Project Proposal

Forth Fisheries Trust

River Allan, Killandean Burn and Bog Burn

30th September 2015

1. Introduction

This report is the output of a site visit undertaken by Gareth Pedley of the Wild Trout Trust (WTT) to three locations in the River Forth catchment for the River Forth Fisheries Trust (RFFT). The visit was requested by Jonathan Louis and Lawrence Bellini of the RFFT who also attended the visit. The aim was to assess habitat and highlight specific actions that can be undertaken to address issues and initiate improvements to in-channel habitat on the watercourses visited.

Normal convention is applied throughout the report with respect to bank identification, i.e. the banks are designated left bank (LB) or right bank (RB) whilst looking downstream. For convenience, upstream and downstream are often abbreviated to u/s and d/s, respectively. Locations are identified using the National Grid Reference system.

2. Background and rationale

RFFT currently have a wide range of projects either ongoing or at the planning stage throughout the River Forth catchment and covering most of its tributaries. WTT were contacted to provide advice on specific aspects of three of those projects. The work primarily focusses on management of bank erosion and habitat improvement on the River Allan and Killandean Burn, and options for channel restoration and habitat improvement on the Bog Burn. The findings and recommendations at each site will be covered individually.

2.1. River Allan

The full Water Framework Directive (WFD) data for the waterbody that this section of river lies within (sourced from the Scottish Environment Protection Agency (SEPA) website) can be viewed in **Appendix A**. Many of the parameters assessed are classed as 'High', although the overall status is classed as 'Moderate'. This is primarily due to failures for 'Fish' and 'Hydromorphology' (although not a Heavily Modified Waterbody), both of which only achieve 'Moderate' status.

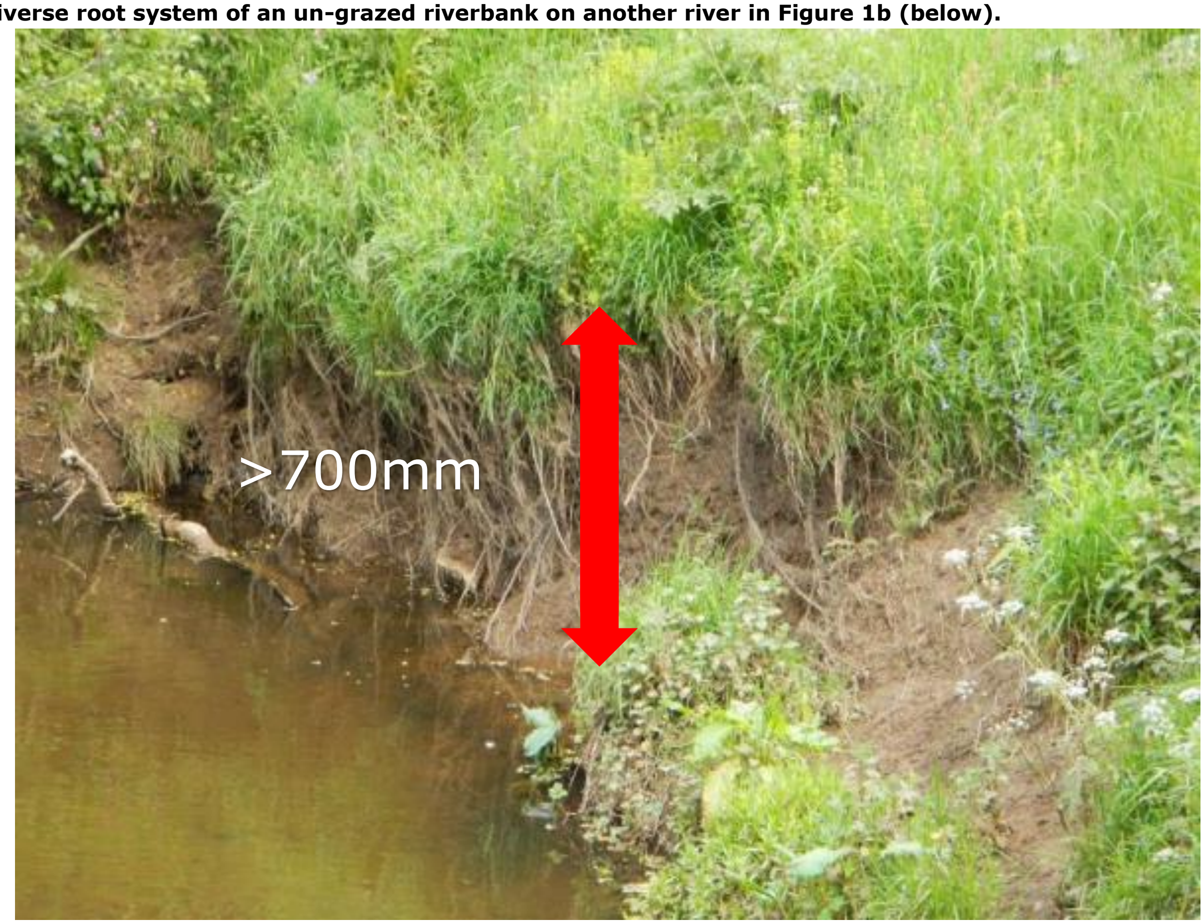
At the location visited (NN7997705785), the River Allan flows through an area of mixed arable and improved grazing land. Historically, some of the fields appear to have been used for arable farming but are now returned to grazing, a likely contributing factor being that the land appears hard to drain in many areas. The river channel has been subject to significant alteration and historic maintenance (including dredging), as evident by the overly wide and deep channel with uniform cross-section and a lack of coarse substrate. The flood banks flanking the River in many places are likely to be constructed from dredged river bed materials that would have been heaped along the river bank to prevent floodwater spilling out of the channel and onto the fields. While these actions may have reduced the occurrence of flood water locally inundating the fields, the action is not without other unintended but often significant consequences, all of which have contributed to the erosion issues now being experienced along the river banks both here and elsewhere.

Dredging a river and creating a lower-lying channel constrains the energy of that flow within that channel, rather than allowing it to spill out and dissipate the energy across the much wider floodplain. Raised flood banks further exacerbate the problem and both factors lead to much greater erosional forces being exerted upon the river banks and bed as the water level rises. As the river then also flows along a bed that is further below the bank top, the banks are far more susceptible to undercutting. Fortunately the flood banks have been breached in many places, relieving some of the pressure.

Livestock grazing up to the very edge of river banks further increases their susceptibility to erosion as it maintains a near monoculture of grasses, closely cropped to the ground; grasses regrow from their base and withstand continual grazing pressure far better than other plants. With only a limited grass sward, direct protection of the soil (via interception of rain and diffusion of high flows) is limited; and as the grasses expend much of their energy replacing the grazed material above the ground, they have far less energy to place into root growth below the ground, so their root structures (which provide physical structure and stability within the soils) are minimal.

By preventing saplings and herbaceous vegetation from establishing, grazing also reduces the diversity of root systems contained within the bank; a diversity of trees and herbaceous vegetation, combined with grasses, provide much deeper and wider-ranging root structures than grass alone. Note the difference between the sparse root system (c.150mm depth) beneath the closely grazed grass banks on the River Allan (Fig. 1a) and the diverse root structure (>700mm depth) within an un-grazed bank (Fig. 1b).

Figure 1a (above) Shallow root system beneath the grazed river banks on the River Allan *vs* the deep, diverse root system of an un-grazed riverbank on another river in Figure 1b (below).



Trampling and poaching by cattle and / or sheep prevents even grass from re-growing in well-trodden areas, as well as physically breaking up the ground and allowing high river flows, rain and surface water to scour away the soil. This prevents the recolonisation of slumped bank material that would otherwise naturally revegetate and stabilise the bank at a shallower gradient (Fig. 2).

Figure 2. An area of bank that appears to have slumped and has stabilised somewhat but remains highly susceptible to further erosion due to the continued grazing and trampling that is occurring.

Several land drains discharging along the upper part of the bank, create localised wet areas that further increase bank susceptibility to slumping and erosion, and are probably causing direct scour when they discharge higher volumes of water in wet conditions (Fig. 3).


Figure 3. Clay pipe field drains discharge water drained from the neighbouring field directly onto the riverbank (red circle). In the absence of root structure to hold the banks together, this greatly increases erosion rates and allows what little turf there is to be undermined.

The combined effect (on the rate of bank erosion) of these degrading factors acting together is compounding the issue and has greatly increased the rate of erosion beyond that which would naturally occur. Attempts have been made in the past to protect the bank with rock (Fig. 4) but this actually leads to additional issues. Whether this is undertaken with large or small rocks, it is a short-term measure as the installation of any hard structure within a river channel only serves to deflect flow in another direction and actually exacerbates erosion issues adjacent to the structure. This is why accelerated erosion usually occurs u/s and d/s of a rock-armoured section, and under the water at the base of the armouring (see examples and further explanation in video clip - https://youtu.be/q7zq1yxaPEA). The rocks also restrict colonisation of the area by vegetation, the roots of which are required to naturally bind the banks together.

Bank protection is far better undertaken with softer (green engineering) techniques that protect a river bank by creating a diffuse structure that actually dissipates the energy of river flows, acting like a baffle, rather than simply deflecting the erosive force elsewhere (see **Recommendations**). Greener techniques also promote the growth of vegetation on the bank that will provide further protection and greater long-term bank stability.

Figure 4. Rock armouring (red oval) has offered some protection to the base of the bank for long enough to allow it to vegetate but will always be susceptible to erosional scour at either end and below the waterline. Note that this is already apparent as flows deflected from the rock cut away at the softer material (red arrows).

As a first step to rectifying the issue, the ideal solution is to exclude livestock from the riverbank. This will allow vital vegetation to flourish and stabilise the bank material with greater root penetration, facilitating long-term natural regrading of the bank to a more stable angle. Further actions can be found in the **Recommendations** section.

2.2. Killandean Burn

WFD data for the waterbody in which this burn section lies (sourced from the SEPA website) can be viewed in **Appendix B**. The waterbody achieves and overall status of 'Poor' driven by a classification of 'Poor' for 'Fish', with other parameters being assessed as 'Good' or 'High'. The WFD data suggests that this has been primarily driven by 'Poor' fish passage. Interestingly, 'Hydromorphology' is classed as 'Good' despite a 'Poor' classification for 'Morphological pressures'.

Although looking natural in places, the area of the Killandean Burn visited (NT 03743 66511 - NT 03115 65931) is a semi-urban watercourse, running through council owned land within an industrial area, much of which appears to have been re-profiled, and which has now been developed for local amenity. The Burn channel has been subject to significant historic modification but is beginning to re-naturalise in places, reinstating a more sinuous channel through the processes of scour and deposition. A generous strip of natural rough ground on the RB, and a buffer strip (in most areas) along the country park on the LB, both comprise diverse vegetation and provide a reasonably healthy margin to the watercourse that complements areas of high quality instream habitat for juvenile (Fig. 5) and adult (Fig. 6) salmonids.

Figure 5. High quality fry and juvenile salmonid habitat provided by a range of shallow slow flowing areas interspersed with faster riffles, with a range of substrate sizes from fine gravel up to boulders.

Figure 6. Good adult trout habitat is provided by deeper pools with well vegetated margins, over hanging bankside vegetation, and a healthy mixture of shade and light, provided by overhanging trees.

Some spawning areas are present for trout (c. 10-40mm gravels) and migratory salmonids (c. 20-60mm gravels/cobbles) but are limited due to a predominance of larger cobble and boulder substrate. This is partly natural, owing to the local geology but is likely to be influenced by the channel straightening that accelerates flows and mobilises finer substrate while reducing the occurrence of slower flowing depositional areas. Heavy gabion revetments in many areas also limit the natural recruitment of substrate to the channel from its banks.

In some sections the revetment is clearly to protect the adjacent footpath (Fig. 7). In other areas, there is no obvious purpose for the revetment, other than constraining the Burn in its current course (Fig. 8), which is not advantageous to the habitat quality of the Burn. Scour along the edges of the gabions has produced some deep water but habitat would be of far higher quality without the gabions. The vegetation and trees present should be sufficient to provide natural bank protection (maintaining a natural, slow rate of erosion) and good habitat in most areas.

Figure 7. Hard engineered revetment in the form of a three-tier gabion wall. While not the most ecologically friendly method for protecting the bank, this structure does serve to protect the footpath along a confined section of bank (for the life of the foundation gabions).

Figure 8. Unnecessary revetment along the far bank. Healthy vegetation and trees on the far bank could naturally maintain erosion rates at a low level. These gabions should not be replaced when they fail.

Excess sediment and nutrient inputs to the system are evident from siltation and heavy algal growth on the bed (Fig. 9), both of which can reduce oxygen levels within the gravels and reduce egg and alevin survival rates. Smothering of the substrate with fine sediment and algae, and the consequential loss of micro-habitats is also likely to have a detrimental impact upon many beneficial native invertebrate species that use those habitats. It is understood that the source of these inputs has been identified as a land holding that is currently for sale, and that RFFT has plans in place to try and address the problem with the new owners once the sale has occurred.

Figure 7. Excessive algal growth and siltation on the bed of the Burn.

Where not protecting the footpath (or other important infrastructure), revetments should be left to degrade and eventually fail, and natural erosion allowed to develop. This will allow the Burn to naturally reinstate more channel sinuosity, enhancing substrate composition and features (Fig. 10).

Figure 10. A section of bank originally armoured with large block stone revetment that has now failed as erosion scours around and undercuts the stone and they slump forward, deflecting even higher erosive forces into the bank (see video - https://youtu.be/q7zq1yxaPEA). While a source of sediment, in this instance, the erosion is beneficial in reinstating natural features to the Burn and developing habitat. Note how the Burn with is already adapting to the increase in width by depositing finer substrate on the slower inside of the bend (red oval), thereby naturally maintaining an appropriate width for the flows received and increasing the sinuosity of the wetted channel.

Where well-vegetated and / or tree-lined, the rate at which bank material is lost will be limited but will occur as a natural feature and is important for mining vital gravels from within the banks (Fig. 11) that will help supplement the limited spawning substrate already available. Planting additional trees a few metres back from the eroding areas can further control erosion rates and enhances future bankside habitat. It is also a great way of capitalising on the short-term bank stability provided by hard revetments so that, when they fail or are removed, the trees and other vegetation are already *in situ* and remain to consolidate the bank.

Figure 11. Some erosion is beneficial and vital as a source of new substrate to the Burn. Tree planting a few metres back from the Burn could help to control the rate of future erosion and provide valuable habitat as the channel migrates in that direction.

In many areas, accelerated rates of erosion jeopardise the banks (Fig. 12) and, in almost all of these areas, the remains of Japanese knotweed (*Fallopia japonica*) plants can be observed (Fig. 12 - inset). Knotweed is almost certainly the major contributing factor to the erosion, proliferating rapidly in the growing season and shading out all other vegetation, only to die back in the winter and leave exposed soils susceptible to erosion. RFFT have been administering a knotweed eradication programme along the Burn, which appears to be working; however, several further treatments will be required to fully control such a voracious species and the sites should be monitored for several years after all plants appear to have been eradicated to ensure that none persist.

Figure 12. Erosion and bare earth around the site of a Japanese knotweed stand. Chemical treatment of the knotweed appears to be working but small plants still remain (inset).

Where the footpath banks are at risk, soft bank protection may be beneficial to prevent the Burn eroding the path (see **Recommendations**), or the council from intervening with hard engineered revetment to protect the path. The areas that are experiencing erosion issues often correspond with locations where the grass has been mown closely to the river bank. While the mowing is not the primary cause of the erosion, closely cropping the grass (akin to grazing, as described earlier on the River Allan), and encouraging footfall and dog access in and out of the water on the closely cropped grass, places those areas of bank at increased risk of erosion. Maintaining a larger buffer strip between the mown path areas and the riverbank will increase the vegetation cover that will afford greater protection to the bank.

Figure 13. Mowing right up to the top of the eroding riverbank further destabilises it by reducing the foliage protection above and root structure within the bank. Creating a buffer strip here to at least the red line would be greatly beneficial.

In other areas, although still subject to past human intervention, higher quality salmonid habitat is present. Some small measures to further enhance the habitat quality throughout would be beneficial. Where willow trees and shrubs are adjacent to the watercourse, they could be laid down along the bank side to trail into the water, providing cover and structure in the channel (as shown in Fig. 14). Planting of willow whips in bare or open sections would also increase the fish holding capacity and provide improved habitat for adult resident trout.

Figure 14. A relatively open pool that could be greatly enhanced with low and trailing cover by laying some of the bankside shrubs into the channel (as indicated by red outline).

2.3. Bog Burn

WFD data (sourced from the SEPA website) for the waterbody into which this Burn section feeds can be viewed in **Appendix C**. The waterbody achieves and overall status of 'Bad', this being the lowest status possible, driven by a classification of 'Bad' for 'Benthic invertebrates', with several other key parameters being assessed as 'Moderate' or worse, including 'Dissolved oxygen', 'Fish', 'Phytobenthos' 'Regulatory ammonium' and 'Morphology', among others.

The section of Bog Burn visited (NS 98557 67701 - NS 98112 67575) flows alongside a new housing estate, on what was previously a carpark for the local industrial area. Discussion with RFFT staff revealed that much of the surrounding land was re-profiled as part of the redevelopment and hence there is little, if any, remnant of the original channel (confirmed by perusal of Google Maps). A long section of the Burn was enclosed within a culvert until recently, when it was opened out as part of the re-development. While the de-culverting is a major improvement, it is a shame that the scheme did not extend to re-meandering and diversifying the channel cross-section, which would have been a relatively simple task at that point, while the machinery was on site.

The current channel is almost completely straight and at a low gradient, which is unusual as straightening a watercourse almost invariably increases channel gradient by reducing the distance over which the gradient is lost. This suggests that the Burn may have been moved significantly from its original course. It now lies within a deep V-shaped trench (high flow channel), with the low-flow channel also being of a much narrower, deeper cross-section than would naturally occur on a watercourse of this size (Fig. 15). The uniform dimensions create a channel that lacks discrete areas of scour and deposition, and is subject to uniform bed scouring at high flows.

Figure 15. Straight, uniform width and depth, low-flow channel sitting within a straight V-shaped trench.

Some limited areas of shallower, faster flowing, higher quality habitat exist. However, where light is able to reach the bed, obvious nutrient issues are evident by excess algal growth which further degrades the habitat (Fig. 16). In many other areas, the uniform cross-section channel lacks shallow, wider, faster-flowing riffles and deeper, self-maintaining pools and allows unimpeded encroachment of emergent and aquatic vegetation. This results in vegetation choking the channel and impoundment and slowing of the flows upstream (Fig. 17). The issue would be far less pronounced in a channel with more natural dimensions that could adapt to the high flows it receives and maintain greater variation in flow direction and velocities. Natural shading from increased tree cover would also limit the encroachment of vegetation.

Figure 16. Shallower, faster flowing areas provide some higher quality riverine habitat but excess algae in the areas with higher light penetration to the bed reveal elevated nutrient inputs upstream.

Figure 17. Uniform flows and depths allow uniform encroachment of vegetation, leading to choking of the channel and impoundment of flows.

Being of uniform width and depth, low energy (low gradient), and with consolidated banks (well vegetated), the current channel course is relatively stable and unlikely to recover a more sinuous course or natural channel dimensions by itself in the short-term. Re-meandering and re-profiling the bed should help to counteract the issues (see **Recommendations**).

Dead sticklebacks (*Gasterosteus aculeatus*) were noted during the visit and this may suggest periodic poor water quality incidents on the Burn (linking to water quality issues identified in WFD assessment) as they are one of the hardiest freshwater fish species; some live individuals were also present. T

Inspection of a culvert entering the Burn, approximately halfway along the reach inspected, revealed a shiny, likely oil-based film on the water surface and a surface boom in disrepair (Fig. 18). The issue is probably linked to misconnections within the drain system and / or surface water (road washings), and the boom an attempt to deal with the problem. It would be worth monitoring the Burn to see if any pollution events can be more accurately identified (see **Recommendations**).

Figure 18. Culvert outflow entering the Burn with a now defunct surface boom. Note the oily film on the water.

3. Recommendations

3.1. River Allan

To improve riverbank stability long-term on the River Allan, buffer fencing to exclude livestock from the banks will be vital. This one measure will allow a healthy coverage of bankside vegetation to naturally colonise susceptible areas and prevent the physical damage that currently is being caused by livestock access. Light re-seeding with a wild grass and flower mix that is native to the area would also accelerate the rate at which protection is provided to the bank.

With stock excluded from the river banks, planting additional trees within the buffer strips will be particularly beneficial. Planting willow from whips and saplings of local provenance, particularly smaller shrub species (*Salix pentandra*, *S. phylicifolia*, *S. cinerea & S. caprea*), will increase bank stability and provide good cover. These smaller shrub species require less maintenance and provide good dense cover at a low level. Planting of other larger willows and native deciduous trees will also assist the process and greatly increase the extent of root structure within the bank.

The quickest and easiest way of planting is with willow, by pushing short sections of willow whip into the ground. This can be undertaken at any time of the year, but will have the greatest success shortly before spring growth begins (ideally late Jan-March). The timing takes advantage of the source trees being dormant, so it causes no damage to them, and healthy whips then spend a minimal amount of time within the ground before they begin to grow (reducing the chances of damage through rotting, freezing or drying out). Whips should be planted into soft, wet earth/sediment so that there is a greater length (c.2/3) within the ground than out of it, to minimise the distance that water has to be transported up the stem; 30-60cm of whip protruding from the ground is sufficient.

Small bundles (faggots) of freshly cut willow can also be staked into sections of softer river bank, along the waterline, where have a good chance of rooting and becoming valuable, dense cover that will enhance riparian habitat.

The above measures alone were used to address a very similar issue on the River Esk in North Yorkshire (effects after one year; Fig 19a&b and 20a&b). Two years on now, stock are still excluded and the banks remain stable.

Figure 19a. Before fencing.

Figure 19b. 1 year after fencing, grass seeding and tree planting. The bank is already much better vegetated and more stable.

Figure 20a. Before fencing.

Figure 20b. 1 year after fencing, grass seeding and tree planting. The bank is already much better vegetated and more stable.

Often, bank erosion is addressed with the above stock exclusion, planting and seeding measures, in conjunction with soft bank revetment. The addition of soft revetment provides physical protection to the bank and increases the chances of success; however, it takes time to install and there is always a risk (as with all bank protections, including hard engineered solutions) that they could fail in the next large floods, before the work can take effect. As funding and resources were limited on the Esk, the lowest intervention measure was trialled first (without brash revetment), with the plan to undertake the work in conjunction with revetment in the future, if the initial measures failed.

Even without revetment, the minimal intervention (buffer fencing, seeding and planting) worked. While this treatment relies upon some luck that high, scouring flows are not experienced before it can become established, it demonstrates the results that can be achieved very quickly and easily if stock are permanently excluded.

Stock exclusion, planting and seeding has a good chance of stabilising the banks of the River Allan; however, the additional soft revetment bank protection measures could be applied to increase the chances of success first time and provide valuable additional marginal habitat. This could be achieved by installing a matrix of brash (including living willow) which would be wired over the bank to dissipate the energy of high flow and encourage sediment deposition (Fig. 21). Alternatively, a simple line of brash/willow could be staked along the bank toe to protect and retain the lower section of bank and prevent it slumping for long enough that vegetation can consolidate the bank material (Fig. 22).

As with all living willow work, these measures would, ideally, be undertaken just prior to the growing season (February/March). This to reduce the amount of time they are in place before the growing season but to maximise the length of first growing season. However, good results can be achieved with living willow through the growing season if it is ensured that that each piece of willow is installed to be in contact with damp ground and / or water.

Figure 21. Brash mattress installed along a section of eroding bank to provide flow dissipation and increase sediment deposition in the area.

Figure 22. A line of willow brash being installed along the bank to prevent further bank slumping and allow the bank to re-vegetate and stabilise.

The field drains are not an easy issue to address, especially as they improve the workability of adjacent fields and so are unlikely to be removed. That said, significantly increasing the vegetation cover along the bank by excluding livestock will reduce the issue; the greater root structure within the ground will help bind soil together, and the foliage above the ground will provide direct protection to the soil and dissipate the energy of flows emanating from the pipes.

It is strongly recommended that no further stone or hard structures are introduced along the bank as these will only serve to increase scour and erosion in other areas. If it is considered that greater bank protection is required, installation of brash, as described previously, should be undertaken.

3.2. Killandean Burn

It is recommended that, wherever possible, the naturalisation already underway on the Burn is allowed to continue. Where not threatening important infrastructure (footpaths etc.), natural rates of bank erosion should be allowed to occur and existing bank revetments be allowed to fail. In places where banks are stable and well vegetated behind existing gabion revetments, and where they are not protecting infrastructure, those revetments could even be removed to allow a natural bank line to establish. Maintaining some areas with natural rates of erosion will be important in supplying coarse sediment to the Burn that will provide spawning habitat for salmonids.

To help stabilise the banks where unnaturally high rates of erosion are occurring, several simple measures would be beneficial. Continued treatment of the knotweed will be vital, as this is undoubtedly one of the major underlying causes. Reducing the access at those locations where the bank stability is already compromised would also be beneficial and could easily be achieved by allowing a larger, unmown buffer between the footpath and the river bank (minimum 3 metres). This could be aided by the installation of posts or boarding around the obvious access point to simply discourage further access to the river and prevent mowing of the grass past that point as depicted in Figure 23.

Figure 23. Possible solution for discouraging access to the riverbank and preventing mowing of the marginal buffer strip with a small (c.20-30cm high), unobtrusive ornamental fence or line of posts.

In the d/s area of Figures 12 & 23 significant erosion (emanating from the knotweed stand) that threatens the bank and footpath could be prevented with a dense brash mattress as depicted in Figure 24. This would reduce the flow impact upon the bank, prevent further erosion, and encourage deposition of sediment that could then revegetate to form the new bank line. The success of reinstating the bank is likely to hinge upon the efficacy of knotweed treatment.

This brash technique could be extended along other areas of bare earth, such as immediately u/s (Fig. 12), to protect the bare earth and reduce erosion in the areas where knotweed has inhibited riverbank vegetation. It would protect the bank, encouraging bankside vegetation to re-establish, while also discouraging trampling of the area by visitors and dogs which appear to be increasing erosion by accessing the Burn at that point.

Figure 24. Example of how a brash mattress could be employed protect the river bank and footpath by plugging the erosion hole and encouraging deposition of sediment in that area. The river side line of posts brash should not extend further into the channel than the existing bank line, maintaining a clear channel for conveyance of higher flows (blue arrow).

In areas of open bank, planting of native deciduous trees (formally, and with simple willow whips pushed into the ground) would be beneficial and, as with the brash revetment, could be undertaken by working with the local community, thereby increasing engagement with them and, hopefully, increasing custodianship of the site.

It is recommended that the sediment issues identified by RFFT, upstream of the section visited, are addressed as soon as sale of the land in the problem areas is finalised and the new ownership established. Siltation of a watercourse has a significant negative impact upon salmonid and invertebrate habitat, greatly limiting their production, and is almost impossible to mitigate. Prevention is the only sustainable solution

3.3. Bog Burn

There are three potential recommendations for Bog Burn: completely restore a more natural, sinuous channel to the Burn; undertake a ‘dig and dump’ type restoration to the current channel; or install flow diversion structures that would help kick-start naturalisation of the channel. Of these options, complete restoration is the optimal solution to create a more natural watercourse and would be undertaken if significant funding were available. However, the site is constrained within its location and channel dimensions due to adjacent infrastructure, and in the current financial climate, it is unlikely that work on the required scale would be feasible. Installation of woody material and flow deflectors to introduce more natural features to an impacted channel can often be a cheap and easy option. However, in this instance, the extent of modification and lack of flow energy available mean that such techniques are unlikely to create significant habitat improvements. This leaves the most realistic option being ‘dig and dump’ type restoration to the current channel.

Using the ‘dig and dump’ technique, it should be possible to create more natural features within the straightened channel and provide improved habitat for rheophilic (flow-loving) wildlife. The main issues stem from a lack of gradient and the uniform channel width and depth, and while nothing can be done to increase the gradient, increasing the variation in width and depth and creating a channel that has a less uniform cross-section should reinstate a more natural sediment transport regime. This will allow the channel to adapt to the range of flows it receives, providing areas that high flows can scour and hence maintain pools alongside areas of deposition where mobilised substrate can be deposited to form a naturally varied bed profile. A basic diagram of the ‘dig and dump’ technique is depicted in Figure 25.

Ideally, in conjunction with the ‘dig and dump’ restoration, re-profiling of the surrounding banks would also be undertaken to widen the second stage of the channel and allow higher flows to spill out onto a broader area. This would reduce the pressure of higher flows and also create an area for limited natural channel adjustment to occur (Fig. 26).

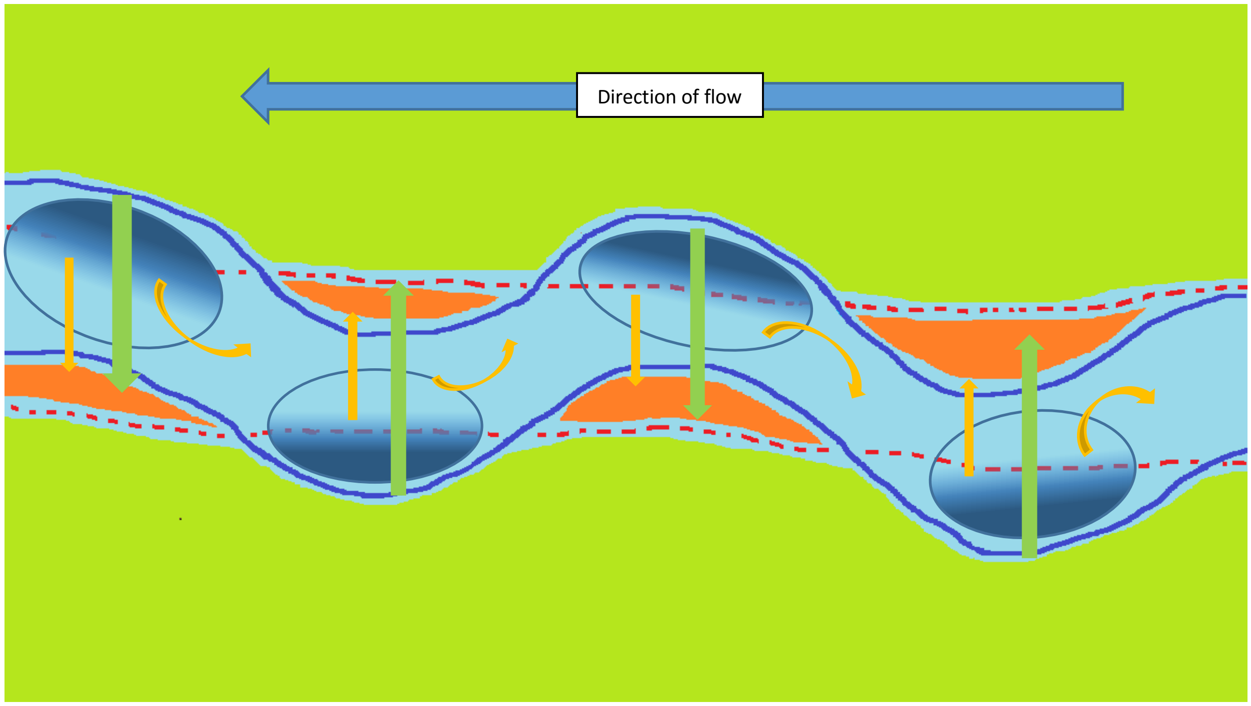
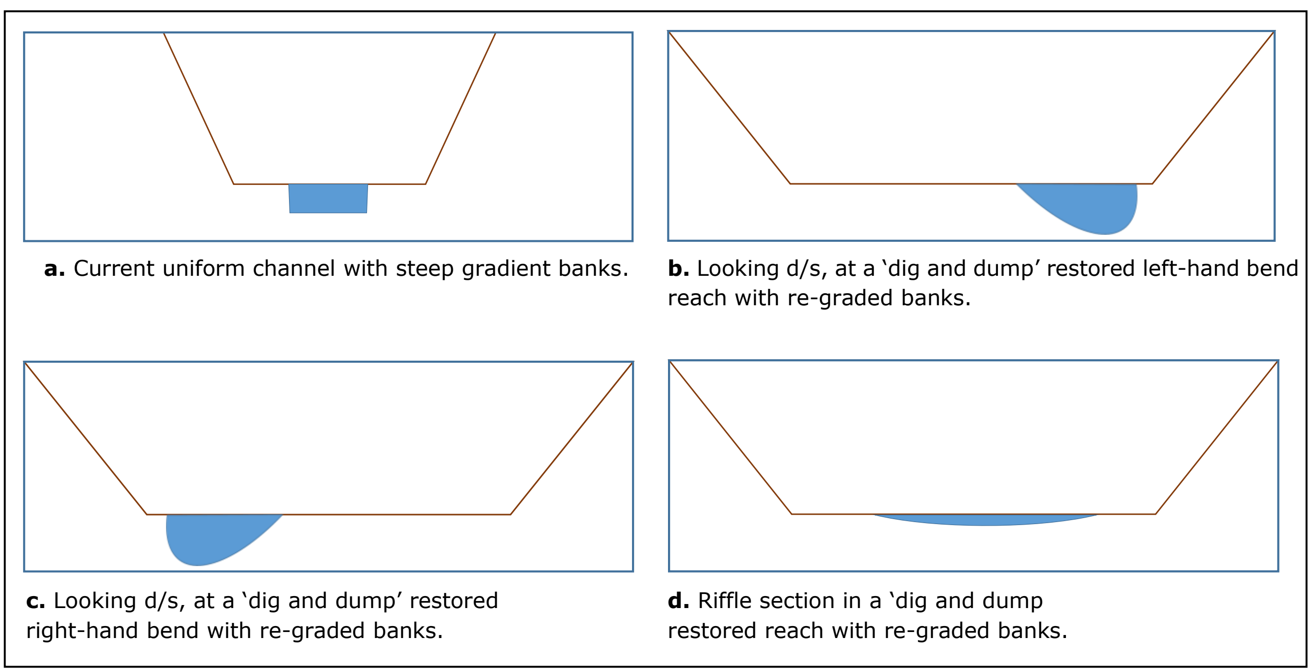


Fig 25. Diagram of a simple 'dig and dump' type river restoration. The dotted red lines represent the original straightened channel course. The dark blue lines represent the course of the improved, more sinuous channel. The dark to light blue graded ellipses represent deeper pool-shallower areas dug into the bed. Green arrows show how material dug out of the bank and bed would be used to create the inside of the bend and gravel bars (orange area), and the coarser gravel material generated is used to create gravel riffles (curved yellow arrow) and the toe of the gravel bars on the inside of the bends (straight yellow arrows).



a. Current uniform channel with steep gradient banks.

b. Looking d/s, at a 'dig and dump' restored left-hand bend reach with re-graded banks.

c. Looking d/s, at a 'dig and dump' restored right-hand bend with re-graded banks.

d. Riffle section in a 'dig and dump restored reach with re-graded banks.

Figure 26a-d. Visualisation of the current, uniform channel (a) and how 'dig and dump' restoration techniques could be employed to reinstate a more natural, self-maintaining channel morphology (b-d) with greater sinuosity. The cross-sections are indicative and not drawn to scale.

In addition to the habitat restoration measures, it is recommended that a programme of invertebrate sampling be initiated on the Bog Burn, which would, ideally, be undertaken by the local community if their support can be gained. Assessing the size and diversity of species within the invertebrate populations of the Burn can provide an indication of the long-term water quality, rather than just the snap-shots possible through water sampling. Changes to the invertebrate populations can then be used to help identify pollution incidents, especially if sites are located us and d/s of the suspected pollution sources.

The Riverfly Partnership operate the 'Anglers' Riverfly Monitoring Initiative' which provides training and support for all organisations (not just anglers) wishing to undertake invertebrate monitoring. More information can be found on the Riverfly Partnership website (www.riverflies.org/rp-riverfly-monitoring-initiative).

4. Making it happen

WTT may be able to offer further assistance such as:

- WTT Practical Visit
    - Where additional assistance is required to initiate any of the recommendations highlighted in a report, there is the possibility of WTT staff conducting a practical visit or workshop. This would usually consist of 1-3 days' work, with a WTT Conservation Officer teaming up with interested parties to demonstrate the habitat enhancement methods described in the report. The recipient would be asked to cover the hours worked per day, travel and subsistence costs of the WTT Officer. This service is in high demand and so may not always be possible but we endeavour to assist where possible. The cost of this service has been included in successful funding bids made by organisations wishing to work with WTT in the past.

In addition, the WTT website library has a wide range of free materials in video and PDF format on habitat management and improvement:

www.wildtrout.org/content/index

We have also produced a 70 minute DVD called 'Rivers: Working for Wild Trout' which graphically illustrates the challenges of managing river habitat for wild trout, with examples of good and poor habitat and practical demonstrations of habitat improvement. Additional sections of film cover key topics in greater depth, such as woody debris, enhancing fish stocks and managing invasive species.

The DVD is available to buy for £10.00 from our website shop www.wildtrout.org/product/rivers-working-wild-trout-dvd-0 or by calling the WTT office on 02392 570985.

5. Disclaimer

This report is produced for guidance only; no liability or responsibility for any loss or damage can be accepted by the Wild Trout Trust as a result of any other person, company or organisation acting, or refraining from acting, upon guidance made in this report.

Appendix A

RBMP Water body information sheet for water body 6833 in Forth

General details

Water body name:	Allan Water (Greenloaning to Dunblane)
Water body Identifier code: 6833	
Length:	15.76 km
Water body category:	River
Baseline:	Y
River basin district:	Scotland
Area advisory group:	Forth
Catchment:	Allan Water
Associated protected areas:	Allan Water - FRESHWATER FISH (EXISTING)
Associated groundwater:	Doune bedrock and localised sand and gravel aquifers
Responsible body:	SEPA Stirling
Heavily modified:	No
Artificial:	No
Typology:	Mid-altitude Medium Calcareous
National Grid Reference:	NN 79599 05393
Latitude:	56.2258
Longitude:	-3.9435

Current status of this water body

We have classified this water body as having an overall status of Moderate with Medium confidence in 2008 with overall ecological status of Moderate and overall chemical status of Pass.

This overall classification of status is made up of many different tiers of classification data. A complete set of classification data for 2008 is shown at the end of this document.

Targets for the future status of this water body

We have set environmental objectives for this water body over future river basin planning cycles in order that sustainable improvements to its status can be made over time, or alternatively that no deterioration in status occurs, unless caused by a new activity providing significant specified benefits to society or the wider environment.

For this water body we have set the overall environmental objectives for the first, second and third River Basin Management Planning (RBMP) cycles as:

Year	2008	2015	2021	2027
Status	Moderate	Moderate	Moderate	Good

We have established an ongoing programme of monitoring in order to identify pressures on our water bodies. The pressures listed below contribute to this water body's failure to meet good ecological status. River basin planning allows us to plan improvements for particular parameters over time. We have collaborated with others to identify measures which will act to protect or improve our water environment in order that all water bodies reach good status over successive RBMP cycles.

Pressures and measures on this water body

The pressures listed below contribute to this water body's failure to meet good ecological status or potential. River basin planning allows us to plan improvements for particular parameters over time. We have collaborated with others to identify measures which will act to protect or improve our water environment in order that all water bodies reach good status over successive RBMP cycles.

The following table shows our collated information on the pressures on this water body, their causes and the measures which could be introduced to mitigate their effects. We have also indicated the current funding status of the measure; with projected measures being potentially funded and agreed measures having funding in place. Finally, we have included information on the potential or actual owner of the measure, the date it will be effective and information on the justification for extending the deadlines or for setting an alternative objective, where appropriate.

Pressure	As a Result of	Assessment Parameter	Objective	Reasons for Failure
	Measure	**Funding**	**Owner**	**Effective date**
Morphological Alterations		Multiple Pressure	Moderate by 2015	Implementation of the measure by an earlier deadline would impose disproportionate burdens
	Improve Modified Habitat	Neither Agreed nor Projected	Landowner(s)	31/12/2026
Morphological Alterations	Road transport	Fish passage	Moderate by 2015	Implementation of the measure by an earlier deadline would impose disproportionate burdens
Pressure	**As a Result of**	**Assessment Parameter**	**Objective**	**Reasons for Failure**

	Measure	Funding	Owner	Effective date
	Removal of barriers or provision of mechanisms to enable fish migration	Neither Agreed nor Projected	Landowner(s)	31/12/2026
Morphological Alterations	Railway transport	Fish passage	Moderate by 2015	Implementation of the measure by an earlier deadline would impose disproportionate burdens
	Removal of barriers or provision of mechanisms to enable fish migration	Neither Agreed nor Projected	Landowner(s)	31/12/2026
Abstraction	Production of renewable electricity (NB nuclear and pumped hydro are not renewable forms of electricity generation)	Change from natural flow conditions	Moderate by 2015	Implementation of the measure by an earlier deadline would impose disproportionate burdens
	Control Abstraction	Neither Agreed nor Projected	Operator	31/12/2026
Abstraction	Aquaculture	Change from natural flow conditions	Moderate by 2015	Implementation of the measure by an earlier deadline would impose disproportionate burdens
	Control Abstraction	Neither Agreed nor Projected	Operator	31/12/2026

Future work

Additional work to identify pressures and to develop and implement measures to mitigate their impacts will continue over subsequent river basin cycles.

Complete classification for this water body in 2008

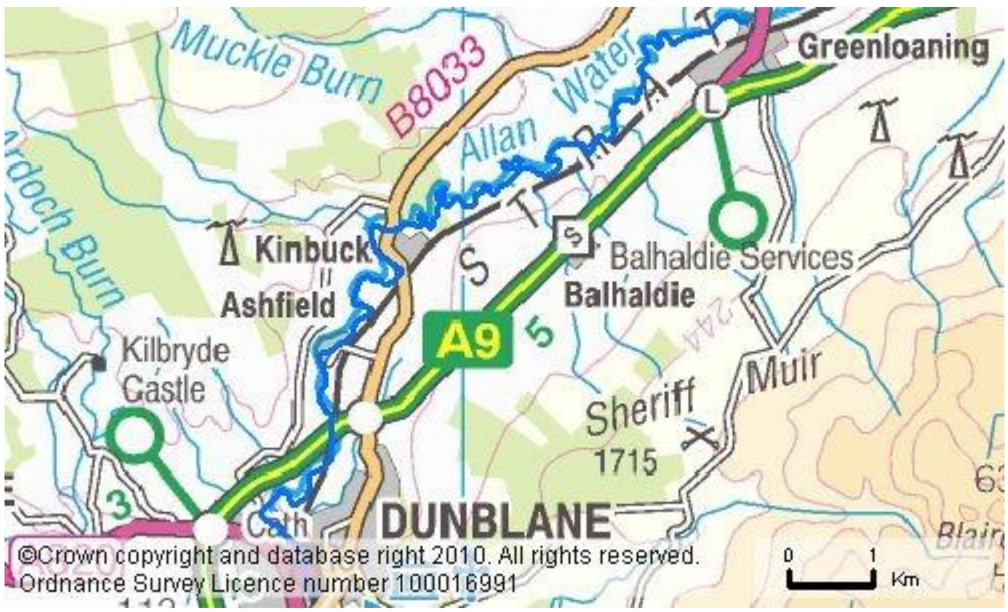
Parameter	Status	Confidence of Class
OVERALL STATUS	MODERATE	MEDIUM
Pre-HMWB status	Moderate	Medium

Parameter	Status	Confidence of Class
Overall chemistry	Pass	Low
Priority substances	Pass	Low
Overall ecology	Moderate	Medium
Physico-Chem	High	High
Temperature	High	High
Soluble reactive phosphorus	High	High
pH	High	High
Dissolved Oxygen	High	High
Biological elements	Moderate	Low
Phytobenthos	High	Low
Macrophytes	High	Low
Benthic invertebrates	High	High
Macro-invertebrates (acid)	High	Low
Macro-invertebrates (RiCT)	High	High
Macro-invertebrates (ASPT)	High	High
Macro-invertebrates (NTAXA)	High	High
Alien species	High	Low
Fish	Moderate	Low
Fish ecology	High	Low
Fish barrier	Moderate	Low
Specific pollutants	Pass	High
Ammonium	Pass	High
Hydromorphology	Moderate	Medium
Morphology	Moderate	Medium
Hydrology	Moderate	Medium
Hydrology (impoundment)	High	Medium

Hydrology (abstraction)	Moderate	Medium
Regulatory ammonium	High	High
Water quality	High	
Morphological pressures	Moderate	

Location of this water body

You can find the geographical location of this water body by searching on water body ID in the interactive maps at www.sepa.org.uk/water/river_basin_planning.aspx



SEPA Contact Details: rbmp@sepa.org.uk

Appendix B

RBMP Water body information sheet for water body 3018 in Forth

General details

Water body name:	Killandean Burn/Harwood Water
Water body Identifier code: 3018	
Length:	12.91 km
Water body category:	River
Baseline:	Y
River basin district:	Scotland
Area advisory group:	Forth
Catchment:	River Almond
Associated protected areas:	River Almond (Lothian) - FRESHWATER FISH (EXISTING)
Associated groundwater:	Edinburgh and Livingston bedrock and localised sand and gravel aquifers
Responsible body:	SEPA Falkirk & W Lothian
Heavily modified:	No
Artificial:	No
Typology:	Mid-altitude Small Calcareous
National Grid Reference:	NT 02234 62062
Latitude:	55.84183
Longitude:	-3.56279

Current status of this water body

We have classified this water body as having an overall status of Poor with Low confidence in 2008 with overall ecological status of Poor and overall chemical status of Pass.

This overall classification of status is made up of many different tiers of classification data. A complete set of classification data for 2008 is shown at the end of this document.

Targets for the future status of this water body

We have set environmental objectives for this water body over future river basin planning cycles in order that sustainable improvements to its status can be made over time, or alternatively that no deterioration in status occurs, unless caused by a new activity providing significant specified benefits to society or the wider environment.

For this water body we have set the overall environmental objectives for the first, second and third River Basin Management Planning (RBMP) cycles as:

Year	2008	2015	2021	2027
Status	Poor	Poor	Good	Good

We have established an ongoing programme of monitoring in order to identify pressures on our water bodies. The pressures listed below contribute to this water body's failure to meet good ecological status. River basin planning allows us to plan improvements for particular parameters over time. We have collaborated with others to identify measures which will act to protect or improve our water environment in order that all water bodies reach good status over successive RBMP cycles.

Pressures and measures on this water body

The pressures listed below contribute to this water body's failure to meet good ecological status or potential. River basin planning allows us to plan improvements for particular parameters over time. We have collaborated with others to identify measures which will act to protect or improve our water environment in order that all water bodies reach good status over successive RBMP cycles.

The following table shows our collated information on the pressures on this water body, their causes and the measures which could be introduced to mitigate their effects. We have also indicated the current funding status of the measure; with projected measures being potentially funded and agreed measures having funding in place. Finally, we have included information on the potential or actual owner of the measure, the date it will be effective and information on the justification for extending the deadlines or for setting an alternative objective, where appropriate.

Pressure	**As a Result of**	**Assessment Parameter**	**Objective**	**Reasons for Failure**
	Measure	**Funding**	**Owner**	**Effective date**
Diffuse Source Pollution	Mining and quarrying of coal	UK Specific pollutants (Annex 8)	Good by 2015	
	Non-urban land management measures	Neither Agreed nor Projected	Coal Authority	31/03/2027
Morphological Alterations		Fish passage	Poor by 2015	Implementation of the measure by an earlier deadline would impose disproportionate burdens
	Removal of barriers or provision of	Projected	Operator	31/12/2020
Pressure	**As a Result of**	**Assessment Parameter**	**Objective**	**Reasons for Failure**

	Measure	Funding	Owner	Effective date
	mechanisms to enable fish migration			
	Removal of barriers or provision of mechanisms to enable fish migration	Projected	Landowner(s)	31/12/2010

Future work

Additional work to identify pressures and to develop and implement measures to mitigate their impacts will continue over subsequent river basin cycles.

Complete classification for this water body in 2008

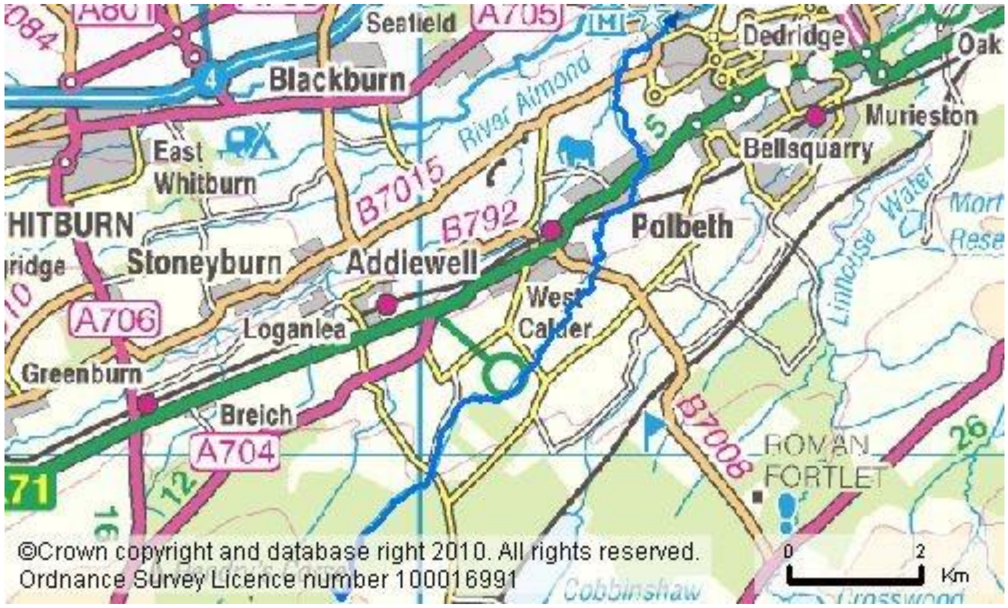
Parameter	Status	Confidence of Class
OVERALL STATUS	POOR	LOW
Pre-HMWB status	Poor	Low
Overall chemistry	Pass	Low
Priority substances	Pass	Low
Overall ecology	Poor	Low
Physico-Chem	High	High
Temperature	High	High
Soluble reactive phosphorus	High	High
pH	High	High
Dissolved Oxygen	High	High
Biological elements	Poor	Low
Phytobenthos	High	Low
Macrophytes	High	Low
Benthic invertebrates	Good	High
Macro-invertebrates (acid)	High	Low
Macro-invertebrates (RiCT)	Good	High
Macro-invertebrates (ASPT)	Good	High

Macro-invertebrates (NTAXA)	High	High
Alien species	High	Low
Fish	Poor	Low

Parameter	**Status**	**Confidence of Class**
Fish ecology	High	Low
Fish barrier	Poor	Low
Specific pollutants	Pass	High
Iron	Pass	High
Ammonium	Pass	High
Hydromorphology	Good	Medium
Morphology	Good	Medium
Hydrology	High	Medium
Hydrology (impoundment)	High	Medium
Hydrology (abstraction)	High	Medium
Regulatory ammonium	Good	Medium
Water quality	Good	
Morphological pressures	Poor	

Location of this water body

You can find the geographical location of this water body by searching on water body ID in the interactive maps at www.sepa.org.uk/water/river_basin_planning.aspx



SEPA Contact Details: rbmp@sepa.org.uk

Appendix C

RBMP Water body information sheet for water body 3107 in Forth

General details

Water body name:	Boghead Burn/Bog Burn/Couston Water
Water body Identifier code: 3107	
Length:	9.80 km
Water body category:	River
Baseline:	Y
River basin district:	Scotland
Area advisory group:	Forth
Catchment:	River Avon
Associated protected areas:	River Avon (Falkirk) - FRESHWATER FISH (EXISTING) River Avon (including Barbauchlaw Burn, Logie Water, Couston Water) - UWWTD SENSITIVE AREA (EXISTING)
Associated groundwater:	Stirling and Falkirk bedrock and localised sand and gravel aquifers
Responsible body:	SEPA Falkirk & W Lothian
Heavily modified:	No
Artificial:	No
Typology:	Lowland Small Calcareous
National Grid Reference:	NS 96283 70357
Latitude:	55.91508
Longitude:	-3.66096

Current status of this water body

We have classified this water body as having an overall status of Bad with High confidence in 2008 with overall ecological status of Bad and overall chemical status of Pass.

This overall classification of status is made up of many different tiers of classification data. A complete set of classification data for 2008 is shown at the end of this document.

Targets for the future status of this water body

We have set environmental objectives for this water body over future river basin planning cycles in order that sustainable improvements to its status can be made over time, or alternatively that no deterioration in status occurs, unless caused by a new activity providing significant specified benefits to society or the wider environment.

For this water body we have set the overall environmental objectives for the first, second and third River Basin Management Planning (RBMP) cycles as:

Year	2008	2015	2021	2027
Status	Bad	Poor	Poor	Good

We have established an ongoing programme of monitoring in order to identify pressures on our water bodies. The pressures listed below contribute to this water body's failure to meet good ecological status. River basin planning allows us to plan improvements for particular parameters over time. We have collaborated with others to identify measures which will act to protect or improve our water environment in order that all water bodies reach good status over successive RBMP cycles.

Pressures and measures on this water body

The pressures listed below contribute to this water body's failure to meet good ecological status or potential. River basin planning allows us to plan improvements for particular parameters over time. We have collaborated with others to identify measures which will act to protect or improve our water environment in order that all water bodies reach good status over successive RBMP cycles.

The following table shows our collated information on the pressures on this water body, their causes and the measures which could be introduced to mitigate their effects. We have also indicated the current funding status of the measure; with projected measures being potentially funded and agreed measures having funding in place. Finally, we have included information on the potential or actual owner of the measure, the date it will be effective and information on the justification for extending the deadlines or for setting an alternative objective, where appropriate.

Pressure	As a Result of	Assessment Parameter	Objective	Reasons for Failure
	Measure	**Funding**	**Owner**	**Effective date**
Morphological Alterations		Multiple Pressure	Moderate by 2015	Implementation of the measure by an earlier deadline would impose disproportionate burdens
	Improve Modified Habitat	Projected	Landowner(s)	31/12/2026

Point Source Pollution	Sewage disposal	Priority Substances (Annex 10)	Failing to Achieve Good by 2015	Implementation of the measure by an earlier deadline would impose disproportionate burdens

Pressure	**As a Result of**	**Assessment Parameter**	**Objective**	**Reasons for Failure**
	Measure	**Funding**	**Owner**	**Effective date**
	Increase treatment	Neither Agreed nor Projected	Scottish Water	31/03/2024
Diffuse Source Pollution	Mining and quarrying of coal	UK Specific pollutants (Annex 8)	Failing to Achieve Good by 2015	Implementation of the measure by an earlier deadline would impose disproportionate burdens
	Reduce Diffuse Source Inputs	Neither Agreed nor Projected	Coal Authority	31/12/2027
Point Source Pollution	Sewage disposal	Phosphorus	Moderate by 2015	Implementation of the measure by an earlier deadline would impose disproportionate burdens
	Increase treatment	Agreed	Scottish Water	16/10/2012
	Increase treatment	Projected	Scottish Water	16/10/2012
Diffuse Source Pollution		UK Specific pollutants (Annex 8)	Failing to Achieve Good by 2015	Implementation of the measure by an earlier deadline would impose disproportionate burdens
	Reduce Diffuse Source Inputs	Projected	Scottish Water	31/03/2024
Morphological Alterations	Paper, pulp and paper products	Fish passage	Poor by 2015	Implementation of the measure by an earlier deadline would impose disproportionate burdens
	Removal of barriers or provision of mechanisms to enable fish migration	Projected	West Lothian Council	31/12/2026

Point Source Pollution	Sewage disposal	Ammonia	Good by 2015	
	Reduce Point Source Inputs	Neither Agreed nor Projected	Scottish Water	31/03/2024
Point Source Pollution	Sewage disposal	Ammonia	Good by 2015	
	Increase treatment	Agreed	Scottish Water	16/10/2012
Point Source Pollution	Sewage disposal	Dissolved Oxygen	Poor by 2015	Implementation of the measure by an earlier deadline
Pressure	**As a Result of**	**Assessment Parameter**	**Objective**	**Reasons for Failure**
	Measure	**Funding**	**Owner**	**Effective date**
				would impose disproportionate burdens
	Increase treatment	Agreed	Scottish Water	16/10/2012

Future work

Additional work to identify pressures and to develop and implement measures to mitigate their impacts will continue over subsequent river basin cycles.

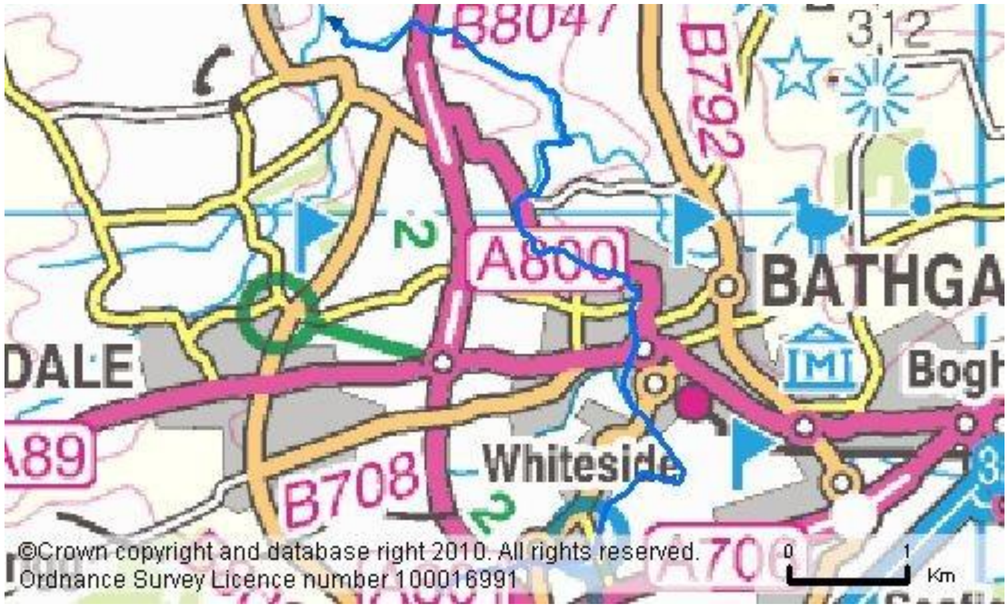
Complete classification for this water body in 2008

Parameter	Status	Confidence of Class
OVERALL STATUS	BAD	HIGH
Pre-HMWB status	Bad	High
Overall chemistry	Pass	Low
Priority substances	Pass	Low
Overall ecology	Bad	High
Physico-Chem	Poor	Medium
Temperature	High	High
Soluble reactive phosphorus	Good	High
pH	High	High
Dissolved Oxygen	Poor	Medium

Biological elements	Bad	High
Phytobenthos	Moderate	High
Macrophytes	High	Low
Benthic invertebrates	Bad	High
Macro-invertebrates (acid)	High	Low
Macro-invertebrates (RiCT)	Bad	High
Macro-invertebrates (ASPT)	Bad	High
Macro-invertebrates (NTAXA)	Moderate	High
Alien species	High	Low
Fish	Poor	Low
Fish ecology	High	Low
Parameter	**Status**	**Confidence of Class**
Fish barrier	Poor	Low
Specific pollutants	Fail	High
Iron	Pass	High
Ammonium	Fail	High
Hydromorphology	Moderate	Medium
Morphology	Moderate	Medium
Hydrology	High	Medium
Hydrology (impoundment)	High	Medium
Hydrology (abstraction)	High	Medium
Regulatory ammonium	Moderate	High
Water quality	Bad	
Morphological pressures	Poor	

Location of this water body

You can find the geographical location of this water body by searching on water body ID in the interactive maps at www.sepa.org.uk/water/river_basin_planning.aspx



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