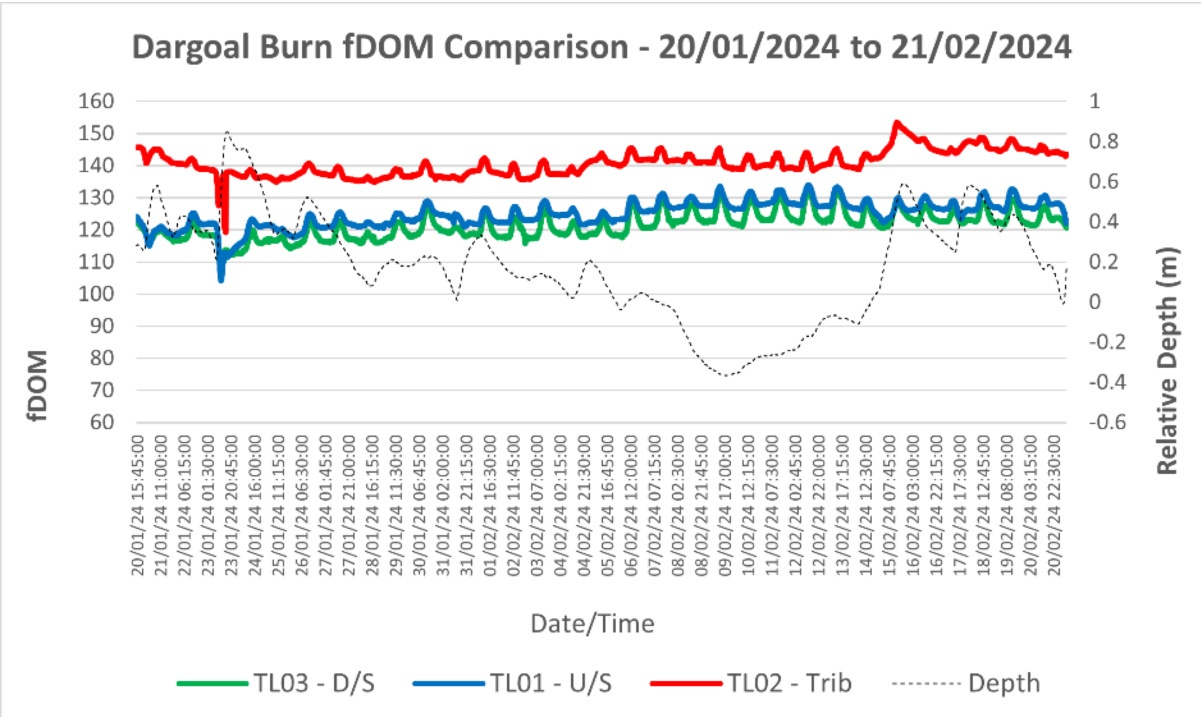
Graph 8: Comparison between fDOM and relative water depth (m) at TL02 (tributary) and TL03 (downstream) on the Dargoal Burn during winter 2019/2020



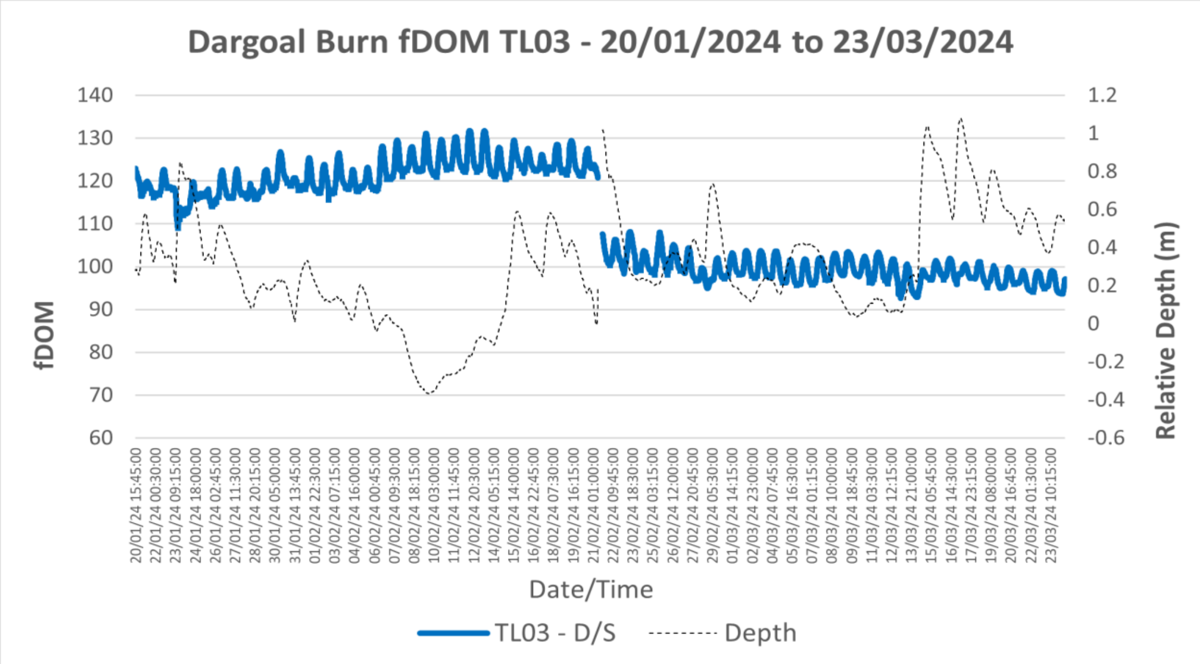
Graph 9: Comparison between fDOM and relative water depth (m) at TL02 (tributary) and TL03 (downstream) on the Dargoal Burn during winter 2020/2021



Graph 10: Comparison between fDOM and relative water depth (m) at TL03 (downstream) on the Dargoal Burn during winter 2021/2022

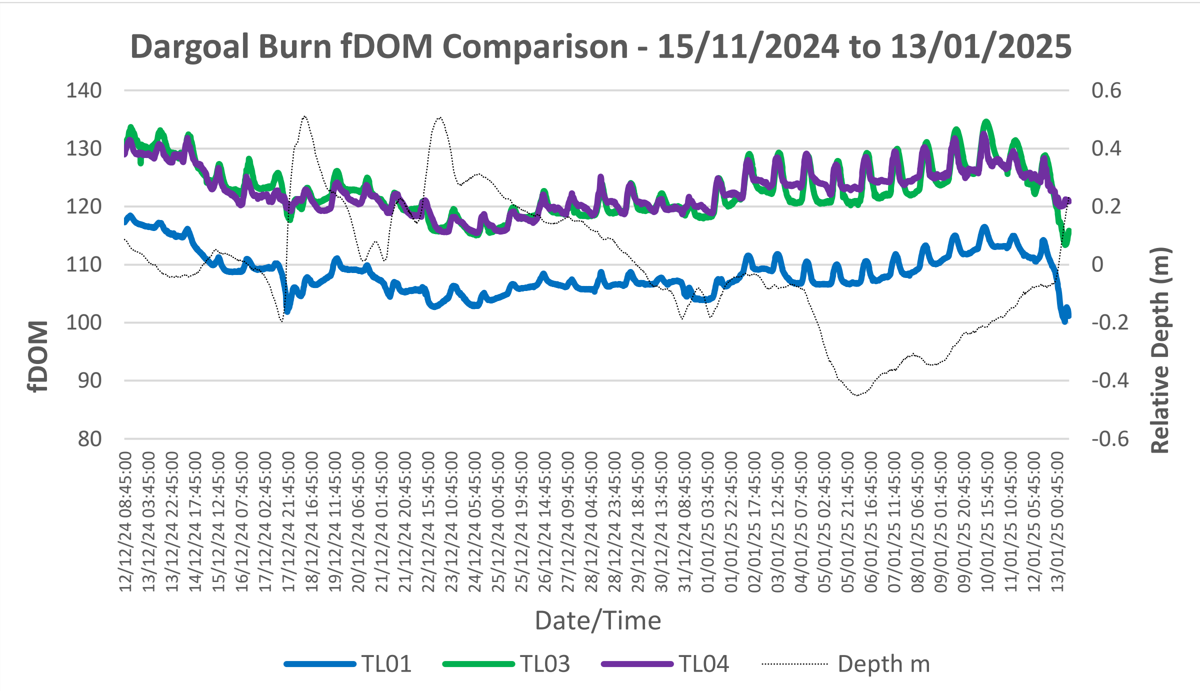


Graph 11: Comparison between fDOM and relative water depth (m) at TL01 (upstream), TL02 (tributary) and TL03 (downstream) on the Dargoal Burn during winter 2023/2024

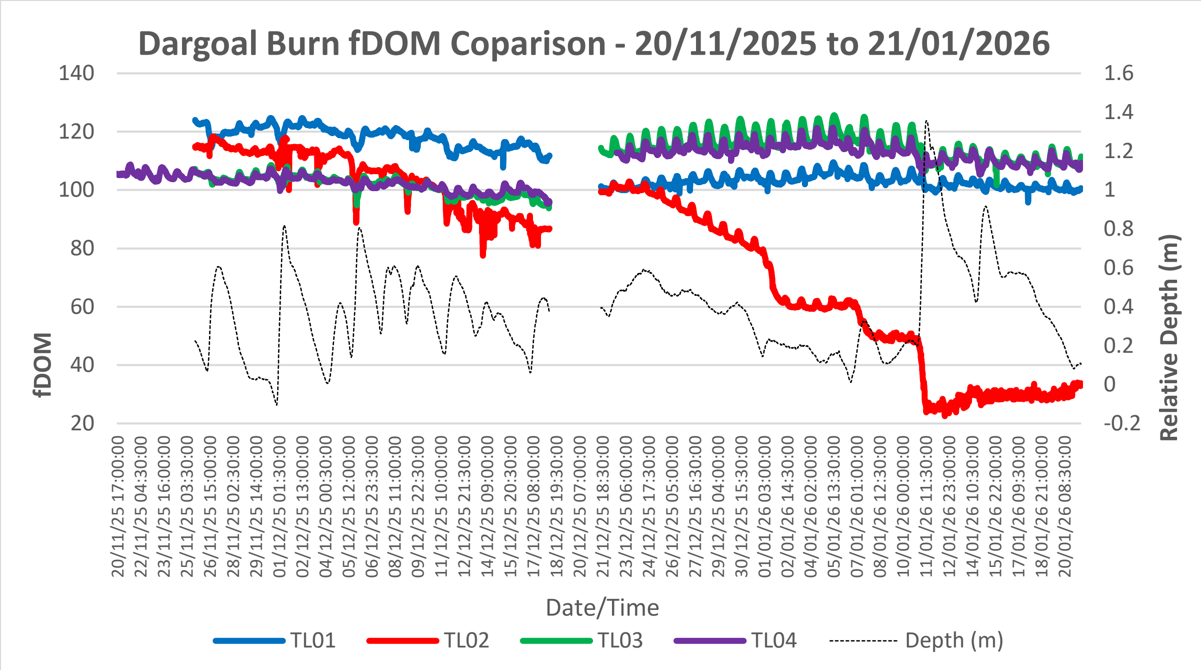


Graph 12: fDOM readings against relative depth for extended monitoring of Site TL03 (downstream) during winter 2023/2024

The drop in fDOM readings in Graph 11 during the latter recording period appears to be the result of a fDOM calibration issue as the data is inconsistent with all data recorded before or after this point.

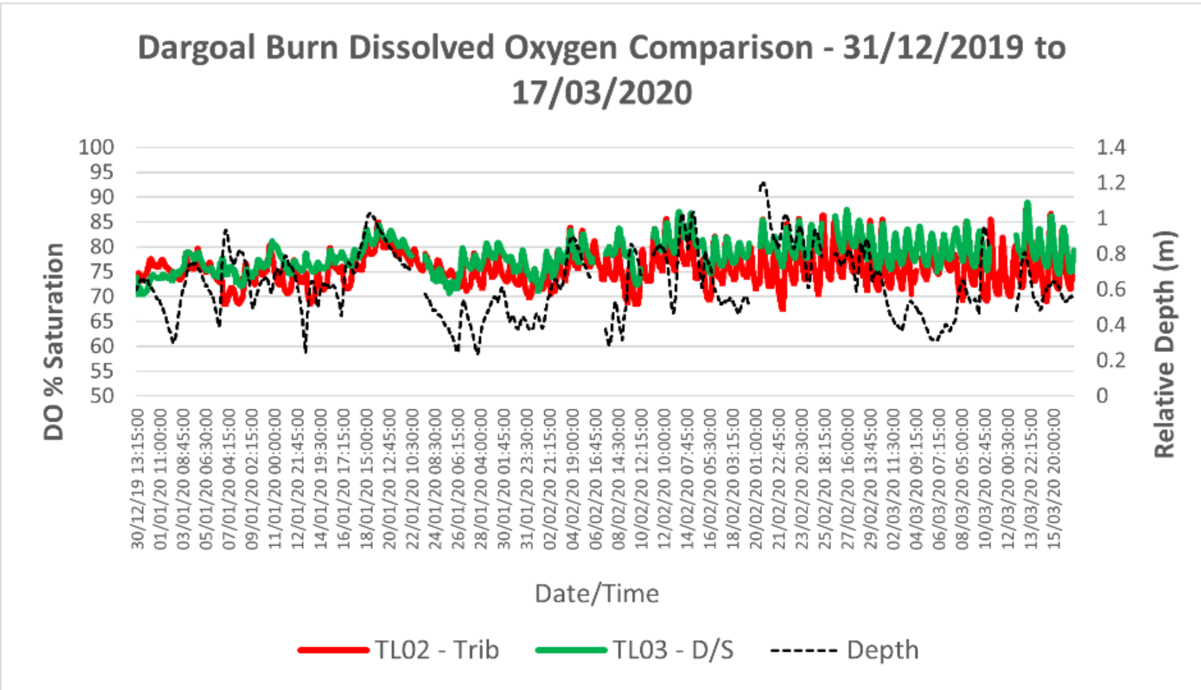


Graph 13: Comparison between fDOM and relative water depth (m) at TL01 (upstream), TL02 (tributary), TL03 (downstream) and TL04 (Lower Burn) on the Dargoal Burn during winter 2024/2025

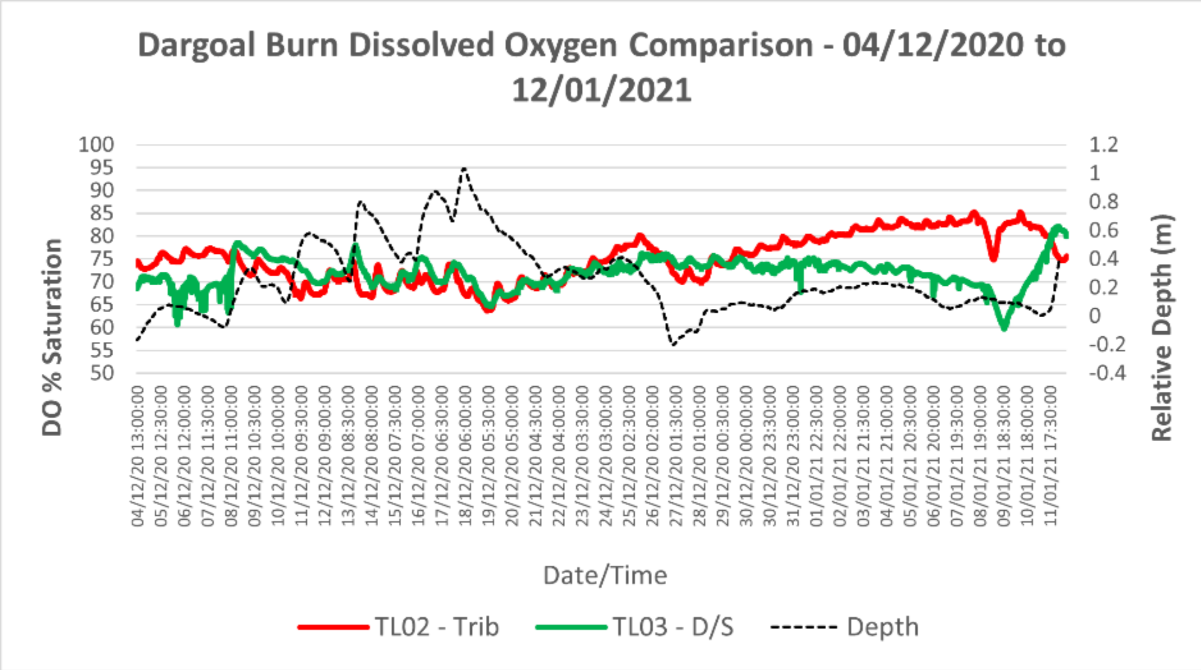


Graph 14: Comparison between fDOM and relative water depth (m) at TL01 (upstream), TL02 (tributary), TL03 (downstream) and TL04 (Lower Burn) on the Dargoal Burn during winter 2025/2026

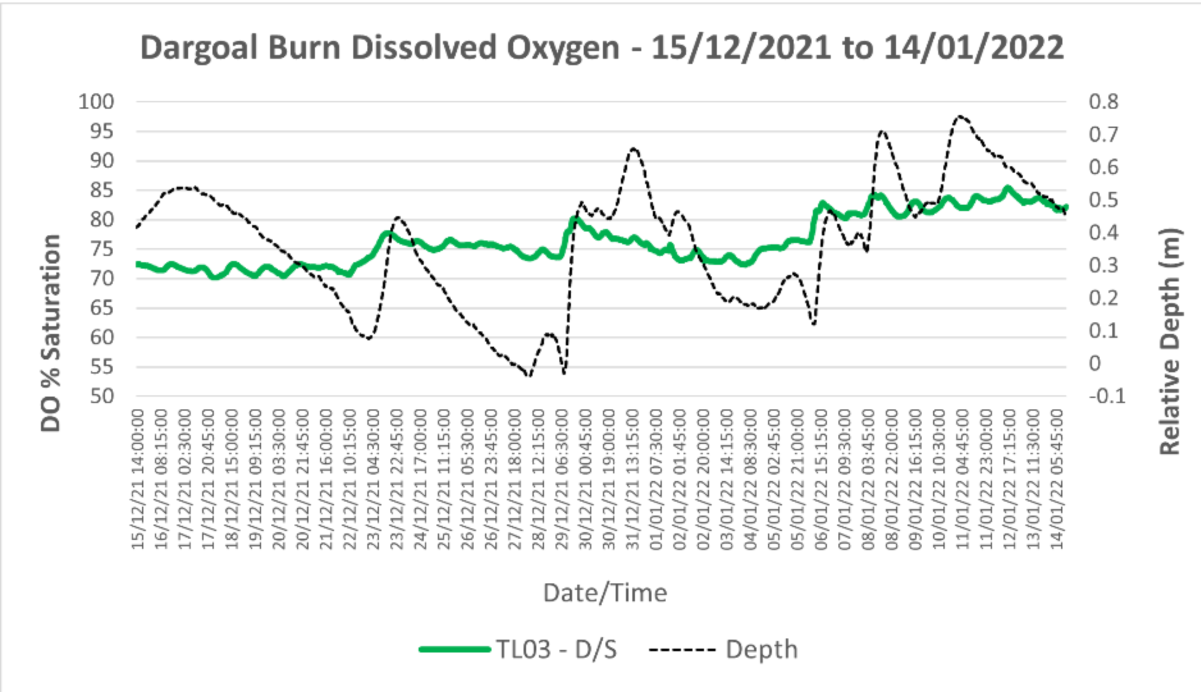
Whilst previous fDOM readings from TL02 indicate that levels can fall significantly during prolonged dry spells, the drop seen in the second half of Graph 14 appears unusually low. The further drop after the rainfall event on the 11th January would indicate an issue with the sensor. After retrieval, re-calibration and re-deployment (on the Black Water of Dee) there were no further issues with this sensor. Potentially indicating the build-up of peat or debris around the base of the sensor (other sensors are less impacted by such a build up as they do not reply on UV light passing through the water).



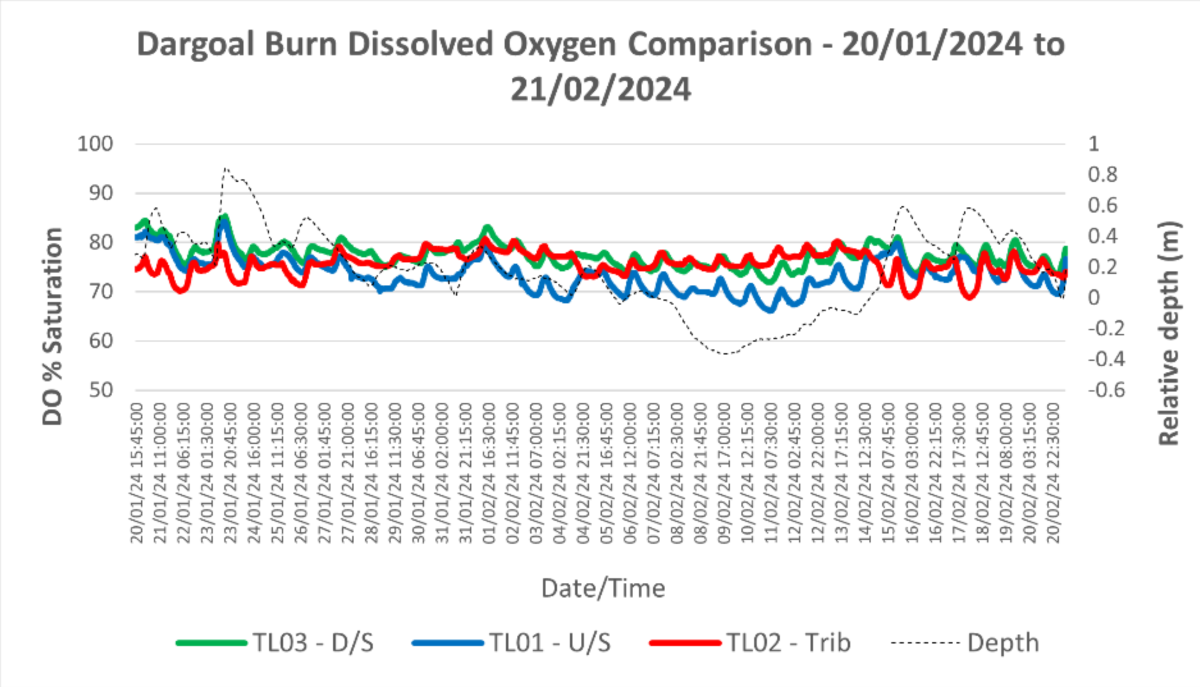
Graph 15: Comparison between Dissolved Oxygen and relative water depth (m) at TL02 (tributary) and TL03 (downstream) on the Dargoal Burn during winter 2019/2020



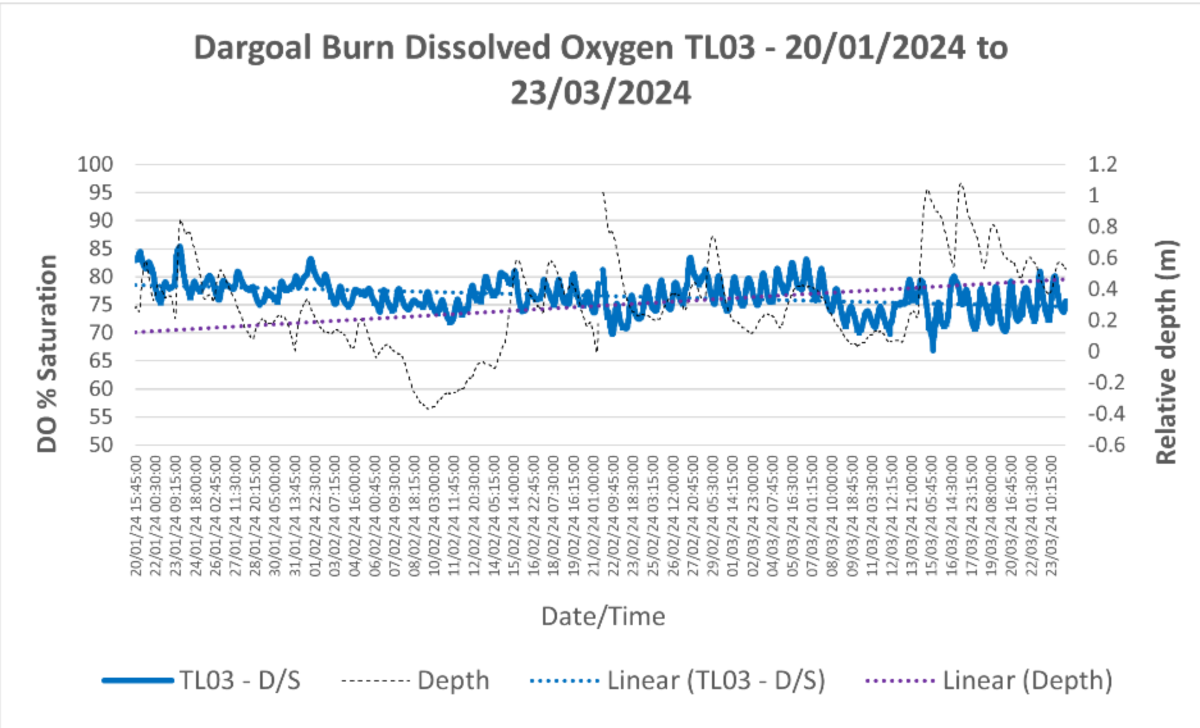
Graph 16: Comparison between Dissolved Oxygen and relative water depth (m) at TL02 (tributary) and TL03 (downstream) on the Dargoal Burn during winter 2020/2021



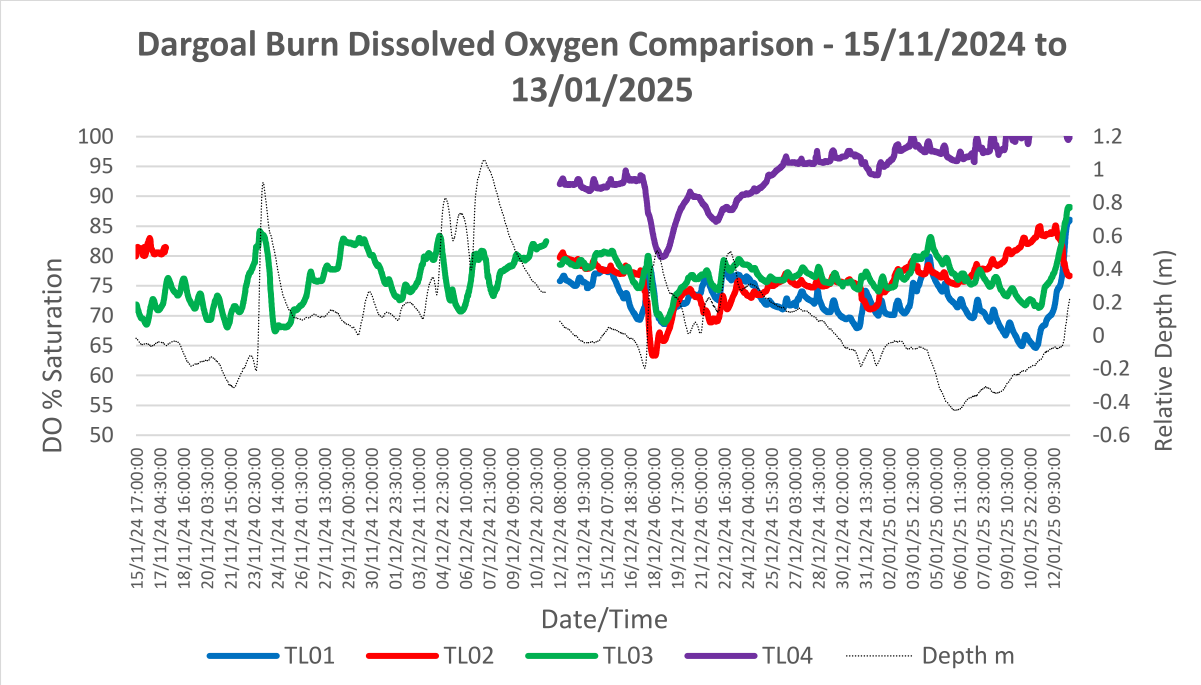
Graph 17: Comparison between Dissolved Oxygen and relative water depth (m) at TL03 (downstream) on the Dargoal Burn during winter 2021/2022



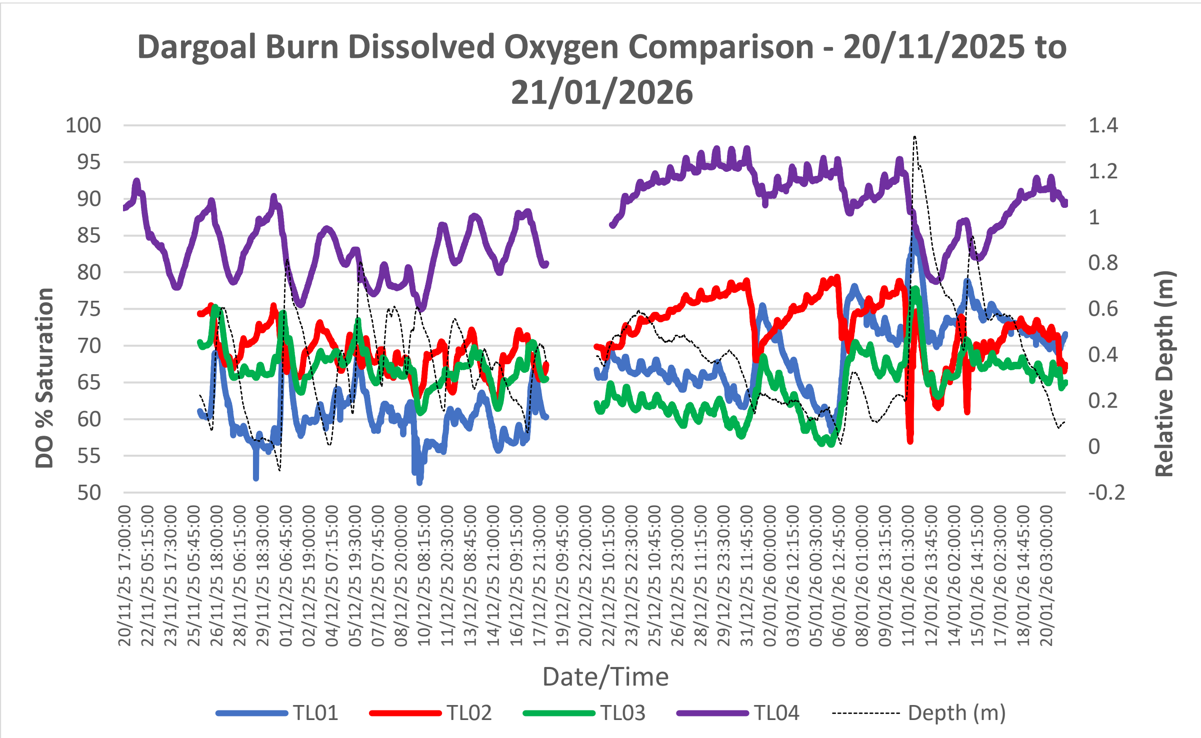
Graph 18: Comparison between Dissolved Oxygen and relative water depth (m) at TL01 (upstream), TL02 (tributary) and TL03 (downstream) on the Dargoal Burn during winter 2023/2024



Graph 19: DO readings against relative depth for extended monitoring for Site TL03 (downstream) during winter 2023/2024



Graph 20: Comparison between Dissolved Oxygen and relative water depth (m) at TL01 (upstream), TL02 (tributary) and TL03 (downstream) on the Dargoal Burn during winter 2024/2025



Graph 21: Comparison between Dissolved Oxygen and relative water depth (m) at TL01 (upstream), TL02 (tributary) and TL03 (downstream) on the Dargoal Burn during winter 2025/2026

Table 4: Dargoal Burn pH averages for each monitoring period

Site	Winter 2019/2020	Winter 2020/2021	Winter 2021/2022	Winter 2023/2024	Winter 2024/2025	Winter 2025/2026
TL01	-	-	-	4.00	3.93	3.98
TL02	4.11	4.37	-	4.17	4.11	4.17
TL03	4.03	4.24	3.98	4.09	3.99	4.01
TL04	-	-	-	-	4.00	4.07

Table 5: Dargoal Burn fDOM averages for each monitoring period

Site	Winter 2019/2020	Winter 2020/2021	Winter 2021/2022	Winter 2023/2024	Winter 2024/2025	Winter 2025/2026
TL01	-	-	-	124.9	108.6	109.5
TL02	86.1	90.54	-	140.7		78.2*
TL03	118.6	106.2	126.28	121.4	122.8	109.2
TL04	-	-	-	-	122.8	108.1

**issues with the TL02 fDOM sensor during January currently being investigated, while some data has been omitted it is unclear whether some other periods of recording are accurate or not*

Table 6: Dargoal Burn Dissolved Oxygen (% saturation) averages for each monitoring period

Site	Winter 2019/2020	Winter 2020/2021	Winter 2021/2022	Winter 2023/2024	Winter 2024/2025	Winter 2025/2026
TL01	-	-	-	73.5	72.6	65.7
TL02	75.8	75.1	-	75.7	76.3	71.2
TL03	78.4	71.9	76.4	77.4	76.2	65.6
TL04	-	-	-	-	94.3	86.9

During deployment there have been some clear issues with some of the sensors. As a result, some data has been omitted from the overall analysis. In the case where the issues have resulted in all, or almost all, of a deployment data being impacted the data has been removed from the graphs. Where data is only partially impacted the data may have been left within the graphs but has been left out of the tables of averages. Examples of this include Graph 20, where the majority of DO data has been left out for TL02 during the initial deployment, and Graph 14 where the fDOM sensor readings for TL02 develop an issue during the second deployment.

A consistent pattern appears evident within the data. Whilst acidified, the pH in the Dargoal tributary TL02 is typically less acidic than the pH in the Dargoal Burn, although only by a relatively small amount. This appears to have a minor diluting effect with the site above the tributary (TL01) being slightly more acidic that the downstream site (TL03). The TL02 pH also recovers faster during prolonged dry periods. There also appears to be a small but significant improvement in pH between the two upper Dargoal Burn monitoring sites (TL01 and TL03) and the lower Dargoal Burn site (TL04). The lower burn does not flow through blanket peat showing the relationship between degraded peatlands and pH. Despite peatland restoration being underway at the current point in data collection the pH averages show no obvious sign of change with flow levels still being the most likely driver of the relatively small variations seen between years.

In contrast to the pH results the fDOM results show more variability between winters. There are clearly some ongoing issues at site TL02 and despite some clearly impacted data being omitted there is still some variation within the TL02 data that may have been because of external factors affecting the fDOM sensor. The burn at TL02 is very small which results in the sonde having to be deployed at a much steeper angle than would typically be the case so that it can remain submerged. This may make it more likely to pick up debris being washed down the burn. If this is part of the reason for the issues with the readings, then there may not be an easy or obvious fix to this issue going forward. As such the fDOM readings and averages for TL02 need to looked over in more detail in any future analysis. Looking at the graphs, when considering the periods of reliable recording the fDOM results show no large-scale changes between years, except in the case of site TL02 (tributary) which recorded higher levels in 2024. This may be because of disturbance from the recently restored section of peatland (as it was at that point in time). If this is the case, then levels should improve as the peatland settles, repairs and vegetation become re-established. It is well established within the published literature that peatlands can take significant time to self-repair after restoration works.

As has been described in previous reports, the relatively low Dissolved Oxygen levels in the Dargoal Burn remain a cause for concern for aquatic life, with the 2026 results being the lowest levels recorded. The upper Dargoal Burn is low gradient, deep and slow flowing. There is only limited capacity for re-oxygenation so is likely very susceptible to deoxygenation through the aerobic digestion of organic matter. However, the results from TL04 show significant oxygen re-saturation in the lower burn. This is likely because of the lower burn being shallower, steeper and faster flowing. This means that the low oxygen levels are not directly impacting the Polbae Burn at the point at which the Dargoal Burn flows into it, at this time of year, and that impacts are relatively localised. However, any peat eroding from Tannylaggie Flow and being deposited within deep, slow sections of the Polbae Burn may be having a similar deoxygenating effect.

Although not having a significant impact on overall results daily fluctuations can be seen in several of the graphs. Whilst the exact reason for these fluctuations is unexplained at present, the day/night rhythm of the fluctuations would suggest the variations are related to temperature and/or biological activity.

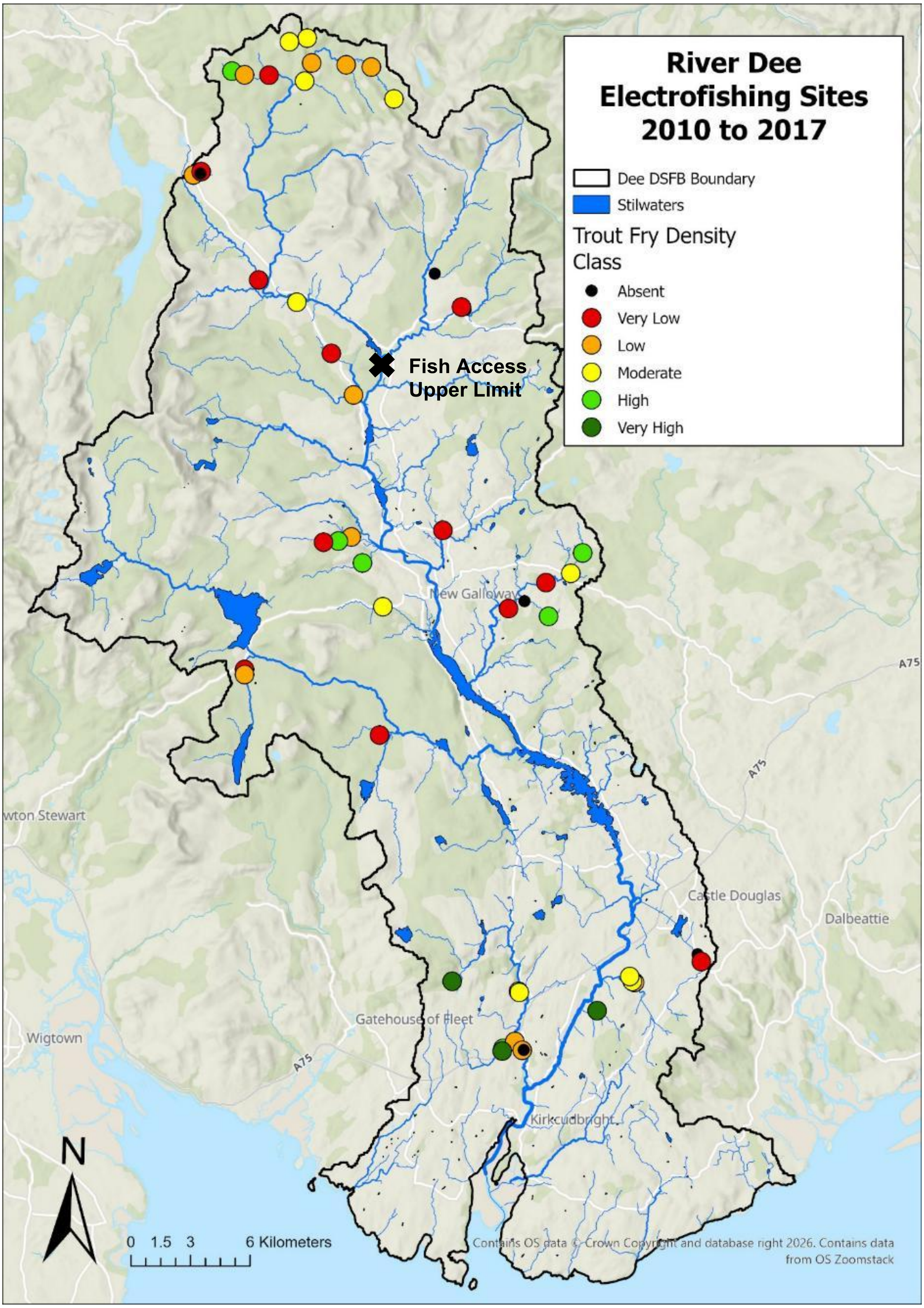
3.2 River Dee electrofishing data review

As a result of the current state of native fish populations within the Dee catchment, and the complexity of the reasons behind this, several factors must be considered when analysing fish survey results. Adult Atlantic salmon counts are available from the Tongland fish counter located at the bottom of the river (listed in Appendix 1). The counter is run by GRT on behalf of the owners of the Galloway Hydro-electric Scheme. The relatively low number of salmon returning to the river to spawn since 2017 (by comparison to the size of the river system) would indicate that juvenile salmon numbers are below carrying capacity for the river. This would make using juvenile salmon densities an unreliable indicator of water quality, as reduced egg deposition for relatively low numbers of adult spawning salmon is most likely the biggest factor impacting juvenile numbers. Unlike previous PA funded water quality monitoring reports, juvenile salmon numbers have not been considered within this report. As Atlantic salmon typically spawn in channel widths of around 3 m and wider this means that most data from electrofishing sites from channel widths around or above this width have been omitted from the electrofishing data review. The current state of the salmon population within the Dee river system is thought to be down to several factors including habitat loss, impacts on migration (both upstream and downstream), flow regulation, non-native invasive species and declining marine survival.

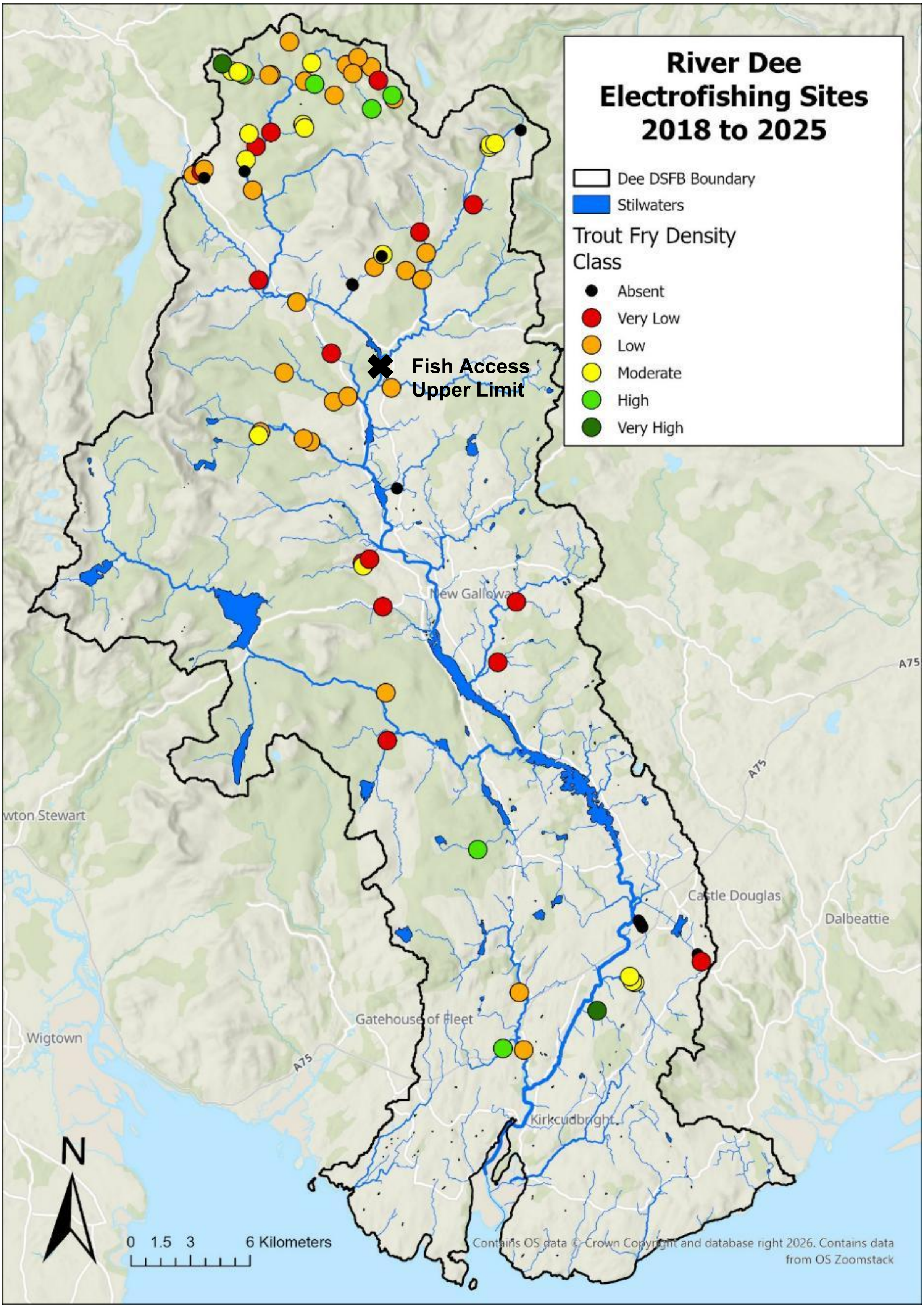
As Brown trout can adapt to both residency and migration their populations are, in principle, less likely to impacted by the factors impacting the salmon population within the Dee, and it should be possible to use juvenile trout to assess the impacts of water quality on their populations. However, several factors within the Dee catchment do have to be considered. A lack of any fish pass on the Dams at Kendoon Loch restricts fish migration. As a result, the Brown trout populations within the Water of Deugh, the upper Water of Ken and the Black

Water are isolated above this point. Due to being unable to migrate to sea, or even the deeper, wider reaches of the lower river, this limits the size and number of adult Brown trout and causes a reduction in egg deposition (and subsequent fry numbers). Therefore, the scoring system typically used to assess Galloway trout fry densities may be inadequate for isolated populations and results lower than would typically be expected may still indicate healthy populations and good water quality. Below Kendoon Loch, while Brown trout have migratory access across the remainder of the river system in principle. However, the impact of having to pass through several fish passes (adults moving upstream) and potentially through turbines (juveniles/smolts moving downstream) may restrict access to the sea, or even the full extent of the river system, for trout in some areas. For any resident Brown trout within the river downstream of Kendoon Loch, there may also be an impact of the hydro-electric dams on the quality of the available adult habitat. Unfortunately, it is not possible to assess the full impact of the hydro-electric scheme on the trout population downstream of Kendoon. However, the potential impacts as explained above should be considered when assessing juvenile trout densities. Unlike salmon, Brown trout tend to spawn in smaller watercourses (burns) generally averaging around 3 m in width and under. Because of this preference in channel size trout fry are often found in low numbers, or are absent, from larger channels (even within populations whose juvenile numbers are well above carrying capacity). Due to this trend this report only shows the trout fry results from watercourses averaging around 3 m width and under.

The trout fry electrofishing results for the River Dee for the 2010 – 2017 and 2018 - 2025 time periods are shown on Maps 16 and 17. Within the maps the electrofishing results have been displayed using the abundance-based colour coding described in Section 2.2.



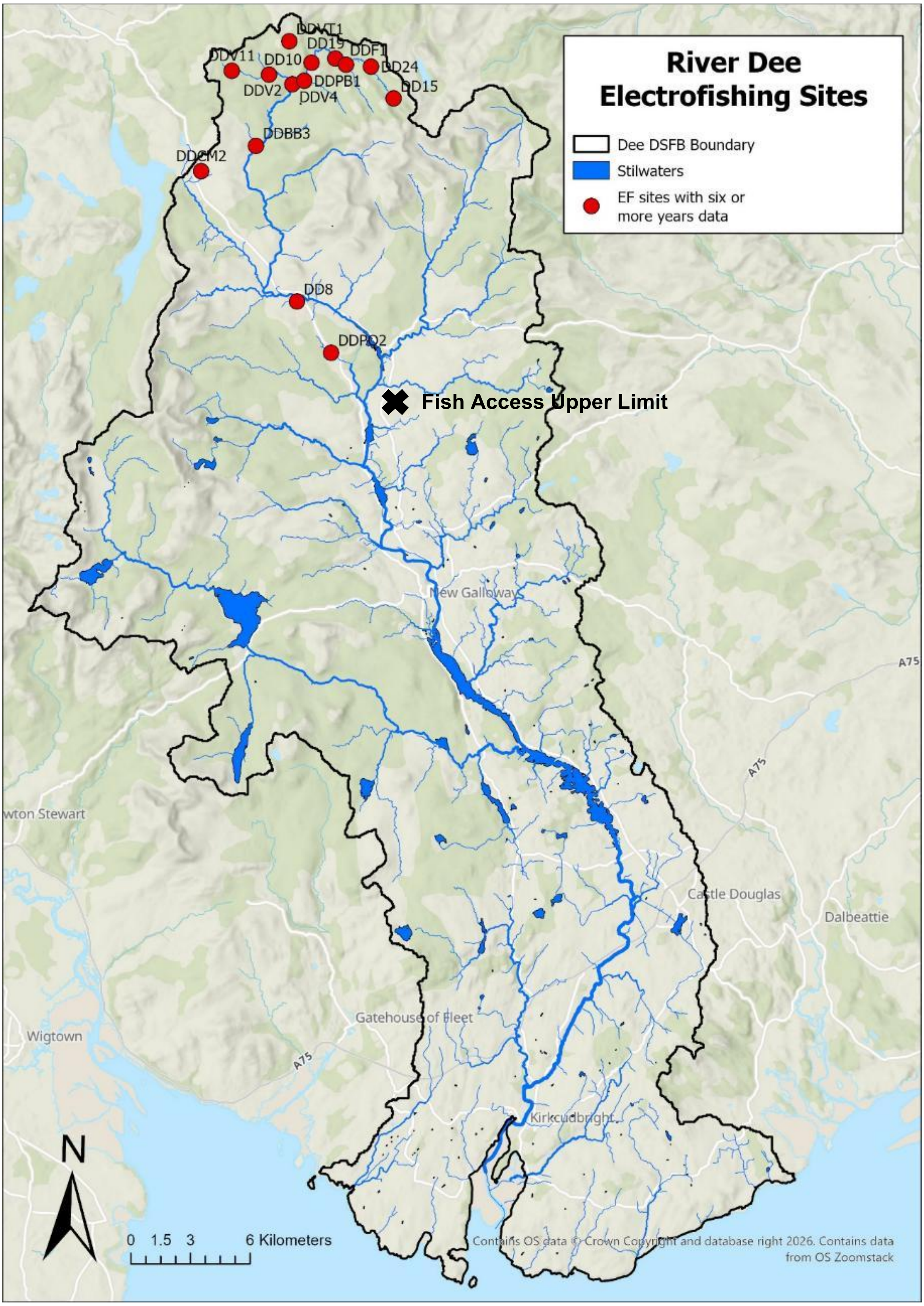
Map 16: Dee single run trout fry electrofishing results from 2010 to 2017



Map 17: Dee single run trout fry electrofishing results from 2018 to 2025

The upper limit of migratory fish access has been marked on Maps 16 and 17. As stated previously, the scoring system used to classify trout fry densities may not represent the health of the Brown trout population above this point, with lower classifications potentially being representative of healthy populations and good water quality. There are also clearly gaps in the data for some areas. The most notable example of this is from the Black Water of Dee. While there are several GRT electrofishing sites on the Black Water of Dee, most focus on the main stem of the lower river to look at the impact of Clatteringshaws Dam and to monitor habitat restoration projects within the river. Electrofishing sites on trout spawning burns are, unfortunately, relatively scarce. What little electrofishing data is available from the Black Water of Dee trout spawning burns indicates “low” to “very low” Brown trout fry densities during both recording periods and may indicate the impacts of poor water quality. However, it would be very difficult to isolate the impacts of water quality from the other anthropological impacts impacting the river system. If we look at the area above the limit of migratory trout (Water of Deugh and upper Water of Ken), the Deugh is dominated by results in the “low” and “moderate” density ranges, with a few “high” density sites appearing in the latter recording period. Given that this population is isolated above Kendoon Loch, and reduced egg deposition should be expected, the results most likely represent a relatively healthy population, with little or no water quality issues. There are far fewer electrofishing sites on the upper Water of Ken making any patterns in distribution harder to see than on the Deugh. However, from what results we have (primarily from the latter of the two recording periods) “low” and “moderate” results are common and most likely indicate few, if any, water quality issues given this is also an isolated population. Downstream of Kendoon Loch, within the area potentially accessible to migratory fish, the electrofishing sites are fairly spread out. “Moderate” to “very high” trout fry densities appear more common from trout burns closer to the estuary/sea. This most likely indicates the presence of anadromous Brown trout (Sea trout) within the lower burns and a subsequent increase in egg deposition resulting from larger female trout (due to marine feeding). Within many river systems Sea trout can migrate significant distances (many miles) upstream to spawn. The electrofishing results from the middle catchment and the area below the upstream migratory limit are generally lower than those from the lower river, particularly during the 2018 to 2025 period. This indicates a lower contribution from Sea trout eggs in this area and may highlight migratory issues for Sea trout passing hydro-electric dams (in either an upstream or downstream direction), although there are several other issues within the catchment including non-native fish and invertebrate species, especially within Loch Ken. The results therefore indicate that water quality appears to be relatively good in the lower catchment. However, no conclusions can be made from the results from the middle catchment (up to the upper migratory limit) as factors other than water quality are likely the driving the trout fry numbers recorded. Changes in the number and location of trout electrofishing sites between two time periods shown makes it difficult to spot any obvious changes over time. The results indicate that there may be a drop in trout fry densities from the middle catchment around New Galloway. However, as the sample site locations mostly differ between the two time periods the results are far from conclusive. The low percentage of degraded peatlands, commercial forestry and the bedrock within this section of the catchment would indicate that any declines in trout fry are unlikely to be related to water quality.

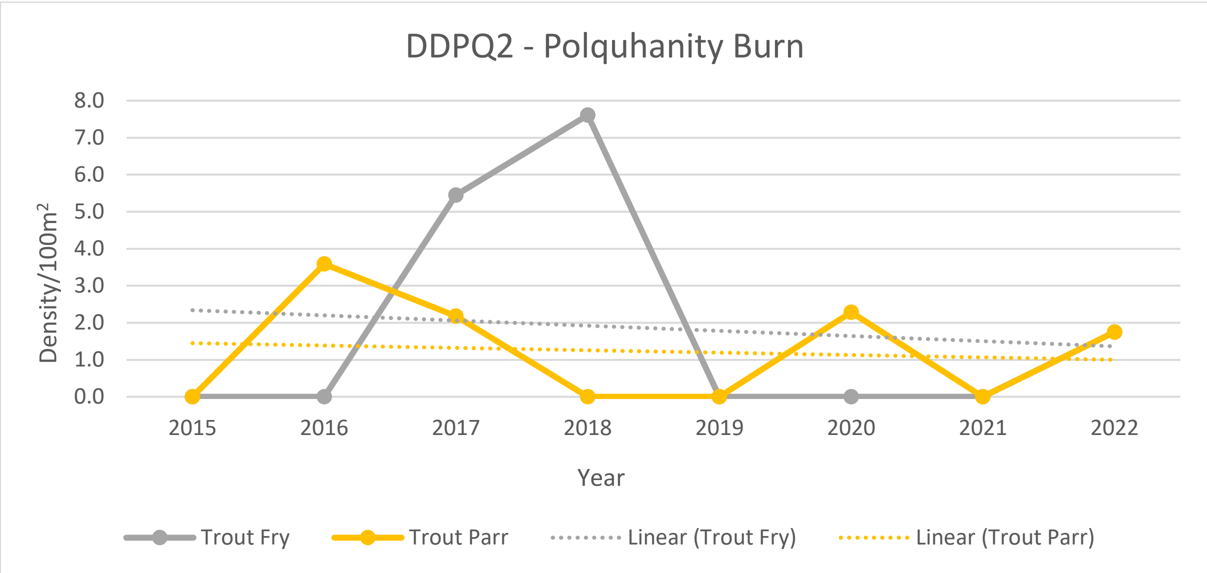
Within the electrofishing results there are several sites that have been visited repeatedly since electrofishing began. To provide enough data to assess trends in fish numbers, sites with six or more years of data have been analysed. As with the previous electrofishing analysis Brown trout fry densities have been analysed. Map 18 shows the location of the sample sites, Table 7 gives the site information, and the results are displayed on Graphs 22 to 35. Because of the nature of GRT’s fish survey work within the Dee catchment all the available data (with six or more years of sample data) comes from the Water of Deugh sub-catchment, with no data available for elsewhere within the Dee system. Much of the data was collected from contract work monitoring renewable energy and infrastructure developments (e.g. wind farms, pylon construction) within the Deugh headwaters. As a result, it is possible that there may be some impacts from the developments within some of the results. When comparing different sites, it should be noted that the period over which each individual site was surveyed varies and, as such, recording at some sites misses out the earlier, or later, time periods shown for some other results. In addition to fry, Brown trout parr results have also been included out of interest.



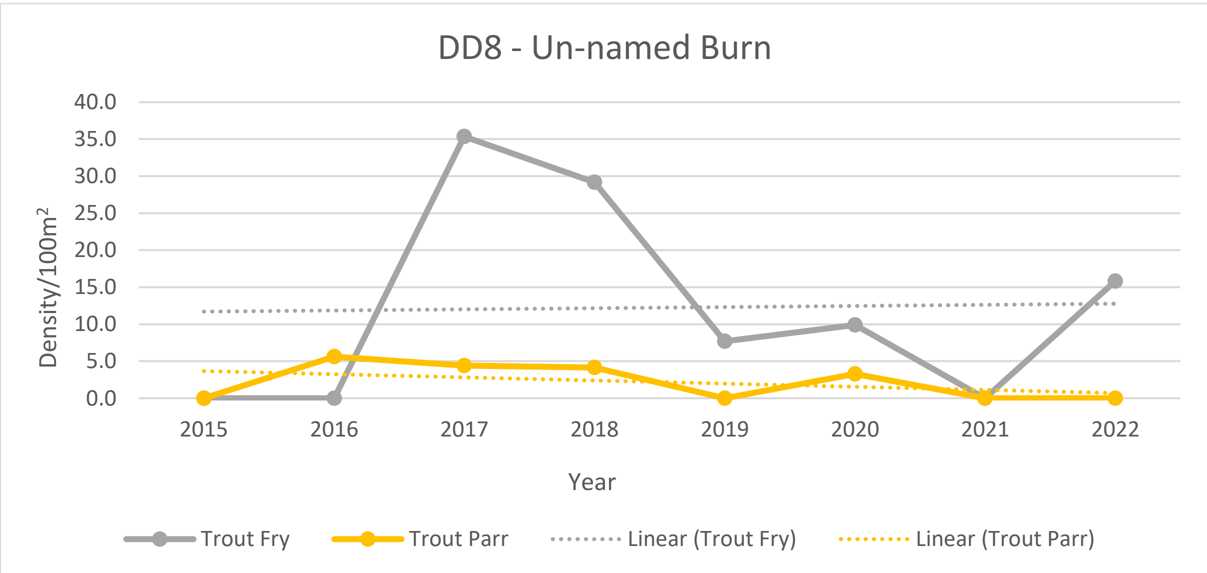
Map 18: Locations of electrofishing sites with six or more years of electrofishing data

Table 7: Location details for electrofishing sites with six or more years of electrofishing data

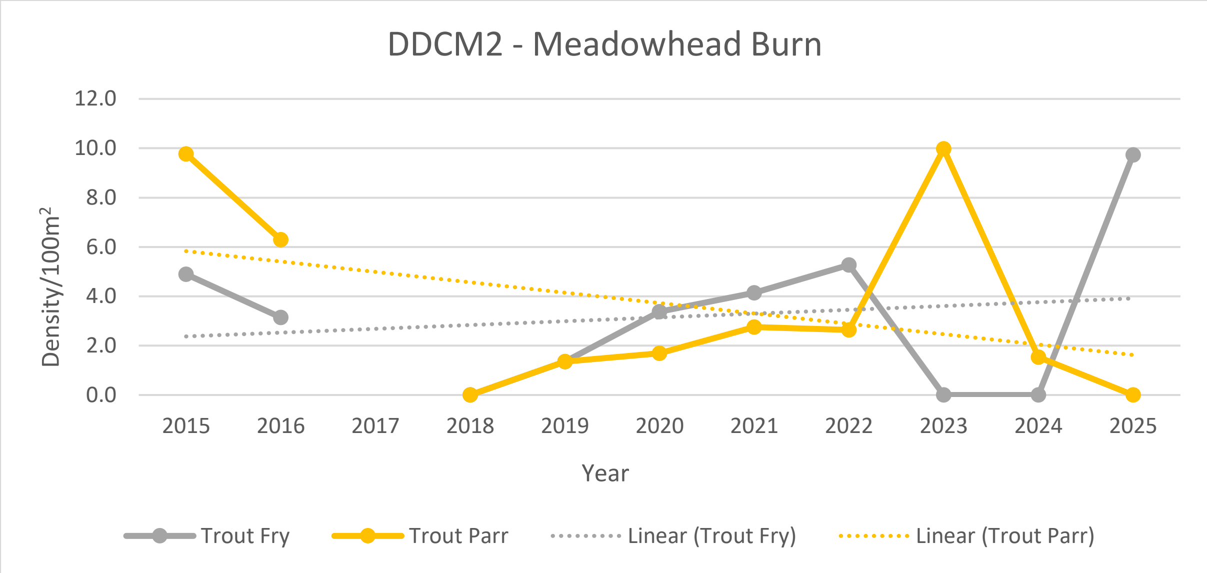
Site Code	Easting	Northing	Dee Sub-catchment	Watercourse
DDPQ2	258773	590095	*Water of Deugh*	*Polquhanity Burn*
DD8	257045	592677	*Water of Deugh*	*Un-named Burn*
DDCM2	252228	599245	*Water of Deugh*	*Meadowhead Burn*
DDBB3	254986	600526	*Water of Deugh*	*Brownhill Burn*
DDV4	256819	603633	*Water of Deugh*	*Pochriegavin Burn*
DDV2	255645	604104	*Water of Deugh*	*Pochriegavin Burn*
DDV11	253771	604309	*Water of Deugh*	*Poughergown Burn*
DDPB1	257423	603795	*Water of Deugh*	*Polwhat Burn*
DDVT1	256667	605785	*Water of Deugh*	*Strathwiggan Burn*
DD10	29345	257784	*Water of Deugh*	*Un-named Burn*
DD19	258981	604923	*Water of Deugh*	*Water of Deugh*
DDF1	259525	604620	*Water of Deugh*	*Fingland Burn*
DD24	260783	604514	*Water of Deugh*	*Water of Deugh*
DD15	261920	602906	*Water of Deugh*	*Water of Deugh*



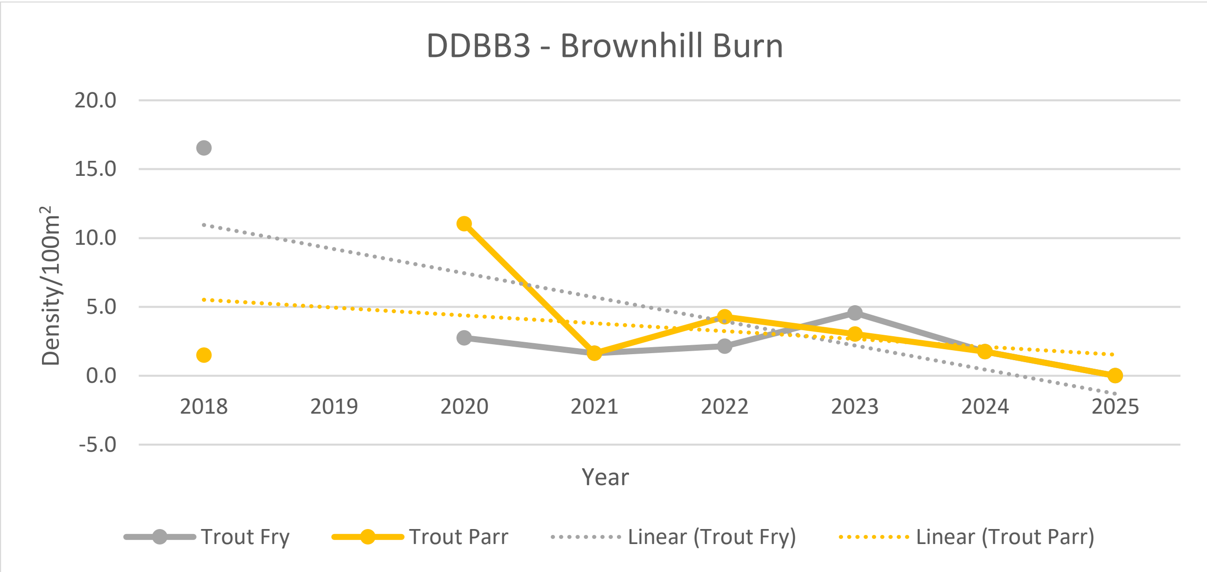
Graph 22: Single run Brown trout fry and parr densities for electrofishing site DDPQ2



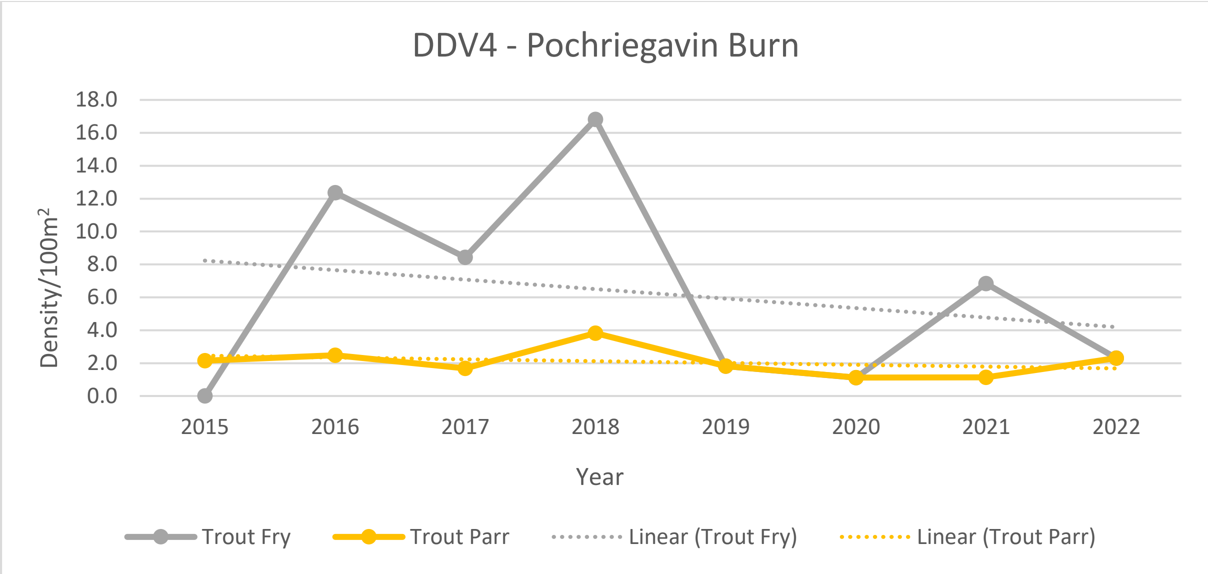
Graph 23: Single run Brown trout fry and parr densities for electrofishing site DD8



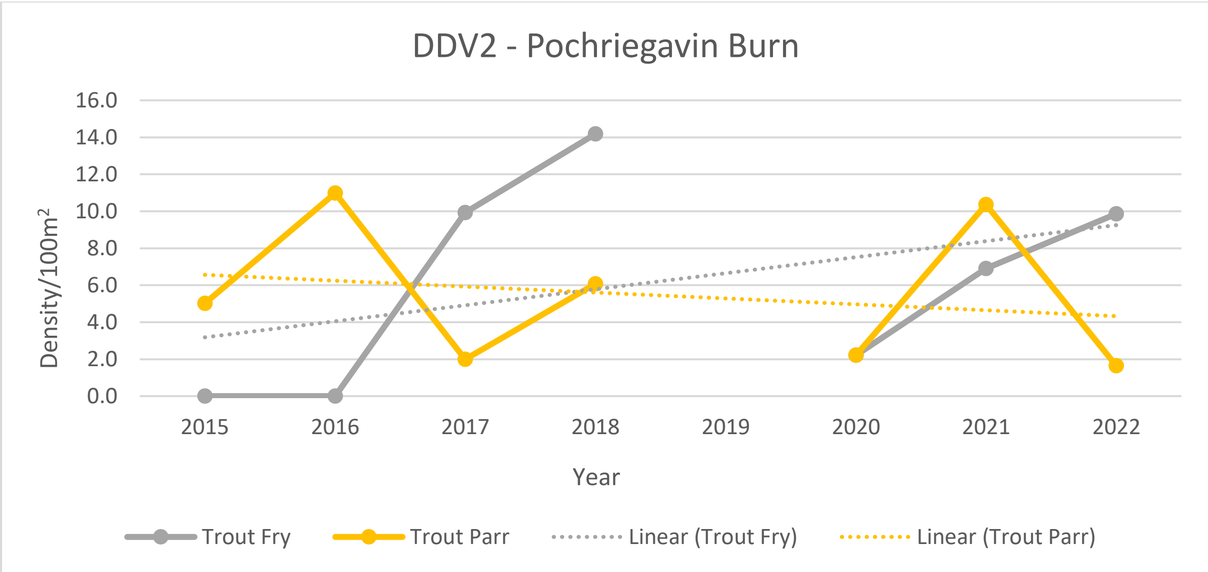
Graph 24: Single run Brown trout fry and parr densities for electrofishing site DDCM2



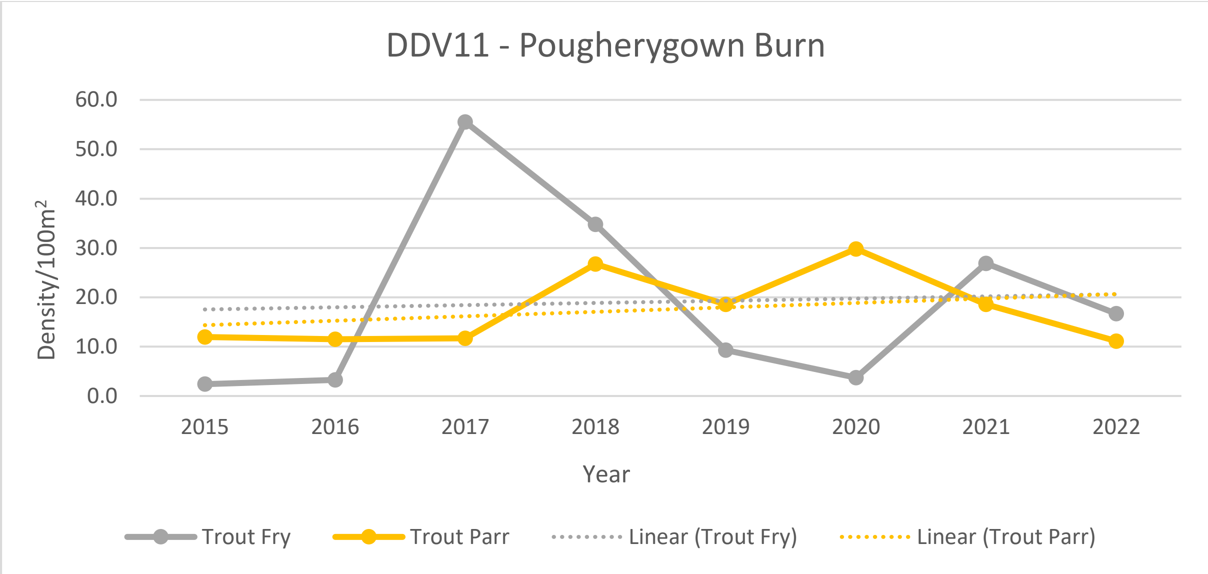
Graph 25: Single run Brown trout fry and parr densities for electrofishing site DDBB3



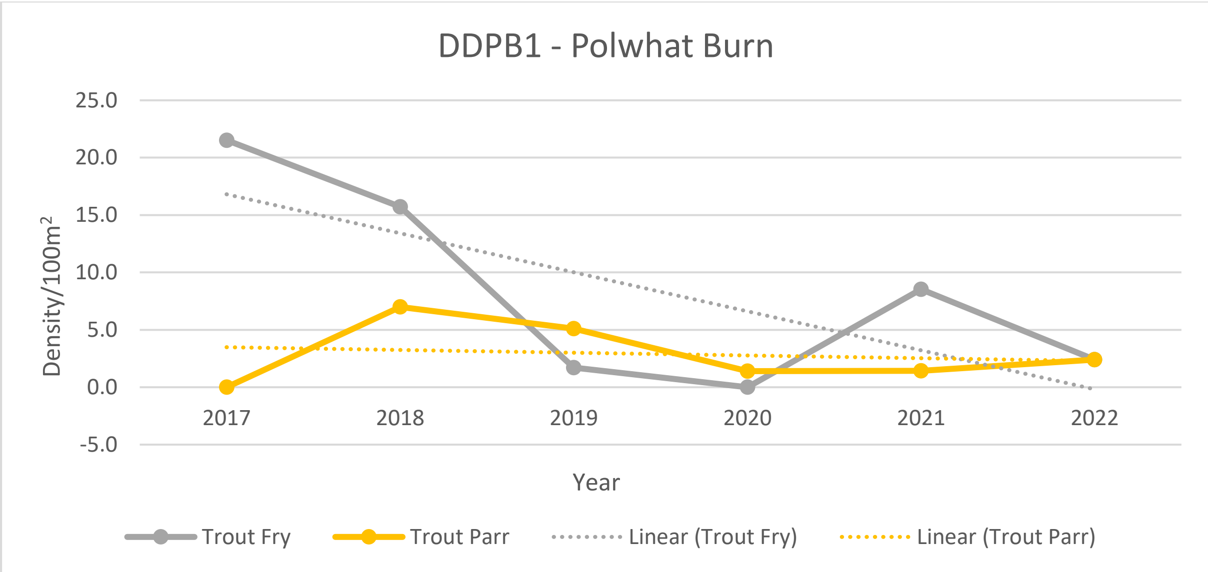
Graph 26: Single run Brown trout fry and parr densities for electrofishing site DDV4



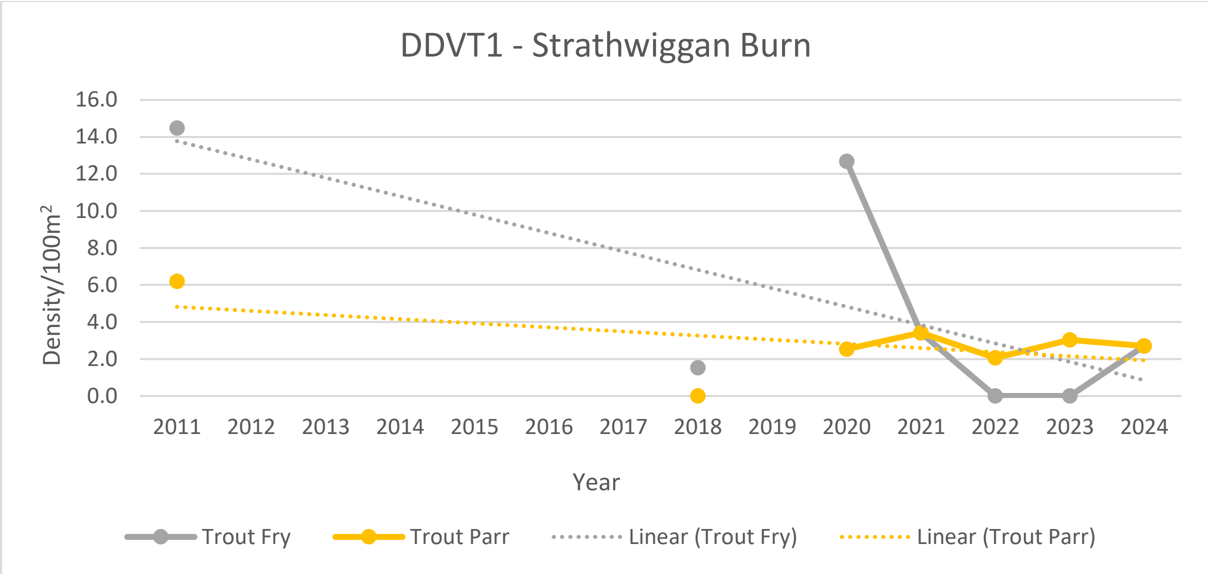
Graph 27: Single run Brown trout fry and parr densities for electrofishing site DDV2



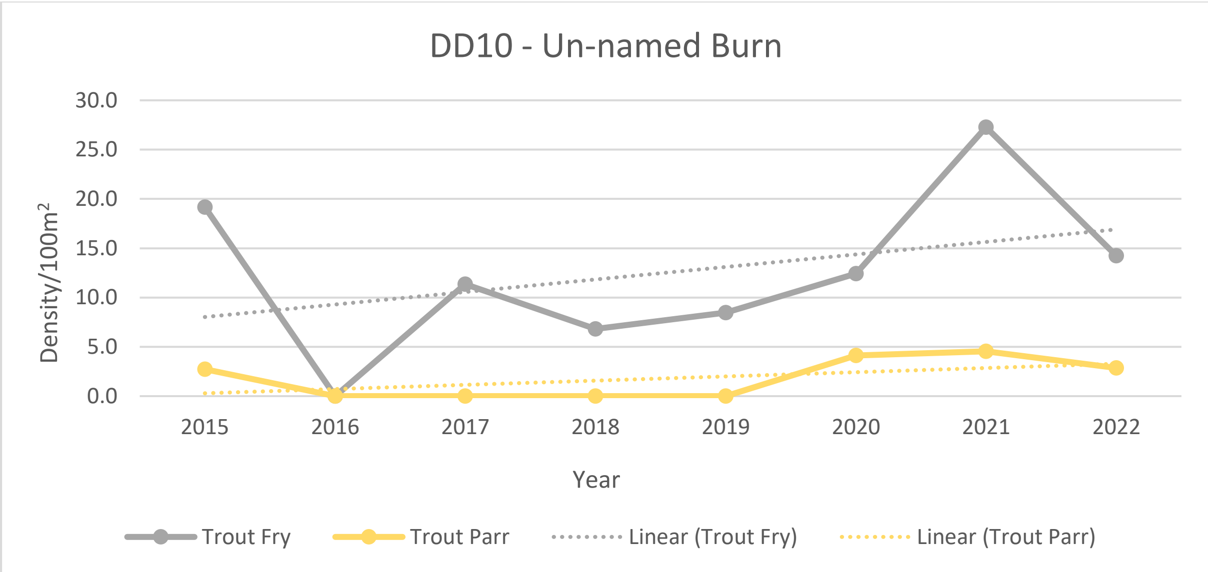
Graph 28: Single run Brown trout fry and parr densities for electrofishing site DDV11



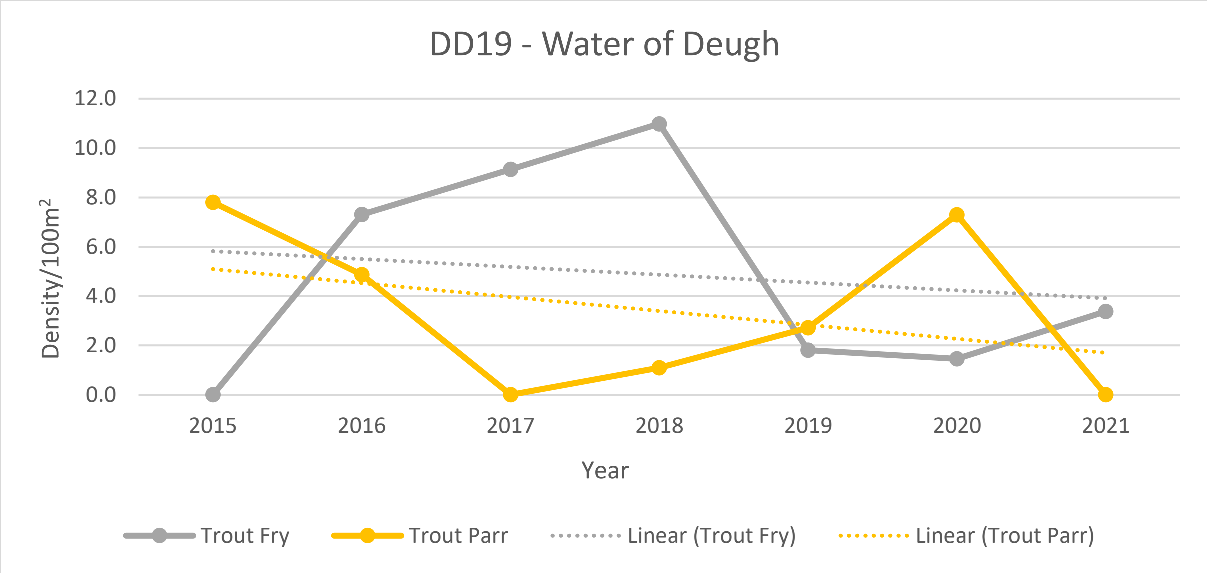
Graph 29: Single run Brown trout fry and parr densities for electrofishing site DDPB1



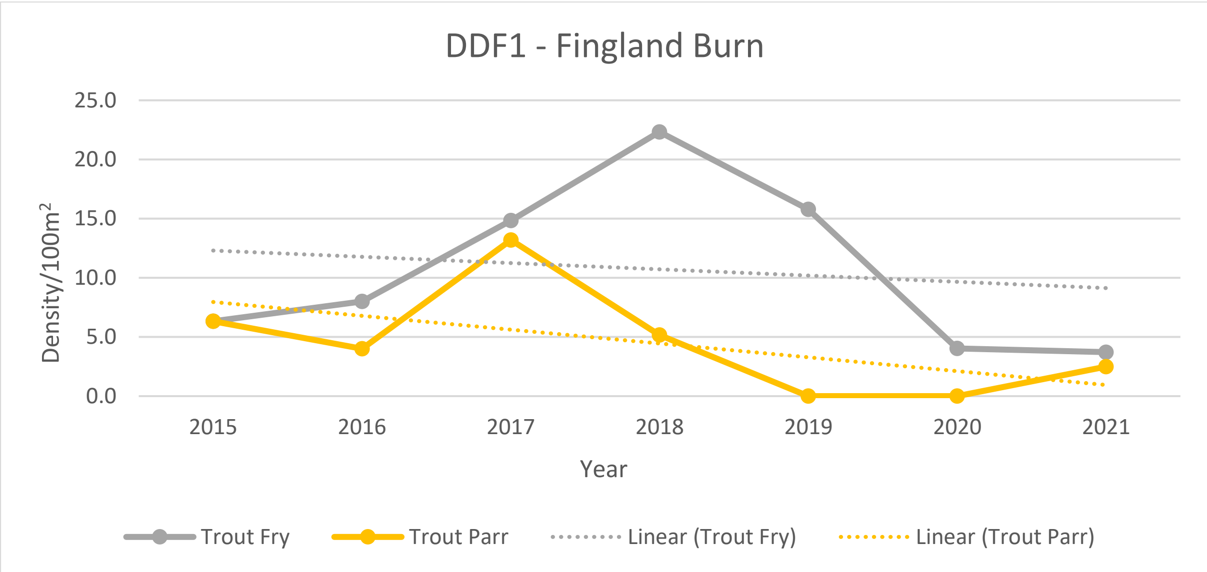
Graph 30: Single run Brown trout fry and parr densities for electrofishing site DDVT1



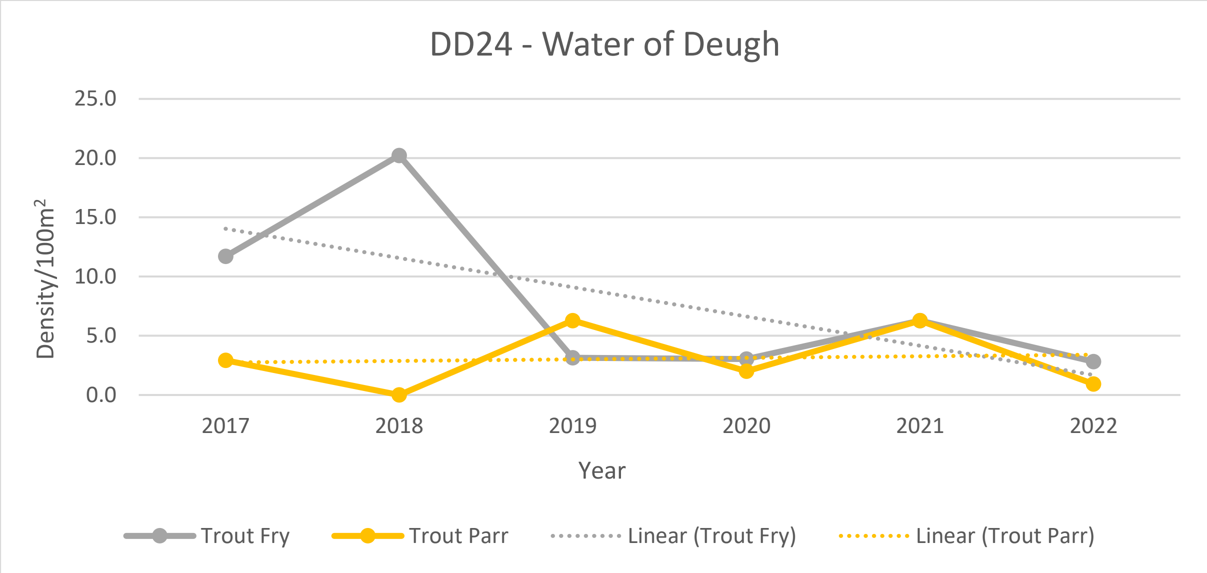
Graph 31: Single run Brown trout fry and parr densities for electrofishing site DD10



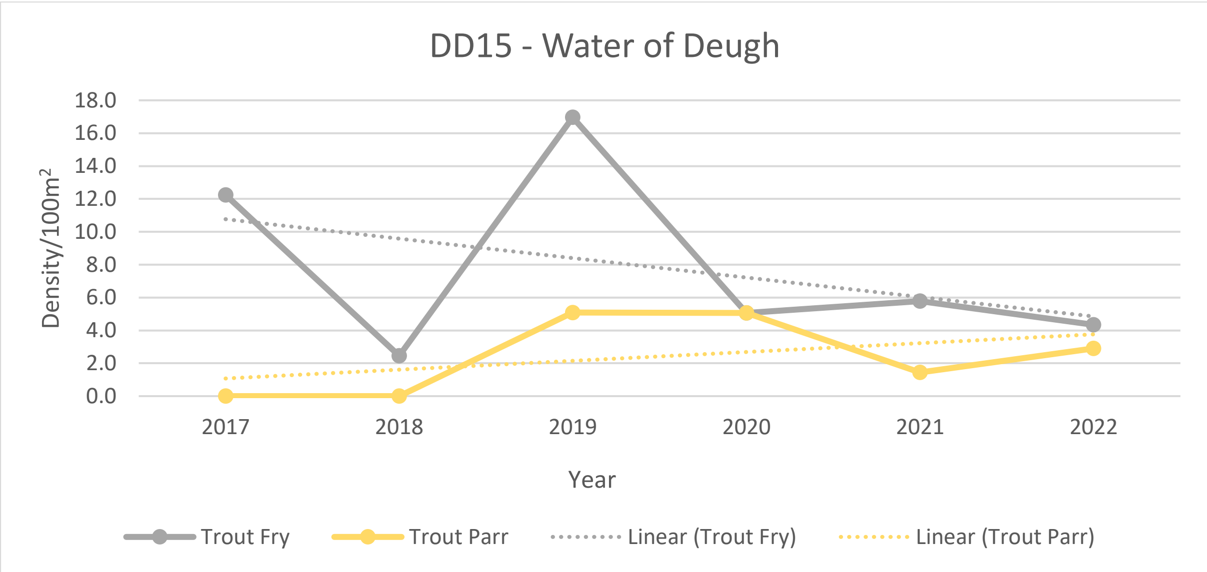
Graph 32: Single run Brown trout fry and parr densities for electrofishing site DD19



Graph 33: Single run Brown trout fry and parr densities for electrofishing site DDF1



Graph 34: Single run Brown trout fry and parr densities for electrofishing site DD24

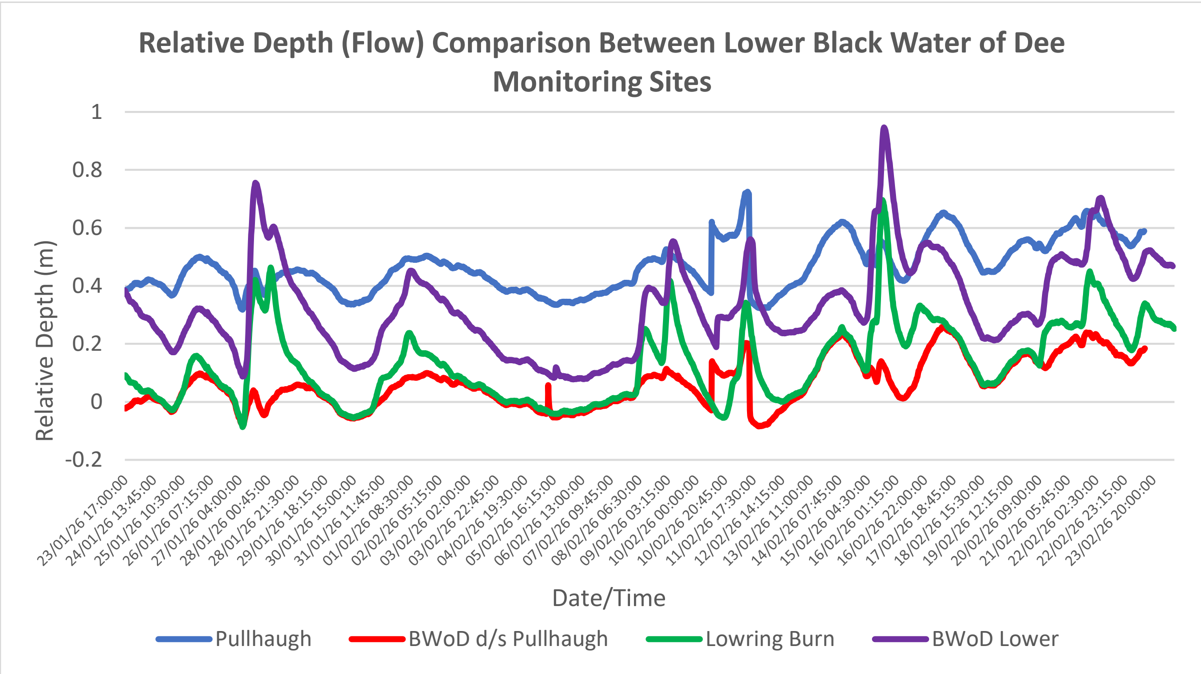


Graph 35: Single run Brown trout fry and parr densities for electrofishing site DD15

As the results for all continual monitoring sites come from the Water of Deugh sub-catchment any conclusions from the results can only be applied to this section of the River Dee catchment. Brown trout fry and parr densities are highly variable between sites, and between years. However, a significant number of sites routinely show fry and parr densities in "moderate" or higher densities indicating water quality is unlikely to be significantly impacting results at each individual site. Of the 14 sites listed above, over the years that data is available, three showed an increase in trout fry densities and 11 showed a decrease, while six showed an increase in trout parr densities and eight showed a decrease. This clearly indicates an overall decline in Brown trout fry numbers, but more stable parr numbers. As most of the electrofishing sites from the Deugh come from long term monitoring of commercial developments the wind power and infrastructure build-up within the Water of Deugh headwaters may be a more likely cause for the decline than degraded peatland and commercial forestry, although there may be a link between these factors.

3.3 River Dee water quality overview

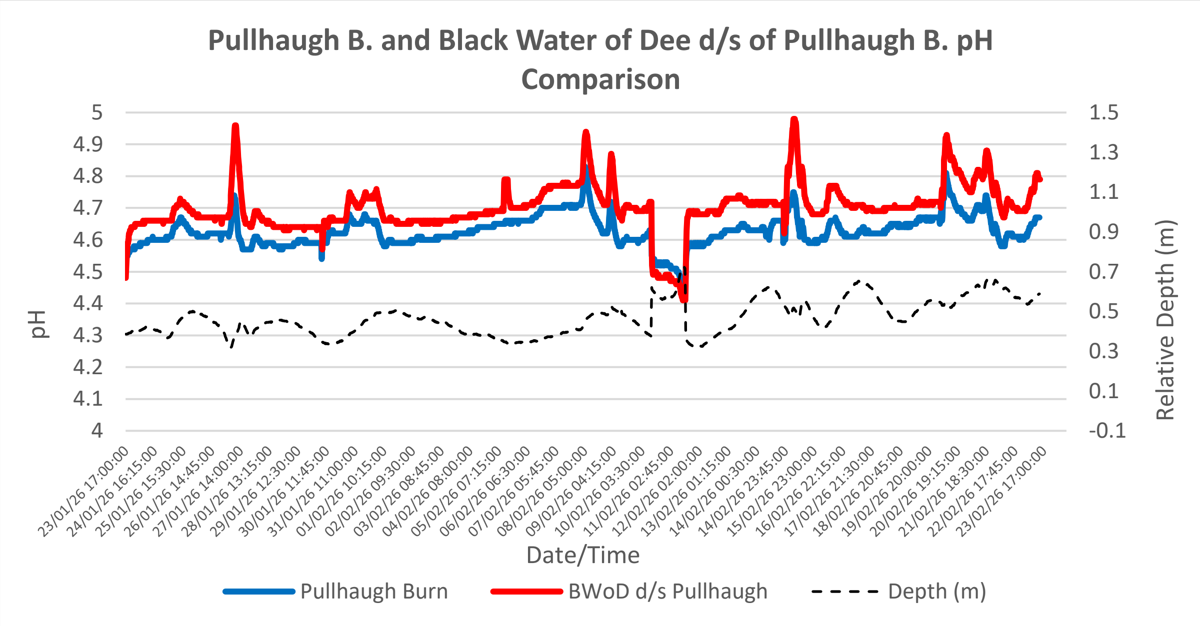
The results for Relative Depth (flow), pH, fDOM and Dissolved Oxygen from the continual monitoring sites on the lower half of the Black Water of Dee (downstream of Clatteringshaws dam) for the late January to late February deployments are shown below in Graphs 36 to 40, while the results for the upper half of the Black Water of Dee (upstream of Clatteringshaws Dam) for the late February to late March recording period are shown in Graphs 41 to 43. The salmonid pH impact summaries are shown in Tables 8 and 9. During recording rainfall (and therefore river levels) were around average for the time of year. The extent of the rainfall is shown in Graph 44 which is taken from the rainfall summary for Lower Black Laggan from SEPA website. The Lower Black Laggan rainfall gauge is located on the banks of the Black Laggan Burn, which flows into the White Laggan Burn, which is a tributary of Loch Dee in the Black Water of Dee headwaters. This is one of three SEPA rainfall gauges within the Dee catchment and was chosen due to its relatively central location within the river catchment.



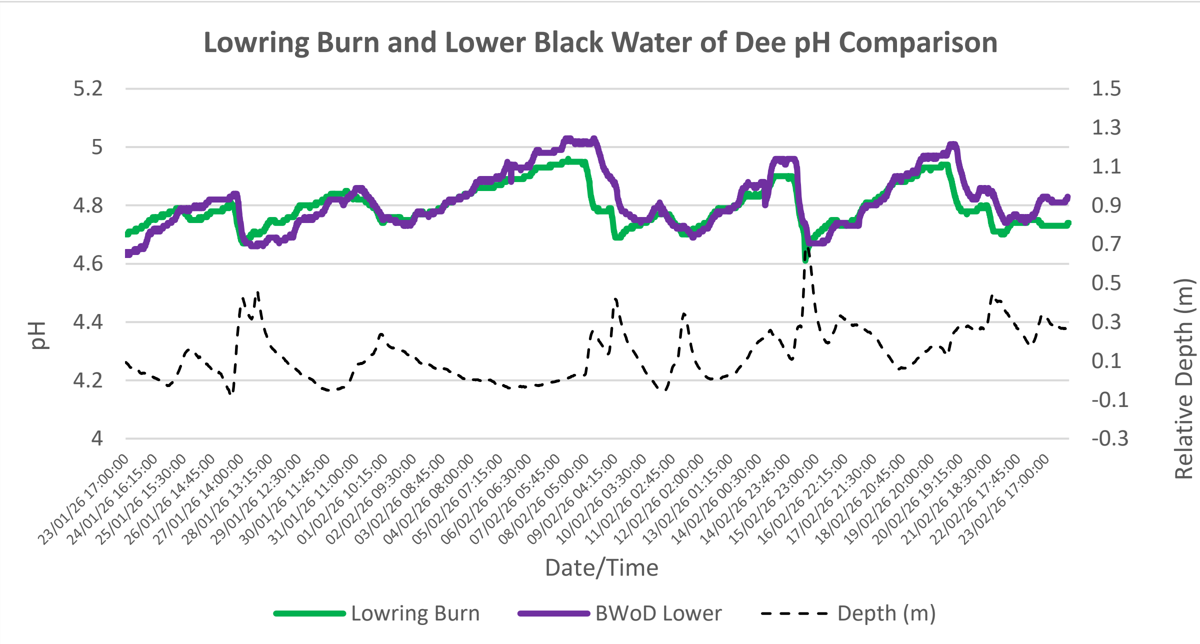
Graph 36: Relative Depth (Flow) Comparison Between the Lower Black Water of Dee Monitoring Sites during the Late January to Late February Deployment

Graph 36 shows a difference in flow regimes between the two uppermost sites (Pullhaugh and Black Water of Dee downstream of the Pullhaugh confluence) and the lower two sites (Lowring Burn and lower Black Water of Dee). During the monitoring period no water was released from Clatteringshaws Dam (as confirmed by the operators of the Galloway Hydro-electric Scheme). As a result, the variations between flows in the graph are largely because of a dam in the middle reaches of the Pullhaugh Burn (which diverts water from the burn into Clatteringshaws Dam so it can be used for power generation). As there is only a relatively small volume of flow coming from Clatteringshaws Dam, and limited groundwater flow, the flows in the Black Water of Dee below the Pullhaugh inflow generally mirror the flows from the Pullhaugh Burn. There are two main impacts from the Pullhaugh Burn dam which dictates the flow in the lower Pullhaugh Burn and causes it to vary from the more natural flows recorded in the Lowring Burn and, to a similar degree, the lowest Black Water of Dee site. The first is high flows being reduced because of flood waters being stored and/or transferred to Clatteringshaws Dam. This can be seen clearly on the 28th/29th January, the 8th/9th February and on the 16th/17th February. During all three occasions significant rises in water depth are seen on the Lowring Burn and lower Black Water of Dee following rainfall. Only small rises occurred on the Pullhaugh Burn and the Black Water of Dee downstream of the Pullhaugh

Burn inflow. The opposite trend also happened between the 10th and 12th January when water was released from the Pullhaugh Dam resulting in a rise in depth in the Pullhaugh Burn and at both sites on the Black Water of Dee (albeit to a much lesser degree on the lower Black Water of Dee site). No rise in water was recorded on the Lowring Burn. Because of the difference in flow regimes two pH graphs have been included for the lower river sites, one showing the results from the Pullhaugh Burn and Black Water of Dee downstream of the Pullhaugh confluence, whilst the other shows the results from the Lowring Burn and the lowest Black Water of Dee site. All remaining graphs for these four sites show all the sites on one graph which includes the relative depth readings for both the Pullhaugh Burn (regulated flow) and the Lowring Burn (un-regulated flow).



Graph 37: pH comparison between the Pullhaugh Burn and Black Water of Dee downstream of the Pullhaugh Burn confluence Monitoring Sites during the Late January to Late February Deployment



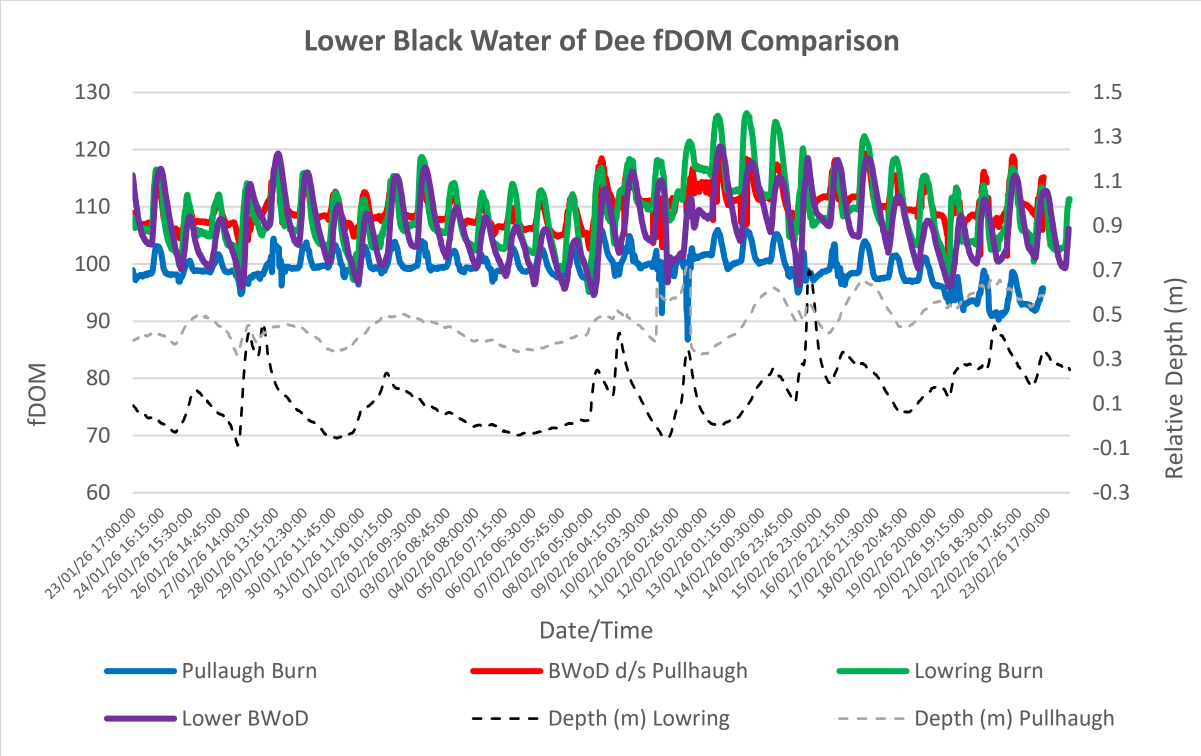
Graph 38: pH comparison between the Lowring Burn and Lower Black Water of Dee Monitoring Sites during the Late January to Late February Deployment

Table 8: Salmonid pH impact (below pH5) summary table

Site	DE01 Pullhaugh Burn	DE02 Black Water of Dee (d/s Pullhaugh B. Confluence)	DE03 Lowring Burn	DE04 Black Water of Dee (Lower)
Percent. of time below pH 5.00	100%	100%	100%	96%
Percent. of time below pH 4.75	99%	81%	26%	24%
Percent. of time below pH 4.50	1%	3%	0%	0%
Average pH	4.63	4.70	4.80	4.82

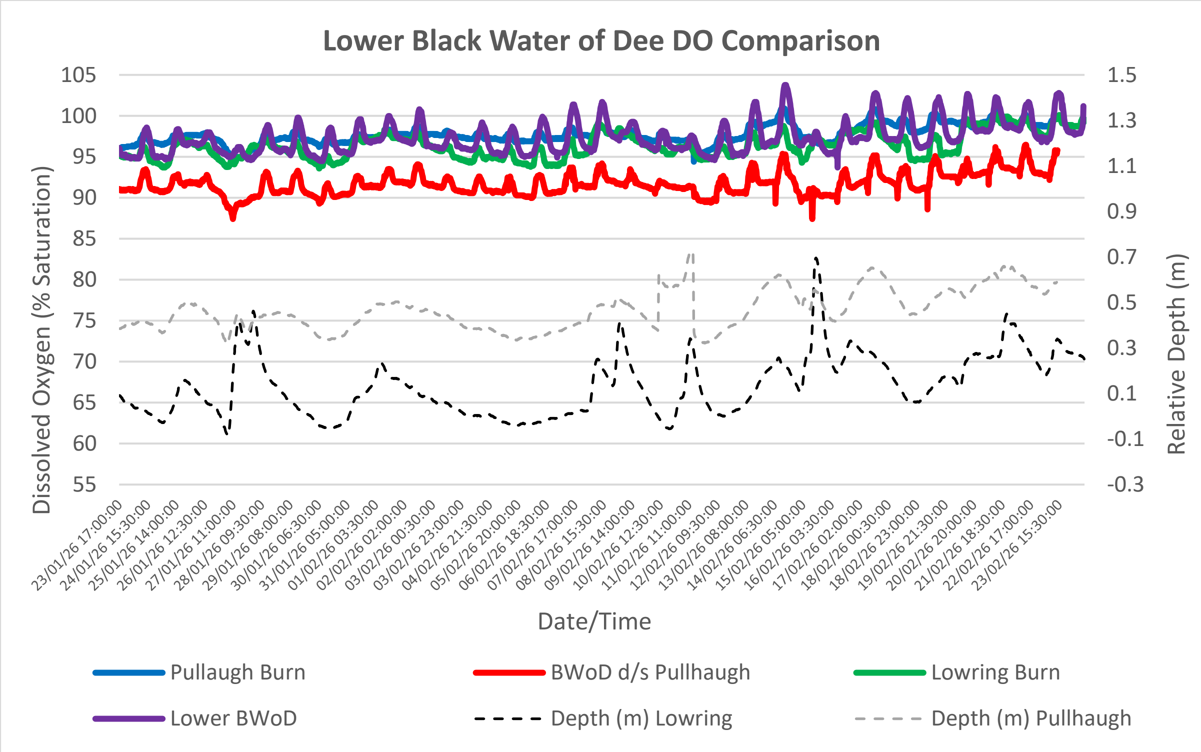
The pH levels recorded showed all four sites to acidified, with pH levels rarely, or never, getting above pH5. Overall, the pH variation within each site is relatively small, mostly varying between 4.6 and 4.9, but low pH levels were clearly persistent during the recording period. The graphs show a clear relationship between pH and depth (flow). The rainfall data for the monitoring period indicated that rainfall was around average for the time of year but was characterised by light to moderate rainfall on most days, with few periods of very heavy rainfall and no prolonged dry spells. Whilst this may explain some of the persistence of the low pH levels recorded, we would still expect to see greater recovery if the watercourses were only mildly acidified (as shown in previous years PA funded water quality monitoring reports). The lack of any particularly high rainfall periods during the monitoring also explains why some of the spot sampling results (shown later) from out-with this monitoring period gave lower/more acidic pH readings (as they sampled during bigger floods). The spot sample results show that due to the lack of particularly heavy rainfall the lowest pH levels likely to be experienced were not picked up during the late January to late February recording period.

Looking at the individual results the lowest Black Water of Dee (DE04) and Lowring Burn (DE03) sites show the relationship to flow that would be expected, with low pH levels being relatively persistent during recording (e.g. it took a number of days without any meaningful rain for the pH level in the lower Black Water of Dee site to get above pH 5, a level it only reached once, and sustained for only around a day). There is clearly a close relationship between the Pullhaugh Burn (DE01) results and the Black Water of Dee downstream from the Pullhaugh Burn confluence (DE02). This is due to limited water being released from Clatteringshaws Dam (seepage only) and as such the Pullhaugh Burn makes up a large proportion of the flow at the Black Water of Dee site, although there does seem to be some dilution by less acidic water with what little water is coming downstream from below the dam. These two sites show differences in flow and some differences in the pH response when compared to the Lowring and Lower Black Water of Dee sites. We can clearly see flow suppression on several occasions (e.g. 27th/28th January and the 15th February) because of the Pullhaugh Burn dam diverting flow into Clatteringshaws Dam. We also see brief increases in pH (declines in acidity) associated with the flow suppression, before pH drops to the previous level, or lower. This is rarely, if ever, recorded within any of the other acidified watercourses monitored as part of the GRT PA funded water quality monitoring (which now spans five years of winter monitoring). In addition to the trends described above, water was released from the Pullhaugh Burn dam for roughly 34 hours between the 10th and 11th February. This caused a clear acidic spike during the release which dragged pH levels below pH 4.5. The water regulation resulting from the use of the dam has the potential to both supress and exaggerate acidification within the Pullhaugh Burn and within the Black Water of Dee (downstream of the Pullhaugh confluence) depending on how the dam is operated.



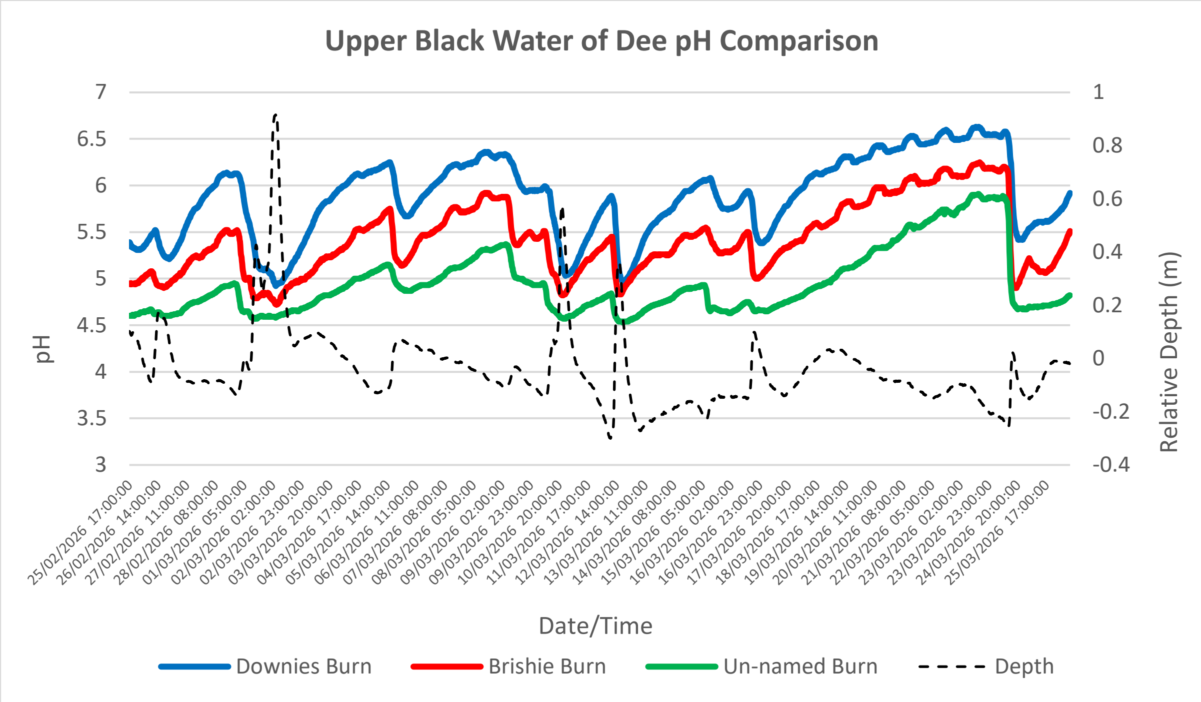
Graph 39: fDOM comparison between the four Lower Black Water of Dee Monitoring Sites during the Late January to Late February Deployment

The fDOM results from all four sites indicates relatively high concentration of dissolved organic matter. In each instance, given the nature of the surrounding land, the most likely source of the organic matter is peat, or peaty soils. Whilst three of the four sites show similar levels of fDOM, the Pullhaugh Burn has slightly lower levels (although still relatively high). This should probably be expected given the Pullhaugh Burn Dam which has the potential to both allow water to settle and remove a percentage of the flow. Given the potential of Clatteringshaws Dam to allow dissolved organic matter to separate from river water and settle on the bottom of the reservoir, it is a surprise to see the fDOM on the Black Water of Dee downstream of the Pullhaugh Burn be so high (and higher than the Pullhaugh Burn itself). This indicated a high input of organic matter over a relatively short distance. Except for the Pullhaugh Burn, the fDOM levels appear higher in the second half of the recording period when flows are generally higher. However, the difference is only minor and overall fDOM levels are generally relatively consistent.



Graph 40: Dissolved Oxygen comparison between the four Lower Black Water of Dee Monitoring Sites during the Late January to Late February Deployment

Clear day night variations can be seen within the Dissolved Oxygen readings from the four lower Black Water of Dee sites. Whilst oxygen saturation is relatively high at all the sites, it is below 100% at all sites. Given the nature of the Black Water of Dee and its inflowing burns (high gradient, high energy) we would expect 100% saturation rates, potentially indicating an impact from eroding peat getting into the watercourses and being broken down by aerobically by bacteria. The one possible exception is the Black Water of Dee downstream from the Pullhaugh Burn inflow. The dissolved oxygen levels are lowest (of the monitored watercourses) at this location and may be the result of reduced reoxygenation capacity because of the artificially low flows. The Dissolved Oxygen levels are higher in the slightly wetter second half of the recording period than they are in the first half, as would be expected from a greater movement of water in higher flows.

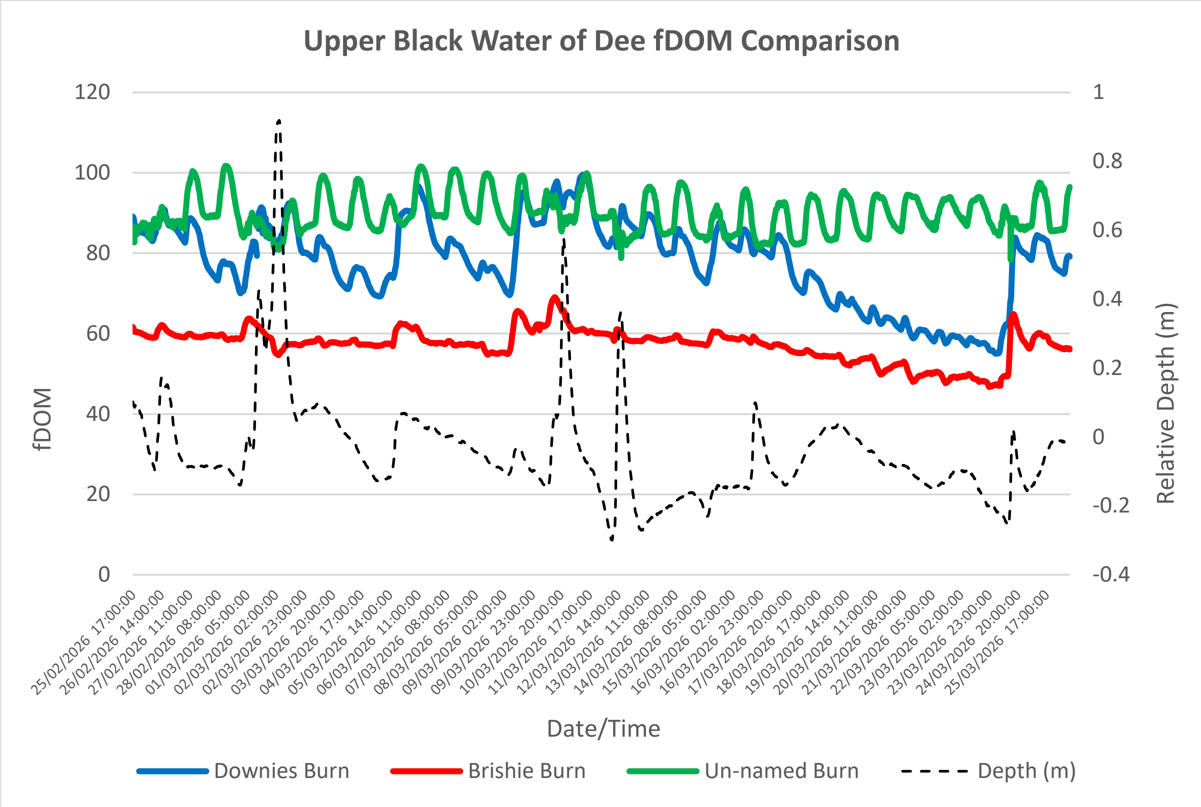


Graph 41: pH comparison between the three Upper Black Water of Dee Monitoring Sites during the Late February to Late March Deployment

Table 9: Salmonid pH impact (below pH5) summary table

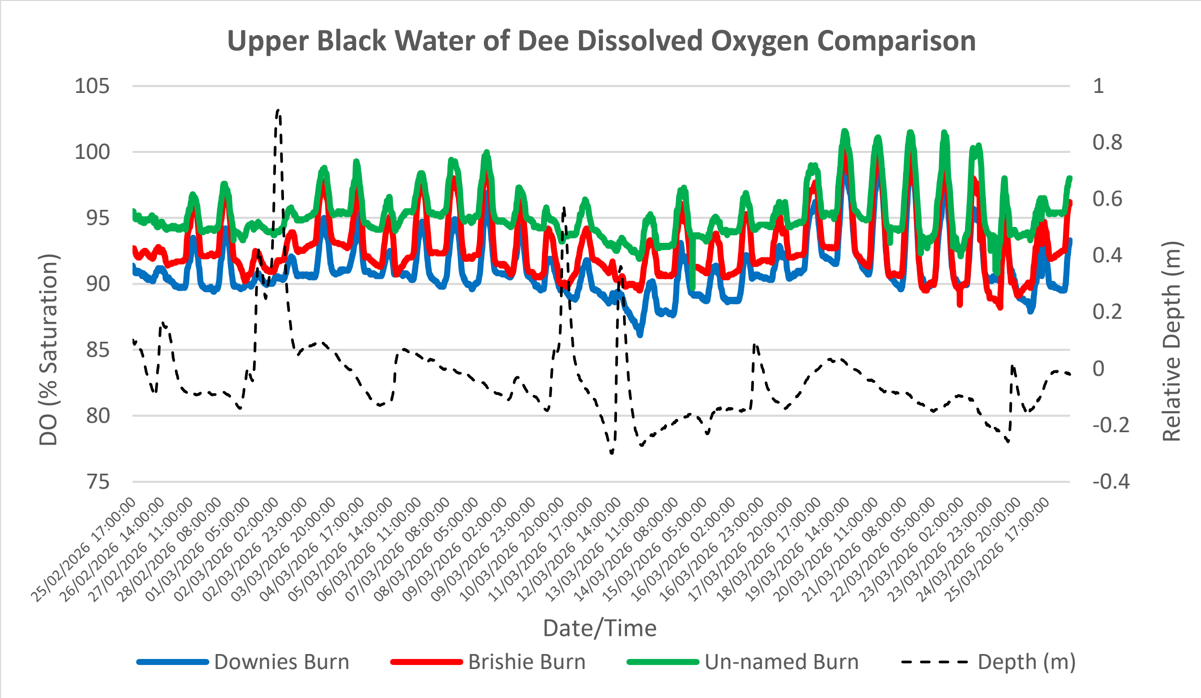
Site	DE05 Un-named Burn	DE06 Downies Burn	DE07 Brishie Burn
Percent. of time below pH 5	68%	2%	14%
Percent. of time below pH 4.75	38%	0%	0.5%
Percent. of time below pH 4.5	0%	0%	0%
Average pH	4.95	5.88	5.42

As with the Sonde water quality monitoring downstream of Clatteringshaws Dam, the rainfall during monitoring above Clatteringshaws was around average for the time of year. Again, the rainfall during the monitoring above the dam was characterised by light to moderate rainfall across most days, with few periods of very heavy rainfall and no prolonged dry spells. As a result of no large floods occurring during the monitoring above Clatteringshaws the results may underrepresent just how low pH levels get. Conversely, because of the frequency of rainfall over the recording period they may overrepresent how persistent low pH is within each of the monitored watercourses. The pH results/summary from Graph 41 and Table 9 show all three of the watercourses monitored to be less acidic than any of the sites monitored below Clatteringshaws Dam. During the period monitored, of the three sites only Site DE05 (Un-named Burn) spent a significant amount of time below pH 5. Of the three upper sites it appears to have the highest percentage of commercial forestry and the lowest percentage of restored or pristine peatland (none) within its catchment. However, given the different nature (e.g. size, slope, etc) of the three watercourses monitored it is difficult to establish a direct link between these variables. During the period monitored the pH levels from sites DE06 (Downies Burn) and DE07 (Brishie Burn) are unlikely to have any impact of salmonid populations. There may be some egg mortalities from Site DE05, but it is likely that salmonid populations could reproduce effectively based on the pH levels recorded.



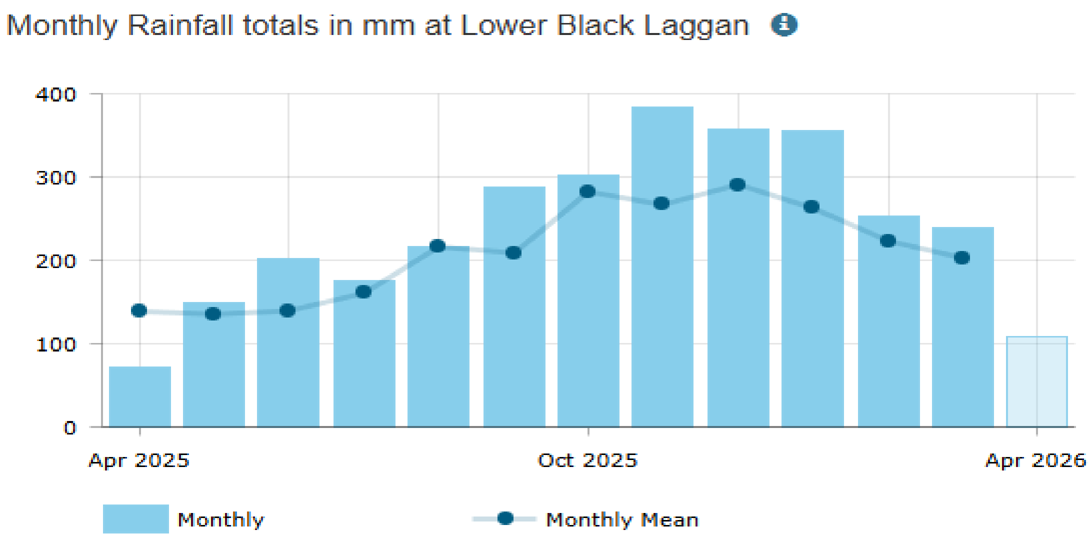
Graph 42: fDOM comparison between the three Upper Black Water of Dee Monitoring Sites during the Late February to Late March Deployment

The fDOM results (acting as a proxy for Dissolved Organic Carbon and peat erosion) for sites DE05, 06 and 07 make for interesting reading. The fDOM readings for all three are lower than any of the sites below Clatteringshaws Dam (DE01, 02, 03 and 04), although only just in the case of DE05. There would appear to be a correlation between fDOM, the restored peat at Tannylaggie Flow and commercial forestry cover. The results from Site DE07 (Brishie Burn) are of note. The burn flows directly through deep peat in the form of the Silver Flowe peatland restoration site, yet the fDOM results are relatively low when compared to any other site within deep peat that we have monitored during PA funded water quality monitoring. The source of the burn is the outflow from the Long Loch of the Dungeon. While we can not rule out a filtering effect from the Loch reducing fDOM concentrations at the source of the burn, we would expect the fDOM levels to rise relatively quickly if the burn was flowing through degraded/drained peat. The burn meanders through the middle of restored peat for approximately 1.5 km yet the fDOM levels are relatively low by the time it reaches the monitoring site (located approximately 100 m above the Brishie Burn confluence with the Downies Burn). Both sites DE05 and DE06 have large percentages of peat within their respective catchments. DE06 has a relatively small amount of restored, unforested peat within its catchment, while DE05 has none. Even the modest percentage of restored peat at site DE06 appears to be having a positive impact, with fDOM levels falling relatively quickly after rainfall/flood events. In contrast, fDOM levels are highest, and relatively consistent, at DE05.



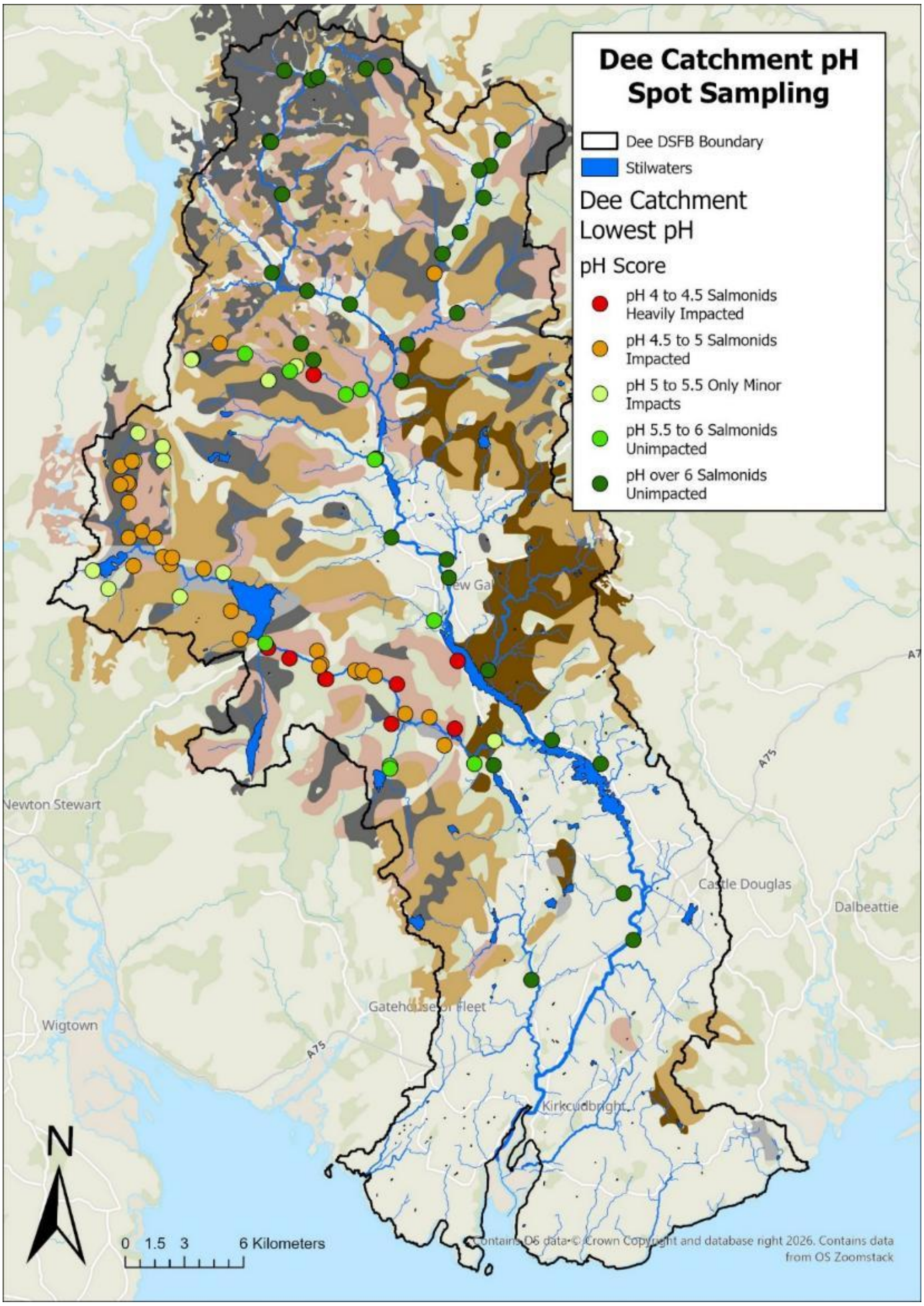
Graph 43: Dissolved Oxygen comparison between the three Upper Black Water of Dee Monitoring Sites during the Late February to Late March Deployment

The Dissolved Oxygen levels for all three sites are below 100% saturation, potentially indicating some deoxygenation from the bacterial breakdown of eroded peat. However, oxygen levels are only slightly reduced at each watercourse and appear at acceptable levels for salmonids. When comparing oxygen saturation levels the slope/gradient of each watercourse must be considered, given the greater potential for reoxygenation within higher gradient watercourses. The contour lines from OS Maps indicate that DE05 (Un-named Burn) is high gradient with significant re-oxygenation capacity (and therefore has significant buffering against de-oxygenation). In contrast DE07 (Brishie Burn) is very low gradient, with limited re-oxygenation capacity (and therefore relatively low buffering against de-oxygenation). The gradient for DE06 (Downies Burn) lies somewhere between DE05 and DE07.

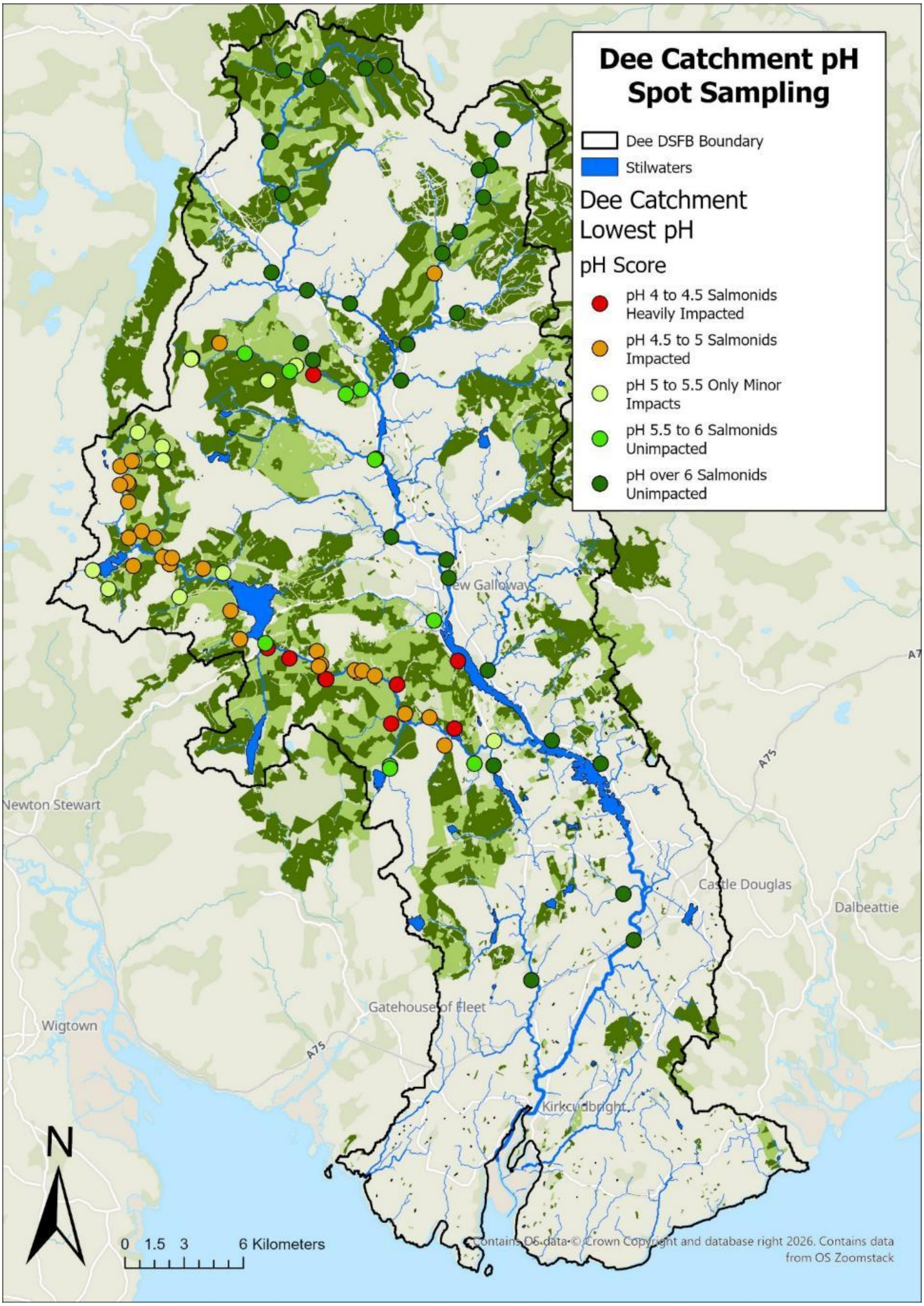


Graph 44: Average monthly rainfall totals for Black Laggan above Loch Dee showing the totals for January, February and March 2026 against the site averages (taken from the SEPA website)

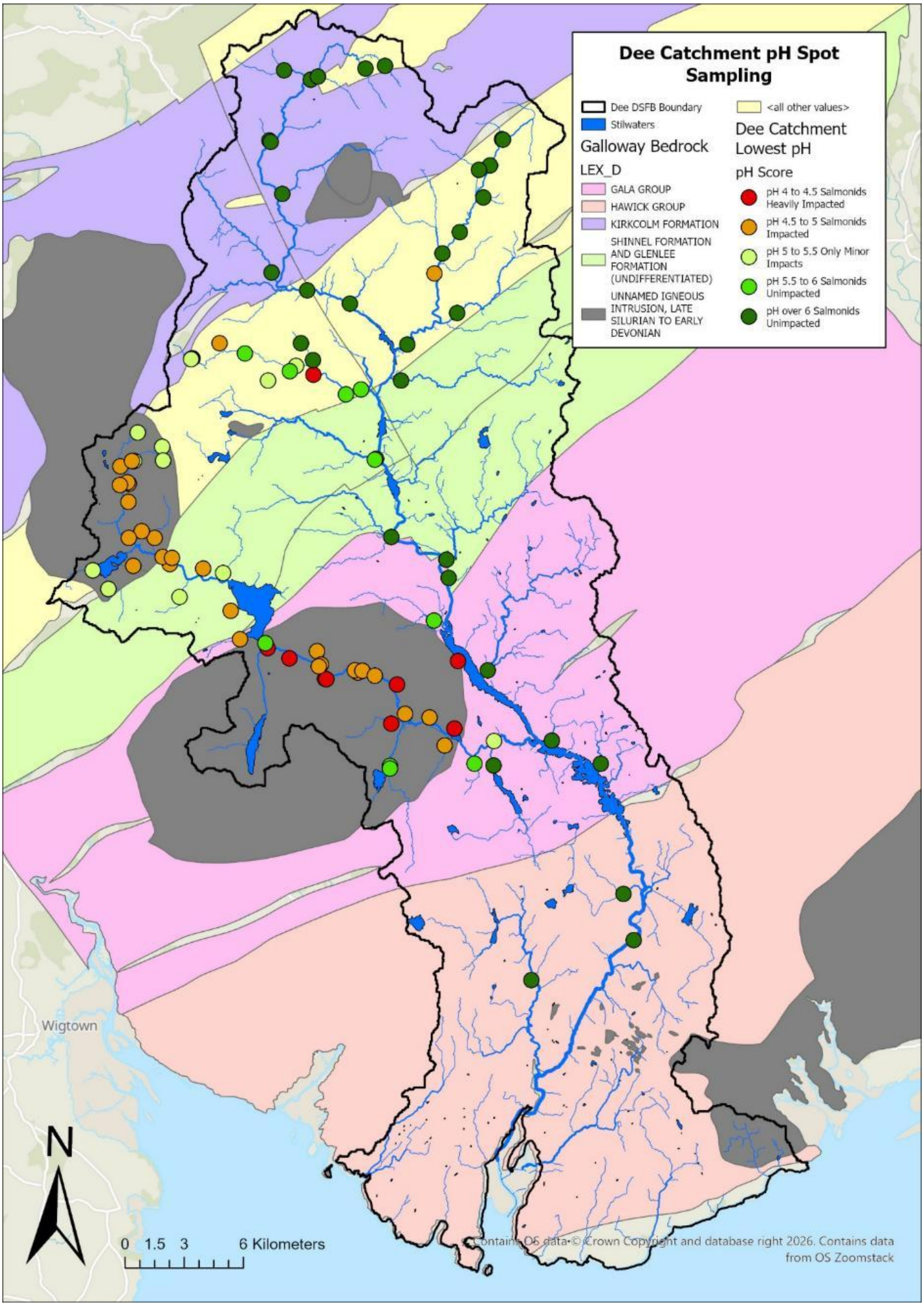
In addition to the Sonde data spot samples were taken at high and low winter flows to show spatial variation in pH across the Dee catchment. The highest pH and average pH (to give an indication of low pH persistence) results are shown in Maps 19 to 26. Spot sampling results from each individual sampling day are shown in Appendix 2. Within the maps the results are displayed using a rudimentary "traffic light" scoring system based on salmonid pH tolerance. Salmonid pH tolerance generally provides a good indication of acidification pressures on the aquatic environment and helps to visualise how native fish populations are impacted across the whole catchment.



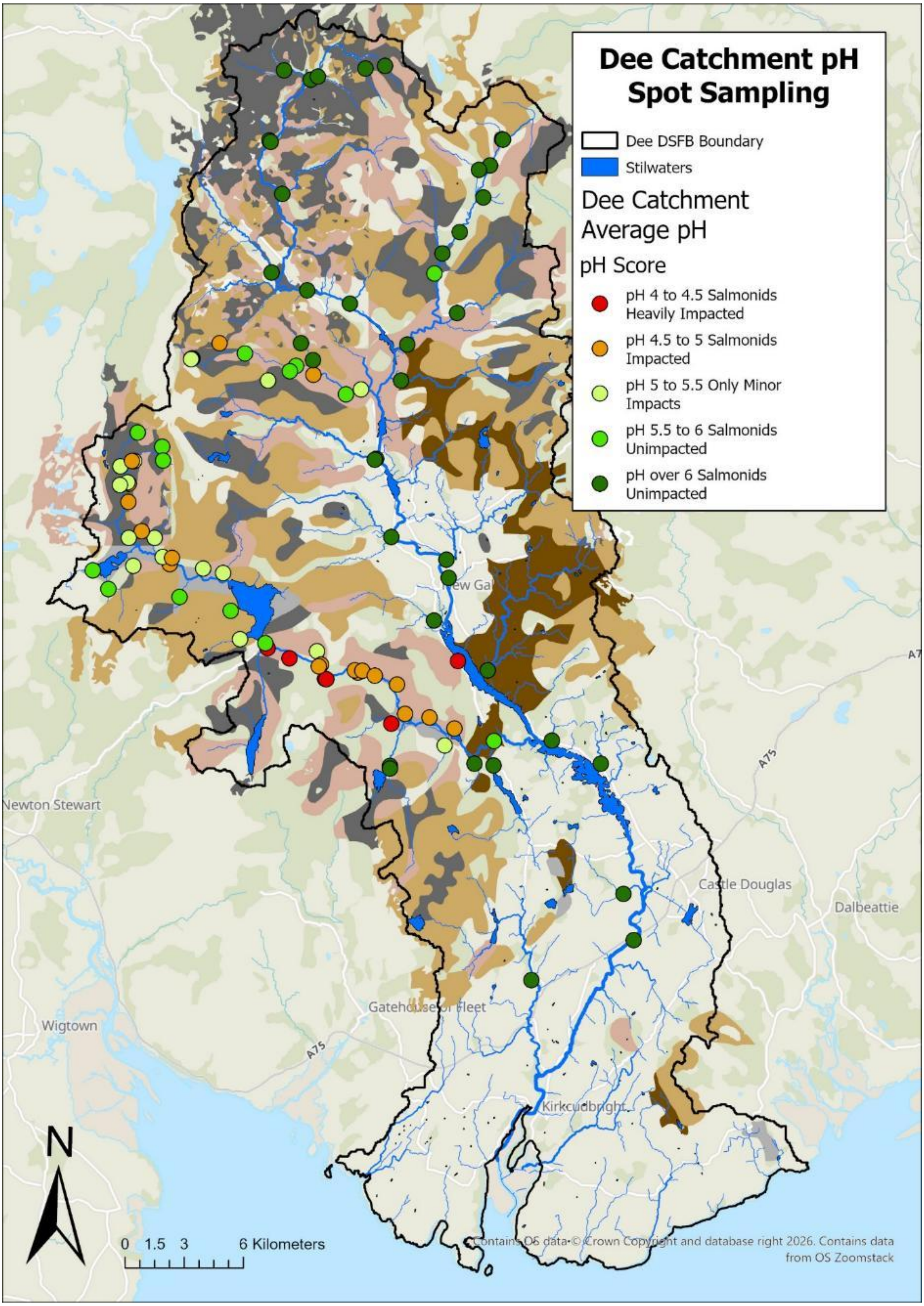
Map 19: Lowest pH recorded from each sampling site during all spot sampling events against peat type



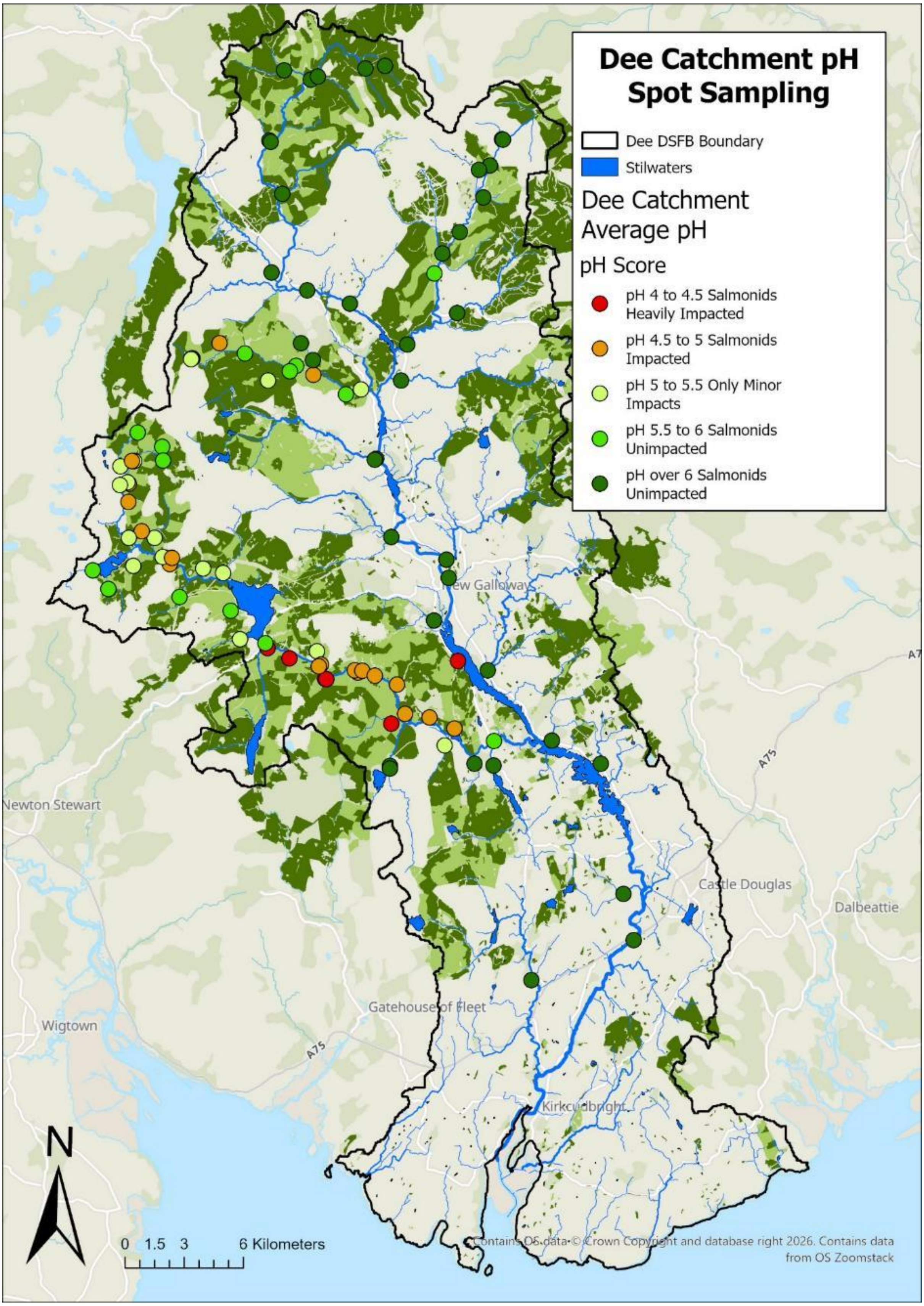
Map 20: Lowest pH recorded from each sampling site during all spot sampling events against commercial forestry cover



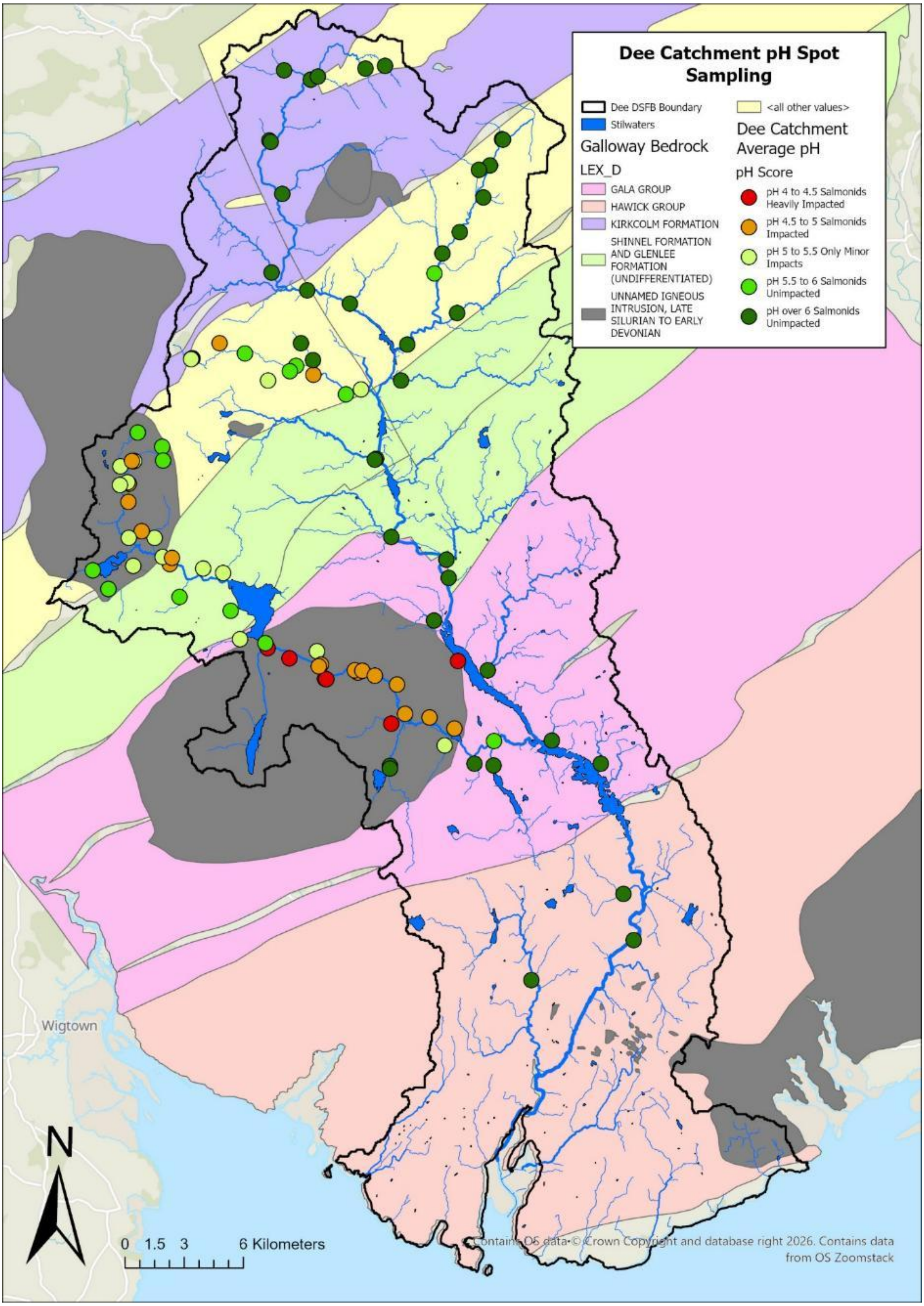
Map 21: Lowest pH recorded from each sampling site during all spot sampling events against bedrock



Map 22: Average pH recorded from each sampling site during all spot sampling events against peat type

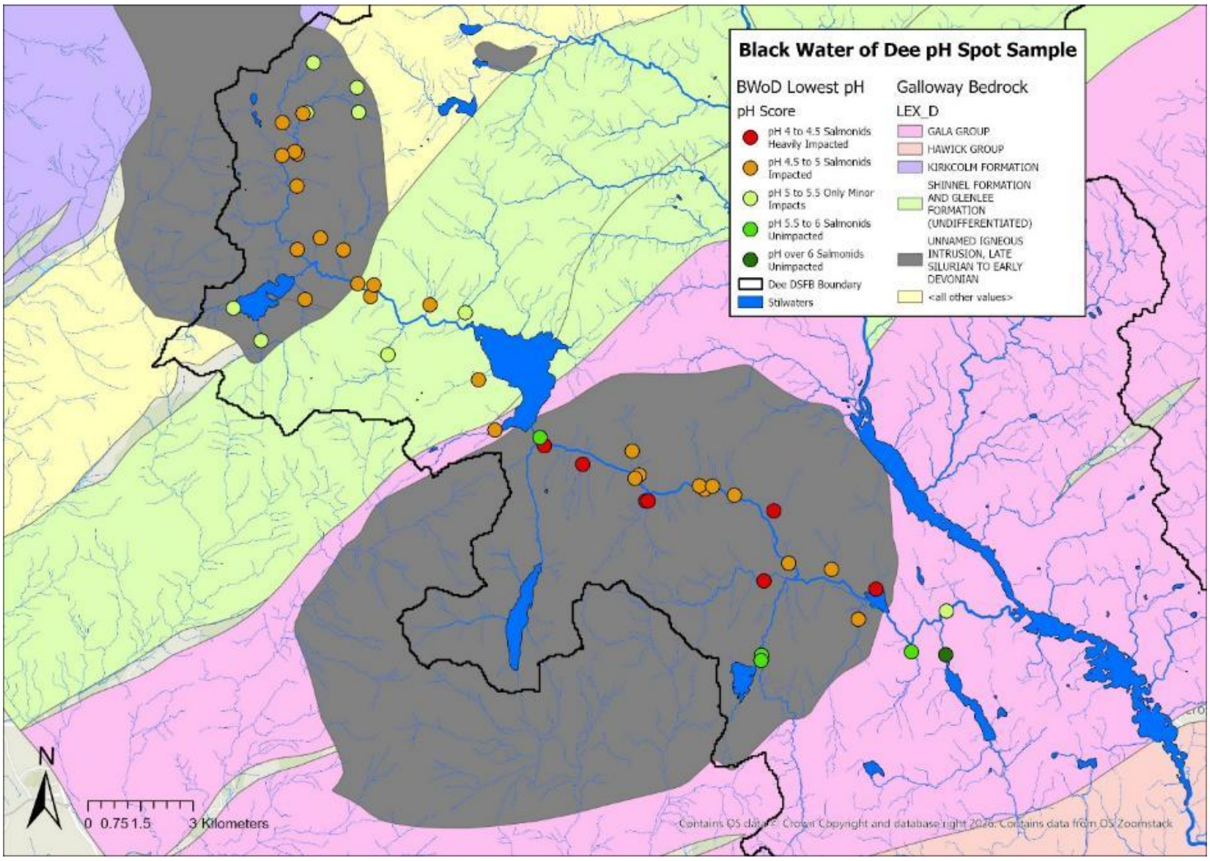


Map 23: Average pH recorded from each sampling site during all spot sampling events against commercial forestry cover

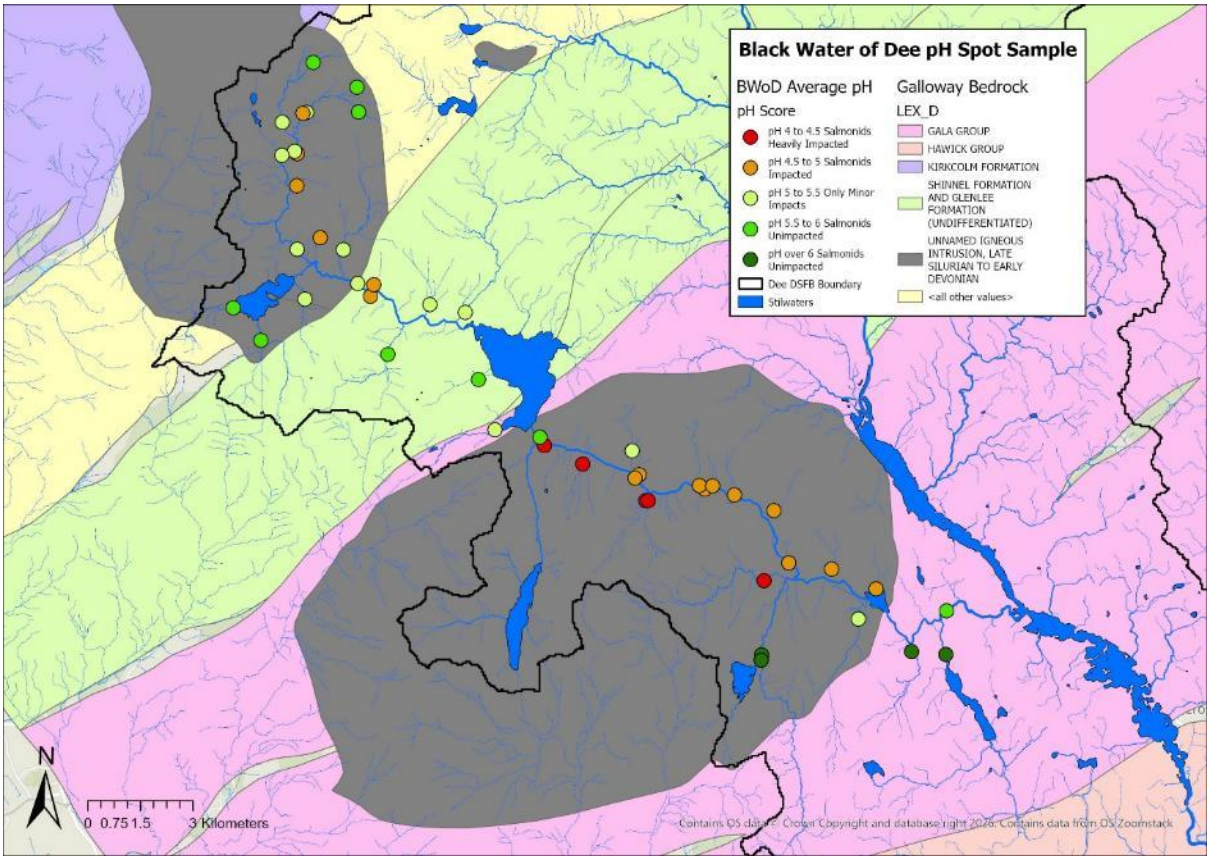


Map 24: Average pH recorded from each sampling site during all spot sampling events against bedrock

The spot sampling results from the Dee show that, except for the Black Water of Dee, pH water quality appears quite good. While there are a small number of localised issues (three were recorded) out with the Black Water of Dee they appear to be the exception and not the rule and are found in areas that otherwise appear to have no water quality issues. The pH levels recorded would also suggest that these localised issues are at a level that is unlikely to be causing significant damage to fish populations. This would suggest geology, soil and land use issues specific to these locations are causing the low pH levels recorded. The spot sampling results (both the lowest pH and the average) from the Black Water of Dee show significant levels of acidification throughout the watercourse and acid persistence within many watercourses. The bedrock map clearly shows a connection between the low pH levels recorded and the un-named igneous intrusion bedrock (granite). To show this in more detail the lowest and average pH maps are shown again below, but just for the Black Water of Dee. Stream order 1 watercourses have also been included within the maps.



Map 25: Lowest pH recorded from each sampling site for the Black Water of Dee during all spot sampling events against bedrock



Map 26: Average pH recorded from each sampling site for the Black Water of Dee during all spot sampling events against bedrock

Areas with underlying granite bedrock are known to be susceptible to chronic acidification. As a result, human changes in land use have the potential to alter the balance between healthy and acidified aquatic ecosystems at a much lower level than in areas where bedrock has a higher acid neutralising capacity. The impact of the underlying bedrock can most clearly be seen when comparing the rest of the Dee catchment to the Black Water of Dee, with sites either partly, or entirely, draining other bedrock types showing notably less acidic pH levels, regardless of land use and peat presence/absence/type.

Due to the susceptibility to acidification (low acid neutralising capacity) and the bedrock uniformity watercourses flowing entirely over the areas of granite on the Black Water of Dee provide an opportunity to compare several different environmental variables and assess the impact on pH. In addition to the water quality parameters recorded during sampling it was possible to collect additional data from the River Invertebrate Classification Tool (RICT). RICT is a web-based application used in the UK to assess river quality by predicting macroinvertebrate communities in near-natural conditions. To make predictions RICT uses environmental data which is calculated for individual sites using a web application hosted by DEFRA:

(https://environment.data.gov.uk/explore/8d1422b3-c960-4ed9-a324-40eefb0c016e?download=true).

It was possible to use this app to collect additional data for the Black Water of Dee spot sample sites. Additional data available included:

- Distance from Source – the distance between the selected location and the source that is furthest upstream

- Slope – the height difference between the closest upstream and downstream contours divided by the horizontal distance between the two contours measured along the river
- Log Area – the decimal logarithm of the upstream catchment area
- Logaltbar – the decimal logarithm of the upstream catchment mean altitude

As well as the variables listed above a figure representing peat is calculated by the application. The figure calculated is the percentage peat upstream of a sample point based on British Geological Survey 1:625K Superficial Geology Version 5. On reviewing the Geological Survey 1:625K Superficial Geology layer only dystrophic blanket and basin peat is used in the calculations, with other peat and peaty soil types being excluded. When compared to both the Soil Survey of Scotland maps used in this report and observations on the ground, the Geological Survey maps appear to underestimate the amount of peat present with predictions of no peat made at several spot sampling sites where peat clearly was present. As such the peat predictions were considered too simplistic for consideration within the analysis. It was hoped that ArcGIS Pro could also be used to calculate peat percentages, peat type, peat condition and forestry cover. However, open-source digital surface models proved too inaccurate to allow for the calculation of upstream catchment area for many of the smaller watercourses sampled, greatly limiting the useable data. This is something it may be possible to address going forward.

Shown below (Tables 10 to 12) are Excel correlation tables for pH and the independent variables for the high flow, low flow and average flow results.

Table 10: High flow sampling % correlation sampling for sampling variables

	pH	*fDOM*	*Conductivity*	*DFS*	*Slope*	*Log Area*	*Logaltbar*
pH							
fDOM	-59.31%						
Conductivity	-74.21%	85.08%					
DFS	-12.45%	-15.98%	1.84%				
Slope	43.31%	-12.08%	-17.57%	-54.58%			
Log Area	-21.27%	-2.75%	10.57%	89.02%	-72.05%		
Logaltbar	64.79%	-85.14%	-82.98%	10.54%	26.55%	2.99%	

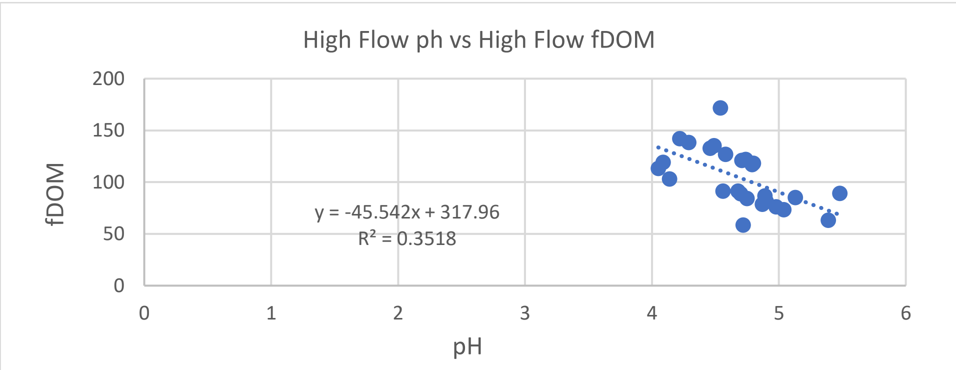
Table 11: Low flow sampling % correlation sampling for sampling variables

	pH	*fDOM*	*Conductivity*	*DFS*	*Slope*	*Log Area*	*Logaltbar*
pH							
fDOM	-75.19%						
Conductivity	-42.55%	54.20%					
DFS	5.17%	-15.26%	-11.07%				
Slope	38.01%	-12.74%	-1.44%	-54.58%			
Log Area	-1.26%	-7.93%	-3.99%	89.02%	-72.05%		
Logaltbar	74.20%	-82.40%	-70.79%	10.54%	26.55%	2.99%	

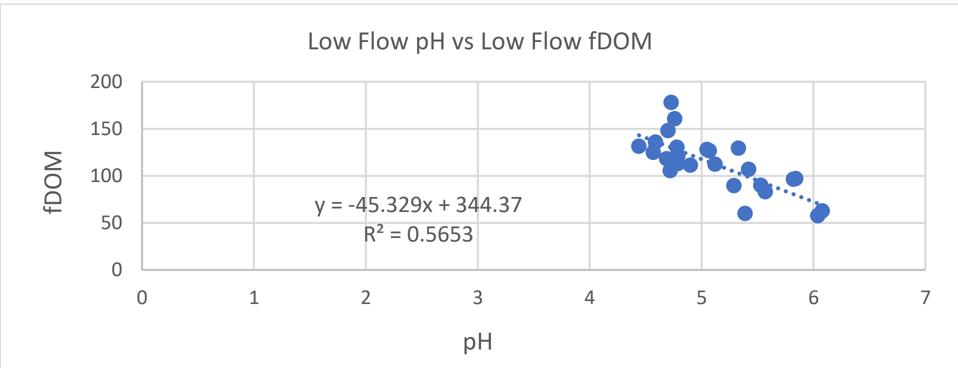
Table 12: Average flow sampling % correlation sampling for sampling variables

	pH	fDOM	Conductivity	DFS	Slope	Log Area	Logaltbar
pH							
fDOM	-70.71%						
Conductivity	-62.77%	77.86%					
DFS	-2.46%	-16.15%	-3.84%				
Slope	41.29%	-12.84%	-10.62%	-54.58%			
Log Area	-10.09%	-5.57%	4.28%	89.02%	-72.05%		
Logaltbar	72.02%	-86.61%	-80.67%	10.54%	26.55%	2.99%	

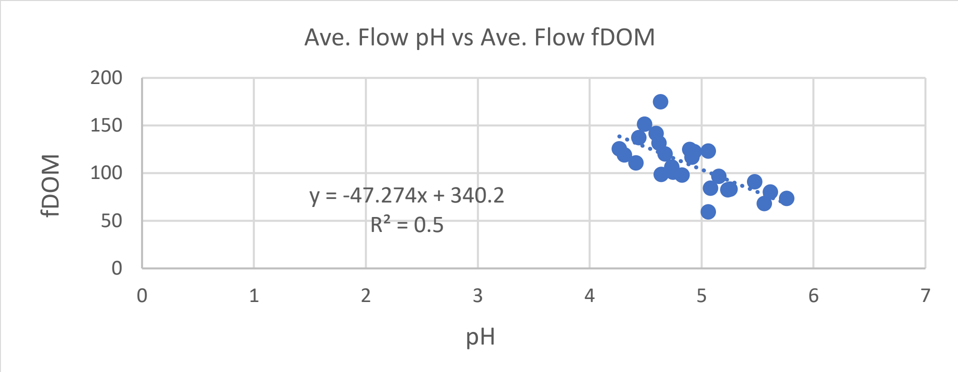
As can be seen from the tables there is a strong correlation between pH, dissolved organic matter, conductivity and the upstream catchment mean altitude. The relationship persists at all winter flow levels but is slightly more pronounced during some flow conditions. Conductivity and dissolved organic matter are clearly related, with both intended to give an indication of dissolved organic carbon levels. As such only dissolved organic matter is discussed going forward. The data shows that lower pH is related to higher levels of dissolved organic matter, with both being related to mean upstream catchment altitude. We also see a weaker relationship between pH and slope indicating that lower gradient water courses are more likely to have lower pH. This indicates that within the Black Water of Dee lower altitude, lower gradient watercourses are more likely to have higher fDOM levels and lower pH. There appears to little correlation between pH and both distance from source and upstream catchment area. Common sense would indicate that both these variables are related, and a correlation between the two is seen in the data. The relationship between pH, fDOM and Logaltbar (mean upstream catchment altitude) can be seen more clearly within linear regression plots, with Graphs 45 to 53 showing the data.



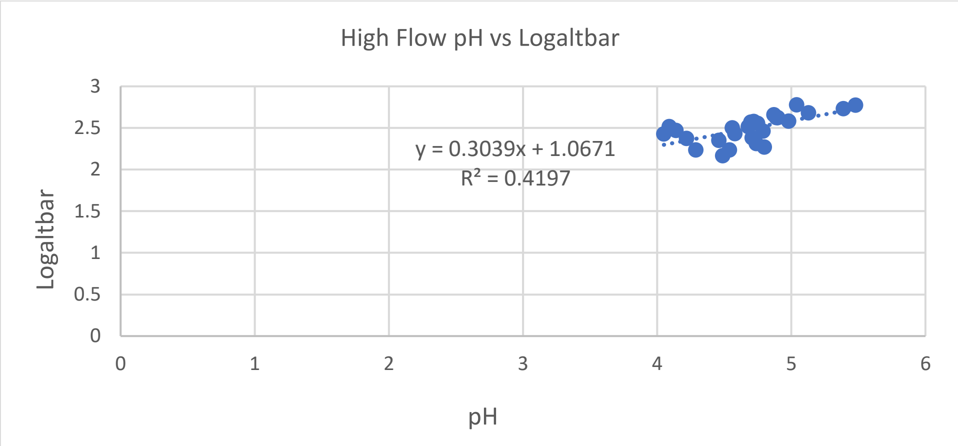
Graph 45: High flow level linear regression between fDOM and pH



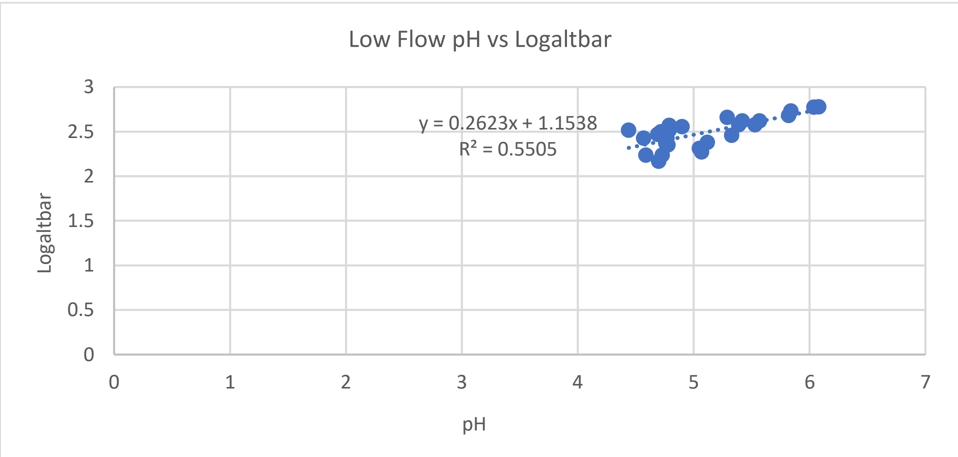
Graph 46: Low flow level linear regression between fDOM and pH



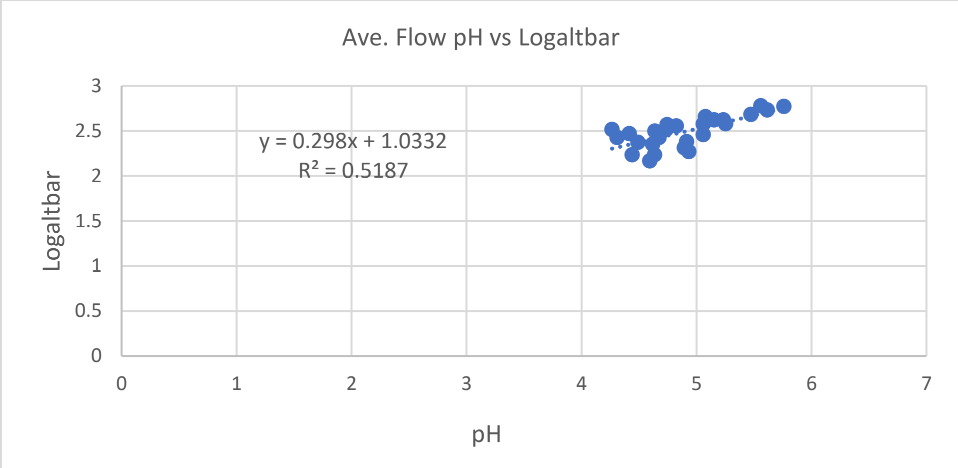
Graph 47: Average flow level linear regression between fDOM and pH



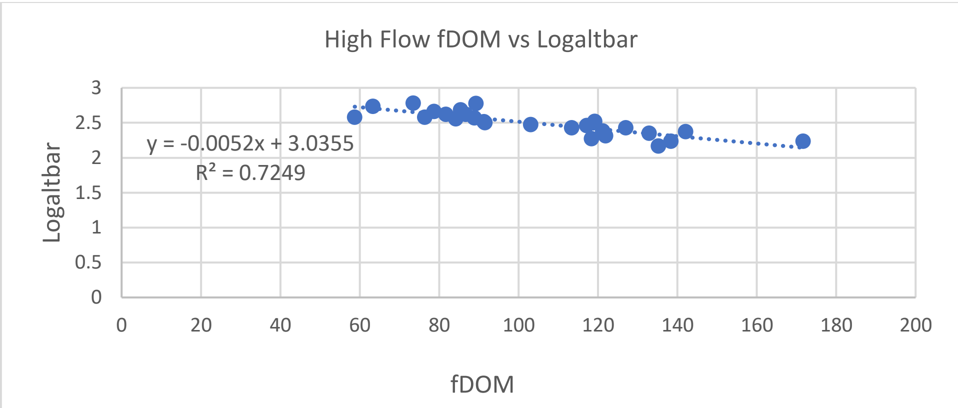
Graph 48: High flow level linear regression between pH and Logaltbar



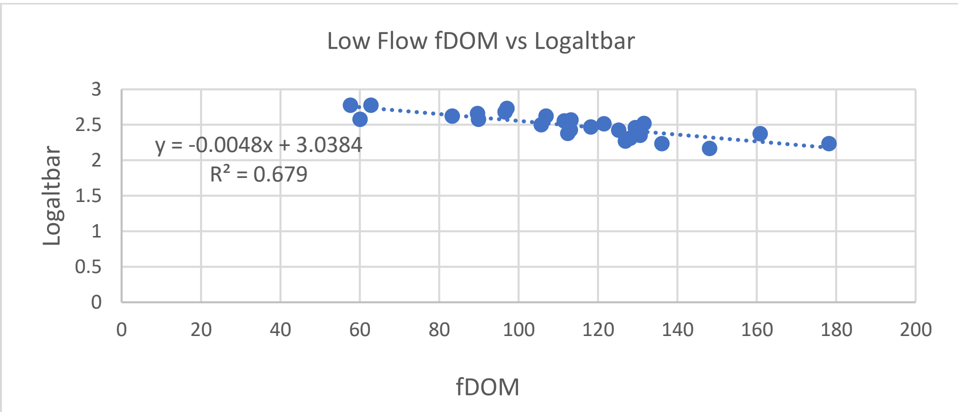
Graph 49: Low flow level linear regression between pH and Logaltbar



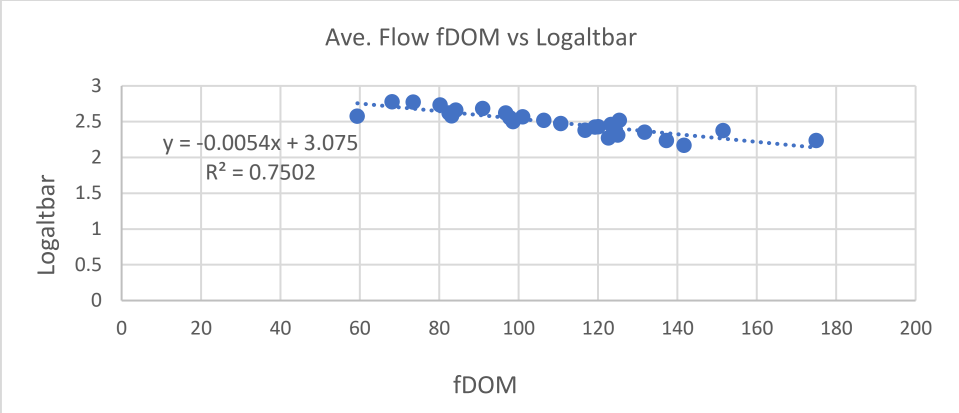
Graph 50: Average flow level linear regression between pH and Logaltbar



Graph 51: High flow level linear regression between fDOM and Logaltbar



Graph 52: Low flow level linear regression between fDOM and Logaltbar



Graph 53: Average flow level *linear regression between fDOM and Logaltbar*

Whilst the variables shown explain a significant amount of the variability within the pH data collected from areas of granite bedrock within the Black Water of Dee, some of the variability clearly remains unexplained. Some of this, at the very least, is likely explained by soil/peat types, peat condition and land use.

4 DISCUSSION

4.1 Tannylaggie peatland restoration water quality data collection

There has been no additional peatland restoration at Tannylaggie Flow since the winter 2023/2024 recording period. As such, it has still only been a modest percentage of the planned peatland restoration that has been restored to date (estimated at approximately 5%), and any potential difference between the previous and current water quality monitoring would be the impact of the current restored section "settling in" post restoration or from the disturbance caused by extensive conifer felling/harvesting during 2025. As a result, most of the conclusions from this section of the report are like, or are a repeat of, the findings from previous reports. As already stated, the only significant difference between the 2025/2026 monitoring, and the monitoring up to the point of last year's report (winter 2024/2025) is the felling/removal of conifer trees from a significant percentage of Tannylaggie Flow and some additional "settling in" time for the area already restored. Because of the felling, much of Tannylaggie Flow is now clear of commercial forestry and is ready for the next stage of restoration. This makes water quality monitoring important to continue in the area so future phases of restoration and recovery can be captured.

As with the 2024/2025 GRT PA monitoring the results from the Dargaol Burn water quality monitoring suggest that, to date, if the FLS peatland restoration at Tannylaggie is having any impact, it is not yet obvious enough to detect as monitoring has not been undertaken for long enough post restoration and only a small part of the restoration project has been completed to date. This is not unexpected given that there has been no additional restoration between the latest recording periods.

Importantly, the results do show that there is limited, if any, impacts from the disturbance caused by the recent felling. However, it is possible that some differences may be noted when the data is scrutinised in more detail at the end of the full restoration. To date, the small differences in pH levels recorded between years are most likely because of variations in rainfall/flow between years. It may be possible to further assess for water quality differences between years by taking flow levels or rainfall into account. Whilst all/any available flow/rainfall data will be sought out going forward any statistical analysis that can tease out subtle differences is beyond the means of the current project. As such, it would be necessary to bring in additional statistical expertise going forward to ensure the results can be sufficiently analysed to draw firm conclusions. However, this would be most beneficial when a significant amount of post-restoration data has been collected when it may be possible to use the data for a PhD or Masters project.

A recent study by Thompson et al., (2025) has highlighted potential inaccuracies within fDOM readings within upland peatland environments when there are high dissolved organic carbon saturation levels. The study showed that when comparing fDOM levels from water samples with laboratory measured dissolved organic carbon levels, fDOM readings became increasingly inaccurate at higher dissolved organic carbon levels. Additional unpublished work from the upper Black Water of Dee by Dr Michael Muir at Glasgow University has shown that fDOM readings are generally representative of dissolved organic carbon levels until about 120/15mg/L DOC. Above this level results become increasingly inaccurate. Given that the fDOM levels within all Dargoal Burn monitoring sites can sit around the 120 fDOM level this has to be explored further to give an indication of how this is potentially impacting results.

Low Dissolved Oxygen (DO) levels continue to be recorded within the Dargoal Burn. Current levels are likely to have a significant impact of aquatic life and when combined with the pH results paint a bleak picture. However, the results from the additional monitoring site just above the confluence of the Dargoal Burn and the Polbae Burn suggest that, during the season/conditions monitored, re-oxygenation is occurring in the faster flowing, lower reaches of the burn and, as such, the reduced oxygen levels are localised within the Tannylaggie Flow region of the burn.

During previous reports we highlighted the extent of conifer regeneration around the Dargoal Burn and the potential issues with the concentration of trees, particularly if they are allowed to mature. During winter 2025/2026 the conifer regeneration was removed by contractors hired by FLS.

One of the major issues slowing down restoration to date had been the time scale for clearing conifer crops that are currently still standing. During 2025 a large area of conifers was cleared and while FLS's exact timescale is unclear at present it is hoped that a large area of restoration can be completed relatively soon. Going forward it is possible that we may see an initial reduction in water quality following full tree harvesting and restoration, followed by a long-term improvement on the current conditions, although the monitoring to date has not shown this but, as discussed above, could be due to a relatively small area of restoration undertaken so far. A decrease in some aspects of water quality has been demonstrated by Shah and Nisbett (2019) who investigated deforestation for peatland restoration at three separate lowland raised bogs. However, it is important to understand the nature of the felling and intended restoration; the restoration at Tannlaggie will be following the most up to date best practice approach to forest to bog restoration. In any case, these issues highlight the need to continue monitoring long term and the significant benefit of having such a good series of baseline data from which comparisons pre and post restoration can be made.

Due to the amount of data being collected, on completion of the Tannylaggie peatland restoration GRT and PA should consider making the long term Tannylaggie water quality monitoring data available for a PhD or Masters project. This would allow the data to be explored fully using the data analysis expertise available within the academic sector.

4.2 River Dee electrofishing data review and water quality overview

The River Dee electrofishing data review was unable to draw any real conclusions regarding water quality within the Dee catchment. The isolated trout populations upstream of Kendoon Dam within the Deugh and Ken appeared relatively healthy and unlikely to be impacted by water quality. Downstream of Kendoon Dam there were a significant number of sites with "Low" or "Very Low" trout fry results but the impacts of the Galloway Hydro-electric Scheme and other anthropogenic factors, and not water quality, are most likely driving the low trout densities. There was potential for water quality impacts on trout populations within the Black Water of Dee, but due to the small number of survey sites/data available the results are inconclusive. Where longer term continual monitoring was available for the Dee catchment this only covered the Water of Deugh sub-catchment. Whilst the results potentially picked up a longer-term decline in trout fry numbers, the most likely cause is the construction of several wind farm and electricity infrastructure developments within the Deugh headwaters. Overall, the electrofishing data review was unable to provide any significant information related to water quality within the Dee system.

Unlike most of its neighbouring rivers to the West, much of the headwater and upland areas within the Dee catchment show pH levels well above pH5, indicating good water quality (based on salmonid tolerance). The Water of Deugh, Water of Ken, Loch Ken and lower river (River Dee) sections of the catchment all predominately show pH levels well above 5 in both high and low winter flow levels. Given that there are significant areas of both peatland and forestry (typically overlapping) within these areas this would indicate high acid neutralising capacity within the bedrock and soils, buffering from any anthropogenic acidic inputs coming from the land or air. For the areas mentioned there are a small number of exceptions to this general rule of good (pH) water quality. Most of these appear to be because of localised land use issues with forestry on deep peat appearing to be the common denominator. One of these is within the Polmaddy Burn catchment. The Polmaddy Burn flows into the lower reaches of the Water of Deugh. Most of the land around the burn is owned by FLS. GRT are currently working with FLS to improve freshwater and riparian environments on the Polmaddy Burn as part of their Flowing Forward project which aims to restore Galloway's rivers. It is likely that GRT will be able to discuss the potential for peatland restoration within the Polmaddy catchment with FLS.

Although most of the Dee catchment generally has good water quality (based on pH levels), the results clearly show one sub-catchment within the Dee system to be heavily acidified. Results from the Black Water of Dee showed pH levels below 5 throughout, with much of the lower catchment recording pH levels below 4.5. There were also a significant number of locations where the low pH levels persisted even at relatively low winter flow levels. The fDOM results also indicated relatively high levels of dissolved organic carbon within many of the watercourses. Much of the Black Water of Dee catchment lies on top of two large areas of granite bedrock. Granite is well established as having very little acid neutralising capacity due to its resistance to chemical weathering. This low acid buffering capacity makes watercourses flowing over granite very susceptible to acidification resulting from anthropogenic changes within catchments. This has clearly been the case within the Black Water of Dee. The pH results line up with the granite bedrock, with much of the catchment being heavily altered by human activity (primarily commercial forestry). The results also indicate a river system that, although naturally acidic, would historically have had widespread pH levels that were conducive to healthy salmonid populations, but in many locations pH levels have been pushed towards a level where salmonid populations are heavily impacted. Due to the uniformity of the bedrock and the acid susceptibility the sampled sub-catchments flowing over granite within the Black Water of Dee provided an opportunity to look at several variables and how they impact pH levels. From the variables that were available the Black Water of Dee granite site pH results tie in strongly with levels of fDOM (dissolved organic carbon) and upstream catchment mean altitude. There was also a lesser correlation with slope. While there are some questions regarding the accuracy of high fDOM levels the upper levels recorded within the Black Water of Dee mostly lie just below the level at which results become less accurate. The linear regression graphs for pH, fDOM and Logaltbar also indicate the fDOM results (Graphs 45 to 53) to be relatively accurate in this instance as the higher fDOM results appear to have no more variation from the trendline than the lower fDOM results. As a result of the relationship between pH, fDOM and upstream catchment mean altitude, the latter when combined with bedrock type would appear to be a strong indicator of susceptibility to acidification within watercourses. The lower Black Water of Dee catchment clearly has lower pH levels than the upper catchment, although both show degrees of acidification. As would be expected from the relationship this also indicates more dissolved organic carbon entering watercourses from the surrounding land. Whilst altitude clearly impacts dissolved organic carbon and pH levels it is also possible that the restored peatland at Silver Flowe on the upper Black Water of Dee is having a positive impact on water quality. The pH and fDOM levels from the Brishie Burn which flows through Silver Flowe support this conclusion, although the impact of two lochs within the course of the burn must be considered. Overall, there are very few watercourses flowing through, or coming from the restored peat at Silver Flowe despite its large area, so it could not feature within the analysis as much as we would have liked (although this retention of water is likely to be the very thing that makes peatland restoration so beneficial). An additional consideration is that there appears to be a higher percentage of commercial forestry, and therefore drainage, within the lower Black Water of Dee, although the exact figures would need to be calculated before this could be considered further. One additional consideration relating to acidification within the Black Water of Dee is the impact of the Galloway Hydro-electric Scheme. During sampling (both continual monitoring and spot sampling) there was no water being released from Clatteringshaws Dam, although there was a very small amount of leakage from the dam. As the pH levels from the upper Black Water of Dee are less acidic than the lower river the water from the upper catchment would have a diluting effect on the acidified water coming in from the burns in the lower catchment. The dilution effect is furthered by an area of sedimentary bedrock above Clatteringshaws which further lowers acidity. The artificial flow regulation at Clatteringshaws Dam would appear to prevent this dilution within the lower Black Water of Dee, reducing the buffering effect from the upper catchment. In addition, if water quality was to improve in the upper catchment (e.g. through peatland restoration), the benefits would not reach the lower half of the Black Water of Dee due to the flow regulation at Clatteringshaws Dam. However, managed releases from the dam could potentially help reduce pH levels during key times in salmonid egg development.

Due to the relationship between pH, fDOM and upstream catchment mean altitude the lower half of the Black Water of Dee catchment would be the obvious priority for peatland restoration aimed at reducing the input of dissolved organic carbon from the surrounding landscape and reducing acidity within watercourses. As there appears to be no peatland in good condition within the lower catchment, and potentially a higher percentage of commercial forestry, restoration would also make sense from this perspective as well. From the peat, forestry and bedrock maps shown earlier within the report the obvious priority locations for peatland restoration would be:

1. The area of dystrophic blanket peat adjacent to the North-west shore of Loch Grannoch - NX54096 71368, referred to as Blood Moss on OS maps
2. The area of dystrophic blanket peat which covers the lower Pullhaugh Burn and the headwaters of the Green Burn - NX54963 73540, referred to as Kaugh Moss on OS maps
3. The dystrophic blanket and basin peat covering much of the Glengainoch Burn catchment - NX61529 71160, referred to as Barney Water Flow on OS maps

The watercourses flowing from each of these peatlands have some of the lowest pH levels recorded and all are afforested (and presumably heavily drained). Restoring these peatlands should reduce the level of dissolved organic carbon entering the watercourses and raise pH levels closer to neutral. While restoration of the highlighted peatlands will help resolve some of the worst water quality issues, poor water quality is common across much of the lower Black Water of Dee catchment and any additional opportunities to restore peatlands should be seized if the opportunity arises. While the upper Black Water of Dee is less acidified than the lower river, the catchment would still appear to be experiencing some degree of reduced water quality. Any opportunity to extend the peatland restoration at Silver Flowe would help address any ongoing issues and add to the favourability of an important SSSI/RAMSAR site. At present the Silver Flowe peatland unit is afforested below the Cornarroch Burn (NX47113 81170) and above the Saugh Burn (NX47334 84555), with most of the peat to the East of Silver Flow (on the opposite side of the Black Water of Dee) also being afforested.

Due to the bedrock uniformity and low acid neutralising capacity the granite bedrock sections of the Black Water of Dee provide an excellent opportunity to carry out more detailed water quality investigations (beyond the reach of this report). The Black Water of Dee provides an opportunity for more detailed investigations into the impact of peatland type/condition and commercial forestry on water quality and aquatic ecosystems. A larger spot sampling network and laboratory dissolved organic carbon testing could be combined with more detailed mapping of peat and forestry cover to look in detail at the exact nature of the relationship between degraded peatlands, dissolved organic carbon and pH/water quality. PA has previously contacted Universities and has made the PA/GRT water quality data available for use in Master's/MRes projects. During 2025 a MRes student came forward under supervision from Edinburgh University. An application has currently been submitted for a detailed water quality study within Galloway River catchments, utilising the GRT/PA data. The application was submitted before this winter's water quality data collection. However, it may be possible to include the Black Water of Dee and the collected data within the MRes project.

4.3 Tannylaggie Flow and River (Kirkcudbrightshire) Dee catchment management recommendations

- There are no obvious improvements in water quality within the Dargoal Burn at such an early stage of the Tannylaggie Flow peatland restoration. This is not unexpected as only a small percentage of the sub-catchment has been restored. Long-term monitoring is required at Tannylaggie Flow/the Dargoal Burn if the full benefits are to be recorded. The monitoring undertaken to date provides a very important baseline to improve our understanding on the impacts of forest to bog restoration on water quality.

- Additional data analysis carried out by experienced statisticians would improve data interpretation once the full Tannylaggie peatland restoration has been completed. This would make any conclusions drawn from the results more robust and useful to further support long term peatland restoration and management in the catchment and provide nationally important information and understanding on how forest to bog restoration could aid restoring water quality and native fish populations. Collaboration with an academic organisation would provide this level of expertise and should be explored by NatureScot and GRT.

- The fDOM results from the Dargoal Burn should be further scrutinised given recent reporting of potentially inaccurate fDOM results from watercourses with very high dissolved organic carbon levels.

- Due to the relationship between pH, fDOM and upstream catchment mean altitude the lower half of the Black Water of Dee catchment would be the obvious priority for peatland restoration aimed at reducing the input of dissolved organic carbon from the surrounding landscape. From the peat, forestry and bedrock maps shown within this report the obvious priority locations for peatland restoration would be:

    1. The area of dystrophic blanket peat adjacent to the North-west shore of Loch Grannoch (NX54096 71368, referred to as Blood Moss on OS maps)

    2. The area of dystrophic blanket peat which covers the lower Pullhaugh Burn and the headwaters of the Green Burn (NX54963 73540, referred to as Kaugh Moss on OS maps)

    3. The dystrophic blanket and basin peat covering much of the Glengainoch Burn catchment (NX61529 71160, referred to as Barney Water Flow on OS maps)

- While restoration of the highlighted peatlands will help resolve some of the worst water quality issues, the poor water quality is common across the lower Black Water of Dee catchment and any additional opportunities to restore peatlands should be seized if the opportunity arises.

- Any opportunity to extend the peatland restoration at Silver Flowe would help address any ongoing issues in the upper catchment. At present the peatland is afforested below the Cornarroch Burn and above the Saugh Burn, with most of the peat to the East of Silver Flowe (on the opposite side of the Black Water of Dee) also being afforested.

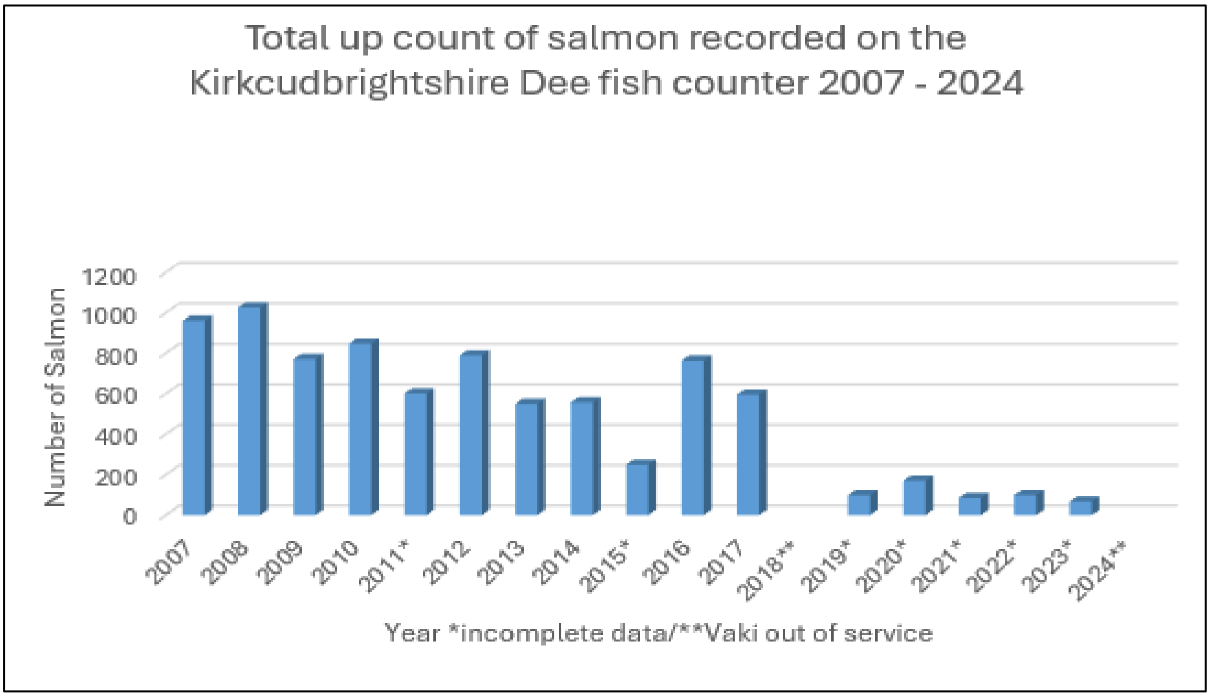
- Any water quality benefits from the peatland restoration at Silver Flowe are not reaching the lower Black Water of Dee due to the water management at

Clatteringshaws Dam. Managed releases of water from the dam could potentially help reduce pH levels in the lower river during key times in salmonid egg development.

- The Black Water of Dee provides an opportunity for more detailed investigations into the impact of peatland type and condition and commercial forestry on water quality and aquatic ecosystems. A larger spot sampling network and laboratory dissolved organic carbon testing could be combined with more detailed mapping of peat and forestry cover to look in detail at the exact nature of the relationship between degraded peatlands, dissolved organic carbon and pH/water quality. PA has previously contacted Universities and has made the PA/GRT water quality data available for use in Master's/MRes projects. During 2025 a MRes student came forward under supervision from Edinburgh University. An application has currently been submitted for a detailed water quality study within Galloway River catchments, utilising the GRT/PA data. The application was submitted before this winter's water quality data collection. However, it may be possible to include the Black Water of Dee and the collected data within the MRes project. If this cannot be tied in with the MRes study then opportunities should be sought out to continue this study and investigate the relationship between peat, land use and water quality in more detail, either through academic, third sector or joint/partnership working.

5 APPENDIX

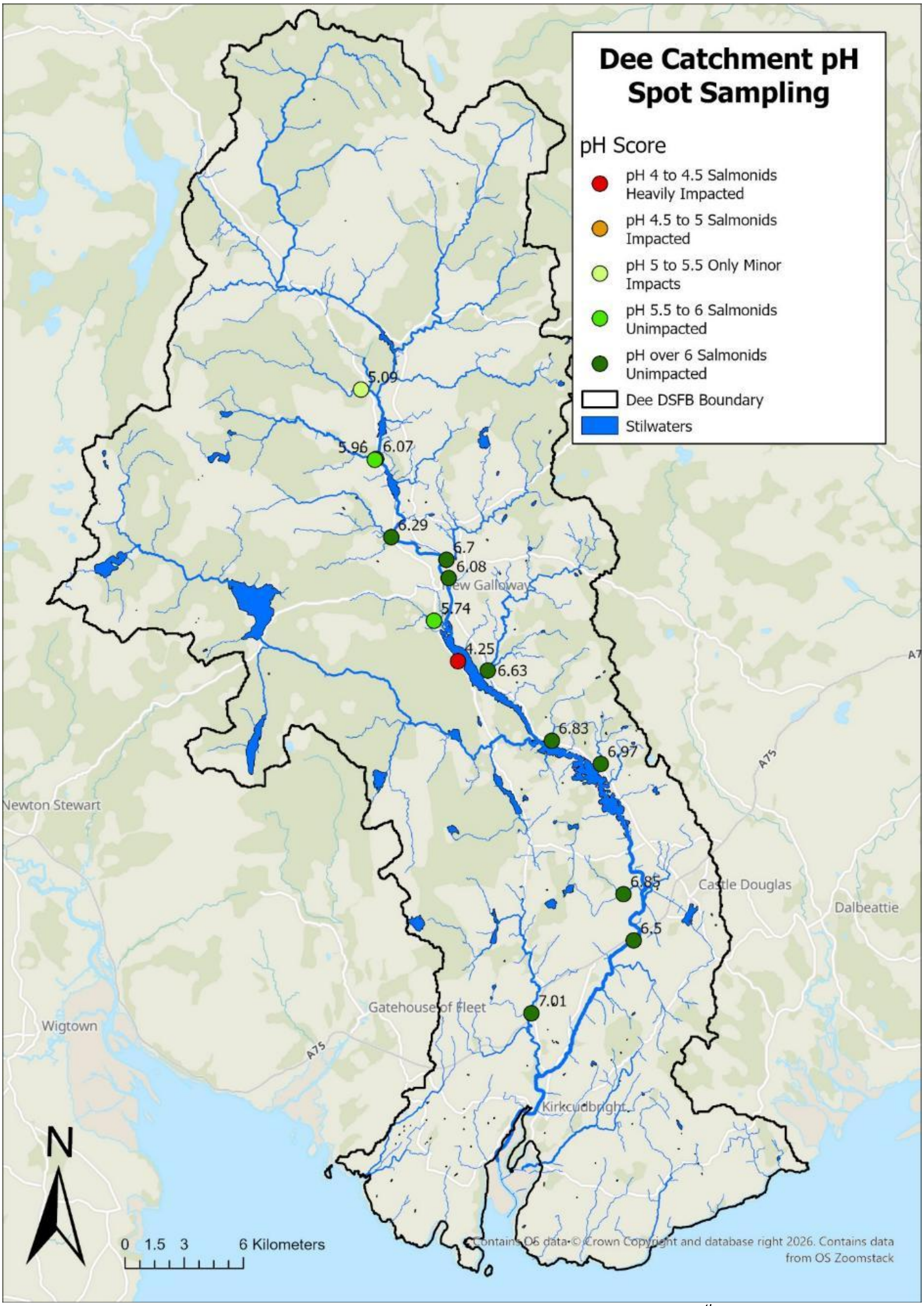
Appendix 1: Fish Counter Results from the Tongland Fish Pass Vaki Fish Counter



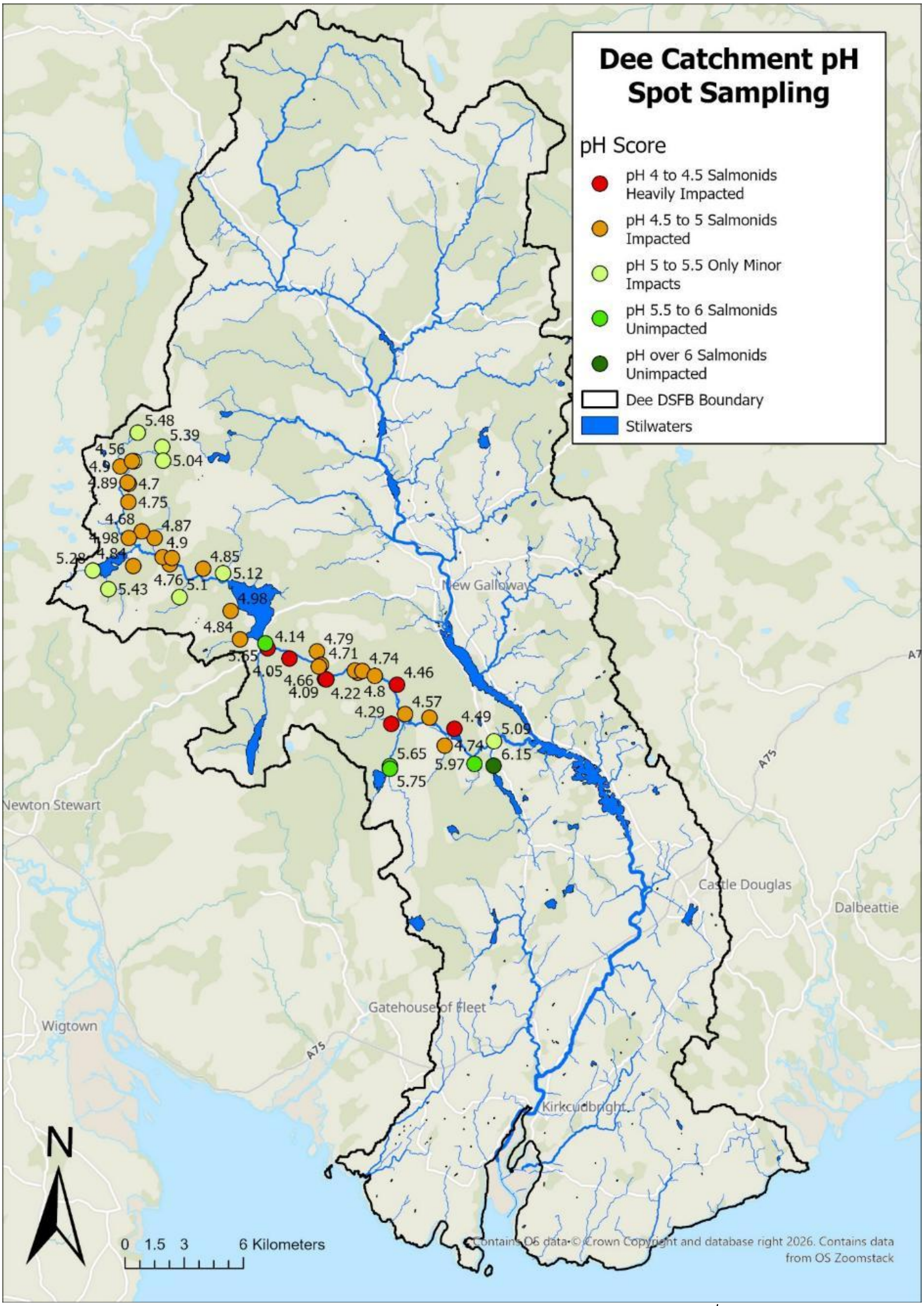
**Vaki data incomplete/Vaki out of service: 2007 due to installation in July; 2011 (4th March – 26th April); 2015 (2nd – 30th April & July – 12th August); 2018 (entire year); 2019 (1st January – 20th June); 2020 (12th March – 20th May); 2021 (88 days); 2022 (39 days) and 2023 (35 days); 2024 (entire year)*

The fish counter is located within the Tongland Dam fish pass, the entrance to which is just above the tidal limit of the River Dee. There is thought to be little or no salmon spawning downstream of the fish pass and all fish traversing the fish pass must pass through the counter. As such, complete counts for each individual year are thought to represent an accurate count of all the adult Atlantic salmon entering the river within a given year.

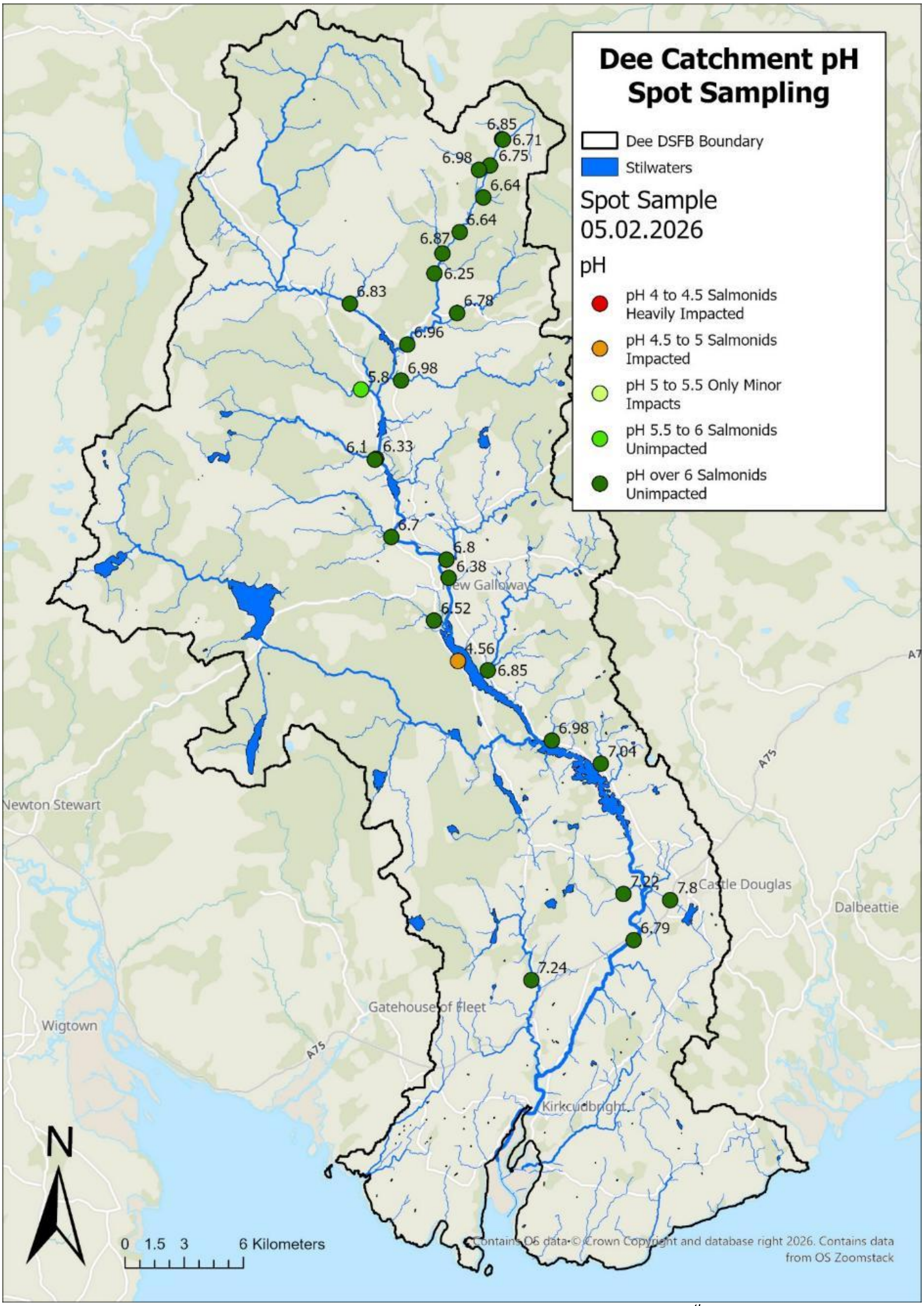
Appendix 2: Results from individual water quality monitoring spot sampling days



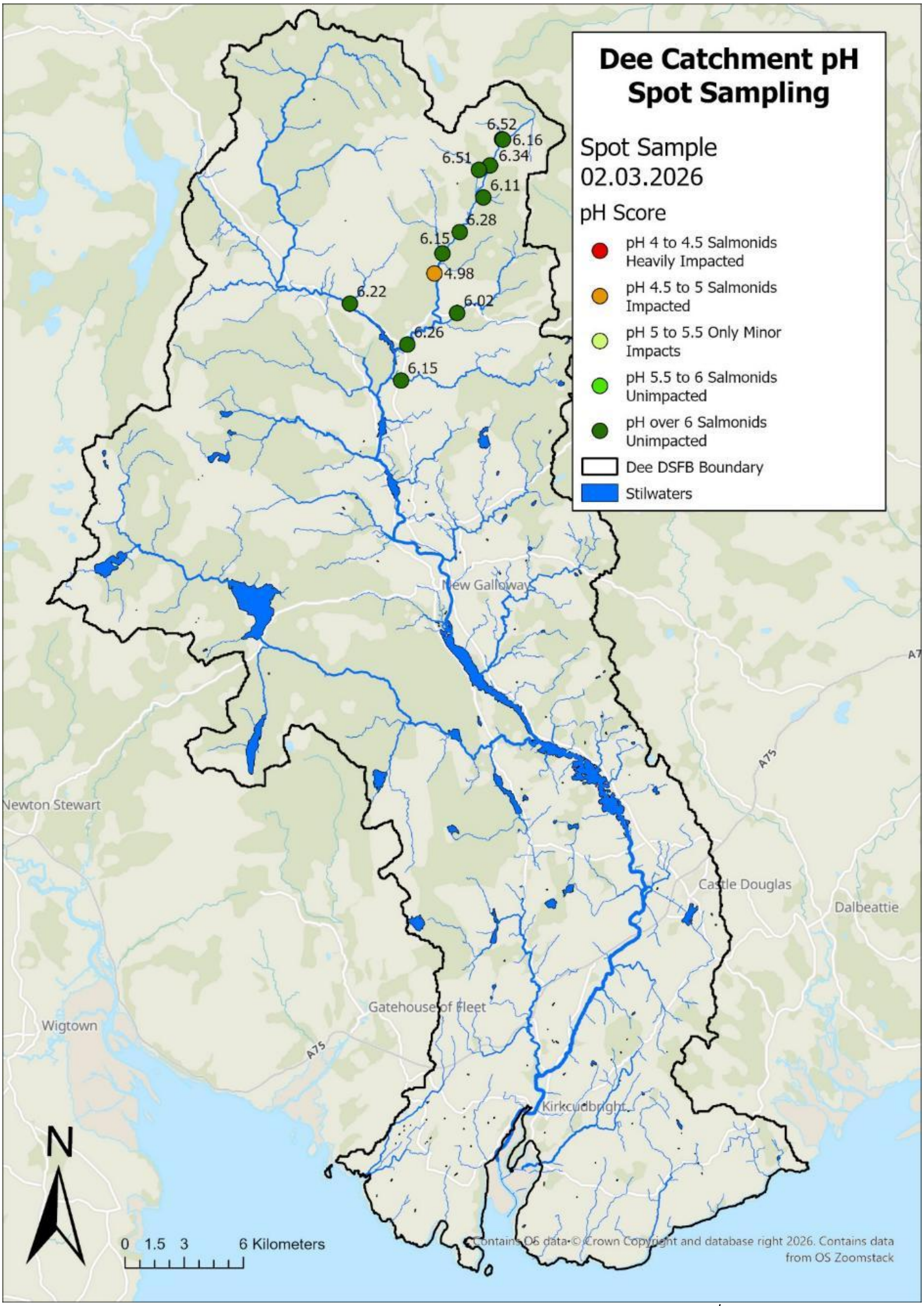
Map 27: The pH levels recorded during spot sampling on the 15th January 2026



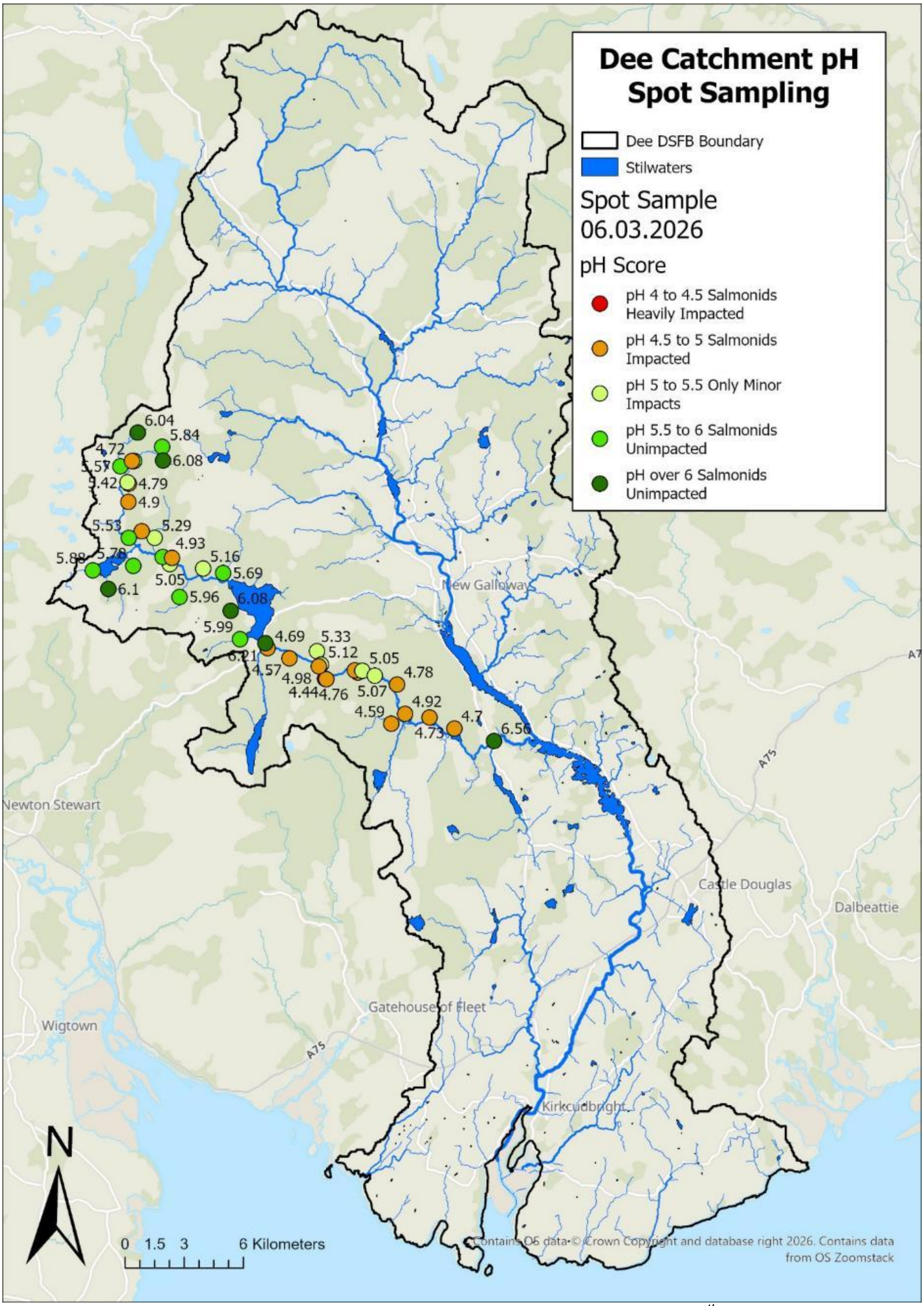
Map 28: The pH levels recorded during spot sampling on the 22nd January 2026



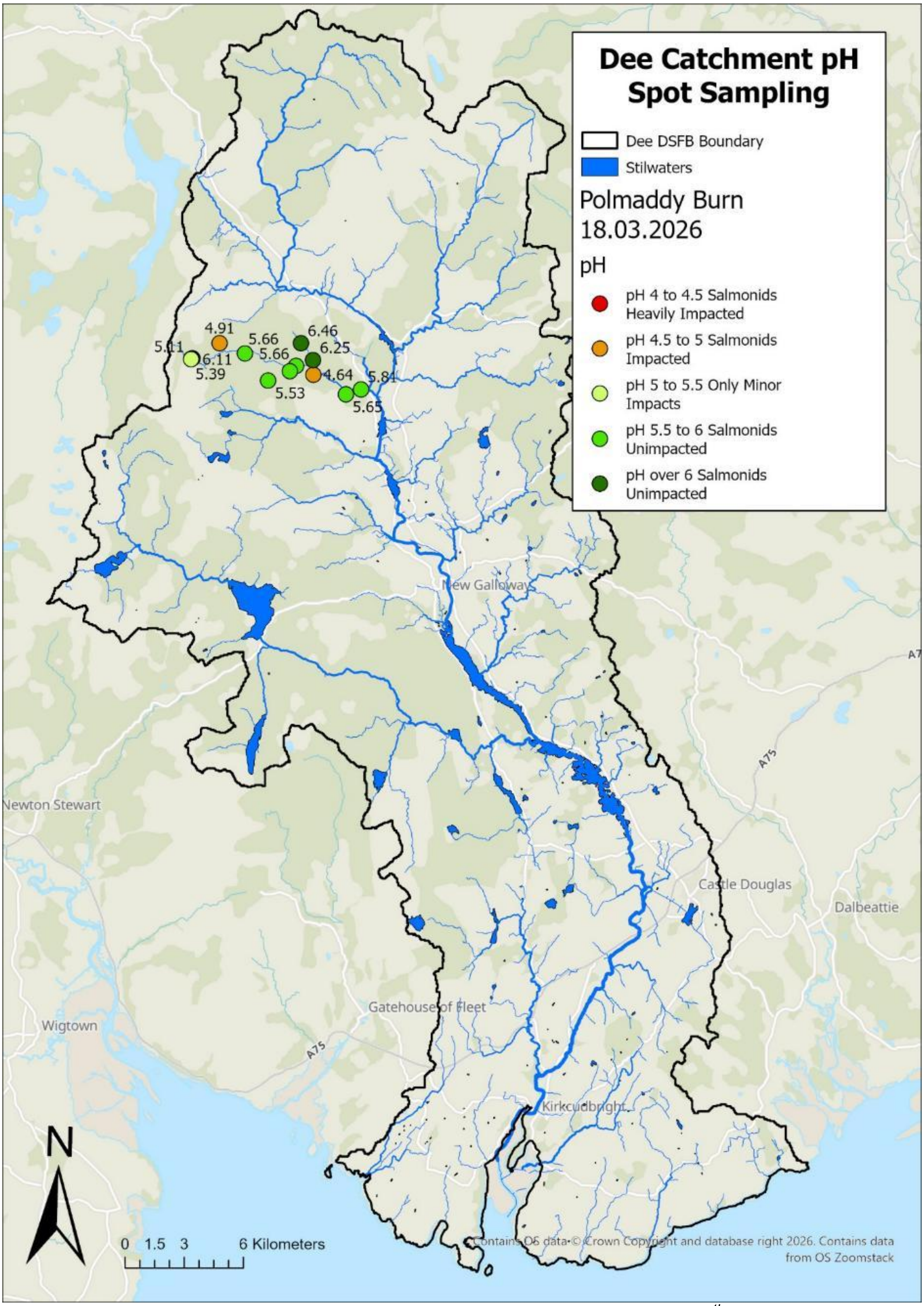
Map 29: The pH levels recorded during spot sampling on the 5th February 2026



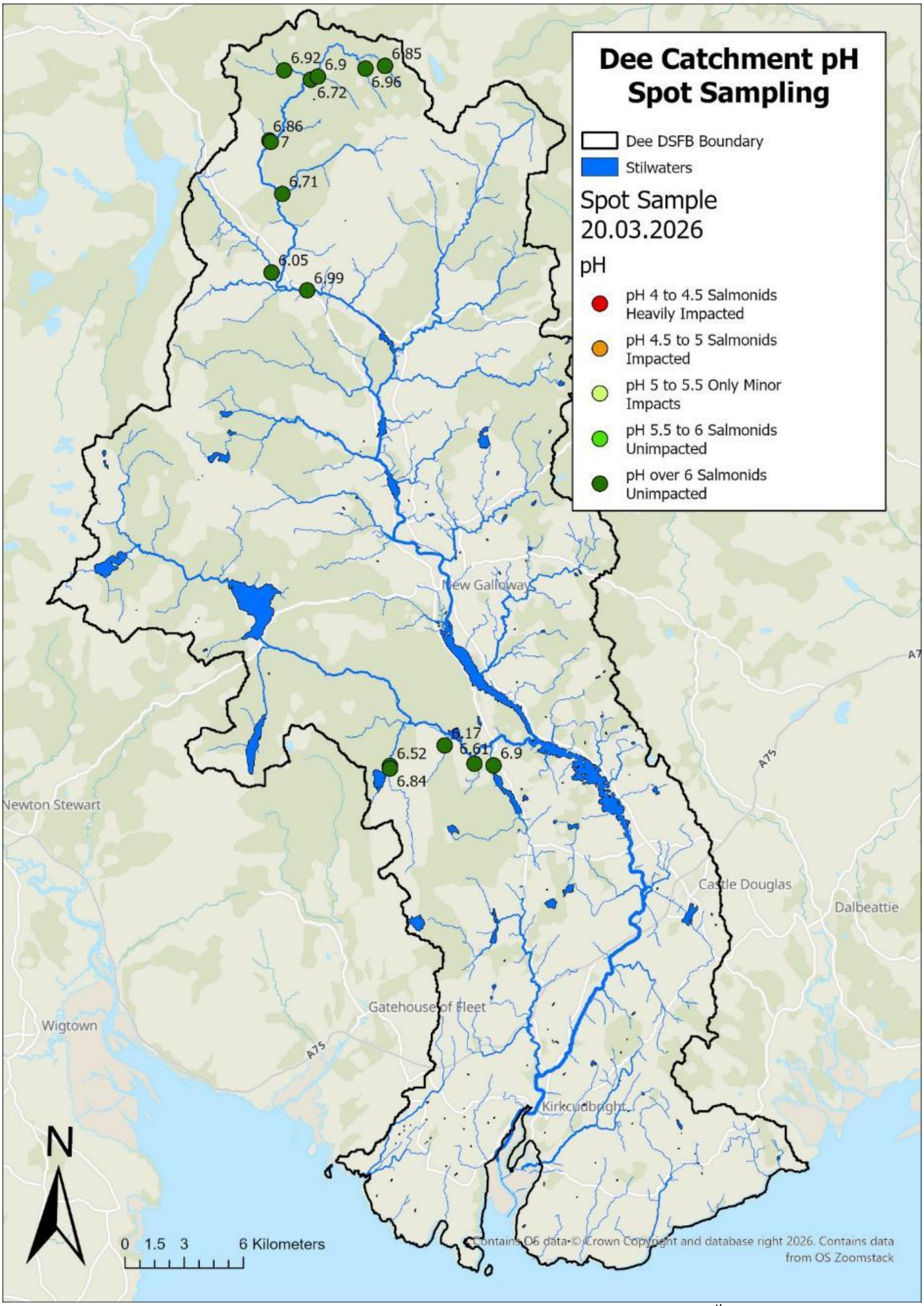
Map 30: The pH levels recorded during spot sampling on the 2nd March 2026



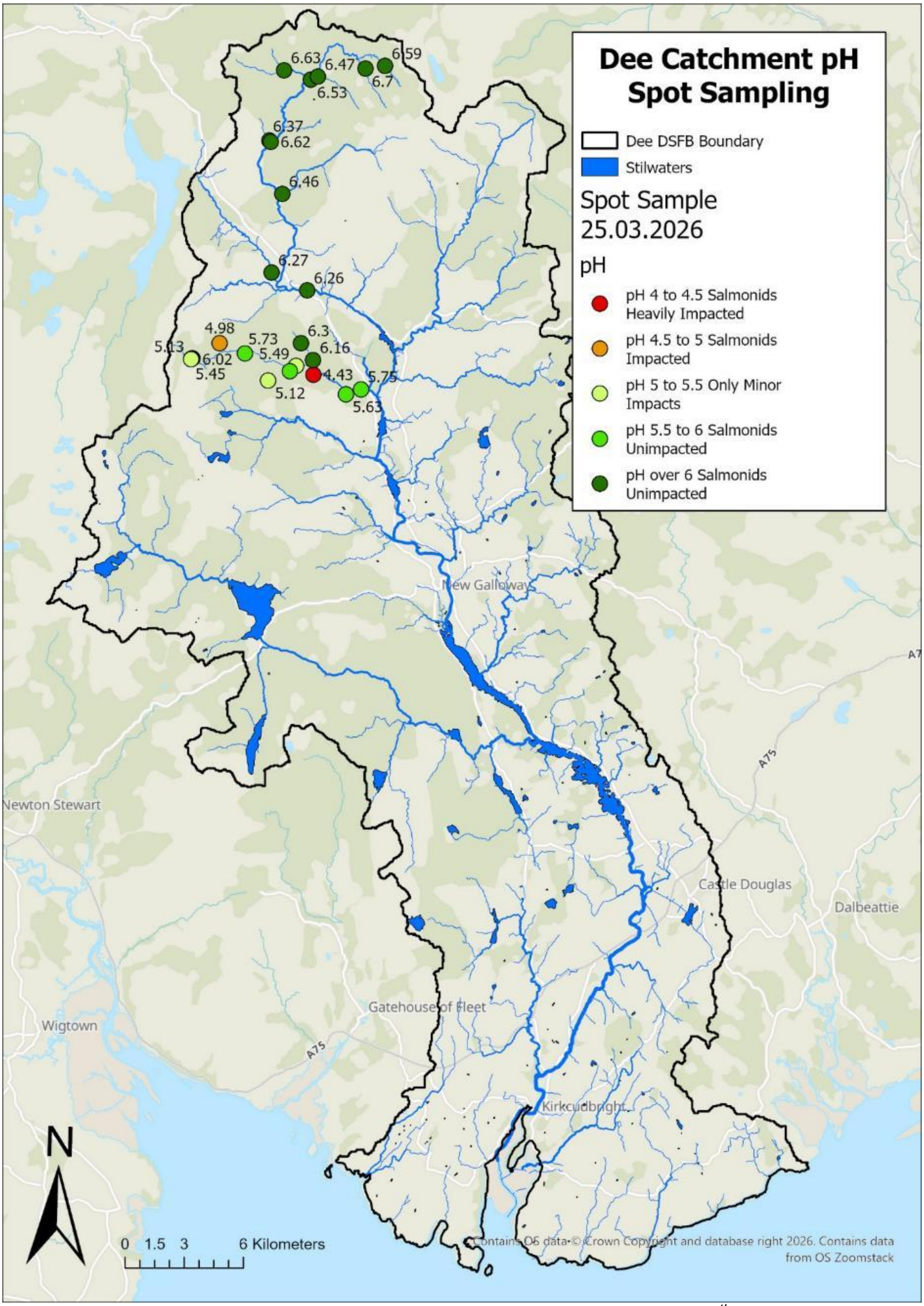
Map 31: The pH levels recorded during spot sampling on the 6th March 2026



Map 32: The pH levels recorded during spot sampling on the 18th March 2026



Map 33: The pH levels recorded during spot sampling on the 20th March 2026



Map 34: The pH levels recorded during spot sampling on the 25th March 2026

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