Advisory Visit

River Avon

Stirlingshire

Undertaken by Gareth Pedley

Key findings

- The main impact upon the river in this area is dredging, with clear evidence of straightening in many areas, particularly the reach downstream of the B803.
- Without cessation of dredging it is unlikely that reinstatement (natural or otherwise) of high quality shallower riffle and spawning habitat is likely to be achievable.
- The increased bank stability provided by buffer strips is of equal (or greater) benefit to the adjacent land users and the ecology of the reach. As such, it is in the interest of the land users to maintain and improve their buffer strips which should not be solely dependent upon ecological project funding.
- In light of the above points, significant spending on land drainage (upstream of the B803) in return for relatively small in-channel improvements may not be the best use of ecological project funding.
- In the absence of an agreement for cessation of dredging and a large-scale channel restoration scheme, simple tree planting within the buffer strips may be the most beneficial course of action.
- Further investigation into the feasibility of a large-scale river restoration for the lower section would be beneficial.

1.0 Introduction

This report is the output of a site visit to the upper River Avon (River Forth catchment), Stirlingshire. The visit was undertaken for the Forth Fisheries Trust (FFT) to provide an overview of options that could be undertaken at two adjoining sites near Slamannan. Conditions on the day were somewhat challenging, with the river flows elevated through heavy rain.

Normal convention is applied throughout this report with respect to bank identification, i.e. banks are designated left bank (LB) or right bank (RB) while looking downstream. The Ordnance Survey National Grid Reference system is used to identify specific locations and references to upstream and downstream are often abbreviated to u/s and d/s for convenience.

2.0 Catchment/Site Overview

Sites were visited immediately u/s and d/s of the B803 road bridge, north of Slamannan. The adjacent land use is slightly different at each site, with both supporting a large areas of pasture but with more areas of arable agriculture alongside the upper site. Much of the river is buffer fenced but it does not extend to all areas. Waterlogging within the adjacent fields highlights perceived issues with land drainage and likely locations of paleo-channels within the floodplain and, potentially, previous more natural river courses. Dredging and straightening is likely to have denuded much of the natural substrate in this area and interrupted the supply of new material.

3.0 Habitat Assessment

3.1 Upstream of the B803

Upstream of the B803, the river is uniformly deep and narrow for the upper reaches of a river. One of the few sharper bends (Fig. 1) does provide some deeper pool habitat but dredging of this area creates an overcapacity channel that will be subject to greatly increased deposition. Further u/s, the lack of discrete wider, shallower areas and gravel bars creates a paucity of pool and riffle habitat and suggests a history of extensive dredging. This interpretation is supported by the local knowledge of FFT staff members accompanying the visit who confirm both historical and recent (ongoing) dredging. The consequent altered channel form and function inevitably reduces habitat quality for fish and invertebrates. Furthermore, the bed lowering and interruption of natural sediment supply d/s resulting from dredging often perpetuates channel incision, leaving areas of higher, unprotected banks, at far greater risk of erosion.

Figure 1. An area where material has been removed from the channel and placed upon the far bank (RB). In a natural scenario, the inside and outside of bends are actively maintained by erosion and deposition according to the flow energy and material supplied from u/s; widening or deepening a channel simply result in increased deposition locally.

Figure 2. At the very next bend u/s of the dredging, bank destabilisation is clearly evident. It is likely that the removal of bed material downstream has accelerated the transport of bed material from this section to fill the void d/s - that bed lowering and destabilisation inevitably leaves the banks here more susceptible to undercutting.

The channel is relatively straight and uniform for extended sections which further inhibits the formation of pools and discrete bed features. In some areas, lower gradient banks combined with abundant vegetation (ground cover and more extensive root matrices protected within riverside buffer strips) contribute to reduced erosion and the channel is stable in some areas (Fig. 3). However, the river appears canal-like and the lack of flow diversity provides poor riverine habitat. At low summer levels flow will be uniformly sluggish and at high flow there will be few areas in which fish can shelter. Although the stable banks limit erosion and fine sediment input, this section is far from ideal and the bank stability may even inhibit the river naturally adjusting its channel dimensions.

Figure 3. A relatively featureless channel section, lacking bends and discrete pool and riffle features. Although being stable naturally limits the supply of very fine sediment it also limits the supply of the important and lacking coarser substrate (gravel, cobble etc.) and the uniform channel provides poor fish and invertebrate habitat. Note the standing water in the adjacent field (red circle), this may be evidence of the rivers past course.

Areas further u/s are eroding (Fig. 4), which is inevitable over an extended reach where dredging has occurred, owing to the lowering of the bed and interruption of sediment transport. In addition to sharper bends, where some natural erosion would be expected, erosion is occurring on the straighter, narrow sections (likely to be maintained or created narrow by dredging/lowering the bed). The erosion appears to be a natural reaction of the higher flow energy being constrained within the incised channel which is consequently adjusting to those flows - the lowered bed will not be so quick to recover, particularly if the gravel supply is limited, as suspected.

Figure 4. A straight and narrow section where the increased flow energy will be contributing to erosion (red ellipse). Dredging occurring at the location, u/s or d/s is also likely to be contributing.

In-channel structures have previously been introduced in this section. Artificial structures can be invaluable in increasing flow diversity, scour and deposition within a degraded channel; however, the use of boulders, which was more commonplace in the past is now often substituted for more diffuse brash and woody structures. Similarly, the design and placing of deflectors may be different, now often tending towards alternating, rather than paired structures. While paired deflectors work well in certain channels, they can inhibit more naturally, sinuous flow by focussing energy and bed scour into the centre of the channel and increasing deposition along opposite banks. Both of these factors can potentially contribute to further bed lowering and inhibit the development of a more sinuous channel with discrete pools and riffles. However, dredging and a lack of gravel supply remains the overriding issue.

Past channel courses (paleo-channels) were observed within the floodplain. These often remain as low points within a floodplain, occasionally after natural channel adjustment but often after artificial straightening (Fig. 5). These areas can continue to accumulate sub-surface flow which re-surfaces or prevents infiltration in wet conditions. Watercourse straightening therefore rarely delivers the intended benefits for land drainage, usually leading to an increased wetted area within the floodplain in wet conditions.

Soil compaction from grazing and trampling also often prevents surface water from soaking away into the ground.

From a land management perspective, it is important to consider the often forgotten value of rivers spilling onto the floodplain, which is invariably of very short duration (usually <24h providing that it is not trapped behind artificial flood banks) and rarely causes a detrimental impact upon the land. Moreover, allowing flow to spill onto a floodplain actually provides a host of benefits to land management. Allowing out of bank flows reduces flow energy within the channel and therefore reduces bank erosion. The dissipation of flow energy on the floodplain then causes fine sediment (new soil) and nutrients to be deposited onto the adjacent fields. This natural process is part of the reason that river valleys/floodplains are so naturally productive. Constraining flows within the channel also potentially creates greater issues with flooding d/s as preventing the temporary use of the floodplain in high flow events prevents the natural attenuation of peak flows.

Figure 5. Wet areas with the adjacent fields may hint at the river's past courses.

While on site, the potential for a major scheme that would address many of the issues encountered was raised, but it is believed that the land owners would be averse to the idea. As an alternative, land drainage improvements had been discussed with the owners in exchange for agreement to install new buffer fencing and in-channel woody material. While the installation of nature-like in-channel structures could provide improvements to the flow diversity, geomorphology (bed profile) and habitat quality, those improvements would be severely limited by the existing channel dimensions and persistent dredging activity. Discrete, wider channel sections d/s of bends (in which material can be deposited and retained) and greater flow sinuosity is also likely to be required for the lacking riffle features to form. A supply of gravel would also have to be reinstated, through cessation of dredging and possibly also through gravel re-introduction. The suspected high cost of the proposed land management interventions (additional drainage, outfall structures and fencing) may therefore make the ecological cost:benefit questionable. Simple strategic planting within the buffer strip might therefore present a much more realistic option, if permitted.

In the absence of a major scheme to restore the channel to a more natural state, some areas of erosion are actually likely to be beneficial in allowing the channel to adapt, creating sinuosity and width variation. The buffer strips present are undoubtedly contributing to the stability of the river banks so, in addition to preventing fine sediment inputs (some ecological benefit), are actually reducing land loss and providing benefits for the landowner and/or tenant. It is therefore in their interest to maintain those fences and well-vegetated river banks. Failing to do so would result in greatly increased erosion rates that would be of great detriment to the land managers but, ironically, probably less of an issue for the habitat quality and function of the river which could then more rapidly recover (providing the erosion is in discrete areas and not throughout).

The area of erosion in Fig. 2 was highlighted for possible brash bank protection work. While brash work is often undertaken to protect vital assets or infrastructure and limit the input of fine sediment, the value of undertaking such work in that location is limited, from an ecological perspective. Again, the greatest detriment from the erosion is the loss of land to the land manager, yet it is the channel dredging and limited buffer with a lack of trees that is exacerbating the erosion issues. Ceasing dredging and moving the buffer fence back away from the river to allow tree planting is therefore in the interests of the land manager who should be seeking to undertake that work voluntarily. The site also appears difficult to work in, owing to the depth of water in which any bank protection would have to be installed, so the time and effort involved may well be better spent on more influential habitat improvements elsewhere.

If large areas of the site were suffering catastrophic erosion and excessive fine sediment input the assessment may be somewhat different; however, in this instance, the benefits of natural channel adjustment should help to mitigate the negative impacts of fine sediment input upon the ecology of the river. It will be well worth monitoring the site and reassessing the situation if future land management and river dredging practices change.

3.2 Downstream of the B803

The channel d/s of the B803 suffers many of the same impacts as u/s, with the addition of rock armouring along the sewage treatment works bank. As invariably occurs, the intended hard revetment with stone rip rap has provided some short-term protection, in one area, but at the expense of the area immediately d/s, where erosion is accelerated (Fig. 6).

Downstream of the sewage works is a short, more naturally sinuous area that, despite comprising two sharp bends, has relatively stable banks and hints at the river's natural planform (Fig. 7). Planting of the banks in this area (particularly the LB) would be beneficial to help consolidate the bank further and protect one of the few naturally sinuous sections and improve the riparian cover. Further d/s, the channel is clearly straightened with a lowered (dredged) bed (Fig. 8). This realignment continues for a long distance past the extent of the site visited (Figs 9 & 10).

Figure 6. Hard, rip rap armouring of the river bank, resulting in accelerated erosion immediately d/s (red circle).

Figure 7. Just d/s of the sewage works is a rare (for this river section), sharp meander. Planting of the LB could help preserve this feature. Sadly, the history of dredging and inhibition of sediment supply is inhibiting the reformation of high quality natural riffle features even d/s of this area.

Figure 8. Although the channel is not completely straight d/s of the meanders, it has clearly been severely realigned and straightened to gradual, sweeping bends.

The sheer volumes of earth moved and the impact upon the river channel is hard to comprehend without comparing the river's course on old maps to that on current maps. What's even more surprising is just how recently some of the major straightening and dredging work was undertaken (1976, according to Slamannan Angling Protective Association (SAPA) website), supporting claims by some local residents that they actually remember the river in its previous course. Figure 9 shows the current straightened course and Figure 10, the pre-straightened course. Although it is hard to accurately ascertain form the maps, on close inspection, the previous, more natural channel appears wider on average, with a greater width variability, as would be expected. LiDAR survey of the site would be very useful as, in addition to the current channel and it's previously meandering course, apparently lower ground to the left of the floodplain may suggest other previous channels from which the river was removed or it naturally abandoned. However, it is very hard to accurately ascertain relative ground levels by eye and land management like drainage can lead to lowering of the ground in areas (hence a further requirement for LiDAR).

Clearly, the river cannot function properly within such an impacted channel. The increased gradient and reduced width will increase sediment transport, particularly at peak flows, with the lack of flow diversity and energy dissipation from bends inhibiting the river's ability to develop a more natural bed morphology.

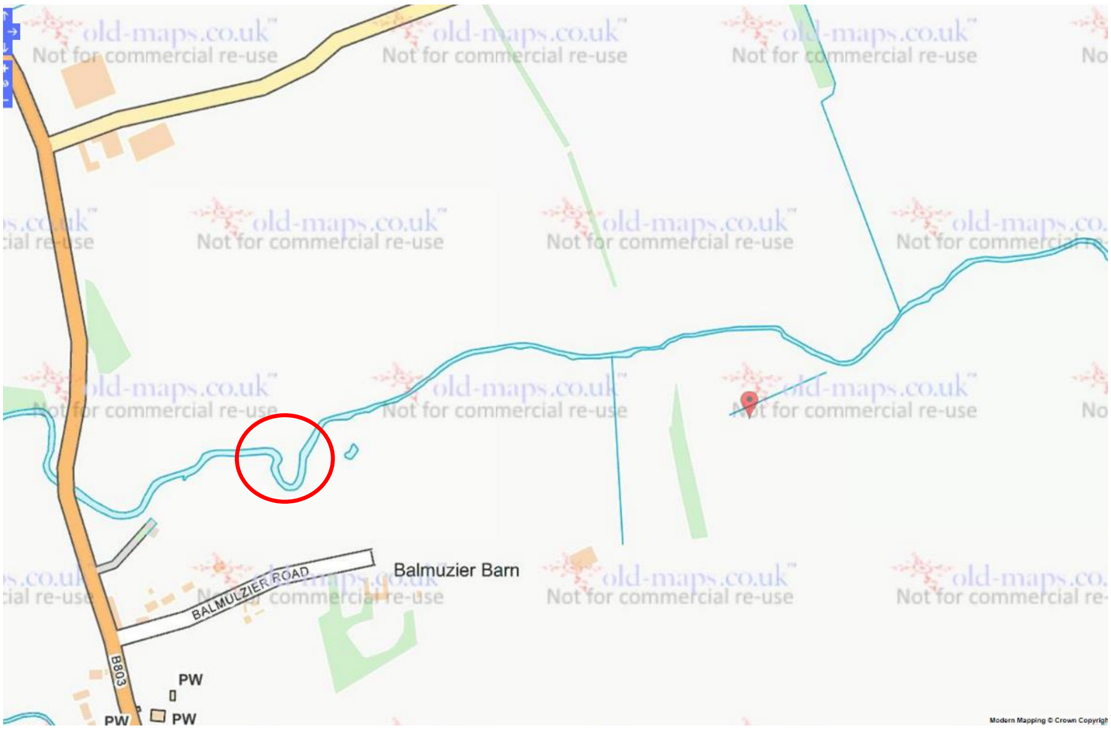

Figure 9. The approximate current position of the River Avon as visited and shown on current maps/aerial photography (www.old-maps.co.uk). The red circle identifies the only existing remnants of a more natural planform.

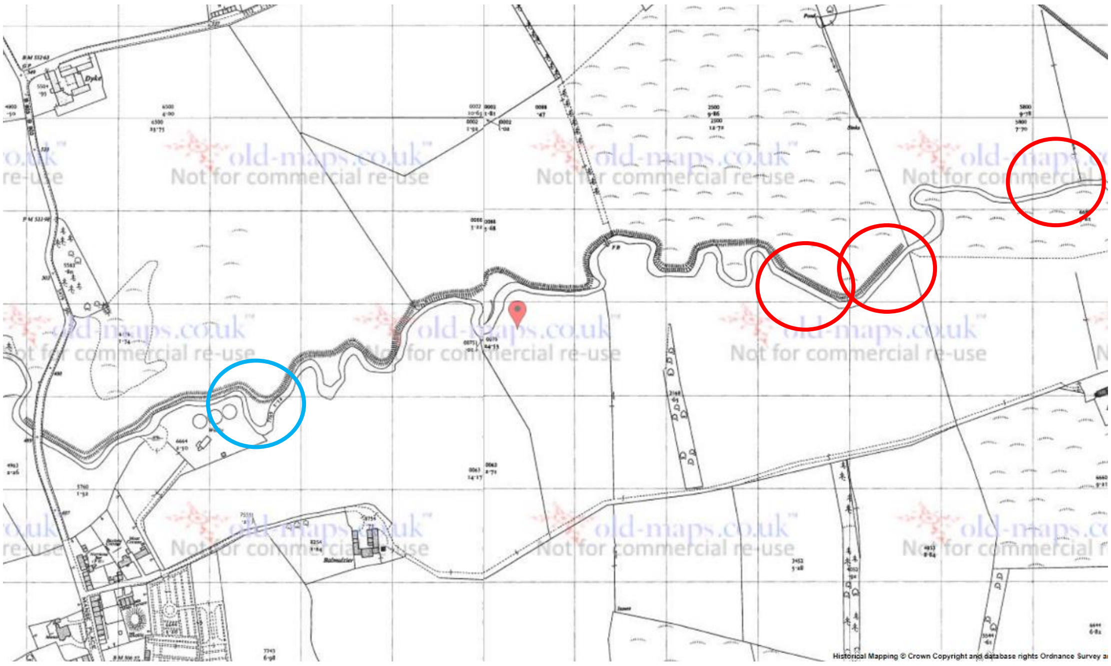

Figure 10. OS Plan 1962 - (taken from the 1:2500 scale map - www.old-maps.co.uk). From the available maps, the channel appears to have followed this approximate course until sometime between 1967 and 1990 (which fits with the timeframe reported on the SAPA website). Note how the sinuous section identified d/s of the sewage works (blue circle) is actually the only near-natural planform remaining. Even there (as far back as the 1897 map), the river is flanked along its LB by a floodbank. Such banks were often created and / or added to with material dredged out of the river. Also note that even in the 1962 map there are already sections that appear straightened (red circles).

4.0 Recommendations/summary

4.1 Upstream of the B803

In the absence of an agreement for cessation of dredging and permission for major in-channel improvements, the ecological benefit achievable from a costly land drainage scheme may be limited. Many of the improvements suggested seem to be for the perceived benefit of the adjacent land users (agriculture), rather than any major land management benefits or improvement to the geomorphology and ecology of the river. Moreover, improving land drainage for a short period during peak flow events has the potential to negatively impact upon natural sediment and nutrient sequestration, water quality, river ecology and peak flows downstream.

One of the suggestions to improve land drainage was to lower the banks/flood-banks/dredging spoil, and while this could provide some benefit for the river, the limited extent of the raised banks and the cost involved mean that simply ceasing dredging would be a far more profound improvement. Helping the land users to understand how the dredging is contributing to their own erosion issues and that temporary inundation of the floodplain is positive would be beneficial.

While in-channel structures are unlikely to mitigate the modified dimensions of the channel without allowing significant additional erosion and deposition, installing alternate pinned brash structures and, ultimately, hinged trees (if they can be planted and established) would provide some habitat improvement. If not agreeable with the landowner, simple strategic planting of bankside trees could be a quick and easy way of improving bankside cover. It is to be hoped that these options may be agreeable without the improvements to land drainage and bank protection, and the associated costs. However, onsite discussions indicated that such interventions alone may not be agreeable with the adjacent land users (presumably precipitating the original proposal of a larger-scale land management project).

4.2 Downstream of the B803

Before any major work is undertaken d/s of the B803, it is recommended that further investigation of the site is undertaken to ascertain the river's natural course and alignment as even the more natural course identified in Fig. 10 may have already been altered. Obtaining LiDAR data for the site would be highly beneficial in understanding the topography of the land and what may be beneficial or even possible at the site. While the LiDAR data may not be definitive and past channels may be masked by backfilling and natural channel migration, it could certainly help improve understanding of the site and what a river restoration/improvement scheme might potentially look like. The land owner could then be approached with a range of proposals (an inclination to consider river restoration was previously expressed). If agreement to proceed with a scheme is given, it would then be worthwhile procuring a geomorphologist to produce detailed designs.

There is no doubt that the most beneficial action will be to reinstate a more naturally sinuous channel that is of appropriate proportions and gradient, and would support a more-natural geomorphological regime (possibly with the addition of bed raising with gravel). Such work would be highly beneficial, facilitating the requisite major improvements to the habitat and ecology of the reach. If for whatever reason such an option is completely ruled out at a later date, it may then be worth investigating options for lesser improvements like the installation of strategically designed and placed in-channel structures.

5.0 Making it Happen

WTT may be able to offer further assistance such as:

- Technical support in investigating river restoration options
    - Several members of the WTT team have delivered large scale river restorations and are available to advise on the merits and potential pitfalls of a scheme. Staff may also be available to advise on the project design and planning process.

6.0 Disclaimer

This report is produced for guidance; 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.