Urban River Don Salmon Recruitment Assessment – Don Catchment Rivers Trust

An advisory visit carried out by the Wild Trout Trust – July 7th 2014

1. Introduction

This report is the output of a Wild Trout Trust Advisory Visit (AV) undertaken along the sections of the Sheffield River Don in the area of Stevenson Road. The main objective of the report is to provide an assessment of the potential for main-river recruitment of Atlantic salmon (*Salmo salar*).

The visit was carried out by Dr. Paul Gaskell and commissioned by Karen Eynon and Chris Firth (MBE) of the Don Catchment Rivers Trust (DCRT). The report concentrates on the section of river between an upstream limit at NGR (National Grid Reference) SK 37239 88940 and a downstream limit at SK 37460 89044. However, the findings of the survey have wider applications to similar main-river salmonid recruitment sites on the urban River Don.

Throughout the report, normal convention is followed with respect to bank identification i.e. banks are designated **Left Hand Bank** (**LHB**) or **Right Hand Bank** (**RHB**) whilst looking downstream.

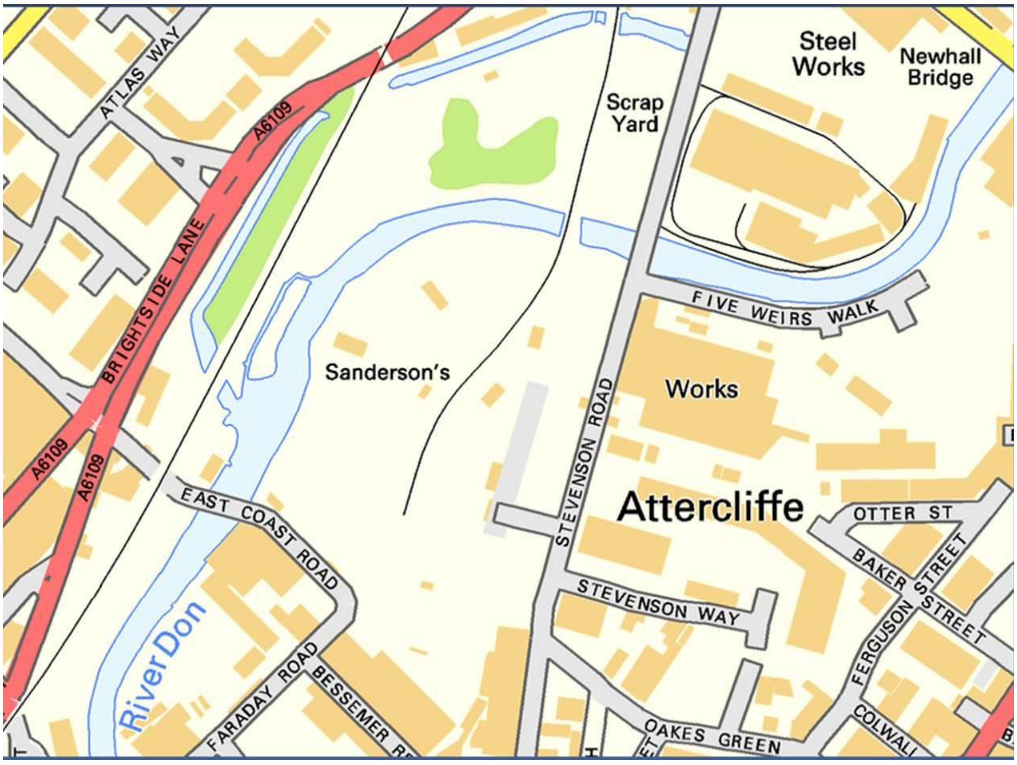


Figure 1: Map capturing much of the 5 km reach walked during the visit

2. Catchment overview

The surveyed section of the main river Don in Sheffield is captured within a single waterbody (GB104027057412) under the European Water Framework Directive. Underlying bedrock geology is shale grit and millstone grit with coal measure influences (including ochreous upwelling discharges) and the river is a typical "peat-stained" upland freestone river. Due, primarily to the impact of the upstream reservoir systems and the presence of weirs and channel realignments, the Don is classified as a "heavily modified waterbody". Table 1 gives a summary of its ecological potential and current characteristics as assessed for Water Framework Directive objectives.

Table 1: Summary designations for the River Don under the Water Framework Directive waterbody classification system

Waterbody Category and Map Code.:	River - R70	**Surveillance site:** No
Waterbody ID and Name:	GB104027057412	Don from River Loxley confl to River Don Works
National Grid Reference:	SK 37269 88315	
Current Overall Potential	Moderate	
Status Objective (Overall):	Good by 2027	(For Protected Area Objectives see Annex D)
Status Objective(s):	Good Ecological Potential by 2027, Good Chemical Status by 2015	
Justification if overall objective is not good status by 2015:	Disproportionately expensive, Technically infeasible	
Protected Area Designation:	Freshwater Fish Directive, Nitrates Directive	
SSSI (Non-N2K) related:	No	
Hydromorphological Designation:	Heavily Modified	
Reason for Designation:	Flood Protection, Urbanisation	
Downstream Waterbody ID:	GB104027057413	

Ecological Potential

Current Status (and certainty that status is less than good)	Moderate (Uncertain)

Biological elements

Element	**Current status (and certainty of less than good)**	**Predicted Status by 2015**	**Justification for not achieving good status by 2015**
Fish	Good	Good	

Supporting elements

Element	**Current status (and certainty of less than good)**	**Predicted Status by 2015**	**Justification for not achieving good status by 2015**
Ammonia (Phys-Chem)	High	High	
Dissolved Oxygen	High	High	
pH	High	High	
Phosphate	Moderate (Uncertain)	Moderate	Disproportionately expensive (P1a)
Temperature	High	High	
Copper	High	High	
Iron	High	High	
Zinc	High	High	
Ammonia (Annex 8)	High	High	

Supporting conditions

Element	**Current status (and certainty of less than good)**	**Predicted Status by 2015**	**Justification for not achieving good status by 2015**
Quantity and Dynamics of Flow	Supports Good	Supports Good	

Costly re-engineering of the river to rectify its heavily modified status is currently deemed technically unfeasible and/or disproportionately expensive (Table 1).

3. Habitat assessment

The river channel was walked in a downstream direction, starting at SK 37239 88940 – just below the large Sanderson's weir that impounds a substantial length of the reach upstream of the surveyed habitat. The weir has contributed to the formation of a (vegetated) cobble and gravel bar downstream of the structure – as well as forming some relatively deep pool habitat (Fig. 2). However, this comes at the expense of the upstream impoundment and attendant interruption to gravel and cobble supply. The weir is also a complete barrier to upstream fish migration under all but the most extreme spate levels – when water velocities over the weir will still prevent the majority of fish from ascending the obstacle.

Figure 2: weir and vegetated mid-channel island below Sanderson's weir at SK37239 88940

For adult salmon that either fail to ascend the weir or otherwise opt to make their breeding attempts in this reach, there is some good resting pool habitat. This is complemented by submerged boulder and water-crowfoot (*Ranunculus spp*.) cover. It is significant that *Ranunculus* in this reach remains all year round due to incomplete die-back during the winter. Obviously, the cover that it provides is more extensive during the warmest months of the growing season. However, the reduction in predator efficiency that it provides at all times is an absolutely invaluable feature of the habitat in this reach – and can be critical for achieving sufficient survival of juvenile salmonids.

At the left bank, adjacent to the island, deposited bed material has formed a back-channel that is only connected at its upstream end during high flows (Fig. 3). This backwater refuge area will be important for the fry of many fish species – especially coarse fish – during the summer months. When purely focussing on Atlantic salmon, this habitat feature may be of lesser importance. Instead, the channel running down the right hand bank from the weir pool contains many features that enhance the prospects of salmon reproduction. The run-out from the weir pool (Fig. 4) is the first such feature.

Figure 3: Backwater at LHB. During normal flow, this is only connected to the main channel at its downstream end - forming valuable nursery areas for a variety of spring-spawning fish

Figure 4: Tail end of weir pool running out into main channel along RHB at SK 37255 88954

The ramp of deposited bed material at the head of this channel (Fig. 5) provides a good opportunity for salmon spawning in silt-free, relatively large (40 – 80mm diameter) gravel and cobble substrate. Although there is a large overlap in the particle-size-range of spawning substrate that brown trout (*Salmo trutta*) and Atlantic salmon can use, only the largest female fish are able to dig redds (nests) in the larger gravel and cobbles. Marine-migratory fish such as salmon and sea trout have, at least, the potential to achieve generally larger sizes than most of the freshwater-resident fish. This can provide a degree of niche separation that allows different species to utilise different resources within the same reach of river. In other words, large female salmon/sea trout can exploit spawning gravels that are too large for smaller trout and smaller salmon.

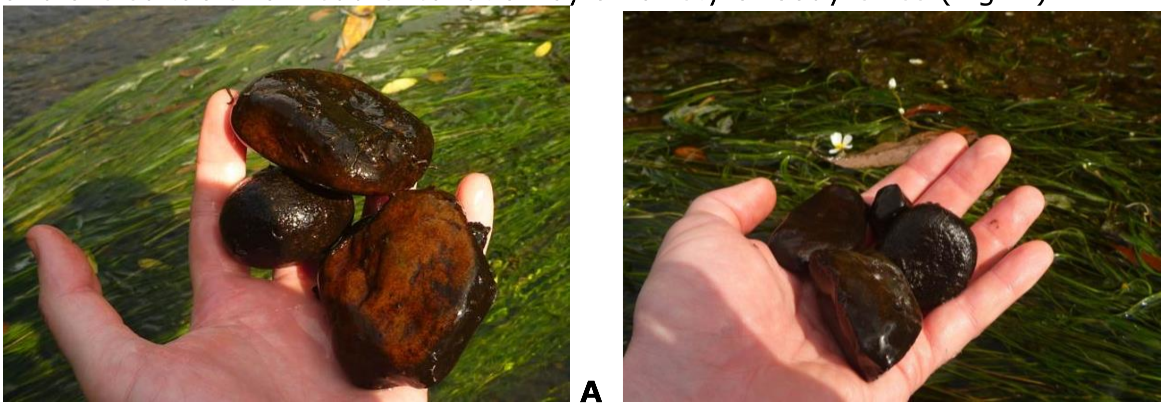
Figure 5: As the channel narrows below the weir pool, bed material has been deposited which decreases the depth and increases current velocity. The naturally patchy character of the *Ranunculus* growth provides excellent varied structure as well as increased variety in local current velocities

The upward slope of the loose riverbed material also generates crucial water flow between the irregular-shaped stones (interstitial spaces). It is this flow through the gravels that is crucial to maintaining a supply of oxygenated water to enable good survival and hatching in the eggs of salmon and trout.

The value of this spawning opportunity is greatly enhanced by being situated directly upstream of excellent quality juvenile salmonid (parr) habitat. Any young fry emerging from the gravels can readily drift downstream to find valuable refuge in this downstream reach (Fig. 6). Whilst there is potential overlap between the preferred parr habitat of trout and salmon, salmon parr tend to either prefer (or perhaps can cope more readily with) faster current flows. Since there is a thriving trout population in this section, the ability of salmon to utilise unexploited resources is a great boon to the prospects of wild salmon in the Don and maximising the river's carrying capacity. Again, the predation-limiting properties of riparian and aquatic vegetation are invaluable features in this reach. In fact, the quality of habitat for juvenile salmon in this section is unlikely to be matched by any of the contemporary habitat within tributary streams of the Don. From that perspective, this (and all comparable) main-river recruitment habitat should be protected as a top priority of the DCRT and any conservation groups with an interest in Atlantic salmon.

Figure 6: Superb potential salmon parr habitat that incorporates vital cover in the form of *Ranunculus*, submerged boulder and cobble structure and bushy marginal vegetation. The structural variety generates an accompanying wide variation in current speed so that individual salmon parr/fish of different species can exploit their preferred conditions. Some of the flows shown here are likely to be too fast for trout or grayling – but would be welcomed by the super-streamlined juvenile salmon

The importance of this parr habitat for salmon conservation is underlined by the presence within this reach of a varied selection of spawning-substrate particle-sizes. These are, again, maintained as largely silt-free (= great egg survival) and are suitable for redd excavation by a variety of body-sizes (Fig. 7).



A **B**

Figure 7: Silt-free substrate in the 40-60mm (A) and 20-50 mm (B) ranges. Similar silt-free deposits in the sub-20mm range were also represented within the reach

<u>Silt-free</u> spawning substrates, fast riffles 20-40cm deep and *<u>plentiful cover</u>* (e.g. Fig. 8) are in very short supply on potential spawning tributaries such as the River Dearne. Additionally, the thriving *Ranunculus* – in combination with the presence of a variety of pollution-sensitive invertebrate species – indicates an absence of chronic and acute water quality problems (Fig. 9). Again, episodic and chronic water quality issues are noted in the River Dearne - which otherwise has the advantage of joining the main river downstream of significant barriers to anadromous (marine adult phase/freshwater reproduction) migration.

Figure 8: More excellent juvenile habitat at SK 37272 88977. Boulder structure and plentiful trailing marginal terrestrial vegetation as well as submerged *Ranunculus* beds.

Figure 9: Specimens representing sensitivity to both metal (Baetidae) and organic *(Seratella ignita,* Simulidae) pollution were readily captured via individual sweeps with a small aquarium net. Although not performed during the site survey, kick sampling by standardised protocols would yield much greater abundances and, judging by adult flies on the wing during the visit, diversity of invertebrates

Continuing downstream to SK 37290 89008 revealed more excellent spawning opportunities associated with deposition of gravels in the margins of the channel, smooth flows and *Ranunculus* cover (Fig. 10). Again this was supported by proximity to excellent juvenile habitat (Fig. 11).

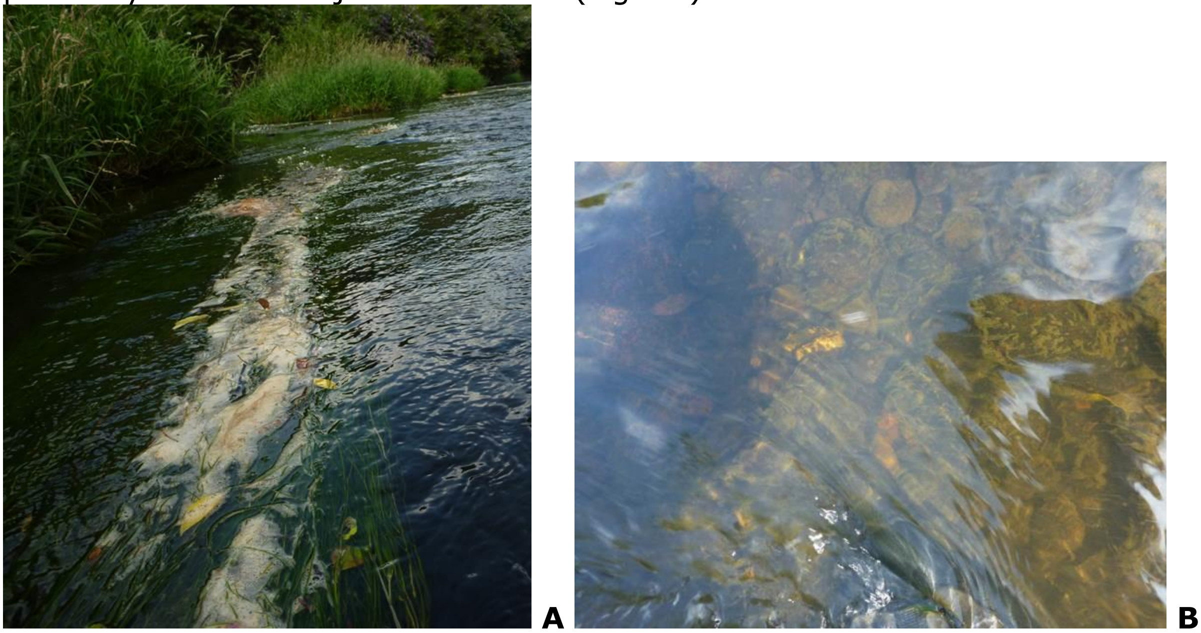


Figure 10: Smooth marginal flows and *Ranunculus* cover (A) over silt-free gravels (B)

Figure 11: Localised scour and associated variation in current velocity and depth generated by mid-stream boulder structures (in this case from historic industrial sources!) provide habitat for both adult and juvenile salmonids

A reminder of the importance of invasive plant control was provided by the presence of a few, relatively small, stands of Himalayan balsam (*Impatiens* *glandulifera*) within the reach (Fig. 12). The great benefits of diverse riparian vegetation for supporting both aquatic and terrestrial invertebrates that form the food supply for juvenile salmon (as well as the valuable marginal cover from predation) can be protected by continued control of non-native invasive species. Additional insight into the impacts of large riparian infestations of plants like Himalayan balsam are outlined in this short video: http://youtu.be/VijmRm-qd4Y

Figure 12: Pink flowers (centre frame) of Himalayan balsam re-establishing small stands amongst diverse native vegetation

The RHB "point bar" deposit at SK 37310 89029 offered particularly good prospects for spawning – marred only slightly in one patch by an input of ochre which could suffocate eggs in that location (Fig. 13).

Figure 13: Point bar of spawning gravel in context of channel (left) and close-up of detail (right) showing smooth flow over mound of gravel in the 20 - 40mm diameter range. Note orange, ochre-affected patch

Looking downstream from the point shown in Fig. 13 reveals another valuable structural feature in this section of the channel. Here the side-channel from the

LHB re-joins the main flow. This occurs as flow from the main channel passes over, and occasionally through, a central "spine" of substrate. The result is that the shallow riffle and glide habitat of the RHB runs up over a hump of gravel before dropping over a lip into deep pool and glide habitat along the LHB. The fall from the hump into the pool (with its preceding slope of gravel on the upstream side) will draw good flow of water through the gravel substrate in this area. Consequently, it provides another excellent spawning opportunity with good prospects for egg survival (Figs. 14 and 15).

Figure 14: Small "breach" in vegetated central gravel bar with good ramp of gravel on upstream side. LHB is made up of a brick retaining wall for the remainder of the surveyed section

Figure 15: Central gravel spine (right of frame) with drop off over lip into deeper glide (left of frame). *Ranunculus* is rooted in shallow gravel ramp towards the right and its trailing fronds are floating over much deeper water to the left; ideal combinations of spawning substrate and downstream juvenile cover

Deep glide habitat along the LHB will also provide attractive resting and holding water for migratory fish – which enhances the value of the proximate spawning and juvenile habitat-features.

Further great illustrations of the concept of ramps of gravel that promote through-gravel water-flow are shown in Figures 16 and 17. These pictures also show a perfect pace of water that is fairly quick – but without being excessively turbulent. The pace – and associated flow through the gravel bed - gives good irrigation/oxygenation of eggs whilst the lack of turbulence means that females can release their eggs into the excavated redd without them swirling away downstream.

Figure 16: Gravel ramp showing smooth, quick flow on the upstream side (left of frame) giving way to broken turbulent flow where the gravel rises up adjacent to the water surface (right of frame) - ideal spawning habitat

Figure 17: Another gravel ramp - this time as part of a marginal point-bar. The smooth, fast flow is to the right of the frame and the breaking/riffled water surface is just visible at the extreme left edge of the frame

The survey concluded with further examples of excellent salmon parr habitat between SK 37399 89055 and the railway bridge at SK 37460 89044 (Fig. 18).

Figure 18: More great parr habitat and also some spawning opportunities in the channel margins - extremely valuable habitat

4. Recommendations

In addition to the formal, scientific literature, the invaluable role in juvenile salmon survival that complex submerged cover plays has been suggested by habitat works carried out by the Wye and Usk Foundation. On some spawning tributaries that previously lacked such cover due to excessive erosion, the Foundation carried out extensive installation of dense marginal brash (Fig. 19, left). Survival rates (relative to the catchment as a whole – so as to take account of broad-scale annual variations) of juvenile salmon following such installations increased dramatically; up to almost 7-fold in some cases.

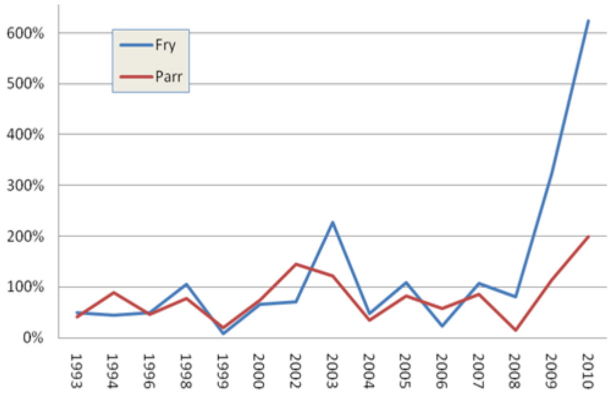


Figure 19: Large-scale thorn brash installation (left) and associated increase in densities of juvenile salmon plotted as a percentage of the density of fish in all other survey sites in the region to account for annual variation in salmon recruitment (right). Brash was installed in 2008, and trout abundance showed a comparable pattern to salmon

4.1 Protect what is good

The findings featured in Fig. 19 highlight how valuable the natural existence of year-round complex cover that is *already provided* by the abundant stands of *Ranunculus*. A great deal of focus is (understandably) placed on the crucial presence of well-irrigated, silt-free spawning substrate. However, quite often, the crucial juvenile survival habitat may be overlooked. Atlantic salmon (in common with brown trout and other salmonid fish) experience the vast majority of their life-cycle mortality at the juvenile stage. Even in GOOD habitat, typically around 95% of juveniles will die before one year of age. The lack of good habitat can, consequently, have dramatic impacts on the number of smolts (juveniles migrating out to sea) that are produced by particular breeding populations. Even relatively small downward shifts in the percentage survival from that maximum of 5% translate into very significant losses of "bottom line" numbers of fish surviving to migrate out to sea. Therefore, the presence of such good habitat within the surveyed reach make it a priority for protection and re-connection to marine migratory fish, with ongoing custodianship of the existing high quality habitat features.

4.2 Reconnect and enhance

Another hugely significant impact on smolt survival is the dramatic mortality that occurs within long impounded reaches of river upstream of weirs. As an example, one study on the Tweed found that in some years around 80% of the total smolt output from one river system was lost to the enhanced predation efficiency within a long impounded reach above a single weir. The simple delay to downstream migration of smolts caused by impoundments can also, cumulatively, cause them to exceed the vital physiological "window", preventing their transition into the marine environment. Therefore, considering the impounding effect (as well as the barrier to upstream migration) is crucial when modifying weirs with the aim of re-establishing wild salmon populations. Restoring upstream connectivity for returning adult fish is only part of the story – albeit a crucial one! To this end, investigating the feasibility of notching, or phased-removal of Sanderson's weir (from the RHB side) at the top of the reach surveyed in this report would provide significant benefits. Retaining some of the structure towards the left hand bank could help to promote varied deposition/remobilization of gravel and cobble substrate – as well as preserving heritage value.

Partial (or phased "near-complete") removal, in this case, would have a benefit to the degraded upstream reach by decreasing/removing the impoundment effect, whilst instigating a more gradual/less extensive shift in upstream channel narrowing and riverbed/bed-slope re-grading compared to complete removal in a single step. In either scenario, the mathematical modelling required to establish a safe and acceptable change to upstream channel morphology will be far cheaper than the costs for a formal engineered fish-pass design and installation. Modelling costs are likely to be perhaps, approximately, £20K to £40K – with the cost of removal being a few thousand pounds for heavy plant machinery costs. This compares to the likely £250K to £450K for a large, engineered fish pass. As indicated previously for more extensive removal scenarios; retaining 25 – 30% of the span of the weir at the LHB (at a height or around 50% of its current level) could provide some valuable habitat heterogeneity.

If necessary, a smaller notch towards the RHB could be combined with the fitting of a fish passage easement structure to at least provide some additional upstream adult access to further spawning and juvenile habitat. However, the same concern over the ability of smolts to migrate downstream is invoked when the majority of the impounding effect remains following structural modifications to weirs.

On the subject of prioritising longitudinal connectivity, as is evident from the main body of this report, there will be huge and immediate benefits to restoring access to the surveyed reach (i.e. providing access up to the base of Sanderson's weir). However, continuing on and sequentially tackling barriers up to the base of the weir at Kelham Island would further dramatically increase (several-fold) the spawning and juvenile habitat available to Atlantic salmon. Every reach between each of the succession of barriers upstream of Sanderson's weir contains valuable spawning opportunities and juvenile salmonid habitat. Of course, the ideal long-term goal would be to reconnect historic spawning tributaries such as the Loxley – as well as the upper reaches of the main river. In the interim, there is much immediate benefit to allocating resources to the urban, main-river reaches.

4.3 Ensure benefits are sustained

Himalayan balsam (*Impatiens glandulifera*) stands were evident along the river banks at various points. As mentioned elsewhere in relation to the survival of trout-eggs, the control of this plant is desirable due to the accompanying reduction in fine sediment inputs. Good results can be achieved by hand-pulling when there are sufficient numbers of participants on working parties targeting specific stands. Other methods of control include strimming below the first node or, in extreme cases, chemical control by spraying; but see consenting for chemical control of knotweed below. It would be necessary to weigh up the *inevitable impacts on non-target flora and fauna* caused by overspray of herbicide. These unintended impacts may occur in both terrestrial and/or aquatic species, so appropriate consideration must be given to the perceived need for spraying. Both hand-pulling and strimming must be undertaken sufficiently late in the growing season to catch late-germinating seedlings, but before the plants set seed. Depending on the conditions within specific growing seasons, the optimum time will vary – usually between June and July.
Japanese Knotweed control has been carried out during the last 5 years in this reach and the native flora is showing the benefits of this action. This work, as with any applications/injections of herbicide adjacent to watercourses, was subject to the consenting processes operated by the Environment Agency. Continued vigilance and control needs to be applied in order to consolidate these gains.

For cases where partial or complete weir removal is not possible - at least in the short to medium term – the fitting of well-designed fish passes and fish-passage-easement structures could be crucial to re-establishing salmon populations. However, such structures become obsolete if a lack of maintenance leads to them becoming blocked. Frequency and intensity of maintenance can be minimised, where site constraints allow, by good design of the pass or easement structure. As a general rule, very narrow fish passes (less than 1-m wide on main river channels) tend to become impassable due to blockages during the flow conditions that are associated with upstream migration of salmon and trout. However, in all cases, engineered solutions to fish passage have a fundamental requirement for ongoing maintenance if they are to be effective. Exploring partnership working arrangements to meet all ongoing custodianship and sustainability requirements may be a productive approach for DCRT to meet its goals.

Acknowledgement

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