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# Restoration of salmon in the upper River Dee (Kirkcudbrightshire)

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# Summary

## Restoration of salmon in the upper River Dee (Kirkcudbrightshire)

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**Background**

The Kirkcudbrightshire Dee is one of the largest river catchments in South West Scotland at over 1000 km$^2$. Since 1935, the Galloway Hydro Scheme has been in operation on the river with its six power stations and associated dams and tunnel networks presenting a range of challenges for migratory fish movements throughout the catchment. Fish passes, located at the three lowermost on-river dams (Tongland, Earlstoun and Carsfad) allow salmon to access as far upstream as Kendoon Dam.

In 2001, the Galloway Fisheries Trust (GFT) undertook the first electrofishing surveys to establish migratory fish distribution throughout the Dee catchment. At this time, on behalf of the Galloway Hydro Scheme operator, GFT began managing migratory fish data gathered by Tongland Fish Counter located at the bottom of the river. This data set has illustrated that there has been a decline in Atlantic salmon abundance in recent years and as such, it is crucial to conserve and protect remaining salmon stocks.

This report details findings from electrofishing and habitat surveys carried out by GFT during the 2019 survey season; to investigate the current distribution of salmon within the upper Dee catchment and direct a programme of habitat works that will help increase salmon production in this important part of the river.

**Main findings**

- Juvenile salmon were present in five out of twenty electrofishing sites surveyed.
- Production of salmon was concentrated within the Polharrow Burn, where salmon were found as far upstream as an impassable fall within Waukers Linn.
- The first record of salmon production within the Earlstoun Burn was made during the surveys undertaken within this project.

- Habitat improvement works should be considered, particularly addition of woody debris. The lower Earlstoun Burn is an area where active bankside erosion was recorded and addressing this should be considered.

- The Water of Ken between Carsfad Dam and Craigs Linn has a lack of smaller substrates which appears to be limiting fish production. Possible option to increase smaller substrates here should be considered.

- Further electrofishing surveys should be undertaken within the upper reaches of the Polmaddy Burn to confirm salmon are not utilising the burn in favourable habitat.

- Water management practices should be investigated for their potential in increasing river flows between Polmaddy Burn outflow and Kendoon.

- A drone survey should be undertaken within the gorge section of river downstream of Polmaddie settlement to investigate for the presence of further impassable falls that may impede salmon access to the burn.

- Smolt sampling methods should be investigated surrounding the outflow of Polharrow Burn in order to input to a future smolt tracking study planned for the river.

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## 1. INTRODUCTION

The Kirkcudbrightshire Dee is considered to be a 'heavily modified water body' in the Solway and Tweed River Basin Management Plan. At its source in Ayrshire, the river arises from extracted Loch Doon water that is passed through the first of six power stations at Drumjohn to form Carsphairn Lane. Drumjohn Power Station also receives water extracted and piped from the Water of Deugh, located eastwards in the upper Dee catchment. At Kendoon - the second Power Station in the network – water is utilised from the Water of Deugh before joining the Water of Ken to form the main body of river that runs southwards, passing through Carsfad and Earlstoun Power Stations then Loch Ken and eventually reaches the estuary at Tongland where the largest Power Station of the network is located. Offset from the main run-on-river power stations and positioned midway in the catchment, Glenlee Power Station utilises water impounded at Clatteringshaws reservoir.

The design and operation of the Galloway Hydro system, owned and run by Drax, has a significant impact across the catchment on fish stocks, particularly salmon. For instance, the large Tongland Dam located at the bottom of the system is impassable to ascending young European eels thus eels are not found anywhere in the river or its tributaries. The upper Water of Ken is located upstream of Kendoon Power Station and its associated dam. This dam does not possess a fish pass so no migratory salmonids are able to access the upper Water of Ken.

Juvenile electrofishing surveys are carried out annually on the river for a range of fishery management purposes that have included data collection to inform and direct the District Salmon Fishery Boards hatchery operation and input to the planning stages of many extensive construction works that have taken place in the catchment. However, because the operation of the Galloway Hydro Scheme plays such a key influence on the entire river network; GFT have placed a great deal of focus into this area as a key contributor in influencing current and future distribution and abundance of migratory fish within the river.

A Vaki Riverwatcher fish counter, located at Tongland Dam fish ladder has indicated that the Dee salmon population could be nearing extinction, having dropped in number from around 1000 adult salmon entering the river in 2007 and 2008 to only 98 salmon in 2019. Whilst adult fish returns have significantly declined in recent years, there is also an immediate threat from the presence of North American Signal Crayfish to salmon production within the lower river. Crayfish are currently absent from the upper river which is accessible to migratory fish.

Genetic data has shown the most diverse sub population of salmon exists in the Polharrow Burn (upper Dee tributary) from within the Galloway Rivers. With the Dee salmon population declining as it currently is, the work undertaken as part of this study was commissioned in an effort to focus effort into enhancing the Dee salmon population, beginning within its important upper accessible catchment.

## 2. METHODOLOGY

### 2.1 Electrofishing survey

#### *2.1.1 Data recording*

The GFT is a partner in the Scottish Fisheries Co-ordination Centre (SFCC), an initiative involving the Scottish Fishery Trusts and others, including the Freshwater Fisheries Laboratory, The Tweed Foundation, the Spey Research Trust, the Tay Foundation and the Cromarty Firth Fisheries Trust.

This group has, in partnership, developed a set of agreed methodologies and record sheets for use with electrofishing surveys and an associated database in which to record information gathered from such surveys.

The electrofishing surveys undertaken by the GFT have been completed to the standards that are required by the SFCC and recorded using the agreed formats.

#### *2.1.2 Electrofishing techniques*

To assess the fish population present within a section of river various techniques have been developed in recent decades. The main method of determining the health of a fish population is by the use of electrofishing equipment.

This technique involves the stunning of fish using an electric current which enables the operator to remove the fish from the water. Once captured, the fish recover in a holding container. They are then anaesthetised using a specific fish anaesthetic, identified, measured and recorded, and once recovered, returned unharmed to the area from which they were captured.

The method of fishing employed by GFT involves the anode operator drawing stunned fish downstream to a banner net held against the current by an assistant. Fish captured are then transferred to a water-filled recovery container. The team works its way across the section and upstream, thereby fishing thoroughly all the river in the survey stretch.

To obtain quantitative information on the fish populations within the river, each survey site is fished through a number of times to allow the calculation of a more accurate population density estimate of the fish population. A Zippin estimation of a fish population is a calculation carried using a depletion method (multiple run fishing). This is an estimate of the fish population density per 100 $m^2$ of water, including the 95% confidence limits (this information is presented in Table 2). When a Zippin estimate of the population is not possible, a minimum estimate of the fish population is provided for that section of river.

The equipment used for this survey was a standard 2.2 kw generator, powering a bankside set of equipment. GFT endeavors to use a bankside generator wherever possible.

Electrofishing was undertaken by a team of three SFCC accredited GFT staff at all survey sites.

It is the policy of the GFT to disinfect all relevant equipment both prior to and following work in each catchment, to ensure that there is no transfer of disease organisms.

### *2.1.3 Electrofishing equipment used*

The bankside generator apparatus which is employed during GFT electrofishing surveys is powered by a 2.2 kw petrol generator (5 horse power) with a variable voltage output (200 – 250 volts) linked to an Electracatch controller unit (WFC7 – 1a). Smooth direct current was used at all sites during the survey.

The Electracatch control unit is linked to a stationary cathode of braided copper (placed instream) and a mobile, single anode, consisting of a pole-mounted stainless steel ring and trigger switch.

### *2.1.4 Age determination*

The electrofishing survey concentrated on juvenile salmonid species, although other fish species are also captured. In the majority of cases age determination of salmonids can be made by assessment of the length of fish present. However with older fish it is more difficult to clarify age classes. In these cases a small number of scale samples are often taken from fish, in addition to length assessments, to verify the ages of fish whose age can not be determined with certainty from the length.

### *2.1.5 Non-salmonid fish species*

At each site the presence of non-salmonid fish species was noted. Population densities for these species were not calculated.

### *2.1.6 Site measurement*

At each site surveyed a total length was recorded and average wet, bed and bank widths calculated.

The average wet width was calculated from several individual widths recorded at equidistant intervals from the lower end of the site (0 m) to the top. At each site a final width was noted at the absolute upper limit of the survey site. From these site lengths and average wet widths the total wetted area fished was calculated.

### *2.1.7 Bankside / instream habitat assessment*

At each site an assessment was made of the instream habitat available for older (parr aged) fish. This assessment graded instream cover present as none, poor, moderate, good or excellent. This grading provides a suitability index of instream cover where diverse substrate compositions will score more favorably than areas of uniform substrate providing poor cover.

In accordance with SFCC protocols, percentage estimates of depths, substrate type and flow type were made at each site.

Additionally, percentage estimates of the quantity of the bankside features undercut banks, draped vegetation, bare banks and marginal vegetation were made.

All of these bankside and instream habitat site features are summarised in Section 5. When reference to left or right bank is made, it is always left and right bank when facing downstream.

### *2.1.8 Site selection*

Twenty sites were selected to cover every watercourse within the upper Dee catchment that salmon may be currently utilising.

Work was carried out over five days between July 2019 and October 2019.

## 2.2 Data recording

### *2.2.1 Walk-over survey*

The walk-over habitat surveys aimed to give general information on the current status of the instream and bankside habitats present within the burn. A modified Hendry and Cragg-Hine (1997) walk-over survey was developed and undertaken.

This method of habitat surveying allows for much ground to be covered, giving the maximum amount of information to be gained in the minimum of time. The walk-over habitat surveys aimed to provide an insight into the status and locations of spawning gravels and juvenile habitat areas within the watercourses.

During the surveys, information on substrate type, bank structure and obstructions to fish movement are recorded. General comments on individual stretches of river are recorded to assist in the rapid overview of the survey area as a whole. A photographic record of the watercourses was collected during the surveys.

### *2.2.2 Method*

Tributaries entering the east and west sides of Earlstoun and Carsfad Lochs were surveyed by a GFT surveyor. The predominant habitat type was recorded within specific stretches, and defined as described in Table 1. The habitats described are not disparate but regarded as definable parts of a spectrum of habitats found in a river. Where spawning gravels were present and accessible, an assessment of their quality in terms of stability, compaction and siltation were made. In addition, the bankside structure and surrounding land use was also described where appropriate.

*Table 1: Habitat Classification for walk-over survey method*

| **Habitat Type** | **Classification** |
|---|---|
| Spawning gravel | Stable gravel up to 30 cm deep that is not compacted or contains excessive silt. Substrate size with a diameter of 0.8 to 10.2 cm |
| Fry habitat * | Shallow (<0.2 m) and fast flowing water indicative of riffles and runs with a substrate dominated by gravel (16 - 64 mm) and cobbles (64 - 256 mm) |
| Parr habitat * | Riffle – run habitat that is generally faster and deeper than fry habitat (0.2 - 0.4 m). Substrate consists of gravels (16 - 64 mm), cobbles (64 - 256 mm) and boulder (> 256 mm) |
| Glides | Smooth laminar flow with little surface turbulence and generally greater than 0.3 m deep |
| Pools | No perceptible flow and usually greater than 1 m deep |
| Flow constriction | Where flows are accelerated between narrow banksides (usually combined with deep fast flows and bedrock substrates) |
| Obstacles | A structure or item identified as a potential obstruction to fish passage at certain water heights |

** If significant amounts of fry and parr habitat were found to co-exist in the same section, these habitat classifications are often combined and classified as juvenile habitat. Where parr habitat is mentioned this will*

*refer to habitat that has principally be identified as habitat more suited to parr than fry, however will habitually contain a lower quantity of fry habitat and habitat which is suited to both fry and parr.*

Problematical bank structures such as areas of erosion were recorded. If the reason for the problem was evident then this was highlighted e.g. over-grazing by sheep causing a collapsing bank.

Obstructions were assessed for complete impassability at any flow or for being passable under certain flow conditions. Additional comments were also made as to the nature and permanency of the obstruction.

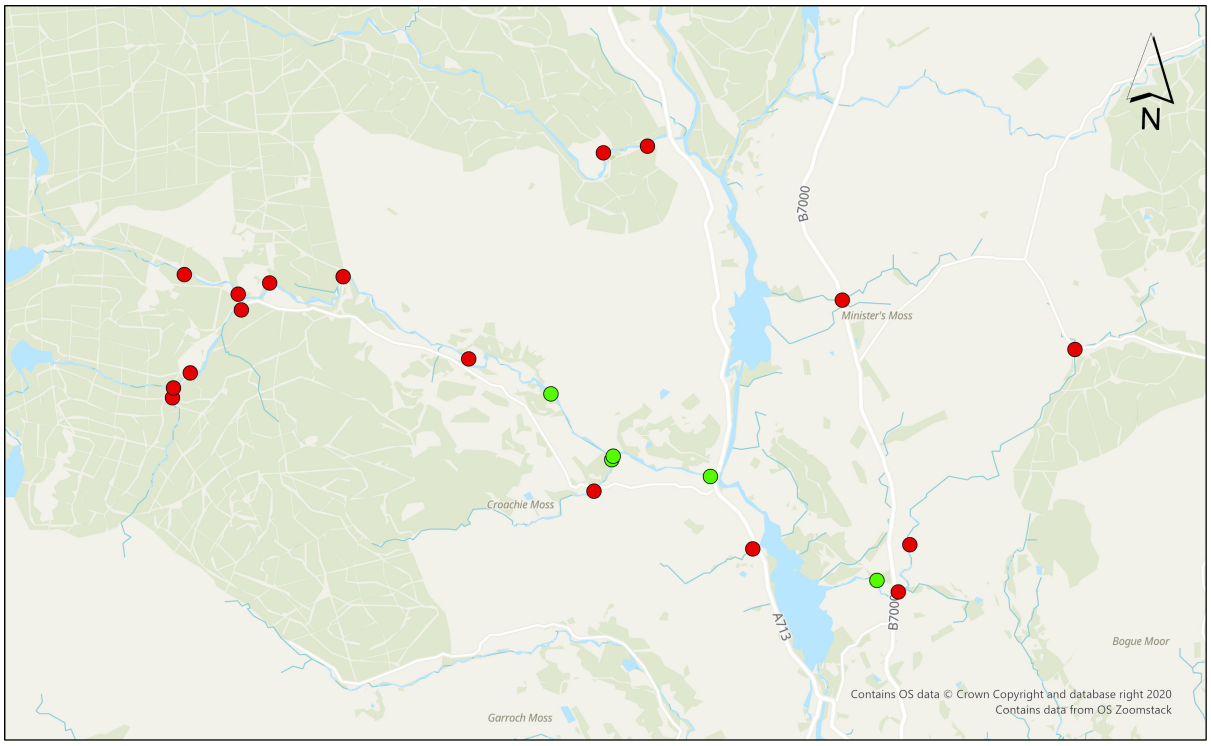
# 3. RESULTS

## 3.1 Electrofishing results

### *3.1.1 Figures presented*

The results of the electrofishing survey are outlined in Section *3.1.3* and presented in detail in Appendix 1 *(Results from Timed (no. fish/minute), Area delineated (no. fish per 100 m$^2$) and Presence/Absence (P/A) electrofishing surveys undertaken as part of the Galloway Glens Upper Dee Salmon Restoration Project).* These provide information on the population densities of juvenile salmonids at each site. Site code, watercourse, site location, O.S. Grid reference, survey date, non-salmonid species and area fished (m$^2$) are also shown where applicable. Map 1 (below) illustrates the location of electrofishing sites completed during 2019 as part of this study and whether salmon were present or absent.

*Map 1 (below): Presence/absence of salmon at 2019 electrofishing sites*




With regard to the juvenile salmonid age classes, these are separated into four categories, which are defined in Table 2:

*Table 2: Salmonid age classes*

| | |
|---|---|
| Salmon Fry (0+): | Refers to young fish less than one year old resulting from spawning at the end of 2018. |
| Trout Fry (0+): | Refers to young fish less than one year old resulting from spawning at the end of 2018. |
| Salmon Parr (1+ and older): | Refers to young fish of greater than one year and greater than two years old (where present) from spawning years 2017 and 2016. |
| Trout Parr | Refers to young fish of greater than one year and greater |

| | |
|---|---|
| (1+ and older): | than two years old (where present) from spawning years 2017 and 2016. If captured, trout of up to three or four years old are also included in this category. |

Within the electrofishing results, juvenile salmonid numbers recorded have been classified into several categories. A classification scheme for densities of salmonids was previously generated by the SFCC using data collected from 1,638 Scottish electrofishing survey sites, covering the period 1997 to 2002 (Godfrey, 2005[1]). From this, regional figures were created to allow more accurate local ranges. The categories are based on quintile ranges for one-sample electrofishing surveys in the Solway region (Solway Salmon Fishery Statistical Region), allowing densities of fish observed to be put into a regional context. Table 3 shows these quintile ranges.

*Table 3: Quintile ranges for juvenile salmonids (per 100 $m^2$) based on one-sample electrofishing events, calculated on densities >0 over 291 sites in the Solway Statistical Region*

| | Salmon 0+ | Salmon 1++ | Trout 0+ | Trout 1++ |
|---|---|---|---|---|
| Minimum (Very Low) | 0.22 | 0.38 | 0.38 | 0.35 |
| 20th Percentile (Low) | 5.21 | 2.86 | 4.14 | 2.27 |
| 40th Percentile (Moderate) | 12.68 | 5.87 | 12.09 | 4.71 |
| 60th Percentile (High) | 25.28 | 9.12 | 26.63 | 8.25 |
| 80th Percentile (Very High) | 46.53 | 15.03 | 56.49 | 16.28 |

Where timed electrofishing data has been gathered, salmon fry and parr densities can be classified using a Galloway timed sites salmon fry index, developed by the Galloway Fisheries Trust in 2019 (Table 4).

*Table 4: 2016-2019 Galloway timed sites salmon fry index: fry and parr classification*

| Breakpoint (salmon fry/min) | Class | Breakpoint (salmon parr/min) |
|---|---|---|
| 0 | **Absent** | 0 |
| <3.4 | **Very low** | <1.0 |
| 3.5 to <7.0 | **Low** | 1.1 to <1.8 |
| 7.1 to <11.4 | **Moderate** | 1.9 to <2.6 |
| 11.5 to <23.2 | **Good** | 2.7 to <4.6 |
| >23.2 | **Excellent** | >4.6 |

### *3.1.2 Survey limitations*

The juvenile salmonid density classification scheme is based solely on data from surveyed sites containing fish in the period 1997 to 2002, and refers to regional conditions at that time; therefore it must only be used as a very relative guide and not be used to draw conclusions. Moreover, the figures for juvenile trout are less reliable for various reasons (e.g. some surveyed populations of trout are isolated; sea trout contributing to stock in some areas etc) and so can only be used as a relative indication of numbers.

Electrofishing and habitat information is discussed, with reference to any specific issues such as sensitivities, in Section 4.

[1] Godfrey, J. D., 2005; Site Condition Monitoring of Atlantic Salmon SACs: Report by the SFCC to Scottish Natural Heritage, Contract F02AC608.

*3.1.3 Electrofishing results*

- Site 1 (DKE1): Earlstoun Burn Grid reference: 264176 585770

Salmon fry and parr were absent at site 1. Trout fry and parr were present in a low density. No other fish species were recorded.

- Site 2 (DKE2): Earlstoun Burn Grid reference: 262420 583693

Salmon fry and parr were absent at site 2. Trout fry and parr were present in a low density. No other fish species were recorded.

- Site 3 (DKE3): Earlstoun Burn Grid reference: 262295 583189

Salmon fry and parr were absent at site 3. Trout fry and parr were present in a low density. No other fish species were recorded.

- Site 4 (DKE4): Earlstoun Burn Grid reference: 262070 583310

Salmon fry were absent at this site. Salmon parr were present in a very low density. Trout were not recorded at this site. Of the non-salmonid fish species, three-spined sticklebacks were also recorded.

- Site 5 (DKC1): Cleugh Burn Grid reference: 261700 586295

No fish were recorded at this site.

- Site 6 (DKPol1): Polmaddy Burn Grid reference: 259159 587862

Salmon were absent at this site. Trout fry and parr were present in a low density. Minnows were also recorded at this site.

- Site 7 (DKPol2): Polmaddy Burn Grid reference: 259625 587930

Salmon were absent at this site. Trout fry and parr were present in a low density. Minnows were also recorded at this site.

- Site 8 (DKP1): Polharrow Burn (McAdams Burn) Grid reference: 254570 585255

Salmon were absent at this site. Trout fry and parr were present in a low density. No other fish species were recorded at this site.

- Site 9 (DKP2): Polharrow Burn (Mid Burn) Grid reference: 254581 585361

Salmon were absent at this site. Trout fry were also absent. Trout parr were present in a low density. No other fish species were recorded at this site.

- Site 10 (DKP3): Polharrow Burn (Burnhead Burn) Grid reference: 255305 586190

Salmon were absent at this site. Trout fry were present in a low density. Trout parr were absent. No other fish species were recorded at this site.

- Site 11 (DKP4): Polharrow Burn (Lumford Burn) Grid reference: 254698 586567

Salmon were absent at this site. Trout fry and parr were present in a low density. No other fish species were recorded at this site.

- Site 12 (DKP5): Polharrow Burn (Lumford Burn) Grid reference: 255272 586356

Salmon were absent at this site. Trout fry and parr were present in a low density. No other fish species were recorded at this site.

- Site 13 (DKP6): Polharrow Burn Grid reference: 256386 586542

Salmon were absent at this site. Trout fry were also absent. Trout parr were present in a low density. No other fish species were recorded at this site.

- Site 14 (DKP7): Polharrow Burn Grid reference: 257724 585667

Salmon were absent at this site. Trout fry were present in a low density. Trout parr were absent. No other fish species were recorded at this site.

- Site 15 (DKP8): Polharrow Burn Grid reference: 258600 585297

Salmon were found within this site as parr in a very low density. Trout fry and parr were present in a low density. No other fish species were recorded at this site.

- Site 16 (DKP9): Polharrow Burn (Crummy Burn) Grid reference: 259056 584261

Salmon were absent at this site. Trout fry were present but trout parr were unrecorded. No other fish species were recorded at this site.

- Site 17 (DKP10): Polharrow Burn (Crummy Burn) Grid reference: 259248 584596

Salmon were present within this site; as parr in a very low density. Trout fry and parr were recorded in a low density. Minnows were the only other fish species recorded at this site.

- Site 18 (DKP11): Polharrow Burn Grid reference: 259262 584632

Salmon fry and parr were present in a very low density within this site. Trout fry and parr were present in a low density. Stoneloach were the only other fish species recorded at this site.

- Site 19 (DKP12): Polharrow Burn Grid reference: 260297 584418

Salmon were present within this site; as fry in a very low density and parr in a moderate density. Trout fry were present in a low density. Trout parr were not recorded at this site. Minnows were the only other fish species recorded at this site.

- Site 20 (DKG1): Glen Strand Grid reference: 260748 583647

No fish were recorded at this site.

## 3.2 Habitat survey results

### *3.2.1 Earlstoun Burn*

The survey of the Earlstoun Burn commenced at (NX) 261608 583233, a short distance from where the burn entered the east side of Earlstoun Loch (reservoir). Deep parr suited habitat, in the form of cobbles and boulders, covered the first 50 m of the burn (*Figure 1*) before reaching the first set of falls at (NX) 261655 583240. This first set of shallow (passable) falls stretched for around 15 m, banked on either side of the burn by elm and birch woodland. Mixed juvenile habitat containing small pockets of gravel extended a short reach upstream from (NX) 261672 583247. From (NX) 261748 583269, the base of the burn was mostly comprised of bedrock, which formed a series of small (passable) falls before the burn steepened and narrowed for a distance of around 30 m containing limited deeper parr habitat (cobbles). A section of falls extended from (NX) 261790 583295, interspersed with small areas of mixed juvenile habitat. A series of steps, up to 1 m high (*Figure 2*); although deemed passable - presented the most challenging obstacle to fish passage encountered so far at (NX) 261852 583334.

*Figure 1: An area of parr habitat on the lower Earlstoun Burn*

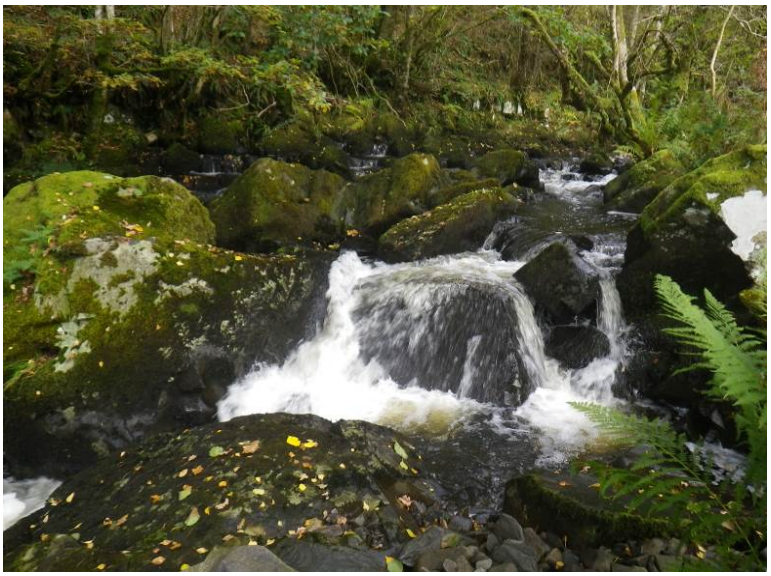


*Figure 2: A section of (passable) bedrock falls on the lower Earlstoun Burn*

From here, the burn began to widen and provide a continuous stretch of mixed juvenile habitat from (NX) 261858 583342. An abundance of woody debris provided ample cover for parr (*Figure 3*) across a 60 m length of the burn, before a series of falls was met at (NX) 261914 583323. From here, the burn steepened and narrowed and together, with greater water velocity, presented an unproductive stretch of water over a distance of approximately 50 m, within which, a small stand of larch was encountered along the right bankside (*Figure 4*).

*Figure 3: Fallen trees provide a source of woody debris within the burn*

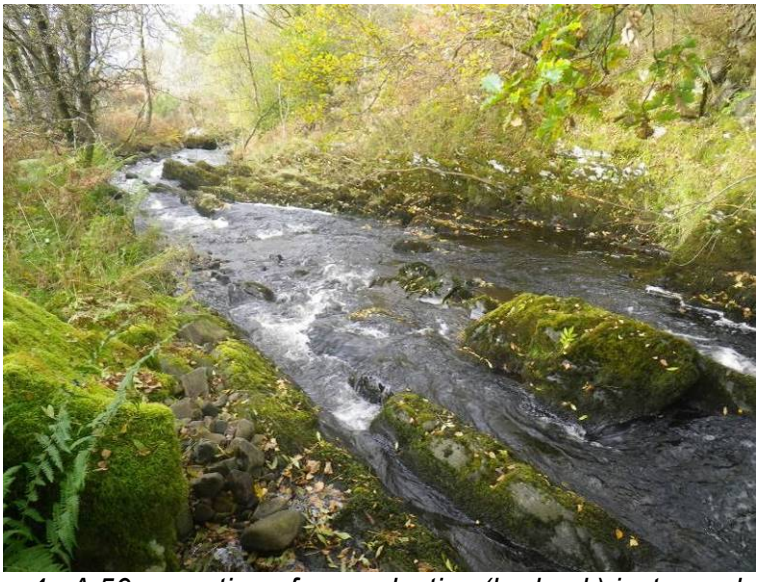


*Figure 4: A 50 m section of unproductive (bedrock) instream habitat*

The burn became productive, presenting good quality juvenile spawning habitat in the form of shallow cobbles and pebbles from (NX) 262036 583372 (*Figure 5*). Mixed deciduous woodland and rhododendrons provided tree cover along the entire right bankside and together with some exceptional woody debris; gave quality mixed juvenile and spawning habitat from as far upstream as (NX) 262070 583288 where habitat quality began to diminish with a lack of tree cover on both banks and some notable bankside erosion (the likely result of bankside grazing by cattle). Despite the limitations of bankside habitat from this point onwards (*Figure 6*), the burn adopted some quality pool-run/riffle flow habitat, suited to

juvenile salmonids and adult brown trout. This habitat terminated at a ford at (NX) 262088 583252, below an old bridge apron.

*Figure 5: Good spawning habitat*

*Figure 6: A gradual increase in gradient produces a nice section of run and riffle habitat at the tail end of a glide*

From (NX) 261030 583211, instream habitat began to diminish as bankside erosion became more notable; existing on both banksides at (NX) 262140 583166. Bank instability and collapse were much more evident at (NX) 262223 583146 (*Figure 7*) where areas of fine sediment were encountered surrounding each section of bank collapse as the burn wound its way up towards a watergate at (NX) 262264 583169, where this section terminated at the road bridge, within 1 km from the Earlstoun Loch.

*Figure 7: A section of actively eroding bankside*

Good quality spawning habitat in the form of cobbles and gravels existed over an 80 m stretch of the burn upstream of the road bridge (*Figure 8*). Here, the bankside was grazed (by sheep) along the right bankside and lined by mature deciduous trees along the left bankside. A series of small bedrock steps existed over a 10 m length, where it is likely trout may inhabit given the tree roots and overhanging cover provided on the left bankside. Shortly upstream, a small dam composed of flood and woody debris (*Figure 9*), existed at (NX) 262401 583231. Beyond a drystone dyke lining the burn at this point, land use adjacent to the left bankside changed from rough pasture to felled conifer woodland.

*Figure 8: An 80 m stretch of good quality spawning habitat upstream of the road bridge*

*Figure 9: A fallen tree gathering flood debris may impede fish movement within the burn*

An exposed side bar of cobbles and gravels lined the right bankside upstream of the debris dam, where the watercourse had been weaving around a mass of tree branches (*Figure 10*) that extended from the left bankside to beyond the right bankside. The burn began to narrow and deepen, becoming much more suited to parr and in particular, trout parr – given the extent of deadwood that was present along the left bankside. At this point, the burn becomes more gorge-like, with steep sides and small sections of natural falls at (NX) 262344 583332. However, a 40 m stretch of mixed juvenile habitat could be seen extending from the corner to a watergate and fence line at (NX) 262345 583406 (*Figure 11*).

*Figure 10: A side bar of fine substrates has been created as the burn weaves around an uprooted tree*

*Figure 11: The burn flattens out above a section of gorge to provide good mixed juvenile habitat*

From upstream of the watergate, the burn entered a gorge. From this point upstream, the burn was steep-sided, narrow and completely over shaded, with no bankside cover for fish. Limited parr habitat may exist for trout throughout this section, up to a large natural fall of over 2 m in height at (NX) 262418 583438, considered impassable to upstream migrating fish (*Figure 12*). The falls were located approximately 500 m upstream of the start of this section at the B7000 road bridge. Given the bare-banked and steep-sided terrain of the riparian zone within the vicinity of the falls, surveying re-commenced at (NX) 262425 583550 upstream of the falls where the burn left the woodland. Here, the left bankside had been recently fenced to exclude livestock from the watercourse (*Figure 13*).

*Figure 12: A waterfall, considered impassable to upstream migrating fish, lies approximately 500 m upstream of the B7000 road bridge*

*Figure 13: The burn opens out into rough upland moorland habitat as it leaves the gorge*

The burn continued upstream for approximately 200 m – self-contained by a fence on the left bankside and dry stone dyke on the right bankside – before reaching a bridge at (NX) 262420 583634. From here, the burn entered open moorland habitat where rough pasture and bracken were the principal vegetation types present within the riparian zone.

In this next section, approximately 800 m of the burn was surveyed through unfenced upland pasture. Immediately upstream of the road bridge, the burn contained excellent quality mixed juvenile instream habitat with an abundance of cobbles making it well suited to parr in particular (*Figure 14*). Grazing pressure by sheep was negligible with overhanging vegetation, including bracken, dominating within the riparian zone. The burn narrowed to approximately 2.5 m at (NX) 262473 583877 and adopted the characteristics of a typical upland trout water with deep glide flows dominating over shallow run and riffle. As the burn turned a corner, it widened to approximately 5 m and straightened out from (NX) 262497 583950 (*Figure 15*).

*Figure 14: A section of the burn where salmon parr would thrive*

*Figure 15: Bankside erosion can be seen along the right bankside*

Further excellent quality mixed juvenile habitat and in particular parr habitat, could be found instream from (NX) 262472 583972 (*Figure 16*). The pressure of bankside erosion was notable throughout the entire section of the burn upstream of the bridge. Given the lack of any bankside protection (i.e. a livestock exclusion fence or presence of established broadleaved trees) there was little opportunity for the banksides to recover regardless of the low grazing pressure that existed surrounding the burn. Erosion was most notable as the burn turned a corner (*Figure 17*) where an exposed gravel bed lined the inside of the bend and fine particulate matter could be seen transposing from the left bankside. A drystone dyke appeared to have been replaced with a fence line along the right bankside where excessive erosion had compromised the field perimeter. A short distance upstream of the corner, the burn narrowed to approximately 4 m wide, and began to steepen, with instream habitat changing from a mixture of fairly mobile pebble/cobble to deep pools lined with bedrock and small pockets of fine gravel at (NX) 262472 584099.

*Figure 16: Good instream cover for fish but a lack of bankside refuge*

*Figure 17: The instability of the banksides clearly demonstrated on an actively eroding bend*

The burn exhibited a series of falls at (NX) 262562 584169 (*Figure 18*) before it transferred through a dyke and became much narrower (NX) 262598 584218. The survey was terminated at this point as the burn transferred from sub optimal mixed juvenile habitat (containing some spawning material) to predominately bedrock (unproductive) instream habitat.

*Figure 18: Instream habitat switches from good quality mixed juvenile to unproductive bedrock at a series of small falls*

### *3.2.2 Cleugh Burn*

The Cleugh Burn is a small tributary which arises from watercourses draining the moorland to the East side of Carsfad Loch. Denoted on the OS map, the Cleugh Burn is likely to have a waterfall a short distance upstream of the B7000 road. This suggests a limited distance of approximately 800 m of the lower watercourse may provide suitable habitat for salmonid production and in particular, salmon.

The burn was surveyed in an upstream direction from (NX) 260957 586369, where it entered Carsfad Loch. The riparian zone included larch woodland along the left bankside and mixed

broadleaved woodland along the right bankside. As a consequence, the burn was heavily over shaded with a lack of any underlying vegetation on both banks. Within approximately 50 m of the mouth of the burn, a series of natural waterfalls were encountered at (NX) 260984 586362 (*Figure 19*). These were considered to be passable by fish. A further series of falls was encountered at (NX) 261019 586362. Despite being unable to access the burn directly at this point (due to the steep-sided banks), it was evident that instream habitat would limit fish production, being exclusively composed of bedrock. Both banksides were bare of vegetation, with only moss able to survive the little light penetrating through the dense canopy. Within approximately 80 m of the first set of falls encountered, a much larger waterfall was recorded at (NX) 261064 586362 (*Figure 20*). This waterfall was considered to be impassable to fish, given its approximate height of 4 m and narrow/vertical chute-like formation.

*Figure 19: A series of waterfalls encountered within 50 m of Carsfad Loch*

*Figure 20: Looking downstream from the crest of an impassable waterfall, estimated to be over 4 m high*

Beyond the falls, some trout parr habitat was encountered in the form of a deep pool located beneath woody debris (*Figure 21*) at (NX) 261111 586358. The burn - inaccessible to livestock up until this point by stock exclusion fencing along both banks - widened and

became shallower to form a water hole located between two watergates at (NX) 261127 586333. Livestock, including cattle, were noted to have access to the burn at this point from a field on the left bankside. Upstream of the waterhole, some light began to penetrate through the dense canopy and for approximately 80 m length, the burn provided some mixed juvenile habitat (*Figure 22*) before narrowing and returning to bedrock composition at (NX) 261243 586276 where the survey ceased at the only point that the burn could be exited safely before entering a further, much narrower gorge. In total, approximately 350 m of the burn was surveyed.

*Figure 21: Good trout parr habitat lies beneath a build-up of woody debris*

*Figure 22: Light begins to penetrate through the canopy upon an 80 m stretch of mixed juvenile habitat*

### *3.2.3 Polmaddy Burn*

Over 4 km of the Polmaddy Burn was surveyed in an upstream direction from (NX) 260054 588007 where the burn enters the Water of Deugh near Dundeugh.

The survey commenced with a short 200 m section of fairly inhospitable water that traversed a number of small bedrock steps (*Figure 23*) before levelling out beneath the A713 road

bridge at (NX) 259868 588057. Instream habitat was composed entirely of bedrock, with some boulders. A mixture of broadleaved trees and mature pine trees partly lined the right bankside and most of the left bankside. This short reach of the river contained very little spawning substrate.

*Figure 23: The lowermost reaches of the Polmaddy Burn*

The river continued upstream in a similar fashion, including run/riffle habitat surrounding small bedrock steps that lay regularly within the first 100 m (*Figure 24*). Parr are likely to inhabit the river up to (NX) 259708 588011 which signified the top of this section where a small burn entered from the left bankside. An extensive conifer plantation lined the river here, situated over 10 m back from the left bankside. Parr habitat continued with the odd small deposits of pebbles and cobbles amongst bedrock. From a vantage point along the left bankside at (NX) 259670 588001, a natural falls of approximately 1 m high spanned the river, and was likely passable on the right bankside (*Figure 25*). When viewed along its side profile from the left bankside (*Figure 26*), the falls were estimated to be around 1 m high by 15 m wide. A shallow and wide bypass channel (*Figure 27*) would likely assist migrants wishing easier transfer to above the falls, however, this channel was likely to dry up during low water/summer flows. Approximately 50 $m^2$ of salmon spawning material (cobble/pebble) was present within the bypass channel – all of which had an algal coating.

*Figure 24: Regular sections of run/riffle habitat lie within the first 100 m upstream of the A713 road bridge*

*Figure 25: A 1 m high section of falls*

*Figure 26: The falls viewed side-on from the left bankside*

*Figure 27: A wide by-pass channel containing spawning habitat*

From (NX) 259659 587947, located upstream of the falls, an exposed area of vegetated boulders would provide good instream parr refuge under higher flows. Parr habitat continued up to (NX) 259468 587930 where a mass of bedrock situated along the right bankside caused a flow constriction that provided run/riffle habitat. A sequence of glide sections containing boulders leading into small natural falls/flow constricted areas continued for a further 150 m up to (NX) 259322 587896 (*Figure 28*) – beyond which the banksides were too steep to access safely to view the watercourse beneath the footbridge at (NX) 259245 587913. This 70 m section would benefit from a drone survey to quickly uncover if a significant set of falls is located within the inaccessible area of the gorge.

*Figure 28: The burn becomes inaccessible by foot as the left bankside significantly steepens*

The survey continued from upstream of the footbridge, with bedrock still the predominate feature instream. As the channel reached a left hand bend at (NX) 259138 587839, the burn widened into a straight section, with deep water and a cobble base providing good cover for parr. Small deposits of gravel lay close to the left bankside. Towards the top end of the glide, the substrates appeared to be compacted. This is likely to be caused by run off from commercial forestry – the main landuse within this catchment.

At the end of the straight, the channel changed course and headed around a right-hand bend, where a vegetated island lay adjacent to the left bankside (*Figure 29*). A deposit of gravel approximately 100 $m^2$ in area lay downstream of the island at (NX) 259175 587757, and was the first encounter with spawning habitat within this section. On the other side of the island, the channel deepened. Substrates that were visible in this area lay amongst silt. At (NX) 259165 587672, the channel widened further through a very unstable section of pool and glide containing a mixture of fine compacted substrates. At the top end of the pool, two islands split the river into three channels (*Figure 30*). The three channels provided areas of run and riffle and on closer inspection, generous deposits of gravel could be seen upstream and downstream of each island (*Figure 31*) at (NX) 259124 587602. An area of wetland extended 20 m out with the right bankside of the pool beneath the three islands.

*Figure 29: A long, thin, vegetated island lies adjacent to the left bankside*

*Figure 30: The river splits into three channels around two islands at the top of a pool*

*Figure 31: Looking downstream from above the islands; large deposits of gravel lie upstream and downstream of the islands*

A short distance upstream of the islands, the channel narrowed and became enclosed by a dry stone dyke along its right bankside. Mixed juvenile run/riffle habitat continued over a 100 m stretch of river from (NX) 259089 587567 to a right hand bend at (NX) 259001 587579. By now, the burn was approximately 10 m wide and continued to provide run/riffle habitat for a further 100 m (*Figure 32*) where spawning substrates lay in abundance.

*Figure 32: Good quality spawning habitat*

Instream habitat began to change from mixed juvenile to parr habitat from (NX) 258910 587659, as boulders featured more densely. Spawning habitat arose at the tail end of each glide section (*Figure 33*). A 1 m wide burn entered along the right bankside here (*Figure 34*). Passage of trout into this burn is likely to be obstructed by a fallen tree at the junction with the main river.

*Figure 33: Spawning habitat follows a section of glide*

*Figure 34: A narrow tributary that may provide spawning habitat for brown trout*

A series of large boulders traversed the river at the top of this section at (NX) 258884 587764 (*Figure 35*), above which there lay a 100 $m^2$ area of spawning habitat. The burn, approximately 15 m wide, continued for around 50 m, providing mixed juvenile habitat with deposits of gravel visible beneath each boulder (*Figure 36).* Conifer regeneration was present along the right bankside.

*Figure 35: Large boulders have been artificially placed across the river*

*Figure 36: An area of mixed juvenile habitat*

The burn began to climb from (NX) 258808 587835 with small bedrock falls a feature over the next 150 m (*Figure 37*). Fine pockets of gravel lay throughout this section with the largest area of 50 $m^2$ being recorded adjacent to where the conifer forestry met the river along the left bankside. Small birch trees lined the right bankside in this section and boulders began to feature as well as bedrock. From (NX) 258734 587923, bedrock continued to feature and conifer forestry now lined both banks (*Figure 38*). Parr habitat continued for a further 100 m with some mixed juvenile habitat returning as placement of boulders captured small pockets of gravel. The river, approximately 10 m wide, now rose through a series of boulders at (NX) 258492 588186. Here, upon the right bankside, conifer regeneration was present.

*Figure 37: The river steadily rises over bedrock and between a series of shallow flow constructions*

*Figure 38: The river is lined by conifer forestry on both banks*

At the tail end of a pool at (NX) 258387 588302, a 10 m by 100 m area of clean spawning gravels were visible in shallow riffle (*Figure 39*). This area marked a change in habitat away from a predominately boulder and bedrock substrate base to >1 km length of river that provided areas of excellent spawning substrates between good mixed juvenile holding water. Lovely run/riffle sequences of water lay throughout this section (*Figure 40*). Of particular interest, was a 300 m stretch of shallow pool and glide water where the conifer plantation sat over 30 m back from the left bankside. A clean bed of gravel, pebbles and cobbles visible here would provide good spawning habitat for salmon if they were present in the catchment (*Figure 41*). However, deep holding water may be a limiting factor to adult fish residing in this particular stretch and upon viewing the clear and still water; no fish were observed.

*Figure 39: Clean spawning habitat at the tail end of a pool*

*Figure 40: A long section of run/riffle habitat*

*Figure 41: Clean substrates are visible within a section of shallow glide and run/riffle habitat*

Upstream of the shallow 300 m section, an area of mixed juvenile habitat was located at (NX) 257969 588471 where a drystone dyke neared the watercourse from the left bankside. Conifer forestry aligned the watercourse once more along the left bankside and clear-fell filled the riparian zone along the right bankside. Shallow glide and run flow types featured with fine gravel - providing spawning opportunities particularly for trout (*Figure 42*) at (NX) 257744 588743. Conifer regeneration was present along this length. Adult holding water existed within a 75 m stretch of glide/pool water beginning at (NX) 257705 588721. Instream habitat was much more stable here with moss covering substrates at the tail end of a pool (*Figure 43*). Mixed juvenile habitat recommenced from (NX) 257627 588684.

*Figure 42: Small spawning substrates particularly suited to trout*

*Figure 43: Moss attached to instream substrates suggest the river is much more stable in this section*

At (NX) 257477 588704, a track neared the river on the right bankside before conifer forestry began to encroach on both banks. Instream habitat was now more suited to parr and adult fish as the channel gently rose in gradient and became dominated by bedrock substrate. Situated within dense forestry, the channel split around an island (*Figure 44*), and upon negotiating the left bankside channel of the watercourse, the bankside became suddenly steep which signalled the entrance to Drumness Linn. On climbing the steep left bankside, a significant section of waterfalls at (NX) 257346 588757 could be seen (*Figure 45),* which despite being unable to view at close proximity; appeared to be impassable under the survey flow. The survey terminated a short distance upstream of the falls where the burn levelled out and an access track could be located to join the forestry road at (NX) 257222 588647. The burn continued upstream for 1.5 km before passing under a forestry road bridge. From here, it runs alongside conifer forestry for over 6 km, arising within the hillside of Craignelder.

*Figure 44: A burn weaves around an island as it enters Drumness Linn*

*Figure 45: A significant set of (impassable) falls lie at the top of Drumness Linn*

### *3.2.4 Water of Deugh – Carsfad Loch to Bridge at Dundeugh*

Approximately 1.1 km of the Water of Deugh was surveyed in an upstream direction from where the river joins the upper reaches of Carsfad Loch, to upstream of the junction with the Polmaddy Burn.

On the day of surveying, electrical generation was being undertaken at Kendoon Power Station. As such, surveying commenced from the right bankside at (NX) 260533 587272, where the river could be safely walked but not entered (due to deep and potentially fast-flowing water). Across the first 350 m of its length, the river consisted of deep pool, containing limited production habitat for salmonids. The river remained inaccessible beneath its junction with the Kendoon Power Station outflow at (NX) 260420 587524 (*Figure 46*) and only from (NX) 260394 587604 could the watercourse be accessed beneath a suspension bridge (*Figure 47*). Covering a 50 m section of river upstream to the footbridge, the instream habitat was largely composed of bedrock, and this continued for a further 100 m length upstream. Water depth was notably limiting to salmonid production with only shallow pool and glide present.

*Figure 46: Looking upstream to the Water of Deugh and Water of Ken junction*

*Figure 47: A section of bedrock within the lower Water of Deugh*

However, by (NX) 260272 587684, parr habitat began to appear with the introduction of cobbles and boulders into the watercourse. Tiny pockets of gravel also began to appear within this 50 m section and accompanied by run and riffle flow types; limited mixed juvenile habitat existed between the bedrock. From (NX) 260240 587720, parr habitat in the form of boulders and cobbles lay within a large section of shallow glide (*Figure 48).* Bedrock continued to feature spanning from both banksides within a further 100 m stretch of the river. By (NX) 260125 587850, the river began to narrow to approximately 8 m wide, and some run/riffle water emerged as the watercourse became constricted between masses of bedrock (*Figure 49*). As the river rose in gradient, faster flows were more readily observed but instream habitat was largely composed of bedrock - making it very limiting to salmonid production. By (NX) 260054 588007, beyond its junction with the Polmaddy Burn; the Water of Deugh dried up significantly (the consequence of upstream water transfer activities by the Galloway Hydro Scheme between the Deugh and Ken catchment). Here, the survey section terminated where the main limiting pressure of water shortage within this part of the Deugh catchment could be seen (*Figure 50*).

*Figure 48: An area of good parr habitat*

*Figure 49: River flow improves as the channel is constricted through a section of bedrock*

*Figure 50: The river is notably starved of water upstream of its junction with the Polmaddy Burn*

### *3.2.5 Water of Ken – Carsfad Dam to Earlstoun Loch*

The Water of Ken was surveyed in a downstream direction for approximately 1.3 km, from downstream of Carsfad Dam at (NX) 260586 585282, to a Linn at (NX) 260651 584205.

The survey began within an area of approximately 15 m wide by 35 m length of river containing good parr habitat, with boulders and bedrock visible above the surface of the water (*Figure 51*). A long slow-flowing pool then continued downstream for approximately 150 m to (NX) 260564 585168. The pool (*Figure 52*) offered limited use to fish other than holding water for adults. The river continued through a small area (~25 m x 30 m) of large boulders suitable for parr habitat between (NX) 260572 585165 and (NX) 2605558 585145 before returning to pool again with a cobble/boulder bed. The pool was approximately 35-40 m wide by 150 m long. At the tail end of the pool ((NX) 260529 585003)), substrate was comprised mostly of bedrock (*Figure 53*) covering an area of mixed juvenile habitat. The section ended adjacent to a road layby.

*Figure 51: Parr habitat lies beneath Carsfad Dam*

*Figure 52: Adult fish-holding water*

*Figure 53: Bedrock begins to dominate substrate composition*

The river continued downstream consisting mostly of boulders with very little substrate movement evident. The channel was approximately 40 m wide although the flow was concentrated to a much narrower section. *Figure 54* pictures the channel looking in an upstream direction from (NX) 260543 584899. Bedrock and boulders created good parr habitat in this section. From here, the channel expanded to approximately 50 m wide with a wetted width of 15 to 30 m. No spawning or juvenile habitat existed in this area of the river. A small stand of Japanese Knotweed was present on the right bankside at (NX) 260501 584725. A 70 m long by 15 m wide pool at (NX) 260463 584630 marked the end of this section. A 10 m section of the left bank was eroded (*Figure 55*). From the tail end of the pool, good quality juvenile habitat existed across a 200 m by 12 m section from (NX) 260432 584566 to the outflow of the Polharrow Burn.

*Figure 54: Looking upstream towards Carsfad Dam, vast sections of bedrock can be seen constricting flows towards the left bankside*

*Figure 55: An area of bankside erosion upon the left bank*

The Polharrow Burn entered into the river within a large deep pool at (NX) 260369 584402, estimated to be 100 m long by 40 m wide (*Figure 56*). From the tail end of the pool at (NX) 260421 584318, a substrate base of boulders and bedrock provided good parr habitat (*Figure 57).* There was no fry or spawning habitat within this section.

The river began to fall through a section of bedrock, eventually turning a corner where it entered into a deep pool (*Figure 58*) lined entirely with bedrock at (NX) 260594 584288. Immediately downstream, the river descended into a gorge (*Figure 59*) which marked the entry to the Craig Linn at (NX) 260651 584205 to which the survey was terminated. The river was concentrated through a 1 m width section of the Craig Linn on the day of survey.

*Figure 56: A large deep pool is located at the entry to the Polharrow Burn*

*Figure 57: Parr habitat at the tail end of the pool*

*Figure 58: A deep pool lined with bedrock*

*Figure 59: Upstream of the entry to Craig Linn*

### *3.2.6 Polharrow Burn*

The Polharrow Burn was surveyed in an upstream direction, for a length of approximately 2.5 km, from (NX) 260082 584467, upstream of the old A713 road bridge, to (NX) 258542 585319 where a substantial set of natural falls was encountered.

The survey commenced upstream of the old A713 road bridge, upstream of a historical electrofishing site where salmon and trout are both regularly recorded. The burn at this point was lined on both banks with mixed broadleaved trees and was unfenced and opens into rough pasture on its right bankside and arable pasture on its left bank before broadleaved woodland was met (over 100 m from bankside). Instream habitat throughout the first 50 m stretch of river was mixed juvenile, with run and riffle flow types featuring (*Figure 60*). A small area of spawning habitat of approximately 4 $m^2$ lay adjacent to the left bankside at (NX) 260293 584426, as a gradual bend in the channel was met. From here, the burn became deeper, with pool and glide flow types featuring. The burn was approximately 12 m along this length. Woody debris was noted at (NX) 260244 584455, presenting ideal sheltering habitat for trout parr. The burn gently weaved to the right at (NX) 260107 584464 where there was a slight break into faster glide. A short distance upstream, began a 50 m long section of juvenile habitat from (NX) 260080 584470, leading up to a slight passable flow constriction of approximately 5 m width at (NX) 260035 584488. Beyond this, the burn returned to deep holding water (adult fish habitat), consisting of glide flow. At (NX) 259808 584516, approximately 20 m stretch of the burn presented mixed juvenile habitat upon a slight bend. Thereafter, at (NX) 259780 584500 at the tail end of a pool, approximately 25 $m^2$ of fine spawning material was encountered. The river continued in glide and a small island sat towards the left bankside where a 15 m length and 45 $m^2$ area of small gravels, suited to trout spawning, lined the inside channel. During low water and prolonged dry weather, the channel may become dry. At (NX) 259702 584504, a more significant area of spawning and juvenile habitat was encountered, covering approximately a 20 m length by 7.5 m width of the river, lying adjacent to a centrally located gravel bar (*Figure 61).* Furthermore, a particularly good area (approximately 100 $m^2$) of salmon spawning habitat was present at the tail end of a glide section at (NX) 259670 584520. A well-vegetated retainer bank was noted to run over 5 m back from the left bankside. At (NX) 259620 584540, approximately 15 $m^2$ of limited spawning, mixed juvenile and glide habitat was present before the river began to widen.

*Figure 60: Run and riffle habitat within the first 50 m of burn surveyed*

*Figure 61: An area of spawning and juvenile habitat*

The river appeared to branch and form a narrow second channel along the right bankside. Bank erosion was evident along the left bankside in this predominantly parr water. At (NX) 259555 584598, a 20 m length of the river contained fry/spawning habitat, leading into parr habitat (*Figure 62).* This led into an area of river containing a bedrock step, where there was a shallow flow constriction (passable) at (NX) 259489 584615 (*Figure 63*). The river continued in glide with some mixed juvenile habitat instream. A quad bike track ran adjacent to the river at this point. As the river gradually turned to the left, there was a small area of riffle and parr habitat (mixed juvenile) at (NX) 259370 584674 (*Figure 64*), changing to glide and run flows with some spawning material at the tail end of the glide. Spawning was patchy throughout this section but more substantial at (NX) 259262 584657 at the tail end of a glide section and downstream of where the Crummy Burn entered the river (*Figure 65*). For a short section of river upstream of the Crummy Burn inflow, the river turned to predominately glide flow but maintained mixed juvenile habitat instream including some patchy spawning matter.

*Figure 62: A 20 m length of fry/spawning habitat*

*Figure 63: A (passable) flow constriction*

*Figure 64: A lovely area of juvenile and spawning habitat*

*Figure 65: Spawning habitat downstream of the junction with the Crummy Burn*

From (NX) 259189 584674, glide flow type and parr habitat began to feature more heavily (*Figure 66*) and from around (NX) 259092 584741, the river noticeably changed with boulders and bedrock featuring heavily as the river climbed towards a passable bedrock step fall at (NX) 259006 584792 (*Figure 67*). Bedrock featured throughout an area that progressed to a flow constriction with turbulent water at (NX) 258965 584829. Parr habitat dominated this area of the river but from (NX) 258846 584885, some mixed juvenile water was present with glide. A section of stepping stones (*Figure 68*) traversed the river in an area of juvenile habitat. Thereafter, the river returned to glide/parr habitat with limited production up until (NX) 258685 585192. White water featured as the river fell through bedrock steps, culminating in a 1 m high obstruction at (NX) 258660 585232 (*Figure 69*). Although problematic to ascend in places, this obstruction was unlikely to cause adult fish any concerns in passing. Across the next 150 m or so, the river remained largely composed of bedrock, with an area of stepped habitat transferring the river upwards and beyond a large island of bedrock, positioned towards the right bankside (where a small side channel separated it from the bank – see *Figure 70*). Very little juvenile habitat existed in this stretch and the river was largely suited to parr throughout. Finally, at (NX) 258542 585319, a very large waterfall spanned the width of the channel (*Figure 71*). This significant obstruction was likely to be impassable to migratory fish.

*Figure 66: Parr habitat lies throughout a section of glide*

*Figure 67: Boulders and bedrock feature heavily on approach to a section of bedrock steps*

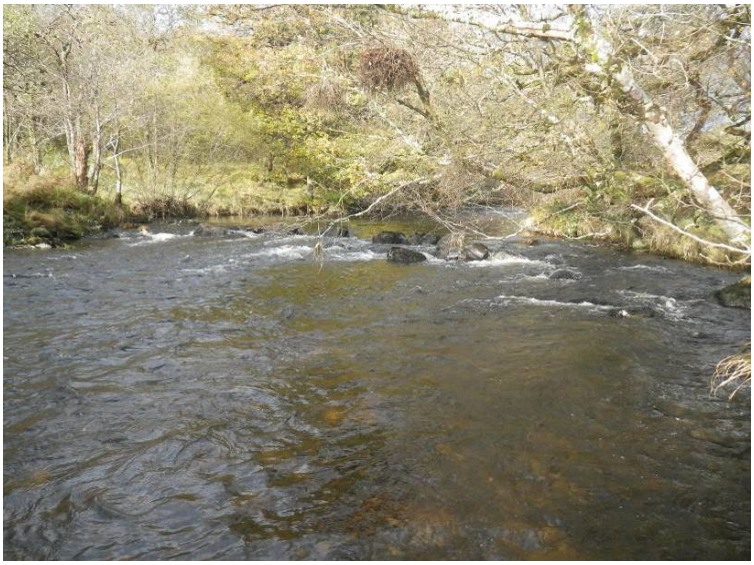


*Figure 68: Stepping stones create a feature between mixed juvenile habitat*

*Figure 69: A 1 m high obstruction at (NX) 258660 585232*

*Figure 70: A large island is situated along the right bankside within an area of parr* habitat

*Figure 71: A large waterfall located within Waukers Linn obstructs migratory fish from passing upstream*

### *3.2.7 Crummy Burn*

The Crummy Burn was surveyed from its point of entry into the Polharrow Burn at (NX) 259242 584616. Over the first 100 m length of the burn, instream habitat would provide for salmon production with a good run-riffle sequence of flow across a matrix of gravel, pebble and cobble bed (*Figure 72*). The burn, approximately 5 m in width, would provide around 300 $m^2$ of spawning habitat, leading into mixed juvenile habitat from (NX) 259242 584575.

*Figure 72: Looking downstream upon the lower reaches of the Crummy Burn*

At (NX) 259252 584550, the burn began to rise, narrow and enter a gorge. With a base comprised mainly of bedrock, the burn provided very limited opportunities for spawning fish, except for some very small pockets of fine gravel that may have provided habitat for trout (*Figure 73*). Now with very steep banksides either side and narrowing to between 1 m and 3 m, the burn continued with a series of stepped falls leading eventually to an impassable fall of approximately >10 m high at (NX) 259222 584443 (*Figure 74*). Overall, the burn was a typical upland tributary that was heavily over shaded and likely to provide instream habitat for limited native brown trout production.

*Figure 73: Bare, steep banksides of the Crummy Burn*

*Figure 74: An impassable waterfall located approximately 200 m downstream of the road bridge*

# 4. DISCUSSION

## 4.1 Electrofishing sites

### *4.1.1 Site 1: Earlstoun Burn*

The Earlstoun Burn was electrofished within its upper reaches, downstream of Corseglass Bridge (*Figure 75*). A site of approximately 15 m length by 2.5 m width was timed electrofished for a duration of 5 minutes. Substrate cover was considered good, consisting of 25% gravel, 40% pebble, 30% cobble and 5% boulder. Flows were noted to be mostly deep glide and run types. Bankside cover, provided by draped vegetation, was between 60% and 80% on both banks. The riparian zone contained tall herbs and overall land use was recorded as upland rough pasture and conifer forestry.

*Figure 75: Site DKE1, looking upstream*

Salmon were not recorded at this site. Four trout fry and a single trout parr were recorded. No other fish species were present.

### *4.1.2 Site 2: Earlstoun Burn*

The Earlstoun Burn was electrofished within its middle reaches, upstream of a farm track near Ardoch Hill (*Figure 76*). A site of approximately 20 m length by 4 m width was timed electrofished for a duration of 5 minutes. Substrate cover was considered excellent, consisting of 20% gravel, 30% pebble, 40% cobble and 10% boulder. Areas of fast flowing water were surveyed (40% run and 60% torrent) upon two breaks. Bankside cover, provided by draped vegetation and undercuts, was only present along 20% of each back. The site was located within rough upland (sheep grazed) pasture. The burn did not appear to be under significant pressure from livestock grazing, however, a lack of trees to help stabilise the banksides, did appear to be exacerbating bankside erosion - visible within this section of the burn.

*Figure 76: Site DKE2, looking upstream*

Salmon were not recorded at this site. One trout fry and three trout parr were recorded. No other fish species were present.

### *4.1.3 Site 3: Earlstoun Burn*

The Earlstoun Burn was electrofished within its lower reaches, in an area of run and riffle habitat (*Figure 77*) upstream of the B7000 road bridge. A site of approximately 25 m length by 5 m width was timed electrofished for a duration of 5 minutes through good spawning habitat (40% cobbles and 60% pebbles/gravels). Undercut banks provided fish cover along 20% of the left bankside whilst the right bankside was bare. The burn was unfenced along the right bankside in a field containing light sheep grazing and lined with mature broadleaved trees along its left bankside (providing 50% canopy cover over the site).

*Figure 77: Site DKE3, looking upstream*

Salmon were not recorded at this site. Twelve trout fry and two trout parr (including one parr of 286 mm in length – *Figure 78*) were recorded. No other fish species were present.

*Figure 78: A beautiful trout parr caught in site 3*

### *4.1.4 Site 4: Earlstoun Burn*

The Earlstoun Burn was electrofished within its lower reaches, downstream of Earlstoun Bridge upon the B7000 road; mid-way across a cattle grazed field within the grounds of Earlstoun Castle. An area of 88.4 $m^2$ (*Figure 79*) was electrofished as a single-run (semi-quantitative) electrofishing survey. Substrate cover was considered good, consisting of 15% gravel, 30% pebble, 50% cobble and 5% boulder. The site steadily rose in gradient towards a pool, producing fast run and torrent flow types. Bankside cover was negligible with only bare rocks noted as lining each bankside. Landuse was considered rough pasture. Both banksides were unfenced and noted as susceptible to poaching pressure from cattle grazing.

*Figure 79: Site DKE4, looking upstream*

A single salmon parr was recorded at this site (*Figure 80*). This is the first GFT record of juvenile salmon to be found within the Earlstoun Burn. No trout were recorded. Two three-spined stickleback were also present.

*Figure 80: A single salmon parr found at site DKE4*

### *4.1.5 Site 5: Cleugh Burn*

The Cleugh Burn was electrofished within its lower reaches, upstream of Cleugh Bridge on the B7000. An area of 66.2 $m^2$ (*Figure 81*) was electrofished as a single-run (semi-quantitative) electrofishing survey. Substrate cover was considered good, consisting of 20% gravel, 30% pebble, 40% cobble and 10% boulder. Flows were fast run (70%) and riffle, with the burn gradually ascending around a bend towards a good break, upon which the site ended. Bankside cover was recorded across 50% of both banks, provided by draped vegetation and rocks. Landuse was considered rough pasture. Both banksides were unfenced and noted as susceptible to poaching pressures from grazing livestock.

*Figure 81: Site DKC1, looking upstream from Cleugh Bridge*

The burn was fishless. Only two small newts were recorded.

### *4.1.6 Site 6: Polmaddy Burn*

The Polmaddy Burn was electrofished upstream of a series of falls upstream of a footbridge near Polmaddie settlement (*Figure 82*). A site of approximately 40 m length by 8 m width

was timed electrofished for a duration of 5 minutes through a sequence of glide/pool and run/riffle habitat. Substrate cover was good with 30% pebble and 50% cobbles recorded amongst boulders and gravels. Bankside cover was present only along the right bank, where 10% cover was provided by draped vegetation and undercut banking. The riparian zone was considered tall herbs and rough pasture within a catchment managed primarily for conifer forestry.

*Figure 82: Site DKPol1, looking upstream*

Salmon were not recorded at this site. Seven trout fry and one trout parr were recorded. A single minnow was also recorded.

### *4.1.7 Site 7: Polmaddy Burn*

The Polmaddy Burn was electrofished downstream of a series of falls adjacent to a forest road upstream of Dundeugh bridge on the A713 (*Figure 83*). A site of approximately 20 m length by 10 m width was timed electrofished for a duration of 5 minutes in run/riffle and deep glide habitat. Substrate cover was good with 50% cobble and 30% boulder recorded. All substrates were noted to have a covering of algae which, by their slippery nature, delayed surveyors progress through the site. For this reason and due to low conductivity making it hard to hold fish; a couple of trout parr evaded capture. Bankside cover was good, with both banks densely lined with birch trees. The riparian zone consisted of mixed broadleaved trees against a backdrop of conifer forestry along the left bankside.

*Figure 83: Site DKPol2, looking upstream*

Salmon were not recorded at this site. One trout fry and two trout parr were recorded. Five minnows were also recorded.

### *4.1.8 Site 8: Polharrow Burn – McAdams Burn*

The McAdams Burn was surveyed a short distance upstream of its confluence with the Mid Burn (*Figure 84*). A site of approximately 30 m length by 4.5 m width was timed electrofished for a duration of 5 minutes in shallow run/riffle and glide habitat. Instream cover was considered to be good; with 50% cobbles and 30% pebbles recorded amongst a small amount of boulders and gravels. However, bankside cover was lacking with both banks being recorded as 100% bare. Conifer forestry was present <5 m back from the left bankside whilst conifer regeneration existed along the right bankside. Water conductivity was recorded as low, which made it hard to capture fish.

*Figure 84: Site DKP1, looking upstream*

Salmon were not recorded at this site. A total of five trout fry and four trout parr were caught at this site. No other fish species were present.

*4.1.9 Site 9: Polharrow Burn – Mid Burn*

The Mid Burn was surveyed a short distance upstream of its confluence with the McAdam Burn (*Figure 85*). A site of approximately 20 m length by 5 m width was timed electrofished for a duration of 5 minutes through gently sloping run and riffle habitat downstream of a forest road bridge. Instream cover was considered excellent, with 60% cobbles and 10% large boulders recorded. The burn was completely over shaded with conifer trees planted <5 m back from each bankside. Low conductivity recorded at this site made it difficult to hold fish.

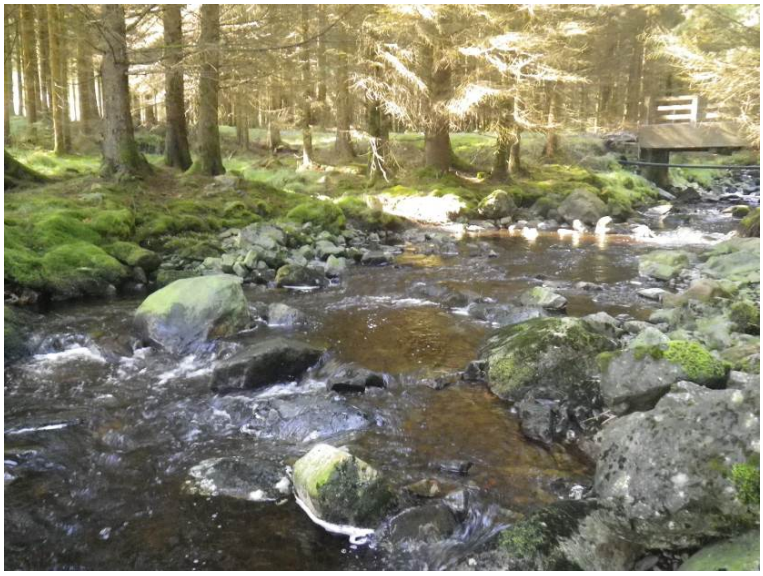


*Figure 85: Site DKP2, looking upstream*

Salmon were not recorded at this site. Trout parr (four in total) were the only fish captured at this site. A single trout parr was lost.

*4.1.10 Site 10: Polharrow Burn – Burnhead Burn*

McAdams and Mid Burn join to form the Burnhead Burn – which is one of two tributaries that create the Polharrow Burn. The Burnhead Burn (*Figure 86*) was surveyed within the forest, adjacent to the road and car park at Burnhead Bridge. A site of approximately 40 m length by 5 m width was timed electrofished for a duration of 5 minutes through good shallow spawning habitat (gravel/pebble/cobble substrates) with run and riffle flows. The site was completely over shaded by birch trees and both banks were recorded as bare of vegetation.

*Figure 86: Site DKP3, looking upstream*

No salmon were recorded at this site. Although the water level was low to medium height and fairly fast flowing (ideal juvenile fish habitat) – no fish were seen escaping from the site and only a single trout fry was captured during the five-minute survey.

*4.1.11 Site 11: Polharrow Burn – Lumford Burn*

The Lumford Burn was surveyed downstream of Fore Bush and downstream of a power house that is part of a hydro scheme operating on the burn. A site of approximately 60 m length by 7 m width (*Figure 87*) was timed electrofished for a duration of 5 minutes through fast flowing run and torrent water formed mainly from the power house discharge water. Substrates were dominated by mobile gravels and there was evidence that dredging activities have taken place within this site to clear excess gravel build up. Both banks were recorded as 100% bare of vegetation. No tree cover was present at this site.

*Figure 87: Site DKP4, looking upstream towards the Power House*

No salmon were recorded at this site. A single trout fry and a single trout parr were captured at this site. No other fish species were recorded.

*4.1.12 Site 12: Polharrow Burn – Lumford Burn*

The Lumford Burn was surveyed upstream of the bridge near the carpark at the Forest Lodge (*Figure 88*). A site of approximately 30 m length by 5 m width was timed electrofished for a duration of 5 minutes through fast riffle and torrent flows. Substrates were dominated by cobble (50%) with finer spawning materials (gravels and pebbles) accounting for 30% of cover recorded. Boulders and bedrock also featured. Both banks were recorded as bare of vegetation but the surrounding forest containing mixed broadleaved trees, contributed overhanging boughs across 80% of the left bank and 60% of the right bank – altogether providing a canopy cover of 60%.

*Figure 88: Site DKP5, looking upstream*

No salmon were recorded at this site. Although the water height was considered to be too fast to effectively capture fish; only a couple of parr were seen to evade capture. Overall, two trout fry and one trout parr (*Figure 89*) were recorded.

*Figure 89: A trout parr of 195 mm length captured from site DKP5*

*4.1.13 Site 13: Polharrow Burn*

The upper Polharrow Burn was surveyed upstream of a road bridge close to the Forest Estate Office (*Figure 90*). A site of approximately 30 m length by 8 m width was timed electrofished for a duration of 5 minutes through a deep, fast-flowing channel, largely consisting of bedrock underfoot (70%) with loose scatterings of cobbles, pebbles and gravels. Overhanging vegetation, undercut bankings and roots provided bankside cover of between 25% and 30% on both banks. Birch trees overhung 60% of both banks. These trees outreached a distance into the main channel to provide a canopy cover of 60% across the entire site.

*Figure 90: Site DKP6, looking upstream*

Salmon were not recorded at this site. Due to the depth of water, its fast flow and the precarious substrate base (mostly bedrock); electrofishing was confined towards the right bankside where only three trout parr were captured.

*4.1.14 Site 14: Polharrow Burn*

The Polharrow Burn was surveyed around 400 m downstream of Knockreoch Bridge, upon an area of shallow run/riffle habitat which presented good salmonid spawning habitat (*Figure 91*). A site of approximately 20 m length by 7 m width was timed electrofished for a duration of 5 minutes through optimal fast flowing spawning habitat at the tail end of a pool. The site fell upon the right bankside of an island, upon which birch trees overhung the left bankside.

*Figure 91: Site DKP7, looking upstream*

No salmon were recorded at this site. No fish were captured within the run/riffle habitat at the tail end of the pool. However, upon a quick investigation into habitat beneath the left bankside upstream of the site, two trout fry were captured.

*4.1.15 Site 15: Polharrow Burn*

The Polharrow Burn was surveyed downstream of a significant set of falls at Waukers Linn (*Figure 92*). A site of approximately 20 m length by 12 m width was timed electrofished for a duration of 5 minutes through deep glide. Only the right bankside of the channel could be fished given the deep water height and underlying substrates (65% bedrock and 10% boulders). Some fine gravels featured along the right bankside. A small riffle area existed at the downstream end of the site. This was also fished but was positioned upon bedrock (and therefore unsuitable for spawning). Overhanging Birch and Rowan trees provided a canopy cover of 30% over the site.

*Figure 92: Site DKP8, looking upstream*

Salmon were recorded at this site (*Figure 93*). Three were captured during the survey. All were parr. Two trout fry and a single trout parr were also recorded. No other fish species were present.


*Figure 93: Two healthy looking salmon parr and two trout fry captured in site DKP8*

*4.1.16 Site 16: Polharrow Burn – Crummy Burn*

The Crummy Burn was surveyed upstream of Crummy Bridge. High water level on the day of survey limited the survey technique that could be adopted and as a result, only a presence/absence survey could be undertaken. Despite the high-water level, three trout fry were captured. No salmon were found at this site.

*4.1.17 Site 17: Polharrow Burn – Crummy Burn*

The Crummy Burn was surveyed 50 m upstream of its junction with the Polharrow Burn (*Figure 94*). A site of approximately 20 m length by 5 m width was timed electrofished for a duration of 5 minutes through excellent salmon spawning habitat, containing a great mixture of flows and instream habitat (35% cobbles, 30% pebbles and 20% gravels). Although the site was quite over shaded by mature birch trees rooted into both banks; grass and bracken provided vegetation overhanging 20% of both banks.

*Figure 94: Site DKP10, looking upstream*

No salmon fry were recorded at this site. A single salmon parr was recorded. Six trout fry were recorded and two trout parr (including one parr of 292 mm in length – *Figure 95*). A dozen minnows were the only other fish species recorded at this site.

*Figure 95: A beautiful trout parr captured within site DKP10*

*4.1.18 Site 18: Polharrow Burn*

The Polharrow Burn was surveyed in a beautiful part of the river, upon a deep area of run and riffle downstream of the Crummy Burn inflow (*Figure 96*). A site of approximately 10 m length by 12 m width was timed electrofished for a duration of 5 minutes through very fast flow (40% torrent). Instream habitat was not visible under the high flows, but felt mobile and of a good range of sizes including 40% cobbles and 5% boulders – particularly towards the middle of the channel. Bankside cover was recorded as between 30% and 60%, provided by overhanging vegetation. Broadleaved trees provided canopy cover across 15% of the site, with Elm and Rowan trees sporadically spaced along both banksides.

*Figure 96: Site DKP11, looking upstream*

Despite the medium to high flows at which the survey was carried out; a single salmon fry and four salmon parr were captured (*Figure 97*). A single trout fry and a parr (*Figure 98*) were also recorded. Three parr were seen evading capture. Two stoneloach were the only other fish species caught during the survey.

*Figure 97: Three very healthy salmon parr captured from within site DKP11*

*Figure 98: A large trout measuring 275 mm long caught in site DKP11*

*4.1.19 Site 19: Polharrow Burn*

The Polharrow Burn was surveyed upstream of the A713 road bridge and old track road bridge (*Figure 99*) close to a historical electrofishing site located downstream of the old track bridge. A site of approximately 20 m length by 13 m width was timed electrofished for a duration of 5 minutes through run and riffle juvenile salmon habitat containing 50% cobbles and 30% pebbles. Substrates were noted to be slippery, which delayed progress through the site. Both banks were recorded as bare of vegetation. Canopy cover, recorded as shading 60% of the site, was provided by mature birch trees – one of which had fallen into the site, providing woody debris refuge for fish along the left bankside.

*Figure 99: Site DKP12, looking upstream*

Ten salmon fry and 10 salmon parr were recorded at this site (*Figure 100*). Four trout fry were recorded at this site but no trout parr. Minnows were the only other fish species recorded at this site.

*Figure 100: A well-fed salmon parr lies between four slender looking salmon parr and below three salmon fry – all captured within site DKP12*

*4.1.20 Site 20: Glen Strand*

The Glen Strand was surveyed a short distance upstream of where it passes via a long culvert, beneath the A713 that runs adjacent to the West side of Earlstoun Loch. A series of steps marked the entry to a narrow culvert; above which the burn was overgrown with only a couple of small pools accessible to survey by electrofishing (*Figure 101*). As such, a presence/absence survey was undertaken where the bedrock could be negotiated safely.

*Figure 101: Site DKG1, looking upstream*

No fish were recorded at this site.

## 5. SUMMARY AND RECOMMENDATIONS

### 5.1 Electrofishing Data

Stocking of juvenile salmon (eyed ova or fed fry) has been undertaken within the upper Kirkcudbrightshire Dee catchment since beyond 2001, when the first electrofishing monitoring of stocking sites was undertaken by GFT (**APPENDIX 2**).

The Polharrow Burn, which maintains a wild population of salmon, has been stocked with salmon in the past – mostly within its upper reaches. The last known stocking to have taken place on the Polharrow Burn was over five years ago and overall, very little stocking has taken place across the entire catchment in the last three years. Stocking has also been undertaken in the upper catchment within the Water of Ken (2005 and 2007) and Polmaddy Burn (2008).

Historical data (**APPENDIX 2**), shows that salmon have been regularly recorded within the Polharrow Burn (2004, 2006, 2007, 2008, 2009, 2010, 2011, 2015, 2017 and 2018), mostly within the very bottom of the burn in a site upstream of the A714 road bridge. Results from historical electrofishing data gathered from the Polmaddy Burn (2004, 2008 and 2017), show that wild salmon have never been recorded within the burn (only trout). Data obtained from the Cleugh Burn (2004), Earlstoun Burn (2004) and Water of Ken (2015 and 2016) all indicate that salmon do not utilise these parts of the upper catchment.

From the 20 electrofishing sites surveyed as part of this report (**APPENDIX 1**); juvenile salmon were found in low to moderate densities at five sites (four sites downstream of a large natural waterfall on the Polharrow Burn and a single site within the lower Earlstoun Burn). This confirms that salmon distribution is likely to be confined to watercourses that lie in close proximity to Earlstoun Loch. Juvenile trout were found at 17 sites; and two sites were fishless. The finding of salmon parr within the Earlstoun Burn was the first GFT record of salmon presence within this watercourse.

### 5.2 Habitat Data

The Polharrow Burn, Polmaddy Burn, Earlstoun Burn, Cleugh Burn and Water of Ken were surveyed on foot to assess their spawning potential for salmon.

In general, all of the watercourses would benefit from the introduction of woody debris in key locations to improve habitats for fish. There are many well used and simple techniques to introduce and anchor woody debris which are known to produce many environmental benefits particularly for fish.

The Earlstoun Burn contained spawning habitat across approximately 500 m of its lower reaches from (NX) 262036 583372 upstream. After which, the burn becomes more gorge-like; eventually meeting a waterfall which is likely to be impassable to salmon. Within the 500 m length of the burn which is favourable to salmon production, bankside erosion was evident. This pressure could be addressed by placing stock exclusion fencing along both banks to prevent further damage by livestock (and in particular – trampling by cattle). This section of the burn could also benefit from broadleaved tree planting along the banksides to help stabilise the banks and provide shade and encourage terrestrial invertebrates (food matter) into the burn. Further habitat works that could be undertaken to encourage salmon to utilise the burn further include debris blockage removal and management of woody debris. The upper reaches of the burn, although most likely inaccessible to salmon; provide a fantastic range of habitats for resident trout populations and these fish would benefit significantly from habitat improvement works to help stabilise the banksides where active erosion was recorded.

The Cleugh Burn was fairly inhospitable to fish production in its lower reaches and impassable to salmon only a short distance from its entry to Carsfad Loch. No habitat improvement works would be advisable to help encourage salmon to utilise the burn, but it would be interesting to further investigate brown trout production within the burn upstream of the road bridge where there is good spawning habitat but no fish recorded within the current surveys.

The lower reaches of the Polmaddy Burn did not contain suitable spawning substrates and only isolated sections of spawning habitat existed from between the A713 road bridge and footbridge at Polmaddie settlement. From Polmaddie settlement, production potential of instream habitat increased dramatically, with long sections of spawning and mixed juvenile habitat present up to an impassable falls at Drumness Linn. Habitat improvement works to encourage salmon utilisation of the burn are limited; mainly because access to the burn is restricted by water management (the lack of water) where the burn joins the Water of Deugh. The section of river which joins the Polmaddy Burn to the Water of Ken at Kendoon does not appear, under the present water management regime, to provide sufficient depth of water and attraction flow to encourage salmon to ascend towards the Polmaddy Burn. Furthermore, once within the Polmaddy Burn, it is a significant distance for salmon to travel to where spawning potential increases. However, to confirm that salmon are not already utilising the best production areas of the burn; further presence/absence or timed electrofishing surveys should be undertaken. It is also advisable that a drone survey is undertaken in the final section of the gorge, beneath the Polmaddie settlement footbridge; to confirm that a significant set of falls is not already preventing upstream access into the best area of the river. Clearance of conifer regeneration may be beneficial along this burn but overall, the instream habitat is already very varied and provides unlimited spawning opportunities for salmon should they be able to access the burn upstream of Polmaddie settlement in future. The Polmaddy Burn is recognised as being at risk of acidification. It is recommended that water quality monitoring is undertaken to examine the pH of the burn particularly during high flow events in the winter and spring. Fish populations may be limited at present due to acid flushes killing eggs and young fish.

The Polharrow Burn contained large sections of deep glide within its lower reaches which would make good adult fish and parr holding water. Spawning potential of instream habitat was particularly good surrounding the Crummy Burn inflow, but from here, the burn contained a lot of bedrock which would limit the spawning potential of the burn significantly. In general, this is a beautiful and wild burn set within naturally reseeding broadleaved woodland with no obvious interference from agricultural or forestry practices in the lower reaches as far upstream as the impassable falls at Waukers Linn. Because salmon production is largely confined to this tributary of the upper Kirkcudbrightshire Dee catchment, it is imperative that conservation measures are strictly adhered to, to ensure the longevity of wild salmon production within the upper Kirkcudbrightshire Dee.

The Water of Ken, surveyed between Carsfad Dam and Craigs Linn, did not contain suitable habitat for salmon production. It is likely that the dam structure is impeding the natural movement of smaller substrates from upstream. The lack of gravels, pebbles and smaller cobbles will impact on salmon spawning opportunities and help explain the lack of fish found here in previous electrofishing surveys. Following the survey, discussions were held with DRAX who reported that in 2020 the operation of the dam was varied to flush some substrates through the dam which may help the situation. If this is insufficient then it may be feasible to introduce smaller substrates back into the river close to the foot of the dam. Below the dam there is large pool located at the entrance to Polharrow Burn, which appeared to contain a build-up of salmon smolts departing the upper river during the low water in spring 2020. The potential of smolt holding water and investigation into options for capturing smolts should be investigated further at this location and within the Polharrow Burn to help advise a smolt tracking study which is planned to be undertaken on the river shortly.

## 6. APPENDIX 1: RESULTS FROM TIMED (NO. FISH/MINUTE), AREA DELINEATED (NO. FISH PER 100 $M^2$) AND PRESENCE/ABSENCE (P/A) ELECTROFISHING SURVEYS UNDERTAKEN AS PART OF THE GALLOWAY GLENS UPPER DEE SALMON RESTORATION PROJECT

| Site Code | Watercourse | Site Location | Grid Reference | Survey Date | Presence Of Non-Salmonid Species* | Catch Per Unit Effort (no. fish caught/min), *Density per 100$m^2$* or Presence/Absence (P/A) of fish (no. fish) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Salmon Fry (0+) | Salmon Parr (1+ and older) | Trout Fry (0+) | Trout Parr (1+ and older) |
| DKE1 | Earlstoun Burn | Downstream Corseglass Bridge | 264176 585770 | 16/10/2019 | None | 0 | 0 | 0.8 | 0.2 |
| DKE2 | Earlstoun Burn | Upstream farm track near Ardoch Hill | 262420 583693 | 16/10/2019 | None | 0 | 0 | 0.2 | 0.6 |
| DKE3 | Earlstoun Burn | Upstream road bridge | 262295 583189 | 16/10/2019 | None | 0 | 0 | 2.4 | 0.4 |
| DKE4 | Earlstoun Burn | Within Earlstoun Castle grounds, upstream fallen tree | 262070 583310 | 03/09/2019 | St | 0 | >1** | 0 | 0 |
| DKC1 | Cleugh Burn | Upstream of road bridge | 261700 586295 | 03/09/2019 | None | 0 | 0 | 0 | 0 |
| DKP1 | Polharrow Burn | McAdams Burn - downstream bridge | 254570 585255 | 02/10/2019 | None | 0 | 0 | 1 | 0.8 |
| DKP2 | Polharrow Burn | Mid Burn | 254581 585361 | 02/10/2019 | None | 0 | 0 | 0 | 0.8 |
| Galloway_2341 | Polharrow Burn | Burnhead Burn – downstream of Mid Burn/McAdams Burn confluence | 254762 585521 | 31/07/2019 | None | 0 | 0 | 0 | >3.79** |
| DKP3 | Polharrow Burn | Burnhead Burn – within forest, adjacent to road | 255305 586190 | 02/10/2019 | None | 0 | 0 | 0.2 | 0 |
| DKP4 | Polharrow Burn | Lumford Burn – downstream of Fore Bush and Power House | 254698 586567 | 02/10/2019 | None | 0 | 0 | 0.2 | 0.2 |
| DKP5 | Polharrow Burn | Lumford Burn – upstream bridge at car park | 255272 586356 | 02/10/2019 | None | 0 | 0 | 0.4 | 0.2 |
| Galloway_2361 | Polharrow Burn | Downstream of car park, upstream of bend | 255606 586477 | 31/07/2019 | None | 0 | 0 | >0.97** | 0 |
| DKP6 | Polharrow Burn | Upstream bridge at Forest Estate Office | 256386 586542 | 22/10/2019 | None | 0 | 0 | 0 | 0.6 |
| DKP7 | Polharrow Burn | On slight bend, upon riffle | 257724 585667 | 22/10/2019 | None | 0 | 0 | 0.4 | 0 |
| DKP8 | Polharrow Burn | Downstream of falls | 258600 585297 | 22/10/2019 | None | 0 | 0.6 | 0.4 | 0.2 |
| DKP9 | Polharrow Burn (P/A) | Crummy Burn – upstream of road bridge | 259056 584261 | 03/09/2019 | None | A | A | P(3) | A |
| DKP10 | Polharrow | Crummy Burn – downstream of | 259248 | 16/10/2019 | M | 0 | 0.2 | 1.2 | 0.4 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Burn | falls | 584596 | | | | | | |
| DKP11 | Polharrow Burn | Downstream of Crummy Burn inflow | 259262 584632 | 16/10/2019 | SL | 0.2 | 0.8 | 0.2 | 0.2 |
| DKP12 | Polharrow Burn | Upstream of A713 Road Bridge and old bridge | 260297 584418 | 22/10/2019 | M | 2 | 2 | 0.8 | 0 |
| DKPol1 | Polmaddy Burn | Upstream of foot bridge to Polmaddie, upon bend | 259159 587862 | 22/10/2019 | M | 0 | 0 | 1.4 | 0.2 |
| DKPol2 | Polmaddy Burn | Downstream of falls | 259625 587930 | 22/10/2019 | M | 0 | 0 | 0.2 | 0.4 |
| DKG1 | Glen Strand (P/A) | Upstream of A713 road culvert | 260748 583647 | 03/09/2019 | None | A | A | A | A |

*SL = Stoneloach, M = Minnow, St = Three spined stickleback

*** Where a Zippin calculation could be carried out, 95% confidence limits are shown. Where only the number appears, a Zippin estimation could not be carried out. In these cases the number represents a minimum estimate of fish density per 100 $m^2$ of water.*

## 7. APPENDIX 2: RESULTS FROM HISTORICAL ELECTROFISHING SURVEYS UNDERTAKEN BY THE GFT ON MAIN STEM AND TRIBUTARIES OF THE UPPER KIRKCUDBRIGHSHIRE DEE CATCHMENT (2001 – 2018)

| Site Code | Watercourse | Site Location | Grid Reference | Survey Date | Presence Of Non-Salmonid Species* | Catch Per Unit Effort (no. fish caught/min), *Density per 100m²* or Presence/Absence (P/A) of fish (no. fish) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Salmon Fry (0+) | Salmon Parr (1+ and older) | Trout Fry (0+) | Trout Parr (1+ and older) |
| * | | Stocking Monitoring Sites Only | | 2001 | | | | | |
| * | | Stocking Monitoring, Skerrow, Water of Dee, Bow Burn | | 2003 | | | | | |
| | Nethercleugh Burn | | 261800 586300 | 28/09/2004 | | | | P | P |
| | Polharrow Burn | U/S Bridge | 260200 584400 | 28/09/2004 | 109.8 | 20.95 | 0.91 | - | 1.82 |
| | Polmaddy Burn | @ Dundeugh | 259400 587200 | 28/09/2004 | 81.4 | - | - | 6.14 | 2.45 |
| | Polharrow Burn | U/S Bridge | 257300 585800 | 18/10/2004 | 108.1 | - | - | 0.92 | 3.7 |
| | Earlstoun Burn | D/S Road Bridge | 262200 583200 | 18/10/2004 | | | | P | P |
| * | | Stocking Monitoring Sites Water of Ken, BWoD,Polharrow Burn | | 2005 | | | | | |
| | Polharrow Burn | | 257300 585800 | 2006 | | | | | |
| | Polharrow Burn | RRWF Monitoring U/S A713 | 260200 584400 | 2006 | 90.28 | >13.29 | >3.32 | - | - |
| * | | Stocking Monitoring Ken – Blackwater Burn | 264700 588650 | 2007 | | | | | |
| | Polharrow Burn | RRWF Site | | 15/08/2007 | 145.3 | 3.55 | 5.67 | 2.75 | - |
| | Polharrow Burn | At Forest Lodge | 255500 586300 | 07/11/2008 | | - | - | P | P |
| | | At Watson Bridge | 256500 586300 | 04/11/2008 | | - | - | p | P |
| | | D/S Watson Bridge | 256400 586550 | | 118.7 | - | 0.84 | 0.84 | - |
| | | 300m U/S Watson Bridge | 256300 586400 | 04/11/2008 | | | | Few Trout | |
| | | D/S Falls | 258600 585300 | 05/11/2008 | 183.0 | >1.09 | 6.01 | >5.46 | - |
| | | U/S Falls | 258400 | 05/11/2008 | | - | - | Few Trout | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 585400 | | | | | | |
| | | Between Bridge and Ford | 255250 586350 | 07/11/2008 | Minnows | - | - | Few Trout | |
| | | Near Forebush D/S Bridge | 254350 586700 | 07/11/2008 | Minnows | | | | |
| | | Lane Mannoch – inflow to Loch D/S Bridge | 252500 588300 | 28/11/2008 | | - | - | 1 Trout | |
| | | Mid Burn | 254000 585400 | 27/11/2008 | | - | - | P | P |
| | | | 255150 586000 | 27/11/2008 | | - | - | P | P |
| | | | 254700 585500 | 27/11/2008 | | - | - | P | P |
| | | Loch Dungeon Outflow | 252800 585100 | 27/11/2008 | | - | - | P | P |
| | | Hawse Burn | 251400 585200 | 27/11/2008 | Fishless | | | | |
| | | McAdams | 254450 584750 | 27/11/2008 | | - | - | P | P |
| (*?) | | U/S Forest Estate | 257350 585800 | 19/09/2008 | | P | P | - | - |
| | | RRWF Site | | 25/09/2008 | | 55.07 | 5.01 | 9.18 | 0.83 |
| * | Polmaddy Burn | | 259350 587900 | 19/09/2008 | | - | - | Few Trout | |
| | | | 256900 589150 | 02/12/2008 | | - | - | Trout | |
| | | | 252806 589801 | 28/11/2008 | | - | - | Trout | Trout |
| | | | 251300 589400 | 02/12/2008 | | Fishless | | | |
| | Polharrow Burn | RRWF Site U/S Bridge | 260250 584400 | 2009 | | 18.0 | 5.85 | 0.45 | 0 |
| | Polharrow Burn | RRWF Site | 260200 584400 | 2010 | | 13.41 | 4.19 | 0 | 0.84 |
| | Polharrow Burn | RRWF Site | 260250 584400 | 21/07/2011 | 153.7 | 12.36 | 9.76 | 4.55 | - |
| | Water of Ken | RH Branch @ Kendoon | 260283 587683 | 22/09/2015 | | - | - | P | P |
| | Water of Ken | RH Branch @ Kendoon | 260283 587683 | 12/10/2016 | | - | - | P | P |
| | Polharrow Burn | U/S A714 | 260331 584342 | 13/10/2015 | 115.2 | 17.355 | 4.339 | 6.074 | 0.868 |
| | Polharrow Burn | RRWF Site | | 27/09/2017 | 100.0 | 32.0 | 1.0 | 4.0 | 0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Polmaddy Burn | D/S Road Bridge | 259895 588018 | 20/09/2017 | | 0 | 0 | 5.797 | 3.865 |
| | Polharrow Burn | | 260331 584342 | 30/10/2018 | 116.5 | >11.16 | >13.7 | >0.85 | 0 |

*SL = Stoneloach, M = Minnow, St = Three spined stickleback

** Where a Zippin calculation could be carried out, 95% confidence limits are shown. Where only the number appears, a Zippin estimation could not be carried out. In these cases the number represents a minimum estimate of fish density per 100 $m^2$ of water.

## 8. APPENDIX 3: SFCC ELECTROFISHING METHODOLOGY

- **Introduction**

Electrofishing is a technique that is widely used in fisheries research. In order to ensure that the technique is used in a consistent way and collects comparable data, the SFCC have a protocol that is used by its members when undertaking electrofishing surveys. There are separate protocols dependent upon the type of survey being carried out.

- **Personnel**

As a standard, the SFCC protocol states that a minimum of three people are required for generator powered electrofishing operations for Health and Safety reasons.

- **Semi and Fully-Quantitative surveys**

Semi-quantitative electrofishing surveys allow population estimates with a low precision to be made. The simplest form of a semi-quantitative survey is a single run electrofishing survey, where the numbers of fish caught give a minimum estimate of the fish population density within the site, presented as fish per 100 $m^2$. This method is used to evaluate broad differences in fish populations where exact numbers are not required.

If a more accurate estimate of fish population density is to be made then fully-quantitative electrofishing surveys must be undertaken by depletion sampling. Here, an estimate of fish population is made by collecting fish from a series of electrofishing runs performed at the same site. The number of runs undertaken depends on the proportion of fish caught during each run (to limit runs to two; there must be a good depletion in fish caught between run one and run two). Under the SFCC protocol, surveyors have the opportunity to perform up to four electrofishing runs per site and an accurate population estimate will require that at least 30% of the fish within the site are caught during each run. Confidence limits for a given population estimate can be derived from this method.

- **Methodology**

Site selection is carried out prior to undertaking the electrofishing survey. The specific location of the survey site is assessed by surveyors whilst on site as there may be features within the river environment that naturally delineate the specific area to be surveyed. In cases where stop nets are not in use; a site is selected where a natural barrier forms the upstream end of the site (this is usually a set of falls or area where fish are likely to be deterred from easily passing upstream of).

Once the site has been selected, the electrofishing team will set up the equipment and begin fishing. As fish are attracted to the anode, they are swiftly removed from the vicinity of the electrofishing ring by the hand net operator and placed in a bucket of water. As the team moves through the site, in an upstream direction, any fish captured are placed in the bucket. When the upstream end is reached, the fishing run ends and the fish are kept in a clearly marked bucket for further processing. The water in the bucket is replenished to reduce stress due to de-oxygenation of the water. The bucket is placed in a shaded area to prevent temperature stress.

Before processing of the fish can begin, they are transferred into a bucket of anaesthetic, where they remain until no longer exhibiting signs of movement. They are then placed upon a wet measuring board and measured. Fork length measurements (the distance from the snout of the fish to the fork in its tail) are used as a standard way of measuring the fish.

Scale samples may also be taken at this time, by using either a pair of tweezers or a sharp knife to remove scales from a specific area on the fish. This is generally only suitable for large fry or parr. Using fish measurement alone, it is usually possible to clearly identify fry (0+) aged fish from parr (1+) aged fish due to a distinctive gap in fish found between the two age classes. Where this gap is not distinctive, it may be necessary to take a scale sample to determine with use of a microscope, the age class of the fish. Reading of scale samples is also useful if parr are to be individually aged (1+, 2+, 3+ etc). Once the fish have been processed, they are placed in a bucket of fresh water to recover. Once processing has been fully completed, the fish are released back into the river.

A habitat survey for the electrofishing site is recorded using SFCC protocol. Photographs of the site may be taken to allow the exact area of river to be identified in future surveys.

## 9. APPENDIX 4: SFCC GENERAL HABITAT SURVEY

- **Introduction**

The Scottish Fisheries Co-ordination Centre (SFCC) developed a general habitat survey method that addresses the needs of fisheries managers and researchers. It was specially developed to assess habitat for juvenile salmon and trout and not used to evaluate habitat for other fish species.

Although a full SFCC habitat survey (which involves surveying the whole river and its tributaries) was not undertaken, smaller but detailed general habitat surveys were undertaken at each electrofishing site.

The survey methodology takes into account many recording requirements and information gathered about river stretches using SFCC fish habitat survey protocol can be used by trained interpreters and within reason to:

- Evaluate quality of habitat for juvenile salmonids
- Identify the potential location of salmonid spawning gravels
- Identify stream stretches that would benefit from habitat improvements
- Target areas for stocking
- Identify and classify point pollution sources
- Identify and grade obstacles to fish migration
- Identify location and type of past channel/bank modifications

Juvenile salmonids have specific habitat requirements. For example, water quality, shelter, feeding territory and availability of food. Table A describes some basic habitat requirements for different life stages of salmon and trout. The precise habitat requirements for each species and life stage are extremely complex, and have therefore been simplified here.

*Table A: Age class habitat requirements of salmonids*

| Life stage | Salmon | Trout |
|---|---|---|
| Eggs/alevins | Golf ball to tennis ball sized substrate | Dependent on fish size:<br>Golf ball to tennis ball sized substrate for large brown trout and sea trout, pea to golf ball sized material for smaller trout. |
| Fry | Golf ball to tennis ball sized substrate, fast flowing, shallow broken water | Golf ball to tennis ball sized substrate, slow to medium flowing shallow water, often concentrated at stream margins. |
| Parr | Tennis ball to football sized substrate, fast flowing broken water, often slightly deeper than fry | Variety of substrate, undercut banks, tree roots, big rocks, deeper slower water. |
| Smolts | Unknown | Unknown |
| Adults | Deep pools | Deeper areas, sustained flow but not too fast, undercut banks, tree roots, good instream vegetation and large rocks. |

- **Data recording**

During the electrofishing survey, habitat survey data is collected on the following to obtain a full review of the suitability of fish habitat along a river system:

- Water depth
- Water flow type
- Instream characteristics
- Bankside characteristics
- Riparian vegetation
- Surrounding land use

Information may also be collected on potential causes of unsuitable habitat, particularly with a view to taking action against further degradation. Characteristics are collected such as:

- Bankside fencing and grazing
- Bankside erosion and collapse
- Pollution sources

- **Method**

The habitat survey is undertaken after electrofishing the site has been completed.

- **General definitions**

o *Instream cover*

At each site a subjective assessment was made of the instream habitat available for older (parr-aged) fish. This assessment graded instream cover present as none, poor, moderate, good or excellent.

- *None* - No cover; stream bed composed entirely of fine uniform particles (e.g. silt, sand, gravel, pebbles) or continuous hard surfaces (bedrock, concrete).
- *Poor* - Little cover; stream bed composed predominantly of fine to medium particles (e.g. gravel, pebbles and cobbles), little or no cover from aquatic vegetation.
- *Moderate* - Moderate cover; stream bed composed of a mix of substrate sizes (e.g. gravel to boulders) and/or with some areas of Good cover (e.g. pebbles, cobbles, boulders), which may or may not have some aquatic vegetation cover.
- *Good* - Good cover; stream bed composed predominantly of medium to large size substrate (e.g. pebbles, cobbles, boulders) and/or with some aquatic vegetation cover.
- *Excellent* - Excellent cover; stream bed composed predominantly of large size substrate (e.g. cobbles and boulders) and/or with extensive aquatic vegetation cover.

o *Site area*

The site length is taken along with wetted width, bed width and bank width at a representative number of points within the site. This gives a value for the area fished in order to calculate the Zippin (1958) estimate (number of fish per 100 $m^2$).

- *Water depths*

The survey stretch wetted are is recorded as percentage depths in six categories:

- <10cm
- 11-20cm
- 21-30cm
- 31-40cm
- 41-50cm
- >50cm

- *Substrates*

In each survey stretch the percentages of each substrate type is recorded. Substrate is always recorded from the point of view of fish cover.

- High organic - Very fine organic matter
- Silt - Fine, sticky, mostly inorganic material
- Sand - Fine, inorganic particles, <=2mm diameter
- Gravel - Inorganic particles 2-16mm diameter
- Pebble - Inorganic particles 16-64mm diameter
- Cobble - Inorganic particles 64-256mm diameter
- Boulder - Inorganic particles > 256mm diameter
- Bedrock - Continuous rock surface
- Obscured - Something obscuring substrates that cannot physically be moved

- *Flows*

Flow percentages of the survey stretch wetted are recorded.

*Table B: Flow percentages and descriptions*

| *Flow type* | *Description* |
|---|---|
| Still marginal | <10cm deep, still or eddying |
| Deep pool | >=30cm deep, water slow flowing, smooth surface appearance |
| Shallow pool | <30cm deep, water slow flowing, smooth surface appearance |
| Deep glide | >=30cm deep, water flow moderate/fast smooth surface appearance |
| Shallow glide | <30cm deep, water flow moderate/fast, smooth surface appearance |
| Run | Water flow fast, unbroken standing waves at surface, water flow silent |
| Riffle | Water flow fast, broken standing waves at surface, water flow audible |
| Torrent | White water, chaotic and turbulent flow, noisy and difficult to distinguish substrates |

- *Bankside cover*

For each bank the percentage of bank length creating physical cover for fish in the site is recorded under the following categories:

- *Undercut* - Fish cover provided by undercut banks.
- *Draped* - Fish cover provided by vegetation rooted on the river bank and draping on to the water surface.
- *Bare* - No cover for fish, or fish cannot get to the cover due to lack of water.

- *Marginal* - Fish cover provided by plants rooted in the stream bed (includes tree roots). Fully aquatic vegetation is excluded from this category.

- *Bank face vegetation*

For each bank the predominant vegetation structure on each bank face. Vegetation must be rooted on the bank face and/or overhanging the bank face. Information is characterised in the following categories:

- *Bare* - Predominantly bare ground (or buildings/concrete), <50% vegetation cover.
- *Uniform* - Predominantly one vegetation type, but lacking scrub or trees.
- *Simple* - predominantly 2-3 vegetation types, with or without scrub or trees, but including tall and short herbs (e.g. nettles and grasses).
- *Complex* - Four or more vegetation types which must include scrub or trees.

Vegetation type does not refer to which species of plant are present. Reference is made primarily to structural complexity (e.g. short grasses versus long grasses/nettles versus taller trees).

- *Overhanging boughs*

For each bank the percentage of bank length is recorded where there are branches from trees and shrubs rooted in the riparian zone overhanging the site.

- *Canopy cover*

The percentage of the site (wetted area) which is covered by overhanging branches is estimated.