WILD TROUT TRUST

Advisory Visit: River Yarrow

Southport Fly Fishers Club, Sept 2023

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Key Findings

- The Yarrow is a highly modified waterbody with a lingering legacy from its industrial heritage, as well as dubious water quality from ongoing sewage pollution.
- In an area of relatively high rainfall and depauperate vegetation in the upper catchment, conveyance is high, and the river response is 'flashy', ie the level rises rapidly and decreases quite quickly afterward. This exacerbates erosion in a catchment of already friable soils and can degrade habitat (especially the substrate) via fine sediment pollution.
- Much of the channel on the upper beat is highly modified, incised and constrained, and beyond the means of the club to address. However, the riparian zone (bankside vegetation) there is relatively natural mixed deciduous woodland providing a plethora of benefits to the fishery. Artificially embanked or heavily grazed sections offer considerably fewer benefits in the lower beat (RB).
- Hence, the biggest bang for buck along the lower beat would be to extend or repair livestock exclusion fencing to rehabilitate the native flora and reinstate the benefits associated with a functional riparian zone. Capital costs for such work, including alternative livestock drinking provision (if required), can be sourced from various schemes, with potential for ongoing reward.
- There is scope for simple, low-cost, habitat improvements by club members using locally sourced woody material laid into the channel in various ways that can be carried out with guidance from WTT.
- Several weirs still fragment the river and impede fish movement within the short reach under the demesne of the club, and should be investigated further for removal or passage solutions.

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1.0 Introduction

This report is the output of a walkover on the River Yarrow, Lancashire, and an artificial trout lake, for Southport Fly Fishers Club (SFFC). Channel and riparian habitat quality was assessed by Prof J Grey of the Wild Trout Trust, accompanied by several committee members. Further assessment was made via subsequent desk-based study.

Normal convention is applied with respect to bank identification, i.e. left bank (LB) or right bank (RB) whilst looking downstream. Upstream and downstream references are often abbreviated to u/s and d/s, respectively, for convenience. The Ordnance Survey National Grid Reference (NGR) system is used for identifying locations.

SFFC waters are located within the waterbody identified as Yarrow DS Big Lodge Water (GB112070064952), designated as a *Heavily Modified* channel of *Moderate Ecological Status*. Reasons for not achieving *Good Status*, the target under the Water Framework Directive, are:

- point source pollution from continuous sewage discharge affecting invertebrates, macrophytes & phytobenthos combined, and phosphate
- physical modification (undefined)

More information can be gleaned by clicking the linked waterbody ID number, above. Against this backdrop of poor water quality, it is interesting to reflect upon a report by Holloway (on behalf of the Wild Trout Trust) for the Friends of the River Yarrow back in 2001 which looked primarily at fish passage and habitat at a couple of major weirs and noted generally good water quality and bed substrate albeit on the u/s side of Chorley (report available, here).

2.0 Catchment & Fishery Overview

The River Yarrow, Lancashire, flows from the West Pennine Moors and was dammed in several places to create the Yarrow Reservoir, which in turn supplies the Anglezarke and Upper and Lower Rivington Reservoirs. Approximately 53km of channel drain ~71km^2 of catchment. Skirting most urban centres, the river flows through varied land use, from farmland through to ancient woodland, eg at Duxbury, contributing to the River Douglas at Sollom just before its inlet into the tidal River Ribble.

It presents a mixed fishery, with a few records of migratory salmonids since chronic industrial pollution was reduced. Water quality clearly remains an issue d/s of Chorley but is probably primarily a combination of sewage and agricultural inputs in recent years. The sewage map compiled by the Rivers Trust suggests that at least four Combined Sewer Overflows discharged untreated sewage into the Yarrow, u/s of the SFFC waters, for a combined total of 843h during 2022.

Another legacy of that industrial heritage, weirs remain an issue along the channel, although fish passes have been installed at Pincock, Birkacre and Duxbury. However, the channel remains fragmented elsewhere and all fish populations will suffer as a consequence, especially with the ever present threat of pollution events.

Map 1. Upper - extract from MAGIC highlighting the extent of the Yarrow observed during the walkover, and (lower) a satellite image of the same reach highlighting current land-use around the channel.

3.0 Habitat Assessment

3.1 River Yarrow

The channel was assessed from the u/s limit (SD 54790 18010) of Southport Fly Fishers' waters, where an old goit and sluice were found on the RB (Fig 1). Due to rainfall, the water was too coloured to make out any submerged features in the main channel. Furthermore, it was a long, impounded reach caused by the weir ~ 50m d/s (Fig 2), and hence artificially deepened and sluggish, of limited habitat value. Several fallen & leaning trees provided low and submerged refugia which would no doubt benefit fish species at certain times.

Fig 1. At SD 54790 18010, the u/s extent of the waters and the walkover, the goit associated with the weir was routed from the RB in a heavily incised channel of consistent proportions. Re-naturalisation of the riparian flora had resulted in a native woodland canopy of mixed age, although ground cover was limited due to a relatively dense canopy and the proximity of a popular footpath adjacent.

As with any artificial, relatively straight channel, the goit was heavily incised and dominated by fast riffle habitat but offered potential backwater refugia during main channel spate flows. The goit may also provide spawning habitat but this would have to be assessed under lower flows. Naturalisation of the goit banks with a well-developed native tree flora provided substantial shade; indeed, the ground cover was relatively sparse (ivy, dog's mercury amongst others, as well as Himalayan balsam). Bare earth resulting from shade and/or balsam dieback was compounded by footfall and dog access to the water where the popular footpath was too close to the bank top (Fig 1: lower panel). The consequent issue of fine sediment pollution could be readily addressed using fascines in problem areas.

Fig 2. The 1m high, vertical weir had been sited on a seam of bedrock visible on the left bank and was causing impoundment for ~150m u/s. The structure was concave, focussing flow with a slight bias initially to the RB, and clearly an impassable barrier to most fish species most of the time.

The weir was sited adjacent to and presumably also at least partly on a seam of bedrock at a natural pinch-point in the valley (Fig 2). It would clearly be a barrier to passage for most fish species for the majority of the time due to its size and configuration, as well as drowning out natural channel features in the impounded reach for ~150m u/s and trapping sediments. Since construction of the weir, the reaches d/s would have been starved of the resupply of smaller fractions of bed substrate such as gravel, leading to a predominance of large cobble and boulder, and hence a reduced physical diversity with fewer niches for organisms to occupy and reduced opportunities for gravel-spawning fish species.

The outflow of the goit, ~33m d/s of the weir, had been modified in an attempt to provide fish passage around the barrier, effectively using the exiting goit as a bypass channel (Fig 3&4). Four notched barrages (to simulate a pool-cascade) were placed in sequence close to the confluence to overcome an initial head loss of <1m. Such engineered structures / bypass channels are rarely very efficient for fish passage which is why weir removal should always be the preferred option when possible. Amongst other issues:

- They are typically designed with salmonids in mind, ie they select against weaker swimming, coarse fish species.
- Efficiency of passage varies with individual size and discharge.
- Require sufficient and consistent attraction flow to lead fish to the entrance of the fish pass, and thus are typically co-located with the toe of the weir. In this case, the fish pass entrance was separate and poses a considerable risk of fish missing it and swimming to the 'dead-end' of the weir u/s.
- The u/s end of the bypass channel also suffers from being difficult to locate – a small aperture in a large, impounded section, and not at the d/s end of the impoundment where the greatest chance of passage would be expected.
- Retention of an aging asset (the weir) and creation of a new asset prone to blockage, damage and ongoing maintenance for which responsibility needs to be assigned.
- Do not address any of the other environmental problems such as impoundment or sediment trapping.

Fig 3. SD54701797: Spatial context of the outflow from the goit, engineered into a stepped fish pass, rejoining the Yarrow from the RB, ~33m d/s of the weir. The ground cover around the fish pass was negligible because of footfall. The foam line from the weir can be seen along the RB u/s of the fish pass but boulder placement (see Fig 4 & 5) seemed to divert flow away to the LB, potentially taking 'attraction flow' away from the fish pass mouth.

Fig 4. The four steps of the fish pass at the d/s end of the goit where it enters the Yarrow. There appeared to be a series of slightly offset notches to focus flow between the steps under lower flow conditions. NB the diversion of flow from RB to LB u/s of the fish pass on the Yarrow (blue arrow).

Fig 5. Looking across the Yarrow from RB to LB (from the fish pass; Fig 4) at the redirection of focal flow. This could potentially be more attractive to fish moving u/s, drawing them to the weir rather than the fish pass mouth.

Indeed, with those concerns in mind, at the discharge observed on the day, the flow and turbulence between the notched barrages would have required considerable power/burst-speed to overcome, and attraction flow appeared to be focussed to the LB rather than the RB and fish pass entrance, hence luring fish to the weir still (Fig 4&5).

In addition, considerable investment had probably been secured to install the fish passage solution at the tail end of the goit. Yet, erosion and failure of the walling, compounded by considerable footfall and hence maintenance of bare earth next to the structure, was clearly evident and would ultimately lead to its complete failure (Fig 6). Best scenario for the natural heritage of the river would be to remove the weir. In the interim, preventative action to address the issues on both sides of the goit, highlighted in Fig 6, should be undertaken soon.

Fig 6. Erosion detail around the fish pass. Clearly time and expense has gone into the building of this structure, yet it was in a poor state of repair and likely to fail in the near future without a little further investment.

The channel from the weir to the M6 flyover was highly modified. It had clearly been historically realigned, straightened and dredged leaving it heavily incised and severed from any connection with the floodplain except in the most extreme of spate flows. Banks were steeply angled, and the channel proportions consistent, rendering a trapezoidal cross-section dominated by fast, shallow riffles (Fig 7). The saving grace was that for most its length there was a fringe of mature and diverse native woodland of mixed canopy age/height, providing good shade and leaf litter input. Unfortunately, with a lack of physical diversity within the channel, eg large woody material (LWM) such as fallen / leaning tree trunks and limbs, there was little structure to retain leaf litter which would provide an important energy subsidy for a considerable component of the aquatic macroinvertebrate community. With abundant and often previously coppiced (multi-stem) trees along the banks, it should be possible to selectively hinge, or fell and lodge or tether, LWM into the channel to diversify the physical habitat – see Recommendations.

It was noted that amongst the widespread Himalayan balsam, there were also a couple of stands of Japanese knotweed which appeared to have been treated. It is important to monitor this particular invasive, non-native species (INNS; and also giant hogweed – see Fig 19) to prevent it spreading further and taking over the riparian flora.

Fig 7. A small stand of Japanese knotweed which looked to have been treated. Any such stands should be monitored / reported in attempt to eradicate this invasive non-native species (INNS). The image also highlights the incised (steep-banked) and consistently proportioned channel dominated by shallow riffle, typical of the reach between the weir and under the M6 to the footbridge at SD 54233 17948 (Fig 12).

At SD 54619 17993, another weir of very different construction was located, assumed to be block stone arranged in three tiers of broad, shallow steps; the channel was almost twice as wide as elsewhere either u/s or d/s (Fig 8&9). Despite the relatively shallow gradient, the weir would still be impassable to most fish species for most of the time as each step would not provide sufficient depth from which to leap to the next. Like many weirs of 150-250 years old, the structure appeared to be degrading with failed stonework ~75% across from the RB (point of observation), which may provide a focal flow under lower discharge and improve fish passage marginally. However, it appeared redundant with seemingly no modern infrastructure such as an associated pipe crossing. Consequently, the weir should be investigated for removal to reinstate all the benefits of a free-flowing, connected channel.

Cascading water and associated aerosolization at the weir highlighted the smell of considerable sewage discharge u/s - despite relatively modest river flow. Water quality issues impact aquatic biota in many ways; based upon observation, this section of the Yarrow appeared impacted more by nutrient/chemical pollution, rather than physical means as there was little evidence of typical sewage litter adorning the vegetation.

Fig 8. SD 54619 17993: three-tiered step weir looked to be degrading at ~75% of the width from the RB which may be improving the situation for fish passage – see Fig 9.

Fig 9. Closer detail of the structure of the weir – broad steps of ~1m base and each ~0.3m high to give a total head loss across the structure of ~1m. Impassable to most fish species the majority of the time. Passability is probably further reduced under lower flow regimes as each step will only be covered by a shallow skim of fluming flow.

At the M6 flyover, the channel was further modified and pinched with large boulder revetment to prevent scour around the bridge footings, and this had caused some modest impoundment u/s (Fig 10). A small beck and presumably drainage from the motorway had been combined and formalised through a culvert on the LB. This was probably perched under low flow conditions, ie requiring a leap into fluming flow through the pipe, and hence a considerable challenge to fish passage if there was any desire for access. The size/condition of the watercourse was not observed directly, only assessed via satellite imagery and mapping.

Fig 10. On the LB, u/s of the M6 flyover, a large culvert formalised the flow from a small beck network, seemingly converted to agricultural drains, and presumably with contributions from the motorway which will be a focal point for pollution.

Fig 11. Large boulder revetment underneath the M6 flyover, pinching and straightening the channel, and increasing flow velocity for the span of the bridge.

The pinched channel under the flyover, whilst extremely straight, was also hydraulically roughened by the large boulder revetment and so was probably not particularly challenging for fish passage, although there appeared to be a step at the mid-point (Fig 11). Based on flow patterns around the step, it probably comprised revetment material and hence had focal flow paths over, around and through for fish passage, but should be reassessed under low flow.

The channel immediately d/s of the flyover was clearly pinned against the LHS of the valley where a relatively steep bank of native deciduous woodland provided good cover. The RB was rough pasture but fenced and hence afforded a small riparian buffer strip. This short section was private and not included in the SFFC waters. The public footbridge at SD 54233 17948 (Fig 12) marked the u/s limit of the club's lower beat, and the channel had a few more natural characteristics compared to the upper beat.

Fig 12. At SD 54233 17948, looking d/s from the footbridge adjacent to a private property that splits the SFFC waters. The field belonging to the property (outwith SFFC influence) was fenced and the riparian zone was as good as could be expected given the straightened nature of the channel. From here in a d/s direction, the channel was more natural in form than the reach u/s to the weir (Fig 3) which had been incised and straightened.

The RB d/s of the footbridge had been artificially raised using building rubble and metalwork amongst other things to create a more level field for agriculture, currently grazed by both sheep and cattle. Buffer fencing was present (to exclude livestock) but had been set too close to the top of the bank and was failing. It is difficult to pin down any one particular cause; the unconsolidated nature of the bank, heavy grazing of grass and therefore little investment in roots, a predominance of balsam on the bank face, and few native herbs and trees that would be present year-round and root deeply (binding the soils and increasing resilience), would all interact to leave the bank susceptible to erosion. Hence, it is important to give sufficient space within a buffer zone to build the resilience required to withstand spate flow. Furthermore, the fencing had been deliberately cut and rolled back in places, thereby rendering the whole scheme pointless. Riparian fencing schemes should include gates or hurdles so errant stock can be removed if required.

Fig 13. At SD 54184 17978, d/s from the footbridge, the RB had been historically raised to form flatter agricultural land but the fencing protecting the bank had been placed too close to the bank top and deliberately removed in places, thereby allowing stock access. A combination of artificial, unconsolidated bank material (building rubble, metalwork etc, evident in middle image), stock access and Himalayan balsam, with a naturally friable sandy soil anyway, rendered the banks susceptible to erosion by both the water and by stock. Note the large stand of Japanese knotweed on the LB that had not been treated (upper panel).

The LB was lower in comparison, possibly an old bank slump or deposition bar colonised and well-vegetated by shrubs (although a large stand of Japanese knotweed was also present; Fig 13). As a consequence, there was greater channel sinuosity and low cover which extended throughout the lower beats.

For the remainder of the SFFC waters, there was a stark contrast in condition of the opposing banks reflecting different land management practices. On the LB, there appeared to be more arable agriculture with uncultivated buffer where a relatively natural riparian flora had developed unhindered by grazing. Consequently, erosion was slowed because the banks were more resilient, with lots of low cover from trailing branches. Underwater, the habitat was vastly improved by tree root masses and the occasional fallen trunk or limb retained within the channel.

The RB was managed as pasture and erosion into the friable sandy soil was rife (Figs 14-17). Almost the entire length had livestock exclusion fencing, yet that had failed in numerous places, probably due to being placed too close to the bank top and leaving insufficient room for a riparian buffer to develop. It was somewhat confusing to see relatively new fence posts having been installed in various sections (Fig 18) and yet there were clear, unaddressed breaches in the fence being exploited continually by sheep, again rendering the original scheme and the recent investment worthless from an environmental perspective.

Where erosion of the RB had managed to widen the artificially straightened channel sufficiently, point bars of deposited material had developed mid-channel and were being colonised and stabilised by vegetation, reinstating some beneficial in-channel diversity. This is typical of an artificially straightened channel breaking free of its historical constraints and beginning to naturalise through geomorphological processes. Two wetted channels around the 'islands' offered various habitat characteristics to be exploited by fish species of differing life-stages under different discharge regimes, eg faster shallower riffle for feeding, vs slower, deeper water for refugia. An increase in physical diversity is reflected by a concomitant increase in biological diversity.

Fig 14. SD 54017 17975: Channel diversification providing different habitat types within the two channels around the island. Unfortunately, the riparian buffer fencing had been placed too close to the bank top again and so had failed, exacerbating the potential for erosion into the RB.

To improve the resilience of the RB (whilst simultaneously improving the habitat for fishery benefits) and prevent the inexorable loss of further land, the integrity of the buffer fence requires reinstating with sufficient space for some augmented planting of appropriate tree species. Alder, grey willow, aspen or bird cherry have all evolved to root well in wet soils and provide high quality leaf litter subsidies to aquatic macroinvertebrates; they also benefit terrestrial invertebrates that may end up in or on the water. Whilst there is undoubtedly a natural seed bank available, the predominance of balsam (as well as sheep access) will have impacted upon natural regeneration. Augmented planting kickstarts the process by giving young saplings a competitive edge over balsam, and in time, the new tree canopy should hinder balsam growth. There are various schemes which pay landowners to manage their land in an alternative manner to traditional grazing to offset the reduction in pasture – see Recommendations.

Fig 15. Immediately d/s of the island in Fig 14, just visible, the width of the riparian buffer strip originally afforded was probably sufficient to build resilience but extensive balsam and livestock access at various untended breaches to the fence would leave it susceptible unless both of these stressors are controlled.

Fig 16. Another failure of the stock-proof fencing because it was placed too close to the top of the bank on an artificially straightened section and the river had undermined the whole lot. A deposition bar had formed within the channel. Note the lack of erosion on the LB afforded a native tree and herb flora in stark contrast to the grazed RB.

Fig 17. More slumping of the bank where the fence has been placed too close to the top. Sheep were clearly exacerbating these scallops to gain access under the fence, maintaining the area as bare soil and hence increasing the risk of further erosion under spate flow. There was no discernible difference in sward height on either side of the fence, indicating that sheep had unfettered access.

Fig 18. Where the buffer strip was ample with the fence set back 4-5m, there was much less evidence of erosion, despite the presence of balsam. The shallower cross-sectional profile of the bank created naturally by erosion also contrasts starkly with attempting to put fencelines at the top of steep, erodible "cliff" style profiles. However, it was noted that despite investment in replacement posts fairly recently, there were still gaps in the fenceline that the sheep were exploiting.

Fig 19. Within 100m of the d/s limit, there was at least one giant hogweed plant on the LB that should be treated as soon as possible, and the area monitored for more.

Himalayan balsam was prevalent throughout, whilst Japanese knotweed was limited to a few stands (see earlier; Figs 7&13). Unfortunately, the third part of the unholy INNS trinity, giant hogweed, was spotted on the LB towards the lower limit (Fig 19) and the landowner should be notified so that it can be treated to reduce its spread as soon as possible. Tackling these INNS before they become well established could save £1000s in the long run and avoid extensive damage to the riverbanks and habitat.

3.2 Lake

The lake was walked around briefly. As with many artificial, shallow lakes stocked with trout, the club has reported issues with temperature, oxygen and disease, and has an air pump system to help overcome these interactive stressors. Strides have been taken to plant up a buffer of mixed native deciduous trees set back from the lake edge, and in time these will provide some natural shelter, shade, leaf input and better habitat for terrestrial invertebrates which will contribute to fish diet. This will reduce the need for supplementary feeding which is a source of excess nutrient and an attractant for undesirable wildfowl and rodents.

Fig 20. Looking toward the carpark and hut, exemplifying the bare nature of the banks. Sections of the bank had wooden shuttering as well as platforms for casting.

However, the bank areas have been maintained as mown, short-sward grass in a concentric ring around the entire lake (Figs 20-22), causing several issues. In essence, this creates exactly the same problem as livestock grazing along riverbanks. The grass invests all the energy derived from photosynthesis to replace shoot material rather than invest in roots, so there is little root matrix within the soil to bind it together; hence, the erosion and turbidity noted in Fig 21. Repeated cutting maintains a monoculture of grass which provides little diversity of food and cover for terrestrial invertebrates and that community will be depauperate as a result, offering little in the way of fish food subsidy. Furthermore, grazing waterfowl such as Canada geese favour short-sward grasses, and roosting waterfowl also prefer the visibility afforded on short swards. Attracting waterfowl brings associated issues of nutrient transfer into the water, as well as exacerbating erosion at the edges, increasing turbidity through feeding and puddling. Ducks, geese, and swans will selectively target submerged aquatic macrophytes whilst ignoring filamentous algae, further shifting the balance of plant growth from macrophytes to algae.

Fig 21. Close up of modest wind action and fetch, yet there was evidence of turbidity from bank erosion along the shoreline. Note that keeping the grass mown as a short sward will exacerbate this problem, as well as make it more attractive for grazing / roosting waterfowl.

Fig 22. Another perspective of the majority of the lake surface highlighting the generally bare banks although there was clearly some natural seedbank of a more diverse herb flora which could be exploited to diversify the sward and encourage more terrestrial invertebrates that could subsidise fish diet.

The lake would benefit from several low-key measures to naturalise the shoreline, both in and out of the water, which would bring substantial benefits, are not onerous tasks, and would save the club time and funds – see Recommendations.

4.0 Recommendations

The following simple suggestions are proposed to improve habitat and the sustainability and resilience of the wild fish population along the Yarrow, and the stocked trout in the club lake, and hence ultimately the fishery potential for the membership.

4.1 Wider issues of water quantity and quality

The Yarrow has been highly modified to capture water, provide historic hydropower, and latterly to prevent localised flooding. Power and conveyance of water has increased within the constrained reaches of the SFFC waters as a consequence. The most beneficial action across the upper catchment then will be to 'slow the flow' in the tributaries, including the smallest feeder streams, to reduce the conveyance speed during and following rainfall events. Interventions from the very top of each system, and a little and often approach, are key for reducing conveyance from the tributary headwaters.

These are beyond the direct sphere of influence of SFFC but at the broader catchment scale it is important to consider upstream thinking. SFFC could offer support to organisations like Friends of the River Yarrow, the Douglas Catchment Partnership and Ribble Rivers Trust, and the landowners who are implementing natural flood management approaches such as grip blocking on the moorland or tree planting to take the sting out of spate flow before it reaches club waters. This is obviously a longer-term, legacy approach but is proven to bear fruit from other systems around the country.

At the more local scale, within the SFFC beats, working with landowners to protect the riparian zone (see below) and reinstate a more natural flora will also help slow the flow by increasing hydraulic roughness and filtering out debris along the river corridor, rather than allowing it to only accumulate at artificial pinch-points like bridges.

Similarly, helping these organisations to lobby or indeed independently lobbying United Utilities and the Environment Agency for better water quality is essential. The club can contribute directly to data collection for helping with the monitoring of water quality via schemes like the Riverfly Partnership's Angler's Riverfly Monitoring Initiative and the Angling Trust's Water Quality Monitoring Network.

4.2 Riparian zone protection via fencing

The most beneficial direct action on the lower beat of the Yarrow would be to limit livestock access directly to the water's edge wherever possible. The benefits were clear to see where grazed and ungrazed banks were co-located on opposite banks. Buffer fencing was in place for most of the lower beat but had been either deliberately breached or left in a state where stock could get underneath it.

Well vegetated riparian habitats function better to slow the flow because of increased hydraulic roughness and are of higher resource quality to a wide range of wildlife. A native herb flora substantially increases resilience to erosion via the diverse root matrix within the soil thereby reducing soil / land loss (Fig 23), as well as increasing invertebrate biodiversity that may ultimately end up in the river as fish food.

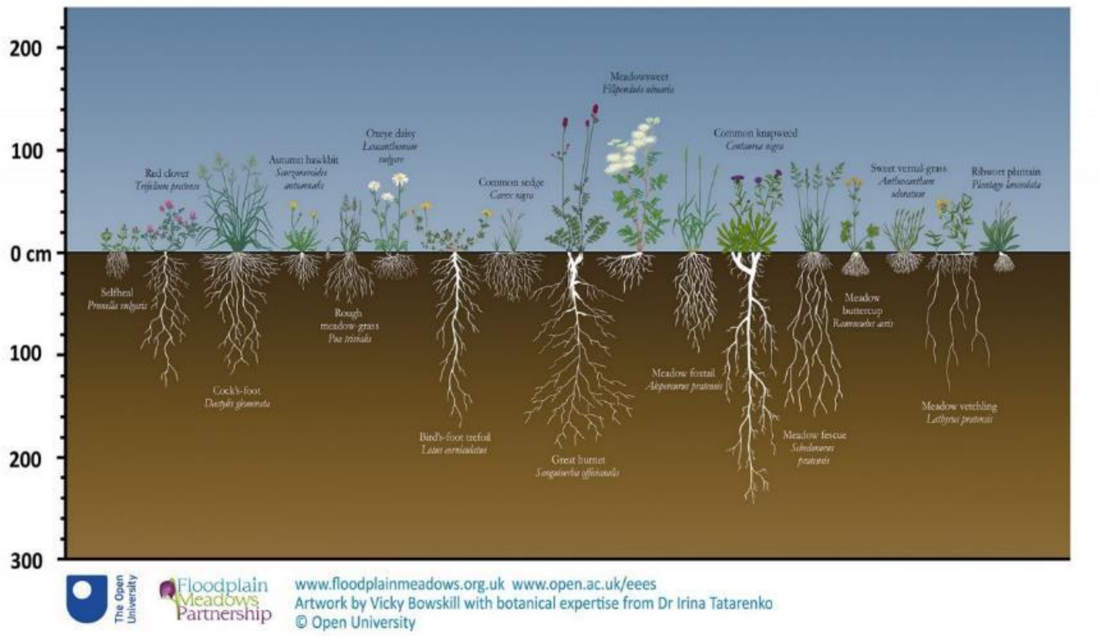

Fig 23. The diversity of roots associated with native riparian flora that help build resilience into bank soils.

Existing fencing should be maintained in a state fit-for-purpose, and sections set back sufficiently around eroded areas to allow for recovery. If new fencing is installed across former pasture, it is worth considering augmented planting of tree whips to implement mitigation for climate change sooner rather than later, whilst leaving space for natural regeneration which may take more time to establish. Key sites to consider: banks that have already succumbed or are susceptible to further degradation; and around established vegetation that is in immediate danger of succumbing to further erosion from stock trampling. Examples of these are highlighted earlier in the report.

Note, there are numerous schemes currently available (with more coming online) for environmental improvements and alleviating flood risk which will cover capital costs for installation of fencing, access gates etc, and may include onward payments to offset taking the land out of traditional production (eg SW11: Riparian management strip - GOV.UK (www.gov.uk)). It would be worthwhile liaising with a Farming Advisor working for the EA or the local rivers trust, and / or the Woodland Trust regarding such schemes.

4.3 Tree management and in-channel habitat

There was substantial scope to introduce simple habitat improvements where there were established trees to work with (ie the upper beat). Obviously, being so incised, the Yarrow is a powerful river under spate flow so site selection is key – it would not be advisable to try and retain large woody material where the brunt of spate flow would be focussed! Wood that is felled can be effectively secured, either as a 'hanger' by wedging it (depending upon the trunk / limb configuration) or as a 'kicker' tethered to the base from which it was felled or to a neighbouring trunk via a suitably rated steel cable and clamps; see the Appendix and the WTT 'How to…' video on tree kicker installation, here:

https://www.wildtrout.org/content/how-videos

It was noted during the walkover that most trees growing at or near the toe of the banks were multi-stem, ie had probably been coppiced in the past. Using the most d/s stem as a lodged or tethered kicker is the most sensible practice, leaving upright stems on the u/s side to protect the lodging / anchor point. Selecting only one stem also rarely detracts from the shade / aesthetic of the remaining crown.

Planting is recommended wherever there has been loss of former tree cover and where there is a lack of low cover and structure along the river margins to break up long expanses of exposed bank – typically on the lower beat. Indeed, if some of the wider, shallower-profiled areas of bank that are currently susceptible to erosion could be set aside for riparian buffer (to prevent unpredictable loss of land and improve flood mitigation), these would be ideal and generally easier to establish trees on (increasing roughness, trapping finer debris and slowing flows).

It would be beneficial to include a range of native deciduous species such as alder (highly nutritious leaf litter), bird cherry, hawthorn, and blackthorn, but goat and grey willow are by far the easiest to transplant and manipulate. Note that adequate fencing or some means of stock exclusion is vital to protect such measures, as without it, any planting is likely to be browsed by livestock.

The quickest and easiest way of planting willow is by pushing short sections of willow whip or sections of willow stake into the ground, using locally sourced material. This can be undertaken at any time of the year but will have the greatest success if undertaken within the dormant season, shortly before spring growth begins (ideally late Jan-March). Whips should be planted into soft, wet earth/sediment so that there is a greater length within the ground than out of it, and at a low angle, to minimise the distance that water has to be transported up the stem; ~30cm of whip protruding from the ground is sufficient, providing that it receives light past the other bankside vegetation. Live willow stakes can be hammered deep into the bank and may provide greater structural stability under spate conditions.

Further advice and support could be sought from The Woodland Trust. See their guidance for 'Keeping rivers cool':

http://www.woodlandtrust.org.uk/publications/2016/02/keeping-rivers-cool/

4.4 Lake improvements

Flag iris was noted growing in a few locations, an emergent plant sufficiently robust to withstand moderate waterfowl disturbance as well as dissipate wave energy along the shoreline, thus preventing erosion. They are also fantastic habitat for ambush predators such as odonate (dragon/damselfly) nymphs which are favoured by trout. Hence, establishing a living buffer around the lake shore as a narrow fringe will provide multiple benefits. Note, iris (and sedges) are much easier to manage compared to reedmace and *Phragmites*.

Irises grow from rhizomes, so the plants can be split and relocated, and the large seeds are easy to collect at the end of the summer and either dib into soft wet soil or establish in wet pots to plant out in specific locations. If the shoreline is too artificial, ie with insufficient suitable substrate for rooting, then hessian sand bags can be filled with poor quality soil and then pegged *in situ*.

One or two small willow had established on the shoreline but had clearly been cut back. However, more (x25) shrubby willows could be established, dotted around to provide many of the benefits already listed for flag iris. Individual shrubby trees at the shoreline are beneficial for emerging aquatic insects as they will use them for refuge and forming mating swarms around, otherwise they seek alternatives further away from the water and may never make it back to lay their eggs and/or become fish food.

Using goat willow pegs cut from the existing trees in the hedge-line, pushed into the soft wet soil at a low angle (to reduce transpirative stress as advised in the previous section) in specific locations is a quick and easy method of propagation.

It may be desirable to maintain a mown path around the lake but set back from the edge for members, but it would be far better to leave the remainder unmown and as diverse herb flora to increase insect diversity and discourage waterfowl, thereby reducing all the associated negative impacts listed in the report.

5.0 Making it Happen

The Yarrow is designated Main River to where it meets the Leeds-Liverpool Canal (u/s of SFFC waters) and the Environment Agency is the responsible authority. The addition of a few tree-kickers along the channel could be carried out by registering an exemption under Environmental Permitting with the EA. WTT can help with submitting such exemptions.

Further information
WTT Fundraising advice - Help and advice on how to raise funds for habitat improvement work can be found on the WTT website - www.wildtrout.org/content/project-funding and should be discussed with your local Conservation Officer.

In addition, the WTT website library has a wide range of free materials in video and PDF format on habitat management and improvement:
http://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 http://www.wildtrout.org/product/rivers-working-wild-trout-dvd-0 or by calling the WTT office on 02392 570985.

6.0 Acknowledgement

The WTT would like to thank the Environment Agency for supporting the advisory and practical visit programme in England, through a partnership funded using rod licence income.

7.0 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.

Legal permissions must be sought before commencing work on site. These are not limited to landowner permissions but will also involve regulatory authorities such as the Environment Agency – and any other relevant bodies (eg Natural England and Forestry Commission) or stakeholders. Alongside permissions, risk assessment and adhering to health and safety legislation and guidance is also an essential component of any interventions or activities in and around your watercourse.

8.0 Appendix

Large Woody Material (LWM) - hinged, lodged and tethered

LWM additions simply emulate the fall and retention of natural woody material but can be used where there has been historic removal or where a river system has been too heavily modified to retain material safely (ie risk of dislodged material blocking man-made pinch-points like bridges). It is a step further than simply laying or hinging stems into the channel whereby the material is retained via a living hinge (Fig A1). This can be done with pliant, living species but larger and/or dead trunks and many species are not suitable.

Fig A1. Two stems from a previously coppiced and hence multi-stem crack willow laid into the channel and aligned close to the bank to provide low / submerged cover. The living upright stems on the u/s side protect the hinge.

Ideally, if the trunk can be retained without a tether, eg by lodging around or opposing forces between living trunks (Fig A2) as a tree-hanger, then that reduces the amount of non-natural material used. If not, or to minimise risk, appropriate gauge stainless steel cable (10 or 12mm equivalent to 6.5 or 9.4 tonne breaking strain) and wire rope clamps should be used (Fig A3).

Fig A2. Simple lodging of material if there is the structure, in this case the fork, to make it work.

Fig A3. Alder of ~350mm girth felled and cabled back to the living stump as a tree-kicker. The coppiced stump will regrow vigorously, providing further low cover and screening of the cable.

Uprooted trees or individual trunks can be retained *in situ* or nearby by winching and cabling to an appropriate living anchor. If none are nearby, consider the use of a ground anchor, eg https://platipus-anchors.com/