Tyne Rivers Trust

Haltwhistle Burn – a comprehensive catchment approach to headwater runoff and pollution

Technical Report of the 2012-2015 Catchment Restoration Fund project, Defra

Edited by Malcolm Newson & Ceri Gibson

Executive Summary

River ecosystem restoration has recently been scaled up, from individual reaches where opportunistic projects have rehabilitated particular elements, to whole catchments where an ecosystem approach demands more holistic concerns and strategies, together with a much more open, engaged delivery. Headwater catchments, such as Haltwhistle Burn in Northumberland, have a disproportionately big influence on large river basins such as the Tyne, providing much of the runoff and, following upland development, many of the diffuse pollutants (including sediments) now regarded as threatening river 'health'. An important new concept in treating the human impact on upland headwaters is the hydrological connectivity between rainfall and the river. We know the importance of headwaters from a variety of experimental catchment experiments, briefly reviewed below; good evidence is vital in achieving stakeholder credibility.

Haltwhistle Burn caught the attention of Tyne Rivers Trust after flooding in 2007 and several following years. Whilst flood risk management is not the theme of the project, we illustrate the interwoven nature of hydrological science in treating runoff and pollutants as a single issue, hoping regulators will catch up! We are particularly lucky to have the active involvement of Newcastle University to demonstrate these linkages at the research level.

Catchment management is no easy matter: it is often based on uncertain evidence, is expensive to implement and requires debate, argument and compromise amongst the population bound by 'catchment consciousness'. The 'catchment-based approach', now espoused by politicians, requires huge amounts of site-specific assessment and we catalogue the Haltwhistle methods and sites – a popular phrase in river restoration is 'Don't fight the site': one size does not fit all. Bracken and Oughton (2013) have stressed a frequently missing ingredient in new environmental approaches: 'innovative behaviour that creates new structures and practices is becoming central to delivering good management of land, water and biodiversity': this project has been living proof!

This project was financed by the Environment Agency (and has attracted significant partnership funding) to restore a 42 square kilometre upland headwater catchment, not just to improve its water quality to comply with the EU Water Framework Directive but to form a sustainable public interest in and engagement with a healthy river. Land use and management are key components of the Catchment-based Approach and this report makes its focus not just the general principles of how to manage land and water together, but the details of the science, assessments, engagement, education and delivery that have been the vital local hallmarks of 'CRF Haltwhistle Burn' for three years. Whilst the practical 'on-the-ground' techniques have long been a feature of Rivers Trust work, we have innovated on Haltwhistle Burn, helped enormously by the skill of our contractors. Space for reporting is limited (we have an electronic Project Record at TRT) so we have employed the 'box' feature in the text to lay out the very specific characteristics of the Haltwhistle Burn – context is a vital component of catchment management and for comparisons with other CRF sites.

Flooding was not a central focus of this project but the experience and interest of the Burn's human residents reveal runoff as a key preoccupation and we have been unable to exclude consideration of high flows at every turn. Runoff processes and high flows are also highly relevant to water quality (diffuse pollution, notably siltation) and fisheries issues which are central to the Catchment-based Approach.

It is important that projects like 'CRF Haltwhistle Burn' do not end with the project funding. We have sought to leave a legacy of public engagement, particularly with the relevant agencies, which will make the catchment and its management as obvious an opportunity for future financial inputs as the heritage of Hadrians Wall which crosses it. We have also 'left lots undone' and have been keen to develop ongoing ideas for the Burn to suggest the first phase of the continuous improvement. Official agencies such as Natural England and Northumberland National Park Authority can now identify and target the catchment as part of vital continuity.

'Science linked to human purpose is a compass: a way to gauge directions when sailing beyond the maps. Democracy…is a gyroscope: our way to maintain our bearing through turbulent seas. Compass and gyroscope do not assure safe passage through rough, uncharted waters, but the prudent voyager uses all instruments available, profiting from their individual virtues'. (Lee, 1993)

Acknowledgements

Water is newsworthy – but often for the ‘wrong’ reasons, especially it seems, in Haltwhistle. Modern river restoration recognises the importance of restoring natural processes so part of the solution relies on educating those responsible for designing and maintaining any interventions.

Being a small charity in a big landscape with many other ‘players’ and only a relatively small window of delivery this project has been a challenge at times but a great exercise in partnership working and seizing opportunities that good communications allow. Both the project and the report could not have been achieved without the dedication, patience and good humour of all concerned. We have been very fortunate in our project board and co-deliverers and are indebted to them for making things happen on the ground and in the water. The full list can be found in appendix 9.4. Positive introductions to people already living and working within the catchment provided by our partners have been essential. In particular we are grateful to Heather York for her ability to fit our proposals with Natural England agreements and her propensity for interpreting set text. The same appreciation is afforded to Jen Hewitson for helping ensure that our proposals match well with long-term National Park projects in the catchment. Additionally the willingness of Graham Gill and Tom Dearnley at the Forestry Commission to embrace changes in their ways of working (including over much longer timescales) in co-ordination with this project has added considerable value.

Our great thanks must also go to our main contractors Countryside Matters and Haywood Contracting who have brought very different but equally valuable skills to the project. We have all learnt a lot and are particularly grateful to their patience as designs are constantly tweaked and ‘improved’.

An award winning trustee for Trent Rivers Trust, Martin Stark moved up to Haltwhistle just in time to be an integral part of the project. From forging trusted working relationships with farmers, to paying meticulous attention to the detail, to championing the River Watch group and being a human deflector for fish passage when required, Martin has been jolly effective and his positivity has always shone through.

This project has demonstrated how we should never underestimate the knowledge and determination that exists within the local community. We acknowledge here the completely essential historic information and immediate reaction to things happening on the burn while we are stuck in offices or meetings. Special thanks go to Patricia Yeats for her photos from 2007, Susan Craig for her comprehensive geomorphological record of the shifting gravels at the mouth of the burn, David Cadwgan for his contacts within the town and all our ‘tweeters’ via the Citizen Science project so ably co-ordinated by Eleanor Starkey as part of her PhD project on ‘Community-Based Monitoring and Modelling for Catchment Management’.

We have run several river days for students at Haltwhistle Community Campus towards engaging and inspiring our river engineers of the future. I wish to warmly express my personal gratitude to Alison Raimes at the Whistle Art Stop for supporting the school activities and coping brilliantly when an event for 60 children became one for 80 children, (some with complex needs) at very short (let’s be honest, no) notice to her.

It is hoped that this report forms one of many useful tools towards a worthwhile legacy to the project. To this end Tyne Rivers Trust is grateful to Eric Wilton at the National Trust who is able to store and maintain work tools for the River Watch group in order that monitoring and maintaining the interventions installed can continue after this CRF period ends.

Finally I wish to sincerely thank Malcolm Newson for creating the project, chairing the board, willingly offering years of diverse experience within and beyond the project budget and for sharing excellent anecdotes and a joke or two along the way – often at the most apt moments!

(Ceri Gibson on behalf of the TRT team)

‘The significance of key individuals is well recognised in environmental management…what matters is the strategic intermediary role of individuals in making something happen on the ground’ (Bracken and Oughton, 2013). Nobody exemplifies this view more succinctly on the Haltwhistle CRF Project than Ceri Gibson, to whom we are all grateful for inspiration and encouragement during the many tough challenges of the project. (Malcolm Newson on behalf of a number of project partners)

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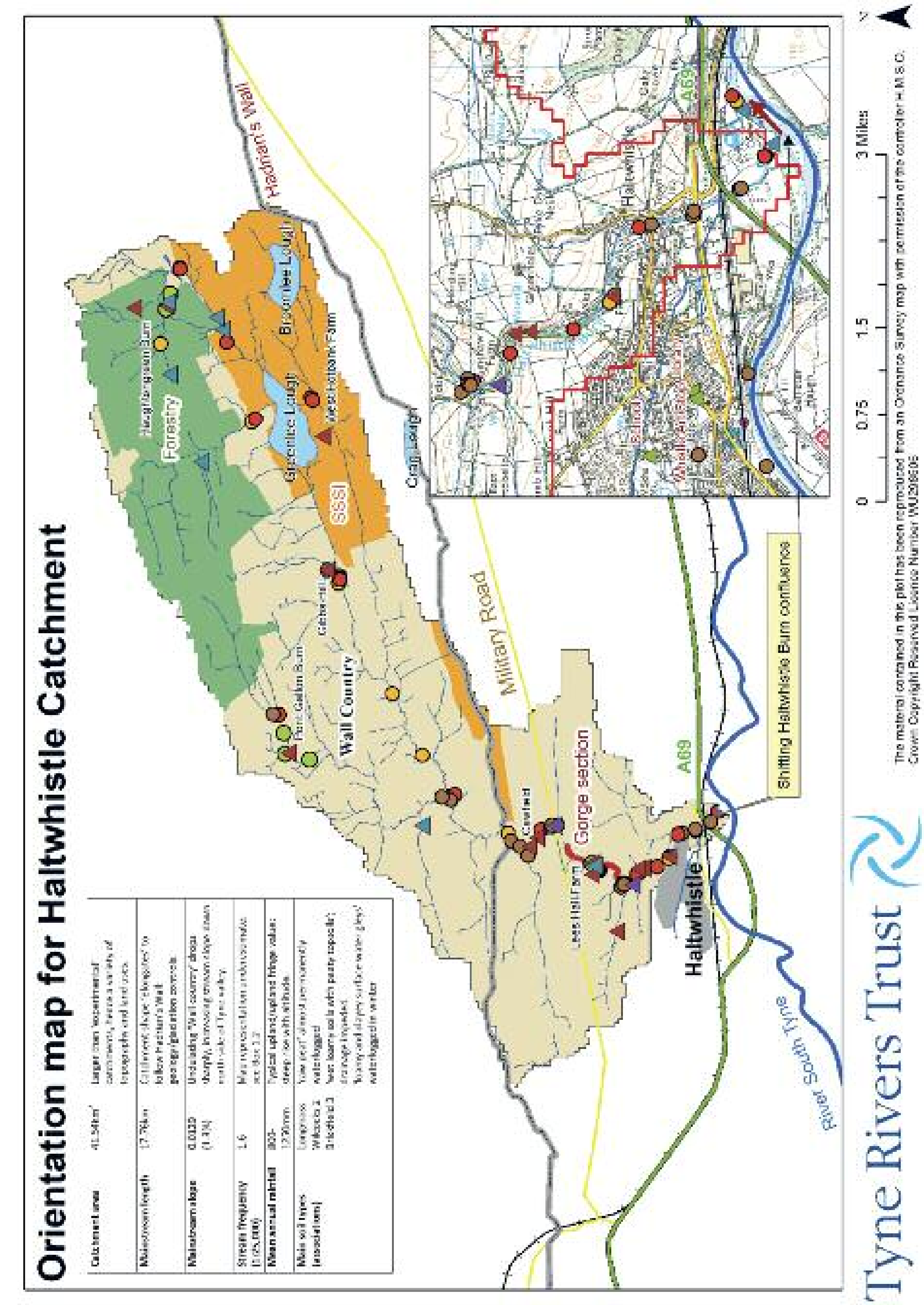

Orientation map for Haltwhistle Catchment
Hadrian's Wall
Military Road
Forestry
SSSI
Greenlee Lough
Broomlee Lough
Crag Lough
Wall Country
Gorge section
Haltwhistle
A69
River South Tyne
Shifting Haltwhistle Burn confluence
0
0.75
1.5
3 Miles
Tyne Rivers Trust

PREFACE

A brief background to the Haltwhistle Burn CRF project.

Early in 2012 the Department of Environment, Food and Rural Affairs (Defra) announced a significant expansion of its funding for river projects designed to promote compliance with the EU Water Framework Directive (WFD). Following Defra's successful River Restoration Fund, targeting physical barriers to fish migration and administered by the Rivers Trust, a Catchment Restoration Fund was launched with the intention of widening the partnership base and showing a geographical expansion of strategic concern (which would later be called the 'Catchment-based Approach', following the success of the 'Catchment Pilots', one of which was the Tyne).

Whilst project outcomes were heavily constrained by policy objectives (notably WFD compliance) and our (England) nominated body for WFD, the Environment Agency, has administered this Fund, there are clearly more holistic justifications for improvements wrought at a catchment scale and 'local governance' and 'citizen science' components are vital ingredients. Looking back at Tyne Rivers Trust's bid for funding we note under 'the nature of the issues your project has been developed to address':

Problems include forest runoff, siltation, invasive species, diffuse rural pollution, flood control, flood damage, old industrial point sources, road runoff and fish passage. However, the Burn is a local 'treasure'…

We added:

The catchment approach would, by combining all these small issues, create significant benefit for the Haltwhistle Burn and South Tyne and address the WFD 'Poor' status.

In reading this Technical Report of the three-year project it is worth recalling that there were seven original significant objectives in the TRT bid, zoned from source to mouth of the catchment (Section 2.4), and there were ten partner organisations named (and consulted) before the bid was submitted (see Acknowledgements). If anything, both lists have expanded as momentum was achieved and 'grounded' information became more abundant.

It is also worth noting that, whilst CRF is dominated by WFD outcomes, the Haltwhistle catchment also includes 'protected areas' in the form of the Loughs near Hadrian's Wall and has a significant local 'flash' flooding problem. Fortunately, management of the practical project delivery by EA and other partners has allowed the incorporation of elements of Habitats and Floods Directives without excessive bureaucratic knit-picking!

'What will success look like?' is, quite correctly, an 'FAQ' in government funding. This is increasingly recognised as a perverse question in catchment systems science: ecological responses will be slow, complex and unpredictable in detail, conventional monitoring sites/parameters are not adjusted to restoration sites/objectives and there will continue to be threats, such as climate change, to sustainability. Success, therefore, will most necessarily be sufficient engagement with stakeholders that they continue to monitor outcomes, defend against further threats and appreciate the 'ecosystem services' they have won (back!) for themselves. An understanding of the 'nature of the beast' bringing peace of mind to residents and a more informed approach to future work on the burn is not to be underestimated.

1. Upland Headwater Catchments – special significance for river systems

The 'catchment-based approach', now part of water policy in England, can be traced to the evidence accrued by catchment experiments conducted by hydrologists in the second half of the Twentieth Century. Sites such as Plynlimon (Severn, Wye), Balquhidder (Forth), Coalburn (Irthing) were all selected to get small-scale, watertight experimental units with no other human influence than a land-use change, or a comparison between two adjacent catchments with different land uses. The 'catchment experiment' became a basic hydrological tool.

Commercial plantation forestry with exotic conifers was the first major topic for 'land-use hydrology' but interest spread to moorland management and upland pasture and to urbanisation (e.g. Hollis, 1974; Gregory and Walling 1974; Johnson, 1995; Kirby et al, 1991).

1.1 Basic headwater catchment dynamics, in nature and with human influence

All headwaters, both upland and lowland, share the fact that runoff generation from precipitation occurs rapidly (except in permeable limestones like chalk) towards the relatively dense, low-order stream channel network. For upland headwaters a high proportion of precipitation (snow has until recently contributed major winter inputs) becomes runoff on an annual basis and in individual storms/melts; 70% or more of incoming rainfall reaches the channel network quite rapidly: downstream both land surface and channel travel times tend to be longer. Evapotranspiration rates tend to be lower, especially in upland headwaters, but other processes, such as the interception of precipitation on vegetation canopies and its direct re-evaporation, also play a part in catchment 'losses', especially for tall crops in exposed locations (Calder, 1990).

During the 1970's the processes of runoff on slopes in the uplands received major research attention. Hydrologists in the UK had largely accepted a view of runoff which focused on the land surface, across which water flowed to streams once the 'infiltration capacity' of the soil had been exceeded in heavy rain. A headline summary of the new evidence gained from careful field investigations is that the soil and sub-surface processes were elevated to the prime role in feeding water to streams. Various routes through the soil, such as via permeable soil horizons, 'macropores' and natural soil pipes were identified; the geography of headwater catchments in floods also changed to one of a partial- or dynamic-contributing-area (Kirkby, 1969, 1979; Ward, 1975).

There were other repercussions. From the 1930s onwards it was considered that urban surfaces enhanced and accelerated the predominant surface route for runoff. However, the new roles ascribed to soil and to vegetation in runoff processes and the new 'runoff geography' of headwater catchments suggested that what we do by way of land use and land management has a profound influence on runoff. Experimental studies began of moorland drainage and heather burning. Later, the headwater runoff process revolution began to set up the notion of 'diffuse pollution', given that rainfall, nett of evapotranspiration (itself influenced by land use), comes into contact with all substances used over the anthropogenic land surface.

Box 1.1 Haltwhistle Burn as a typical headwater catchment

Catchment area	41.54km^2	Larger than 'experimental' catchments, hence a variety of topography and land uses.
Mainstream length	17.76km	Catchment shape 'elongates' to follow Hadrian's Wall: geology/glaciation controls.
Mainstream slope	0.0129 (1.3%)	Undulating 'Wall country' drops sharply, increasing stream slope down north side of Tyne valley.
Stream frequency (1:25,000)	1.6	Map representation underestimate: see Box 1.2
Mean annual rainfall	800-1250mm	Typical upland/upland fringe value: steep rise with altitude.
Main soil types (associations)	Longmoss Wilcocks 2 Brickfield 3	'raw peat' almost permanently waterlogged 'wet loamy soils with peaty topsoils'; drainage impeded 'loamy and clayey surface water gleys' waterlogged in winter

1.2 Catchment 'connectivity' and runoff

In Section 1.1 we briefly describe a scientific revolution, half-a-century old which has focused the minds of hydrologists on anthropogenic influences on runoff processes and hence the importance of land use and management, notably in high rainfall headwaters. An upland 'wilderness' for Britain is a myth – there have been human imprints on the land surface and hence on the runoff process for the whole of the archaeological record. Successive waves of cultural history deforested, grazed and drained headwater catchments, and latterly they were tracked, paved, roaded and reservoired.

Recently, hydrologists have become interested in catchment 'connectivity': basically the available and preferred routes for runoff created by the human impact on slopes, soils and watercourses (Bracken and Croke, 2007). Recent examples of 'runoff flooding', 'pluvial flooding' or 'surface water flooding' have hit the headlines. Flooding from unexpected sources often reveals the subtle catchment influence of the flow lines created by increased connectivity during long or intense rainfalls. Moorland 'gripping', a cheap form of open drainage, achieved a particular focus for hydrological research (Conway and Millar, 1960) and there has been a recent revival in hydrological interest in both the open drains used for forestry ground preparation (Kirby et al., 1991) and in the restorative action of blocking grips (Holden et al., 2004; Ballard et al., 2010). In the United States the need for a 'bible' of scientific evidence to inform catchment managers about connectivity issues has produced a 400-page dossier (USEPA, 2015).

It may help the reader to consider, in an example used in schools by Tyne Rivers Trust, 'the life of a raindrop'! Assuming it escapes a rapid return to the atmosphere by evaporation, or uptake by plants on its way through the soil, it can encounter, en route to the surface stream channel:

- A crack in the soil;
- A drainpipe, perhaps from a roof, or in the soil;
- A ditch;
- A footpath or cart track with a hard surface or already gulleyed by previous raindrops;
- A plough line (rare in the uplands) or wheel track, perhaps from a quad-bike;
- A minor road, perhaps leading from the cart track to a major road.

These may not all be 'fast' routes but they are often steeply sloping and offer no storage volume or time, especially in comparison with a 'natural' moorland or wetland surface which presents a tortuous route to the stream. In hydrological terms, upland development has tended to replace a hydraulically rough environment with a hydraulically smooth one – a further feature of 'connectivity'.

Of course there has been, in some headwater catchments, a reversal of connectivity in terms of the main streams. In the case of upland dam- and weir-building, with its hey-day in the Victorian period, we now think of catchment 'discontinuity', especially in ecological/fisheries terms (Wohl, 2004).

Box 1.2 Connectivity and runoff for the Haltwhistle Burn catchment

Taking the First Edition of the Ordnance Survey map for the Haltwhistle Burn catchment (ca. 1867) and comparing with the most recent edition (2002) we can note the following changes in elements of catchment connectivity or 'routes for runoff':

Large expansion of rural and urban 'hard top' roads and (unseen) associated drainage;
Expansion of improved pasture over moor and bog, with (unseen) drainage;
Large expansion of commercial afforestation with (unseen) drainage;
Expansion of Haltwhistle town cluster (but reduction in industrial activity and mining).

1.3 The headwater sediment system and 'hydromorphology'

Geomorphologists divide the fluvial sediment system at the catchment scale into three prominent zones (which may repeat in several sequences between source and sea): source, transfer and deposition. Clearly, source zones are prominent in headwaters: sediment is available because of higher rates of weathering and steep slopes, whilst stream power (Bagnold, 1980) is high, especially during flood events, or 'spates' as they are often known in upland Britain. In fact, large rare flood events have often opened up prominent and enduring sediment sources in the form of landslides, peat slides ('bog bursts') and river cliffs (Beven and Carling, 1989; Warburton et al., 2003). However, the three zones can occur in the 'wrong' spatial order and in the heavily ice-sheet glaciated area of the Haltwhistle Burn 'Wall country' (see 2.4) there are no peaky mountains or scree slopes to create the conventional headwater sediment sources. Instead, however, there are glacial deposits forming river bank and cliff sources and peat deposits adding particulate organic sediments. The more conventional slope failures and landslides then occur in the Gorge section of the catchment, i.e. geographically 'in the middle'. Finally, the significant depositional zone where the Haltwhistle Burn meets the South Tyne has been a feature of this project.

Upland headwater sediments are coarse and bedrock is a frequent occurrence in channel beds. The veneer of glacial deposits is a major influence on the calibre of sediment supplied to channels and so boulder-cobble streams predominate. Only in slate or shale geologies do weathered scree slopes sometimes provide a finer input material direct to channels. Another glacial legacy is in the form of lakes, lochs and tarns which become local sinks for deposited sediments (as do artificial reservoirs).

Box 1.3 ‘Fluvial Audit’: a basic catchment tool

In order to manage the catchment-scale sediment system, i.e. to address problems such as the erosion of access routes/drain and sewer outfalls, loss of farmland, and loss of flood conveyance, we need to understand where the inputs and outputs occur. Short of constantly monitoring the sediments carried by the river at multiple points throughout the system, geomorphologists use the trained eye to survey, record and interpret the form, features and dimensions of channels. Within the context of this ‘audit’ it is then possible to manage site conditions in relation to the likely sediment budget, i.e. to identify the causation for erosional or depositional problems. This is like the traditional civil engineering approach to e.g. protecting river banks where normally just the site conditions of stability in pure engineering terms are used to select a ‘long-term’, often ‘hard’ remedy. A geomorphological approach has the ambition to work with natural processes, access stakeholder information and aim for a cheaper, repairable solution.

Fluvial Audit is an established and definitive survey technique, described by Sear et al. (2010), but consisting of:

- Walkover survey (perhaps employing remotely sensed data too);
- Measurements of channel forms and features to establish the sediment balance sheet;
- Use of documentary, archival and local knowledge;
- Use of map analysis;
- Normally use of formal GIS archive for all relevant data;
- Interpretative report.

One way in which we have demonstrated some of the principles and processes of fluvial geomorphology in the CRF Haltwhistle Burn project is via the ‘Em River’ portable flume tank in which a model ‘river’, with variable flow, transports sediments to create channel forms.

Fig 1.3.1 Using the Em River to explore and better understand river processes and to recreate Greenlee Lough

1.4 Floods – key events in catchment dynamics

The upland environment is one of extremes, not the least in rainfall (snowfall), runoff and the resulting stream power. Despite the inertia of the coarse channel bed material and the apparent tenacity of the bordering peat, gley and podzol soils, 'lift off' (almost literally!) can occur during 'large, rare' floods. The application of the flood frequency approach (e.g. 'the one-in-a-hundred-year flood etc.) to upland spates is inappropriate because of the very skewed distribution of recorded flood peaks in the uplands. Some of these headwater-generated floods are legendary for the extreme conditions on the ground and the damage, even fatalities, caused: Lynmouth, Boscastle, Hebden Bridge....

In such events the 'flesh' of the tough glacial veneer becomes 'lacerated' by water moving through all the catchment connectivity routes, powered by gravity, volume and depth. Velocities in the channel of >7m/s have been recorded. There is a sound effect as the boulders and cobbles move over and against each other. From time to time, hydrologists compile archives of these prodigious upland floods (Beven and Carling, 1989; Archer, 1992). Subsequent analysis (although 'hard' data are understandably scarce) reveals general patterns of seasonal events – summer convection rainfall, winter snowmelt and long-duration frontal storms. It is sometimes claimed that 'short, sharp' and 'long, low' rainfalls (the latter including snowmelt) have distinctively different geomorphological effects (Newson, 1980), the former focusing on comprehensive channel sediment effects and the latter also impacting slopes and supplying big sediment yields from tributaries. Such a discrepancy has been given a long-term interpretation for the Tyne by Rumsby and Macklin (1994), who also reveal the part played in decadal cycles of the two main rainfall patterns by the 'North Atlantic Oscillation', a kind of northern hemisphere El Nino.

It is now also realised that several northern British rivers with long flow records have exhibited 'flood rich' and 'flood poor' periods, alternating over one or more decades and possibly linked to the North Atlantic Oscillation (see Rumsby and Macklin, 1994). During the project at Haltwhistle, the town experienced at least three significant flood events, though none came from the Burn itself, unlike that of 2007 (see below).

Box 1.4 Flooding problems in the Haltwhistle Burn catchment

There are potentially four flood-related problems in the lower Haltwhistle Burn catchment:

- Flooding from the Burn in the Town Foot area;
- Flooding from the Burn's flashy tributary, Slaty Sike, just north of the town along Willia Road
- Flooding from the Hemmel Burn to the west of the town, partly caused by culverting (with reduced capacity due to collapse and root damage) / diverting this channel;
- Surface water flooding from the steep, increasingly developed slopes to the north of the town centre;
- Flooding at the Haltwhistle Burn – South Tyne confluence (mainly notable for it's geomorphological impacts).

Although these issues are clustered within the 'impact zone' where the catchment becomes extremely steep and narrow, the majority of the fluvial flood waters originate from first and second order ditches and streams located higher up in the catchment. Valuable local knowledge has confirmed that farm land is also affected by flooding during heavy and/or prolonged rainfall events which enhances the catchment connectivity effect.

Archer (1992) makes only a few tangential references to Haltwhistle floods in his 'Land of Singing Waters' book describing large, rare Tyne floods. Thus, it appears that the local flood risk is changing, notably the risk from pluvial or 'runoff' flooding, perhaps associated with changing rainfall patterns, soil capacity/connectivity, lack of drainage management or the decay of Victorian infrastructure.
The EU Water Framework and Floods Directives are not yet integrated in regulation; CRF Haltwhistle Burn addresses WFD failures, not flood risk management. However, such has been the concentrated occurrence of flooding in the town during the life of the project that stakeholders have expected TRT to play at the very least an educational, advisory and representative role. Fortunately, our approach to the WFD issue of siltation/diffuse pollution has included land-use and land management techniques which also impact on runoff.

Further site-specific flood problems affecting residents of Haltwhistle were highlighted recently in a report commissioned by Northumberland County Council (Royal Haskoning DHV, 2014).

Prior to the CRF project the Haltwhistle Burn catchment did not benefit from any long-term monitoring equipment. With support from Newcastle University, we now have a network of automated equipment and 'River Watchers' (volunteers) which harvest a wealth of information. Recent 'cloud bursts' were therefore characterised, including the 30th April, 10th -11th May and 8th August 2014 events. Information collected has highlighted how extremely localised heavy rainfall events are across this small catchment. For instance, on the 30th April a member of the community manually measured 41mm of rain in their Town Foot garden which was reported to have fallen within just a 40 minute period. A local resident commented that "the floods had been and gone within a few hours" and Northumberland County Council confirmed that they did not have any reports of flooding elsewhere in the country that day. River levels shot up immediately (figure 1.4.1) and returned back to normal conditions within 24- 48 hours. Evidence of fluvial and pluvial flooding within the town was captured by the River Watchers (examples in figure 1.4.2).

Despite being just a few kilometres away, only 17mm of rain fell in the upper catchment and over a longer time period. These cloud burst events have highlighted the importance of local information which is required to support catchment management and restoration activities.

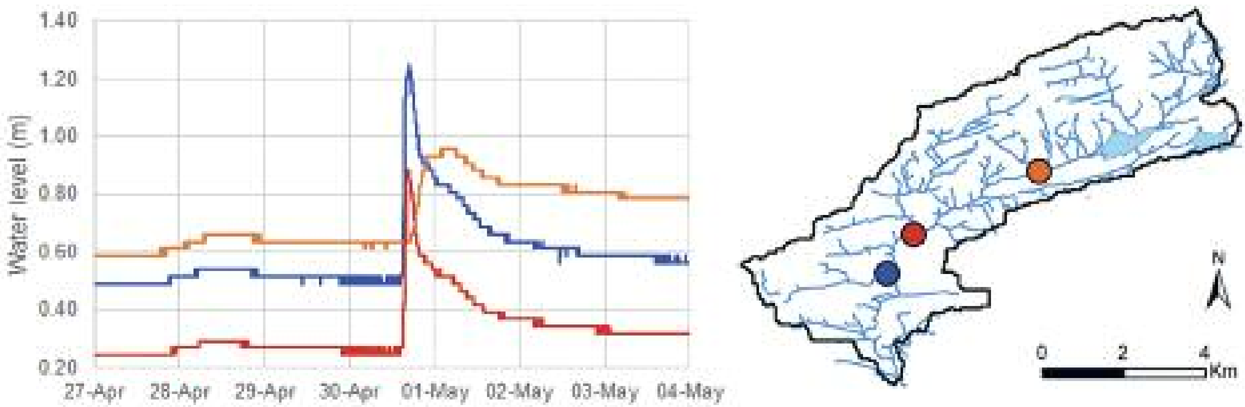


Figure 1.4.1 Caw Burn's response to the cloud burst event on the 30th April 2014 at three separate locations (line colour matches with colour of the location point). Data has been shared with the River Watch Group during workshops, through social media, posters and on webpages.

Figure 1.4.2 Catchment response during 30th April 2014 heavy rainfall events. (Images provided by the community).

2. Channel and catchment restoration: history and development

Channel restoration in the UK has tended to avoid high-energy (stream power) upland sites: a sensible strategy, given the perpetual failure of ‘hard’ engineering approaches (unless heavily over-designed and financed) in these streams.

However, a more recent engineering philosophy of working with the forces of nature (e.g. Environment Agency, 2014) – meaning we share an understanding of them – has turned on, notably through the Rivers Trust movement, - a change to ‘green engineering: no less intrusive and also risk-prone but capable of enhancing habitats and of replacement at low cost if damaged. There is a growing literature supporting technical design and applications of ‘green engineering’ in support of habitat creation; the River Restoration Centre has an established coordinating role in this support and in maintaining a database of restoration efforts (RRC, 2002).

Despite the fact that the moves from rehabilitation of individual river features, to a reach-length channel dynamics approach and thence the Catchment-based Approach (each upscaling suggesting more strategy, evidence and sophistication) much restoration action remains opportunistic. In fact, one of the motivations for stakeholder engagement and multi-agency involvement is that it creates more and better opportunities.

2.1 Current principles and the ‘Catchment-based Approach’

It is now widely acknowledged that early river restoration projects concentrated on ‘repair mode’ – such was the damaging influence on habitats of the earlier, less informed, less regulated ‘land drainage’ era. Channel impact (‘damage’ – an evocative word, often inappropriate) was targeted by geomorphologists who gathered evidence about the ‘natural’ sediment system and its outcomes for channel dimensions, features and habitat quality (see e.g. Lewis and Williams 1984).

However, we live in an era during which public expenditure is required to be evidence- and risk-based. This context has, since the 1980s, demanded assessment of the river ecosystem ‘services’ (a more recent term) offered by features which were damaged in the past, e.g. by land drainage activities. The evidence has been collected by the river management authorities, initially via River Corridor Surveys (NRA, 1992) but subsequently via the Environment Agency’s River Habitat Surveys (NRA, 1996). Haltwhistle Burn has three RHS sites, these being surveyed in 1999 and again in 2005. TRT staff have been trained in RHS techniques and have therefore compiled updates at these reference sites.

Whilst RHS is not catchment based, its database has been promoted as a potential design tool for catchment restoration strategies (Walker et al., 2002). Another device now being employed in Scotland involves a geomorphologically-based evaluation of the capacity a channel has to retain natural processes against the damaging impacts of existing or proposed developments: restoration increases capacity (SNIFFER, 2006).

Whilst channel-focused restoration (there are other definitions – RRC, 2002) continues, often in urban rivers where the ‘damage’ is a true view and perpetuated by careless development, it is now considered essential to take an approach which incorporates catchment processes, notably because of the ‘damage’ to river health caused by diffuse nutrient/pesticide pollution and, particularly, siltation. This helps explain why we have used frequent visits to the Haltwhistle Burn catchment to create an interactive, repetitive assessment of evidence, rather than relying on a formal desk-based strategy development producing a ‘do this here’ project management.

2.2 Options for Haltwhistle Burn and chosen techniques

Fortunately, by an accident of history, TRT has good experience of key assessment techniques such as ‘Fluvial Audit’ (see Box 1.3) and River Habitat Surveys. Fluvial Audit comprises a largely walkover survey style during which sources and sinks of sediment are mapped and quantified (approximated). In part, the quantitative results are an objective guide to the catchment-scale sediment system but the actual survey is often the prime, subjective, guide to ‘what needs doing’ by identifying the sites and systematic causes of sediment problems. Diffuse pollution is not a prime target but negotiated access to farmland to conduct Fluvial Audit often yields vital spatial information on farm water/runoff management. It can also yield those opportunities referred to in 2.1 above.

The reconnaissance Fluvial Audit of the Haltwhistle Burn catchment, as reported to funders and stakeholders, is shown in Appendix A. Its key conclusions are shown in Box 2.2 (see also Box 1.3). We ‘struck lucky’ in adding the vital detail to the problematic Burn/South Tyne confluence in finding a local landowner who is a former consultant geomorphologist and who has constructed a very valuable archival record, using maps and flood photos of the confluence area. Her records of floods and channel change have been a huge positive benefit to interventions in both erosion/deposition management and to refining the operations (and possibly the future design) of Haltwhistle Sewage Treatment Works.

Box 2.2 Reconnaissance Fluvial Audit and repeat River Habitat Surveys: summary conclusions

Whilst the Fluvial Audit technique has achieved ‘industry standard’ status with official bodies and their consultants, Tyne Rivers Trust has adopted a simpler form of presenting the findings of walkover surveys so as to put the information in a form for stakeholder discussion and debate, i.e. reconnaissance audits directly enter decision support; this is often a longer process with the more sophisticated industry standard.
Fluvial Audit of the catchment was divided into four phases, depending on the level of detail required:
Main stem of the Burn from source to mouth;
Catchment and culvert conditions for the Hemmel Burn;
Detail of the sedimentation zone at the confluence with the South Tyne;
‘Wall country’ walkovers to focus on diffuse pollution sources.

The Project Record contains comprehensive photographic records and annotated PowerPoint format is an effective and engaging format which the stakeholders, including the community understand.
The major conclusions of the Audits is that the sediment system of the Burn is dominated by coarse material in the Gorge section, with a series of anthropogenic ‘aggravations’, and by sources of finer material from farmed and forested land in the headwaters. There is a further complication of combined agricultural and urban sediments and debris in the headwaters of the Hemmel Burn. Floods and flood deposits dominate the time-line of the sediment system. Channel migration is locally a source of sediments and rapid channel change is a risk where the Burn crosses the Tyne floodplain towards the confluence sedimentation zone (largely created by the South Tyne itself).

River Habitat Surveys were carried out on the Caw Burn above the Military Road and the gorge section of the Haltwhistle Burn. The Caw Burn was a repeat RHS from an initial survey in 1995. The 1995 survey suggested that the right bank consisted of undercutting banks which in 2014 had collapsed to form vertical banks with a toe. In 1995 the right bank was reinforced but in 2014 there was no sign of the reinforcement. The original survey also showed that vegetated mid and side bars were present but not in 2014. This stretch of burn is very active shown by the change in bank structure and movement of the channel over time. Work has been carried out since the survey to reduce erosion and protect the banks so this may show on future surveys.

The gorge section of the Haltwhistle Burn has not been surveyed before. As part of this project tree and bank works have been carried out just above the survey section prior to the survey. Fish passage, tree work and wall repairs were carried out in the survey section after the survey. Therefore the 2014 survey makes a good baseline survey for future monitoring to assess the impacts of the work on the project.



Figure 2.2.1 Measuring a culvert (left) and recording a check point site (right) for the River Habitat Survey.

2.3 Appraisal/assessments of Haltwhistle Burn

It is the norm in fluvial science that first assessments are never sufficient – we are dealing with dynamic systems: no river remains the same between visits. In an engaged project, vernacular sciences ‘pops up’ with new sites, new histories and new impacts not covered by the ‘definitive’ survey such as our Fluvial Audit. Additionally, each new ‘rare, large’ flood reconfigures parts of the system and raises new public issues. As already stated, interactive repeat visits have been a very positive feature of this project. It is hoped that this can continue as part of the project legacy.
Thus, appraisal and assessment continued during the life of the project, almost defining the recommended ‘adaptive management’ for river restoration (Newson and Clarke, 2008). It was spectacularly expanded by the involvement of the citizen scientists of the River Watch group and by our close relationship with NIRES at Newcastle University (another accident of TRT history) but a relationship refreshed by the Defra Tyne Catchment Pilot project.

Box 2.3 shows the many other appraisal and assessment ventures conducted under the deliberate adaptive management needed to progress and available due to the generous funding of the project, an available and willing workforce and the necessity to convince regulators for permitting procedures and land owners for access to private land.

Box 2.3 Back-up appraisal and assessment, Haltwhistle Burn

Location within catchment	Focus of assessment	Significance to CRF Strategy
Hemmel Burn	Sources of polluted flood runoff and conveyance problems between upland pastures and (diverted) entry to lower Burn	Identification of mis-connected foul drains and poached pasture as sources. Pressure for underground surveys of culvert. Contacts established with Haltwhistle schools.
Gorge footpath	Footpath a major identity with Burn for stakeholders but in vulnerable position for erosion. Identifying causes of failure (e.g. Large Woody Debris) and potential to use tree material to protect from erosion.	Liaison with Town Council and financial assistance for silt control element of post-flood repairs. Linked to effective maintenance of ageing woodland cover on Gorge sides. ‘River Watch’ tree planting on land slip.
South Tyne confluence/STW	Discharge of Haltwhistle Burn into the South Tyne coincides with a ‘sedimentation zone’ on the latter river – a highly dynamic, multi-thread channel with an unpredictable reaction to high flood. The Burn receives discharges from a major STW upstream of the confluence and in the diverted Burn channel (when sedimentation blocks its direct outfall). Riparian erosion is caused by channel swings and fish migration is compromised.	Clearly, both processed and ‘storm’ sewage cannot be discharged to a blocked channel and there are tourism/amenity and angling issues at this site. Our ‘source to mouth’ philosophy demanded professional assessment and NWL have submitted proposals to improve discharge points under AMP5. ‘Green engineering’ was indicated for the diverted channel and has been installed.
Gorge trees on banks and growing through historic revetment and walling	Linked to Gorge footpath appraisal. Identifying potential of shallowly rooted trees to blow over in strong winds releasing large slugs of (contaminated) sediment into the burn or ripping out wall structures. Identifying local resource for protecting and reinforcing the river bank through the gorge.	Climate proofing the stretch and protecting habitat for invertebrates, fish and others. Prevention of the release of sediment from mining heritage with root ball. Easily publically accessible demonstration of green engineering techniques throughout the burn catchment and elsewhere in the Tyne catchment.

Lees Hall Farm above Gorge section in lower reaches of the catchment	To explore potential improvements using a PinPoint (Practical Initiative for Pollution Information Targeting) style assessment. This farm is one of few in the catchment that does not have HLS agreements.	Concerns were identified by community members relating to impacts on the burn seen from footpaths in the locality. Work at this site has greatly enabled dissemination to young farmers through workshops with local agricultural colleges visiting and working at this farm.
West Hotbank Farm in SSSI area around Greenlee Lough in headwaters of the catchment	Before this project a Farm Infrastructure Audit had been completed for this farm but contained some disputed figures. Our focus was to understand the true situation at the farm and explore the validity of River Trust techniques such as guttering and wetland creation to alleviate the pollution threat.	Identified in first Project Board meeting by three different partners as of concern and deemed to be at risk of polluting water courses in a SSSI area. Enabled early partnership working and dialogue with established farmer in the catchment. The farm has been used on at least 3 occasions within the project timescale as a case study demonstration site for dissemination visits.
Inflow channels to Greenlee Lough	To gather information on water quality entering the Greenlee Lough to better understand the condition of the lough relative to its SSSI status.	Identification of potential threats to water quality upstream of the lough.
Pont Gallon Burn above High Edges Green	Potential sites for slowing the flow and reducing the force of the water above areas of bank erosion and mining discharges.	Utilises green engineering. In this case increasing temporary wetland area was considered beneficial by NE for upland wading birds.
Mossy Banks 'bedrock' barrier to fish	After the gravels at the mouth of the river this is the next barrier to fish. This is a known site for poaching fish. Fish have different potential routes depending on flow. The site of a former mill, the location is a popular beauty site on the burn with an adjacent picnic site.	There is great interest from anglers at this site as well as the less desirable attention it experiences. The intervention required technical knowhow and flow experience but also provided a vital opportunity for education, engagement and involvement.
Military Road culvert barrier to fish	The 'Mossy Banks' fish pass opened up 1.8km spawning and juvenile habitat. The next upstream obstruction is the culvert under the Military road. This culvert is 46m long and includes a concrete weir in the middle section.	This site is less accessible by humans but opens up the rest of the WFD defined channel (7.4km) for potential spawning of fish. The rest of the project has been addressing improving water quality (including a pollution source discovered n site) and habitat to enhance opportunities for all fish species.
Cawfield Farm	Site meeting at Cawfield farm took place with English Heritage, land owner (National Trust) and the tenant farmer. This farm lies on the path of Hadrian's Wall and includes several archaeological features. Communication with partners was essential to ensure that our farm improvements were sympathetic with the adjacent monuments.	Tyne Rivers Trust's physical assessments of the site were of interest to CRF partners. River improvements also had potential to preserve archaeology and access routes. Partners remain keen to aligh objectives and to adopt maintenance and explore further improvements.

Slaty sike – a tributary flowing west to east through Glendale and into the Haltwhistle burn at Broomshaw Hill Farm	Massive sediment load has been observed entering the Haltwhistle burn via the Slaty sike during this project, especially during cloud burst events. This sike discharges into the burn directly above the Mossy Banks fish pass. The walk-over assessment was conducted with representatives from NiRES (Newcastle University) and looked for suitable sites to 'slow the flow' and therefore erosive force and prevent pollution incidents from cattle – sediment and nutrient load.	The CRF project is driven by WFD and water quality. As explained elsewhere in this report the link to high flows and flooding is strong. The Slaty sike provides a Haltwhistle catchment in miniature and allows not only physical intervention towards improving water quality and habitat but is also suitably close to the town and accessed via tracks and footpaths that the site lends itself to a demonstration site.
Forestry – headwaters of Greenlee, Haughtongreen and Pont Gallon burns	Walkover surveys along burns to look for potential sediment inputs and areas where sediment could be retained. Forestry activities including felling, harvesting, restocking and road drainage were assessed	Similar walkovers have been employed in our WFD Kielder Forest Streams project. Overlapping principles between the two projects include reducing sediment input, retaining sediment before it leaves the forested area and slowing the flow. Working with UK Forest and Water Guidelines and Forest Streams work.
Catchment-wide hydrology: upper, middle and lower reaches (see figure 2.4.1 on page 21 for a map of monitoring sites)	A network of water level recorders and rain gauges have been installed to characterise the catchment's response. The 'backbone' watercourses, including the Caw Burn, Pont Gallon Burn and Haltwhistle Burn, were instrumented between January and May 2014 so that the upper, middle and lower regions of the catchment are now monitored for response. Further citizen science based monitoring activities now occur in and around the town to increase spatial coverage – these are monitoring activities which are also expected to support the legacy of the CRF project.	It is necessary to characterise the catchment's hydrological regime as low and high flows affect fish and their spawning grounds. High flows and flooding are also strongly linked to morphological activity, high erosion rates, connecting diffuse pollution with the watercourses and subsequently poor water quality. High flows can also be used to identify hotspot areas and subsequently target sub-catchments of interest for management activities. It is expected that monitoring will continue beyond the CRF project by Newcastle University and the River Watch Group.

2.4 Breaking down the catchment management themes whilst retaining system cohesion

In one sense, the project has created, partly through messages networked through our large and representative Project Board, an awareness of catchment connectivity, not just in the hydrological sense but as an Agenda for collaborative actions. However, for our own scientific sanity and to develop other funding opportunities we have developed, from the outset, a themed, source to mouth, sub-division of activities, from assessment to delivery:

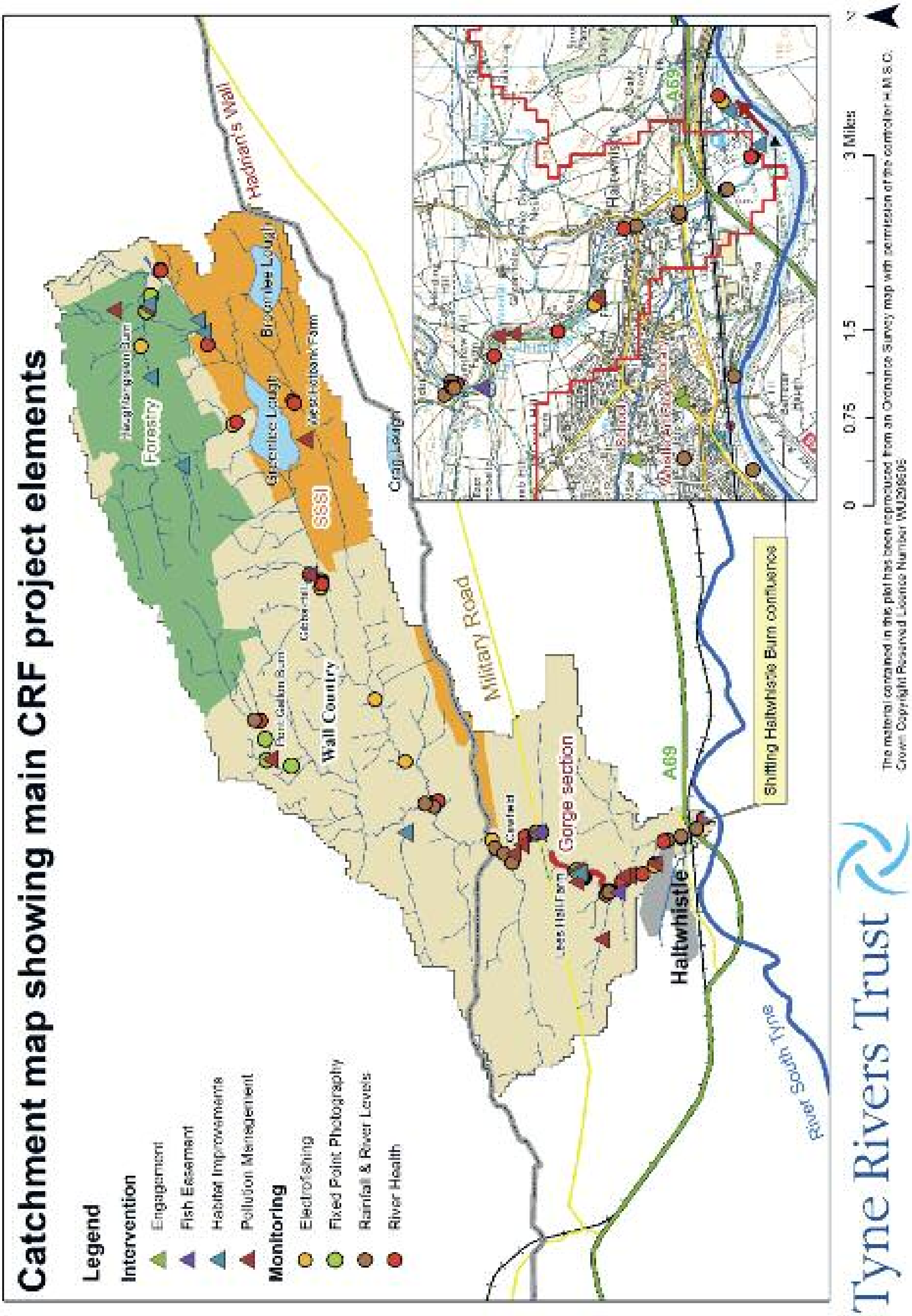
a. Forestry headwaters (in collaboration with Forestry Commission and Tilhill Forestry)
b. Loughs (glacial lakes aligned east-west north of Hadrian's Wall – in collaboration with Environment Agency, Natural England, Northumberland Wildlife Trust and Northumberland National Park Authority)

c. ‘Wall country’ diffuse pollution from livestock farming (in collaboration with Natural England and Northumberland National Park Authority)
d. Haltwhistle Gorge trees/walls/erosion (in collaboration with local landowners and Haltwhistle Town Council)
e. Town Foot suburban flood hazard (in collaboration with flood-affected property-owners, Northumberland County Council, Haltwhistle Town Council, Northumberland Community Flood Partnership, Environment Agency)
f. Sewage Treatment Works and its outfalls in relation to (g) (in collaboration with Northumbrian Water and local landowners)
g. South Tyne sedimentation and rapid channel change (in collaboration with local landowners)

We also identified a generic, catchment-wide pressure, one of the Burn’s ‘Reasons for Failure’: Fish passage. Our principal focus for easing fish passage has been ‘Mossy Bank’, an extensive bedrock exposure at the northern limit of the town. Whilst this is a natural feature, and therefore outwith a funding remit under WFD, there is clear historic evidence of changes due to road construction and milling activity in this area which has exacerbated the conditions for fish passage here and it does form sufficient of an obstruction to the upstream migration of salmonids at certain flows that it has become a notorious poaching spot on the Burn. We have also completed similar easement work at other migratory ‘pinch points’ such as the ‘Military Road’ culvert. For details of our approach to fish passage work in the Haltwhistle burn see Appendix 9.1.

These seven, zoned, themes are identified on the accompanying map (Figure 2.4.1) which also shows the ‘hot spots’ for fish passage.

Figure 2.4.1 – Map of Project Elements



3. Channel and flooding approaches (within diffuse pollution control)

River restoration is just that – it has a channel focus; despite the logical and necessary extension to catchment-scale processes and a heavy implied engagement for other stakeholders, geomorphologists have tended to guide the restoration of channel features for which they have most evidence and understanding: the riffle is an obvious example. Whilst not ignoring catchment processes, river restoration has, in its development triumphs such as the EU Life Projects (Holmes and Nielsen, 1998), concentrated on channels, with appropriate consideration of banks and the riparian zone. There has also been a general preference (ensuring less risk of 'surprise') on low energy river channel systems. The understanding, amongst geomorphologists, of the role of large, rare floods has also meant the inclusion, where possible, of flood mitigation measures (e.g. better channel flow access to the floodplain, compound channels with high habitat quality during 'normal' flows but 'room for the river' in flood).

Because of the need to 'hit the ground running' on ***Catchment*** Restoration Fund projects, we also, inevitably prioritised channel projects, but with one eye on flooding. It is a regrettable policy mis-match in current regulatory practice that the EU Water Framework Directive and the EU Floods Directive do not necessarily interact at the delivery scale. In fact, for Haltwhistle Burn, we ran the risk of dangerous public misunderstanding (notably in the local press) and took considerable care to avoid mis-allocation of CRF funds for work considered to overlap with statutory Flood Risk Management, (as administered for the Main River section of the Burn by the Environment Agency or the 'Ordinary Watercourse' section administered by Northumberland County Council).

However, the links between runoff control and the amelioration of diffuse pollution, especially siltation, are sufficiently strong, and the acknowledgement of 'Natural Flood Management' sufficiently widespread, that our project delivery has included 'slowing the flow' measures within forest and pasture sections of the catchment. Northumberland has the advantage, via R&D activities hosted at Newcastle University (Wilkinson et al., 2010) and the role of the Northumberland Community Flood Partnership, of considerable 'on the ground' experience of 'slowing the flow' and its tangential impact on diffuse pollution control.

3.1 Riparian approaches and erosion controls

One of the most rapidly increasing forms of diffuse pollution is that by sediments released by erosion. These are mainly fine sediments (hence the problem is mainly labelled 'siltation') and the sources are sites that are normally (but not exclusively) river banks. Aggravated erosion may be caused by neglect of riparian tree cover, by some invasive plants and by unrestricted access by livestock to the riparian zone and channel – often labelled as 'poaching' (Newson, 2010).

Tyne Rivers Trust's widespread Habitat Improvement Programme, mainly directed at salmonid and Pearl Mussel breeding/juvenile habitats, quickly became involved at Haltwhistle, applying an 'accepted wisdom' of riparian vegetation management (both live and dead wood plus tree planting) and of curtailing stock access, either by fencing or by providing alternative water supplies (Newson, 2010).

The CRF Haltwhistle Burn, however, ran into an historical legacy of riparian management which would prove a test of technical understanding and of partnership funding and action. During 2007, the obvious attraction of the Haltwhistle Burn gorge section and its previous use as a routeway for its mines and other industries, led to construction/refurbishment of a west-bank footpath up from the town towards Hadrian's Wall. The route became a focus for educational and tourism literature; samples of these publications can be found at http://haltwhistleburn.org and http://www.haltwhistlewalkingfestival.org.

Work on the public access route up the gorge has been supported by CRF to ensure its protection from erosion by the Burn in its most energetic section: it is fair to say that river restoration has seldom, if ever, addressed such high-energy stream conditions with such unstable and poorly-managed banks (crumbling cliffs mantled by unmanaged mature woodland). In a sense the project inherited a set of problems it would not have set up for itself. However, given the local and national/international significance of access for walkers 'up the burn', we initially addressed problems of path erosion and engineering as they have developed in this 'flood rich' period (see Box 2.3).

The available techniques for ‘green engineering’ have a growing evidence base and cost implication. Tyne Rivers Trust has built up a small portfolio of the techniques with which it is familiar, shown as Table 3.1 below:

Table 3.1.1 Indicative costs for unit lengths of river treatments (highly site dependent)

Treatment	Cost per metre	Extras	Comments
Riparian fencing (wire)	£3.50 - £3.80 + strainers at £15 (often per 100m but shorter at difficult sites)	Strainers may need to be strong, deep and buttressed. Can boost cost to £5/m. (see gate costs)	Mesh fencing to be avoided at all costs in flood-prone locations.
Riparian fencing (post and rail)	£7.50	(see gate costs)	Vital for e.g. horses and in some landscape-sensitive sites
Willow spiling revetment	£50	Aggressive sites may require stone foundation; fencing from stock at above costs.	Basal bank conditions must be suitable as planting medium. Timing vital.
Stone or sleeper river crossings	£100/m^2 for stone; £60/m^2 for concrete sleepers.	Often an extra demanded in conjunction with fencing/gating	Second biggest sources to high river cliffs – crossing point erosion tends to spread.
Drinking point (timber) construction with gates both sides of river	£1300-£1500 for 5m wide.	Often an extra demanded in conjunction with fencing/gating	Second biggest sources to high river cliffs – crossing point erosion tends to spread
6-foot gates	£110 each (water gates £100)	Wicket gates often sufficient but not much cheaper.	Vital in longer fencing schemes to retain Single Farm Payment, allow emergency stock watering and combat invasive species.
Trees (1/2m)	£0.30 from Woodland Trust; £4 commercially	Commercial price includes guards and stakes.	Planting trees, if done by contractor can cost £1.50/m
Trees (where just willow whips)	£5.44 - £6.40	Requires care with provenance, placing and timing	Price includes planting.
Stone revetment (large block stone)	£150 - £350 / m depending on the number of stone layers	Often associated with bank vegetation re-instatement. Access for materials may include rebuilding fences/walls (£30/m). (see gate costs)	Expensive approach but very strong for high risk and / or flood prone sites. Price also includes construction pollution control. For Haltwhistle this method was also in keeping with the heritage.

Dry Stone Walling	£80 / m	Erection of stock-proof fencing while working may be an extra cost.	
Brash Bundles	£25 / m	Utilises woody material obtained on site but pins, posts and twine must be brought in	Use of willow can allow living brash bundles to regenerate in following growing seasons.
Tree Management; laying trees	£10 / m	If posts, pins and steel wire also required to secure trunks to bank.	Tree branch removal, coppicing, pollarding, felling.
Timber revetment	£25 / m	Posts/ pins and steel wire also required to secure timber to bank	Suitable tree material often available on site from tree management.

Table 3.1.2 Indicative costs for unit remediation works on farms and 'off' rivers.

Treatment	Cost per unit	Extras	Comments
Farm building rain water harvesting to include guttering, water tanks and feeding troughs	£1.49 per m^2 roofing	Farmer time for labour (in –kind for this project.)	Number of tanks and troughs may be driven by farming conditions and number of cattle as well as average rainfall calculations
Wetland creation	£34.73 / m^3 silt trap capacity Or £9.05 / m^2 wetland created	Gates supplied by farmer from farm business	Quite site specific wrt to climate-proofing and farmyard considerations
Containment of FYM	£160.27 per head of cattle	Levelling of farm yard to ensure containment of material.	
Leaky dams in headwaters	£104.84 per structure	Material and delivery if cannot use local resources. Maintenance of structures once in place – can be my land owner / farmer or trained River Watch volunteers	Brash and tree trunks were provided by project partners and delivered free of charge where activity could be co-ordinated throughout the catchment.
Cleansing of Hemmel Burn - culverted section	£5.75 per meter length	Cost assumes salaried staff in place to carry out this work wherever deployed. Therefore no vehicle or equipment hire included.	Conducted by Northumberland County Council as part of their flood alleviation assessment in the area.

Box 3.1 Riparian approaches and erosion controls in the Haltwhistle Burn

An important output of this project has been to share Tyne Rivers Trust's approach to green-engineering techniques developed through working with key contractors over several years and different locations widely throughout the whole of the Tyne catchment with statutory bodies, local practitioners and interested residents. This project has used green-engineering techniques at several of its work sites to create habitat, 'slow the flow' allowing silt and sediment to drop out onto the floodplain, protect river banks from erosion and create access to the Haltwhistle burn from the South Tyne.

Using living material from the immediate surroundings reduces transport costs and avoids introducing non-native provenance. Live material often 'gives' more in high flow conditions and is less likely to fail catastrophically. Some comments from land owners when seeking permission to install green-engineering have been 'We are willing to let you experiment but you must not make the situation any worse!'

At the 'new' downstream mouth of the Haltwhistle burn locally cut wood was used to hold back silt and gravels keeping the channel open to allow fish passage up and STW consented effluent out. This also saves the land owner a lot of repeated effort in digging the channel by hand to prevent a stagnant pool developing.


Fig 3.1.1 Haltwhistle burn mouth before and after simple green-engineered interventions

Further up the burn in the 'Gorge' section, trees have grown overly tall in search of sunlight. Many are at danger of collapse and taking out large volumes of the river bank. Some are ideally positioned, if laid like a hedge, to protect the water course from land slippage of contaminated sediment. Green-engineering techniques have been improved / enhanced in this rapid response catchment to build confidence from statutory agencies and local residents.


Fig 3.1.2 Living tree is laid to reduce river bank collapse at old quarry / mine site. Additional trunk is secured on the river bed to direct flow away from eroding bank. One season of growth demonstrates how well the bank is repairing. This is a fixed point photography site (from marked post on footbridge).

Fig 3.1.3 Usual hemp rope which will degrade in time as the trunk / brash bed into position is augmented by 6mm tensile cable threaded through live growing tree and felled trunk to ensure trunk does not detach in high flows and cause damage downstream.

In the head waters simple timber sluices and secured brash bundles take the power out of the water in storm conditions, pushing sediment onto the floodplain. These forms of interventions are easily installed and maintained by trained volunteers.

Fig 3.1.4 Volunteers working as a team (left) to produce brash bundles to add to the timber sluice constructions (right). Brash material was acquired from Environment Agency tree maintenance work further down the catchment and transported to site by a project partner.

3.2 Wetland/runoff detention approaches

The Haltwhistle Burn catchment is ‘hinged’, in terms of runoff propagation and storage, at the ‘Military Road’ (B6318), close to Hadrian’s Wall. Here is where the undulating ‘Wall Country’, with its natural Loughs and hollows, vegetated by rush and mosses, suddenly funnels into Haltwhistle Gorge. The Gorge channel offers very little opportunity for runoff detention and opens up directly into suburbs of the town itself (Town Foot, badly flooded in 2007), where space for channel modifications is extremely restricted. Northumberland National Park and Natural England provided in confidence, at the outset of the project, candidate areas and (critically!) candidate land owners where some form of silt control and/or runoff detention could be practiced. The funding and momentum of this project advanced those candidate sites very quickly. We also want to stress the beneficial influence of the best practices implemented by both organisations under Stewardship funding, prior to the CRF Haltwhistle Burn project (see Box 3.3).

Given the significant plantation forest cover of the sources of Haltwhistle Burn it was vital that the technical learning and joint delivery ethos of an existing Tyne Rivers Trust project (jointly funded by EA and FC) was allowed to ‘spill over’ into the project. The Tyne Forest Streams project is described elsewhere – Forest Stream Project; Interim Report, (Holyoak, 2014) and follows in the context of the very long-running LIFE Project to restore the Border Mires (Smith et al., 1995; Lunn and Burlton, 2010).

Commercial plantation forestry came off badly from the early days of ‘land-use hydrology’ (see Section 1) but the forestry industry needed to respond to criticism from hydrologists because of the opportunity to plant catchments feeding water to upland reservoirs like Thirlmere and Kielder. Five editions have now appeared of the ‘Forests and Water guidelines’ (Forestry Commission 1988-2011), amounting to the most prominent UK attempt to promote catchment-sensitive land management. However, the Guidelines are a broad brush and the TRT project has taken water issues into the core of forest management strategy and operations at Kielder.

Box 3.2 Wetland/runoff detention/forest management approaches in the Haltwhistle Burn catchment

Wetland / runoff detention

One of the first sites to be highlighted by project partners as needing attention was a farm in the Greenlee Lough area of the catchment. Issues at this site fell across two of the themed activities; b. Loughs and c. ‘Wall country’. Farm business aims are sometimes at odds with water quality and land protection and this can be exaggerated in harsh farming conditions such as uplands. The Haltwhistle catchment area is wet: lower parts of the catchment have an average annual rainfall of 850mm but in the headwaters double this may occur, with wetter months experiencing ‘a foot of rain’ (300mm).

An introduction from the NNPA allowed initial dialogue with the farmer. Two activities were identified as mutually beneficially to the farm business and the protection of the SSSI area and water courses. Guttering, water tanks and troughs allow the collection of rainwater from farm yard buildings to be harvested and used to water stock reducing the volume of water that exacerbates run off of farmyard material into the SSSI areas and water courses. Using double walled tanks and piping the water to inside the farm buildings helps guard against potential problems generated if the water freezes.

The hard standing area of the farm yard was slightly extended and laid to direct all run-off flow to one corner. A wetland area was created to connect via this point. The wetland area collects run-off water in a settlement pond to allow all nutrients and material to settle out. An over spill creates capacity for ‘cloud burst’ conditions by feeding into a winding channel to allow further settlement before reaching the final holding pond which includes a last silt trap and allows reconnection with field drains.

It is worth noting here that the guttering work was carried out by the farmer as in-kind contribution and that the contractors completed the wetland creation work within 2 working weeks. Most of the time and effort is spent in engaging with land owners and statutory bodies. To create the most appropriate and resilient solution it is important to fully understand the farm as a business, the environmental considerations and any history. During construction of the wetland and since ’completion’ the work has been re-evaluated and adapted to suit discoveries made. For example additional reinforcement of the settlement pond wall was added to better withstand the strong prevailing westerly winds at this site and the first channel receiving overflow water from the settlement tank has been re-sculpted to better deal with any potential jetting from the inlet pipe.

With the farmer’s full support, this site has since been used for 3 educational visits and will continue to be used as a demonstration site for Tyne Rivers Trust.

Figure 3.2.1 First settlement pond, also showing access track for emptying the pond, reinforced wall and stock proof fencing (left). Winding settlement channel with first settlement pond, farm buildings with guttering and water tanks in the back ground (right).

Forest Management

The approach to forestry management that has been undertaken has followed that of the Forest Streams project involving walkovers along the burns running through the forest to identify sources of sediment as well as identifying any other potential management that could aid slowing the flow or retaining sediment within the forested area. The main opportunity for working within the forest cycle is within the restocking phase. Unfortunately, none of the forestry within the project area has been due for restocking during the period of the project. One site has been felled and issues have arisen regarding upgrading the road drains; see appendix 9.2. Once brought to the attention of the Forestry Commission this was remedied. During the harvesting an opportunity was taken to use timber from the site to install leaky dams. The restocking of the site will occur after the end of the project but has been discussed with the forester to put forward ideas to improve the quality of the water exiting the site.
The leaky dams are not intended to hold back large volumes of water or to make the wetted areas permanently wet; the intention is that there will be some backing up of water at each of the structures but that these will quickly drain once a rainfall event has passed. This reduces the erosive force during storm flow as well as letting sediment settle out in the riparian areas. Good practice for this type of work suggests that it is better to have a large number of small structures rather than a small number of big ones. Therefore, ten leaky dams were installed to offer a more effective and comprehensive solution.

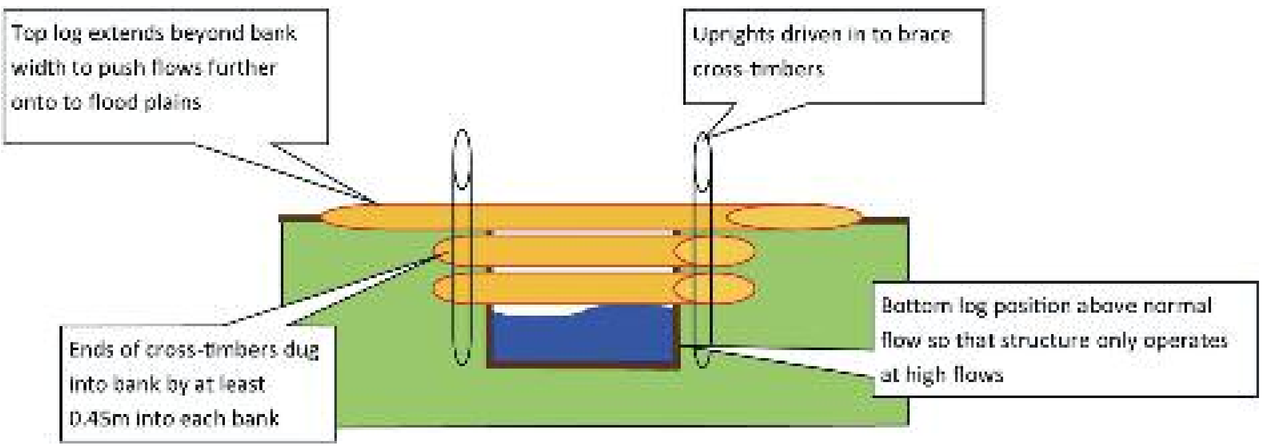


Fig 3.2.2 Schematic design for leaky dams

Tree planting has been carried out along the Haughtongreen burn (covering an area of 2.8ha) in order to create dappled shade, increased invertebrate life and a supply of woody debris in the future. The selection of trees used were approved by the Northumberland National Park Authority, NNPA and consisted of 500 willow, 500 alder, 200 rowan and 200 hawthorn.

The Forestry Commision Design Plan includes planting of broadleaf scheduled for 50 years time. The CRF project has brought this forward by supplying the trees in partnership with the Woodland Trust and providing a workforce of TRT contractors and volunteers. This planting will take place along the Greenlee and Haughtongreen burns within the Forestry Comission boundary and as with that agreed with the NNPA includes a good mix of alder, rowan, willow and hawthorn. It is intended that planting on this scale will help regulate the temperature of the streams as well as binding the banks, whislt providing further habitat for terrestrial invertebrates and shelter for fish.

3.3 Wider catchment land-use and land management approaches

There is no tradition of joint management/regulation of land and water together in the UK. The Common Law enshrines ‘riparian rights’ making landowners with river frontage mutually responsible for avoiding ‘nuisance’, but in the wider landscape only the regulations controlling pollution apply and these are difficult to police in terms of runoff, sediments and diffuse chemical pollutants. River managers have made sporadic attempts to influence land use and management via the planning system: the EU Water Framework Directive’s River Basin Management Plans take this a (small) stage further through the identification of problem hot-spots.

Realistically, land use and management remain bound by free market forces and so ‘carrot’, not ‘stick’ appears to work best in the catchment-based approach. This assumes a joined-up application of fiscal incentives to best practice (be it agriculture, forestry or development control) in spatial patterns following runoff routes. The incentives will never be massive and so the simple techniques followed in the Haltwhistle Burn project look ideal to be disseminated much more widely via the locally grounded finances available to agencies such as National Parks and Natural England. At present the whole EU system of agri-environment measures is under review and renewal; the CSF reporting phase is thus, coincidentally, highly relevant to the new Countryside Stewardship measures. Whilst third sector organisations such as TRT will remain capable of delivering measures, we admit that it is at a higher, official, level that the big moves will occur.

Box 3.3 Catchment-sensitive land issues and actions: Haltwhistle Burn

The Haltwhistle Burn CRF Project has benefitted enormously from its location being partly within Northumberland National Park and from national interest in the protected sites in the upstream part of the catchment. We therefore had 'ready-made' influential partners who were already engaging with land users/managers and supporting 'stewardship' in relation to multiple objectives, including habitats, species, resource protection, historic environment and access.

The Roman Wall Loughs (Greenlee, Broomlee, Crag) are designated for their open water component as a Special Area of Conservation (SAC) under the Habitats Directive. Along with the surrounding land, including Caw Lough, a peat-filled basin now covered by fen vegetation, they are also designated as a Site of Special Scientific Interest (SSSI) with Greenlee Lough also having National Nature Reserve status. In addition the area is designated as a geological SSSI for its exposures of the whin sill and classic cuesta landscape. The open water bodies are currently in unfavourable recovering condition under UK conservation regulations, and one of the attributes failing to meet the targets is water quality. Strategies are therefore being developed to boost and protect the water bodies from any impacts from the surrounding catchments from diffuse pollution. Remedial actions have already been proposed by Northumberland National Park Authority, supported by Natural England's agri-environment financial incentives to farmers. The CRF project has successfully added commercial forest managers to the list of active agencies, and has been able to 'fill the gap' with those farmers who have not previously been interested in environmental stewardship. Where these agreements already exist, this has made collaborative and augmenting actions 'on the ground' much easier for the CRF project.

Greenlee Lough, wholly within the CRF catchment, has recently been the subject of Environment Agency monitoring and the Agency also commissioned Stirling University to develop a restoration strategy. This lists 28 activities likely to damage the Lough and 15 action points of which at least six are prime objectives of the CRF project.

The presence of Hadrian's Wall in the catchment and the catchment being a partly with Northumberland National Park is of growing environmental influence given the proposal by Northumberland National Park and the YHA to develop the 'Sill' National Landscape Discovery Centre, focused on nearby Once Brewed. It is hoped that the Sill will transform how people engage with landscape acting as a hub to greater exploration, access, research and understanding of the unique and diverse cultural and environmental landscape of Northumberland National Park and the wider landscape of Northumberland. Diverse learning opportunities for wider-ranging audiences is at the heart of the proposal. (www.thesill.org.uk).

3.4 Designing in resilience and sustainability

It is occasionally alleged that river and catchment restoration is a high-cost fashion item, a child of its time, representing the mixture of guilt for past 'land drainage', excessive stocking and chemical abuse, operated with cynical opportunism by 'greens', guided by 'turning back the clock'. This has occasionally been dangerously close to being a valid critique for totally opportunistic schemes, yet even those have been acclaimed by most stakeholders.

The allegation is much less appropriate where careful, long-term monitoring identifies systematic problems in the quantity or quality of runoff from a catchment or in the quantity and quality of its freshwater habitats and biodiversity scores. It has been a notable feature of the UK's implementation of the EU Habitats and Water Framework Directive that we have become increasingly able to confidently state 'Reasons for Failure', many of which can be uncertain in the scientific sense but invite works to repair and 'heal' in a precautionary way. There are many who doubt the analogy implied by the term 'river health' but, retaining it for a moment, the sorts of actions turned on by the whole catchment approach at Haltwhistle, whilst precautionary, are designed with change in mind. This future change can either be towards a more hazardous environment for the 'remedial' action (as with climate change) or a more conducive one because of improvement in levels of 'best practice' upstream. The approach is, therefore similar to that of the general practitioner in medicine, rather than the surgeon.

Figure 3.4 Run-off Processes System Diagram

Atmosphere: not part of our project but changing! Project increases resilience.

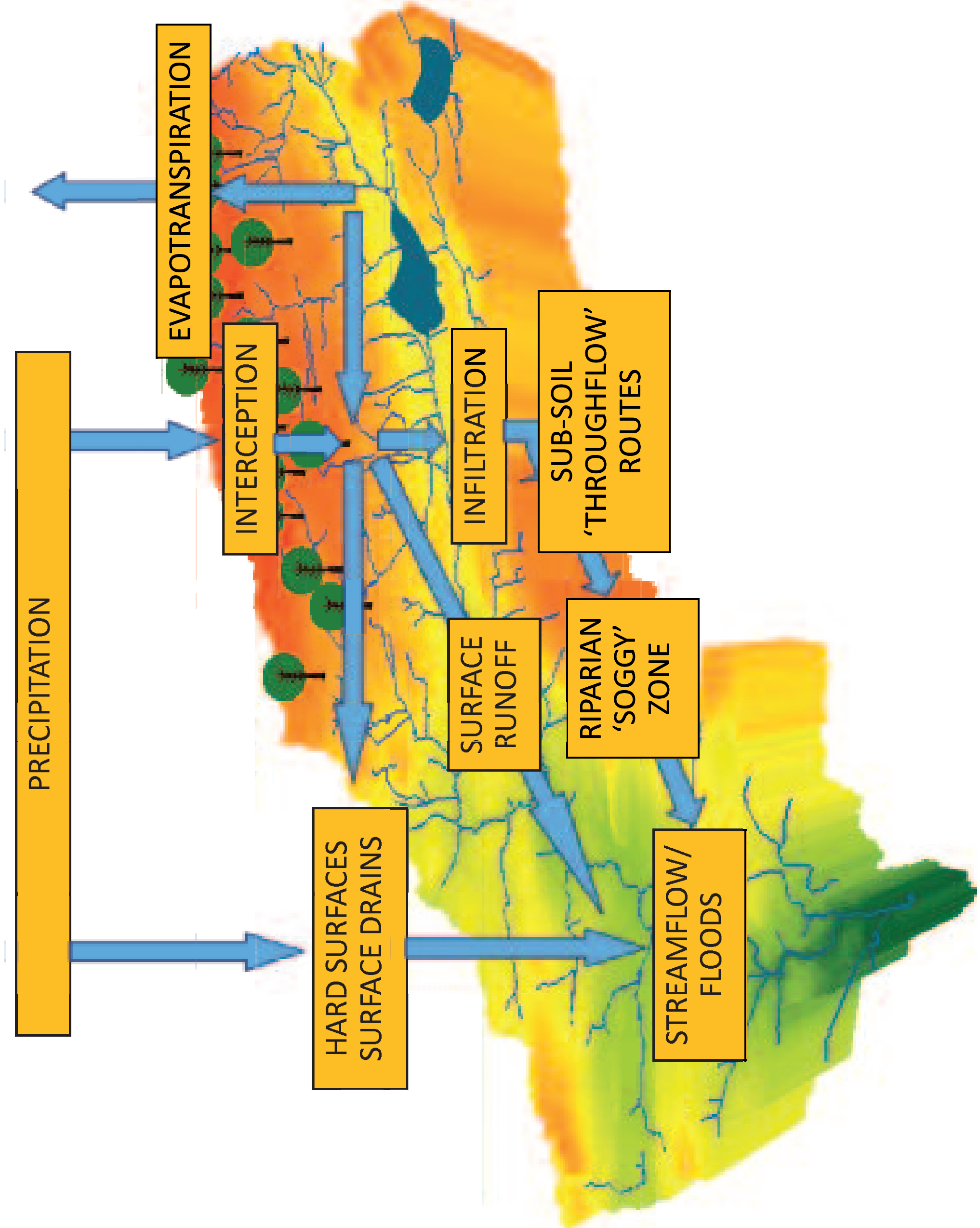
Project has limited impact on plant canopy cover but improved forest/moorland management relevant going forward.

Urban runoff and forest/farm drainage management to 'slow the flow'. Silt source management by the Project. Catchment surface awareness part of the educational and engagement agenda of the Project.

'SUDS' guaranteed for new housing development after Project pressure. Farm runoff management delivered.

Tree planting makes route zone more permeable: Project has achieved this.

Wetland conservation and restoration by the Project is adding storage.



4. The catchment map after the project: building in place values for the future

4.1 Monitoring the outcomes

One of the most persuasive ideas in environmental management of late is that stakeholders for improvement projects are likely to be 'keen as mustard' on both an engagement with the whole process – notably wet and whacky work – and as 'citizen scientists' (Newson, 2011). Thus, from the outset, the Haltwhistle Burn project has tried to ensure both an engagement 'up front' by appropriate communications (notably of our enthusiasm for the river) but also by training assessors to help assure a legacy beyond the end of the project by those keen to monitor outcomes, hydrological, chemical, geomorphological and biological.

We have been extremely fortunate to find that the catchment is home to a number of active freshwater experts who can provide enthusiasm and leadership as well as devoting considerable effort and skill towards education and training. The banner for these activities has been the longest-running TRT project of all (i.e. over a decade) recently extended to Haltwhistle, namely 'River Watch'.

We are also fortunate that our partner organisations are also driven by scientific evidence: principally Environment Agency and Newcastle University. However, other notable expertise, data sets and monitoring schemes exist in Northumberland Wildlife Trust, Northumberland National Park, Natural England and Northumberland County Council. All of these have stumped up at one stage or other and, with the 'oxygen of publicity' we have good reason to believe that the Burn (also thanks to the access routes) now has a core fixation for all generations of 'Halty' residents.

Box 4.1 Current and proposed long-term monitoring of project outcomes

Much of the practical restoration carried out at a catchment scale is directed at physical habitat: hydromorphology dominates but also runoff management to influence diffuse pollution. The causal linkages between physical habitat and ecological response are largely based on a mantra of 'geodiversity=biodiversity' – the interdisciplinary research base is weak, making post-project appraisal of restoration effort vital.

TRT's CRF bid was asked to include 'Arrangements for monitoring and evaluation' and we referred to three key elements: the experience of Trust staff in Project Performance monitoring (we have a specific assessment form), our rapidly accumulating Tyne-wide 'River Fly' and e-fishing databases (including Haltwhistle Burn) and the very crucial involvement of 'citizen scientists' (hence the early establishment of a River Watch group in the town).

Given the importance of ascertaining the long-term value of catchment-based approaches, monitoring outcomes (pre-project data are often scarce) has gained prominence in the evaluation of CRF. The River Restoration Centre (RRC) has made significant attempts to set norms, if not standards, for restoration projects: RRC's 'PRAGMO' (Practical River Appraisal Guidance for Monitoring Options – published in 2010). Many practitioners come to realise a need for a 'nested' set of monitoring tools and protocols at various levels of sophistication and demands on time; RRC base the options for choice within this set on the size, complexity and risk of the restoration. PRAGMO helpfully uses 'size v risk' as a graphical guide to options available for monitoring ecology, fisheries, macrophytes, geomorphology and hydrology. Later it also addresses monitoring options by project focus under the headings: 'specific' (to project objectives), measurable, achievable, realistic and 'time-bound' (how long it takes). PRAGMO was not used formally during the Haltwhistle CRF project, mainly because of our in-house experience of monitoring a variety of TRT projects. TRT has long had its own published Monitoring Policy which overlays the key advice of PRAGMO almost exactly.

Table 4.1 Monitoring of Project Outcomes

Project outcome element	Detail; location / frequency	What / When / Who	
		During CRF	Beyond CRF
Stabilised banks in gorge section	Above top bridge, above footpath repair, seasonal	FPP by TRT & RW	FPP by RW / public
Reduced land slippage	Below quarry, seasonal	FPP by TRT & RW	FPP by RW / public
Habitat improvement	River Fly invertebrate sampling, monthly	RF by RW	RF by RW
Increase in fish numbers upstream of obstructions	Electro-fishing, once per year Redd counting	e-fish by TRT & volunteers TRT	? requires funds or training RW (following training)
Resilience to high flows	Broomshaw Hill Farm footbridge, Townfoot road bridge Rainfall monitoring? Slaty Sike Run-off Attenuation Features Hemmel Burn inlet & grill	Gauge board readings by RW RW TRT / NU HFAG / HTC	Gauge board readings by RW RW / Gibbs Hill Education Centre RW / Riparian owners HFAG / HTC
Reduced Diffuse Pollution from Agriculture	Effectiveness of wetland and guttering at West Hotbank Farm and Lees Hall Farm Effectiveness of leaky dams at Lees Hall Farm, High Edges Green and Haughton Green Burn	Photography by TRT Photography by TRT	Assessments by NE Photography by RW
Engagement events	Guided walks, Try It Days, Public events, River Watch workshops, INNS control and WCC protection, Further demonstration events at farms.	TRT staff	RW & partners
New events relating to the burn restoration	Ugly Bug Ball float at Haltwhistle Carnival		July 2015 WAS
Continued protection of burn	Observation of reduced 'poaching', maintained river banks, less littering, continued water quality monitoring	RW and staff RW, CS, EA	RW Public, RW
South Tyne sedimentation and channel changes	South Tyne & Haltwhistle Burn confluence	TRT Riparian Owner	Riparian Owner
Continued protection of SSSI sites – SAC condition is derived from the underlying SSSI monitoring	Frequency is variable depending on site features and risk. On average every 7 years	NE	NE
Roman Wall Loughs improved condition	Inlets and outlets on a 3 yearly cycle within Water Framework Directive requirements	EA	EA

Welcome the public and their participation into the catchment management process	Include the public as a key stakeholder, encourage sharing of local knowledge, training and uptake of citizen science activities – all on a regular basis to support empowerment	NU PhD, TRT and RW	NU PhD until 2016, RW and wider public
Develop, use and maintain citizen science monitoring techniques, data submission and visualisation tools	Developed by Newcastle University, co-produced and tested with the community. Can also be applied across the Tyne catchment.	NU (PhD)	TRT and RW to own, use and evolve CS
Understand the Haltwhistle Burn's hydrological regime and response during/after flood events – current and future	(A) Automatic monitoring equipment logging data at a 2 or 5 minute interval. Maintain equipment, download data and process once every 2-3 months. See Map on page 20 for locations (B) Citizen science monitoring techniques which vary depending on the parameter. See http://bit.do/mytraining (examples shown in Appendix 9.3) for locations, frequency and techniques (mostly daily/weekly and within the Broomshaw and Town foot areas of Haltwhistle)	(A) NU PhD and SINATRA (B) RW	(A) NU PhD then RW post 2016 (B) RW / public CS
Plan for, visualise and evaluate the impacts associated with natural flood management techniques in the Slaty Sike sub-catchment	Monitoring will be required upstream and downstream of each feature once they are installed in early 2015.	NU PhD and RW FFP	NU PhD then RW FFP and CS post 2016
Haltwhistle Burn website, email account and social media sites	Initially set up by Newcastle University as tools for raising awareness, understanding, submitting observations and sharing information.	NU PhD	NU PhD then RW post 2016.
FPP = Fixed Point Photography RF = River Fly invertebrate sampling as per River Fly Partnership methodology RW = River Watch volunteers CS – Simple Citizen Science monitoring techniques NU – Newcastle University HTC – Haltwhistle Town Council HFAG – Haltwhistle Flood Action Group WAS – Whistle Art Stop			

4.2 Assuring a legacy

We describe, above, the way in which a commitment to understanding the local environment is easy to encourage and maintain in a community so focused on one river, especially now that the project has 'wired it up' as an entity in local people's minds.

However, memories in official agencies, even local democratic bodies, tend to be shorter as personnel change and we are uncertain as to how to retain a governance system in place, such as a 'standing committee' or some such. Given the continuing role for the Rivers Trusts this is clearly one to consider by TRT at the close of this funding. Plans are already afoot for fundable extensions to the project which might retain the possibility of both prolonging governance and monitoring.

Box 4.2 develops a 'wish list' of areas of the catchment needing further attention, some of which have been assessed to the point where design and delivery could be rapid, others requiring long 'slog' to get interested parties and funders together.

Box 4.2 Plans for the future: a 'wish list' of deliverables for Haltwhistle Burn and its catchment

Deliverable	Opportunity	Detail
Secure Funds	Apply to Community Foundation LEAF – request has been made by LEAF for more science proposals	Via fully constituted River Watch Group &/or Flood Action Group
Secure Funds	Northumberland County Council	NCC commissioned a Flood Report from Royal Haskoning. Use the findings of this to request funds. Continue to demonstrate the link between flood events and erosive force.
Secure Funds	Encourage further community fund raising	The River Watch group ran a successful coffee morning to raise awareness as well as funds. Build on this format.
Secure Funds	Continue to work with project partners in the area	Seize opportunities as partner organisations identify other projects in the catchment
Secure Funds	Possible potential through Countryside Stewardship Scheme	Consider 'group' applications on a landscape scale to address objectives such as water quality, &/or specific capital works
Monitoring	Continue existing sites	Support River Watch volunteers and potential BSc of MSc project students
Monitoring	Further develop Citizen Science approach	Encourage the wider community to contribute to monitoring data
Monitoring	Use Haltwhistle Catchment as a site to test new methodologies	Can compare results to growing data set. Develop opportunities as volunteers and university links allow.
Monitoring	Continue fishery surveys	Use observational count system developed by TRT for Hexham. Request data from EA regular monitoring.
Monitoring	Development of telemetry system	Through a Knowledge Transfer Partnership (KTP)
Engagement	River Watch	Continue monitoring programme and maintenance of green-engineering intervention structures.
Engagement	Flood Action Group	Lots of overlap with RW in people and objectives. FAG now concentrating on realising improvements from Royal Haskoning report and community resilience.
Engagement	Whistle Art Stop – co-host for schools activities during the project	CRF activities have spun off into art groups, eg Ugly Bug Ball Big Draw event – appreciating the invertebrates that dwell in the burn. Art projects will continue to take inspiration from the burn and the changes the project has made. This will maintain the link with the school and community. A Community Garden at Whistle Art Stop will include features exploring water and wildlife.

Engagement	Continue to work with existing Partners	Where new themes and funding allows maintain a presence in the catchment. Guided walks of project works through the seasons and work parties to maintain interventions are easy tasks to fit into National Trust and Northumberland National Park programmes.
Engagement	Project legacy and community resource	The PhD has generated a detailed and comprehensive website as part of the project and community engagement. This will be handed to TRT / Halty RW at the end of the project to be maintained. http://research.ncl.ac.uk/haltwhistleburn/projectbackground/ https://twitter.com/Haltwhistle Burn It will be important to identify capability levels associated with managing the website, tools and social media accounts in the future.
Demonstration Site	West Hotbank Farm	Farmer very much in support of showcasing his guttering and wetland creation solutions. The farm has already featured in a Haltwhistle Walking Festival guided walk and PinPoint workshop (DWPA). Continued opportunities here as the site matures
Demonstration Site	Lees Hall Farm	The farm hosted a hurdle creation workshop for local Agricultural Colleges and one college has returned for a second session. There is plenty more similar work that can be achieved by college students at this site; the young farmer who has just graduated from the college himself is keen to support.
Demonstration Site	Slaty Sike	This tributary – a mini Haltwhistle catchment in itself has won CRF Enhancement funds (£10k) to deliver further improvements and interpretation.
Continued Partnership working	PhD student continues her studies until Sept 2016	Continued monitoring and modelling including ongoing community engagement and development of visualisation tools. Sharing experiences and best practice with other catchments: publications and conference material using the Haltwhistle Burn as a key case study site.
Continued Partnership working	'Just an Hour' employee volunteering programme at NWL	Northumbria Water has expressed a keen interest in adopting the maintenance of the improvement work at Seldom Seen Caravan site near their Sewage Treatment Works as a regular 'Just an Hour' task.
Continued Partnership working	SINATRA (Susceptibility of catchments to INTense RAinfall and flooding) A multidisciplinary team of world-leading experts to advance scientific understanding of the drivers, thresholds, and impacts of flooding from intense rainfall.	Project started in 2013 and will use Hatwhistle catchment as one of the projects target catchments. Visits have already been made to collect data for cloud burst flood events
Continued Partnership working	Continue working on links and opportunities with Newcastle University	Presentations about the work produced for this CRF project has generated interest from other departments – Environmental Law, Geography. Regular communication will ensure opportunities in new and related projects towards building a long-term working relationship with departments.

5. CONCLUSIONS

Smith et al., (2014) have analysed the changing aims, methods and modes of delivery for river restoration across the world and a similar review exercise is in process for the British Isles as part of a new IUCN Commission of Inquiry. Clearly, the agenda constantly moves forwards (and backwards), not the least because of the vagaries of public finance and the slightly different policy drivers from e.g. the Habitats Directive for SAC rivers and the WFD for ‘the rest’. We also need to factor in purely opportunist projects and those occurring as mitigation for development, including some associated with flood risk management and fisheries management.

In the Preface we suggested that the only consistent answer to the question ‘What will success look like?’ is ‘sufficient engagement’. This is not a trite answer but needs substantiation; it is, however, consistent across CRF projects whose details of restored river features, biodiversity improvements and catchment management changes will differ profoundly: one size does NOT fit all! The ‘sufficient engagement’ criterion is not achieved without time, effort, communication and not small amounts of pain: it follows a political agenda because of the diversity of stakeholder interests.

We feel that the Haltwhistle Burn project has achieved ‘sufficient engagement’ and put this to the Project Board at a recent meeting. Amongst the spontaneous outcomes were quite a few unintended benefits of the project ‘because it was there’. Examples include:

- Interesting the local angling fraternity, previously considered as marginal (also mentioned: electrofishing, ‘try-it days’ and simple fish passage easements);
- River Watch training events and (much more fun) doing the monitoring and tree planting;
- Helping set up a communications network within the town and between the town and its hinterland;
- Workshops for key current and future stakeholders, such as school classes and young farmers;
- Empowerment of the community to understand and respond to flooding;
- Recognition of Haltwhistle’s unique situation (especially in regard to flooding) by public agencies;
- ‘Sorting out’ the Hemmel Burn;
- Getting the planners to insist on ‘SUDS’ for a proposed new housing development;
- Demonstration sites to ‘spread the word’;
- ‘Friendly, purposeful’ Project Board, allowing direct conversations between disparate agencies;
- ‘Helping us see river issues through new eyes’;
- Good ‘legacy’ plans, enthusiasm to continue (River Watch mentioned) and case study information sheets;
- Raising awareness of invasive non-native species, precautions and direct actions;
- Changes being made to the way Fire and Rescue will respond to future floods
- Flood Action Group and plan for the town of Haltwhistle.

The list could go on! We are keen that this list is given more prominence than the simple auditing approach which lists ‘length of riparian fencing’, ‘number of trees planted’, or lists of monitored outcomes (which, as discussed above, will only accrue if the project has a significant engagement legacy).
To return to an earlier message in this report; ‘Science linked to human purpose is a compass: a way to gauge directions when sailing beyond the maps. Democracy…is a gyroscope: our way to maintain our bearing through turbulent seas. Compass and gyroscope do not assure safe passage through rough, uncharted waters, but the prudent voyager uses all instruments available, profiting from their individual virtues’. (Lee, 1993)

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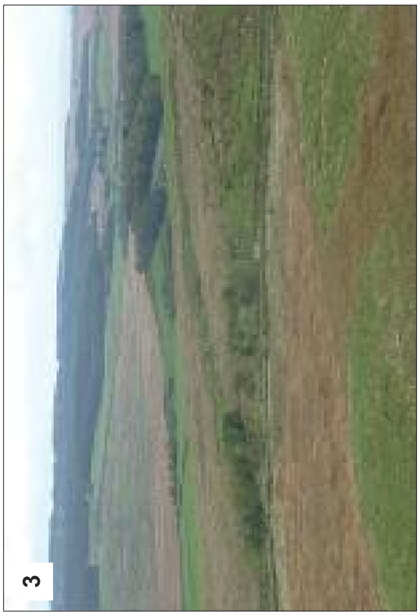
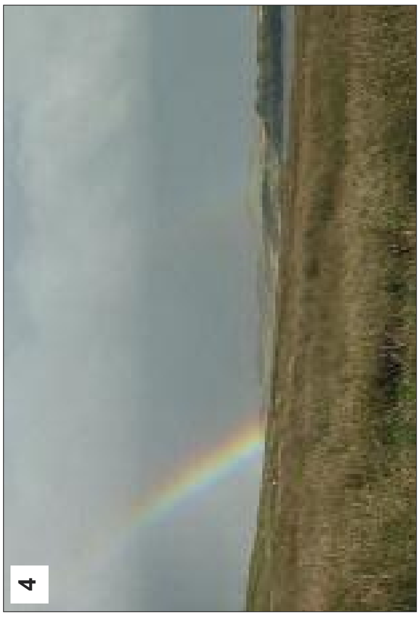
7. GLOSSARY

This is a technical report but we hope it has a wide readership, in keeping with the engagement themes we have described. We offer below a purpose-made original glossary of some of the terms we have used.
Anthropogenic: changes caused to ecosystem functions and features by human activities.
Catchment: The gathering ground of land which feeds rainfall (runoff – see below) to the river at a given point.
Catchment-based Approach: a Defra policy framework for all relevant agencies to follow, making water issues a prime consideration in land use and management.
Catchment Restoration Fund: Part of the government (England and Wales) response to complying with the EU Water Framework Directive (WFD), encouraging a geographical approach to 'reasons for failure' against the standards of the WFD
Citizen science: the data and knowledge created by 'ordinary' citizens becoming engaged in gathering measurements and making assessments of the chosen topic.
Connectivity: 'Routes for runoff' (see runoff below). By developing land surfaces we tend to channel surface water disposal downhill in focused routes like roads, tracks, agricultural/forestry drains. This network 'connects' rainfall to river flow via rapid flow routes and is often the cause of 'runoff' or 'pluvial' floods and produces rapid response in rivers.
Depositional zone: Large, upland rivers like the South Tyne occupy formerly-glaciated valleys which probably finished their glacial phase, 12,000 years ago, as a string of lakes and stagnant ice plugs. The result is often a 'string of beads' or wide and narrow valley floors with the former parts encouraging modern river deposition because of weaker sediments and reduced energy.There are at least five deposition zones on the South Tyne, one being at the confluence with Haltwhistle Burn.
Diffuse pollution: Pollution diffused across the landscape as is the case with agricultural waste, aggravated silt sources etc. The opposite case is 'point-source' pollution as in a pipe discharging sewage.
Discontinuity: As well as connectivity issues in developed catchments we have also created fragmented routes for rivers by building dams, weirs, log-jams etc. Particularly affected are fish which migrate both upstream and downstream as part of their life cycle. Remedies include 'fish passes' and 'easements' to make migration feasible during at least part of the river flow range.
Ecosystem: the sum total of the habitats and species within a particular landscape unit. Rivers are relatively simple to understand as ecosystems from source to mouth but also extending into riparian zones, either side of the channel, valley floors and floodplains and even to the furthest catchent divide or 'watershed'.
Ecosystem services: The, as yet, formally unrecognised financial contributions made by in-tact ecosystems to human welfare, both direct as in flood control and water purification, and indirect as in landscape aesthetic values and heritage.
Evapotranspiration: The nett loss of rainfall back up to the atmosphere, both through plant tissues (transpiration) and by direct evaporation of water 'intercepted' on the plant canopy of leaves and twigs.
Evidence: Data and knowledge amassed to support policy delivery.
Flood frequency: The statistical likelihood of a flood of a particular height/flow happening, often (misleadingly) quoted as the 'recurrence interval' such as 'once in a hundred years' (but we have experienced two of those in a week on occasion. This is a long-term average.
Flood risk management: A broad approach to loss and damage caused by river and coastal floods focusing on all the risks and all the costs of mitigation, also on non-site remedies like Natural Flood Management (see below).
Fluvial Audit: (see Box 2.2 for details and application) River sediments have sources, transfers and sinks, rather like a bank account. Walkover surveys of whole catchments establish where and how much sediments are 'income' and where 'expenditure'.
Geomorphology: The science of landscape development and process: there is a British Society of Geomorphology.
GIS: Geographical Information Systems – the computer basis of modern mapping allowing overlays of different features from different sources. A basic tool for catchment science.
Glacial veneer: The last glaciation of northern England ended 10-12,000 years ago and left a mantel of glacial sediments for the subsequent rivers to work on; glacial sediments have a big control on present-day river forms.
Gripping: Scandinavian term for digging drains across wide spaces such as peat bogs.
Headwaters: Source areas for rivers, in the uplands, heading up to a hill or mountain ridge. Vital ecosystem 'push' because impacts here travel downstream.
Hydrology: The science of rainfall and runoff. There is a British Hydrological Society.
Hydromorphology: A new term, coined for the EU Water Framework Directive. It brings together patterns of

the flow and channel sediments which we all observe from the bank and which, as we know, change with the flow level. A basic component of physical habitat and river 'health'.
Infiltration: The volume and rate at which rainfall enters the soil; soils differ in their ability to take in surface rainfall, a property known as 'infiltration capacity'.
Invasive non-native Species (INNS): Species arriving in our native ecosystems which have a negative impact on, e.g. by replacing, species which define our natural history.
Natural Flood Management (NFM): Using natural features which store water (wetlands, woody dams) or restoring them to 'cream off' the downstream flood wave – a headwater contribution to the rest of the catchment.
North Atlantic Oscillation: Driven by ocean current impacts on the temperature and moisture of the air above, this is the equivalent in our latitudes of 'El Nino' in the Pacific. Said to produce 'flood rich' and 'flood poor' periods in large northern rivers.
Pluvial flooding: Property and land flooding deriving directly from rainfall, not from a spilling river.
Poaching: Damage to surface soil structure and infiltration capacity (see above) caused by livestock loadings in wet areas, e.g. on river banks.
Reach: Length of river used for assessment, most often between significant tributaries but also lengths of river sharing the same geomorphological features.
Reasons for Failure (WFD): The WFD has a large number of ecological standards which are monitored by responsible authorities to assess compliance. If the unit of assessment ('water body') does not reach Good Ecological Quality it 'fails': the 'reason' is the failing variable.
Resilience: Allowing 'elastic' behaviour of natural processes and features, such as recovery from flood, rather than a 'threshold', perpetuated response which 'changes things for ever'.
Restoration/rehabilitation: Restoration takes the clock back to some previous condition, often called 'reference condition' (about which scientists differ); rehabilitation achieves the re-establishment of key features such as riffles and pools in the channel system.
Revetment: Mechanical or 'green' protection against erosion of river banks.
River Habitat Surveys (RHS): Initiated in the 1990s these detailed and standardised river channel/riparian surveys anticipated a need to assess habitat quality for river restoration and for compliance with WFD.
Riffle: Raised part of river bed, most frequently in gravel-bed rivers, showing turbulent flows and good habitat for salmonid spawning.
Sediment yields: The total volume or weight of sediments arriving at the mouth of a catchment in a year.
Siltation: Arrival and deposition of upstream fine sediments in a river reach with, often, damaging impacts on biodiversity.
Storm sewers: The sewer system is driven by water flows and surface flows from drains provide a vital transporting agent. During heavy rainfall 'storm sewer overflows' (SSOs) add un-processed sewage can reach river channels.
Stream power: The product of river depth and velocity, giving a power to transport bed sediments and used in formulae to predict sediment transport.
Sustainability: Long-lasting resilient (see above) behaviour of natural and human systems.
Uncertainty: Scientists can predict the future but only within wide bounds set by their ignorance of key variables and 'shocks' like climate change.
Vernacular science: The 'every day knowledge of ordinary people'.

8. Gallery



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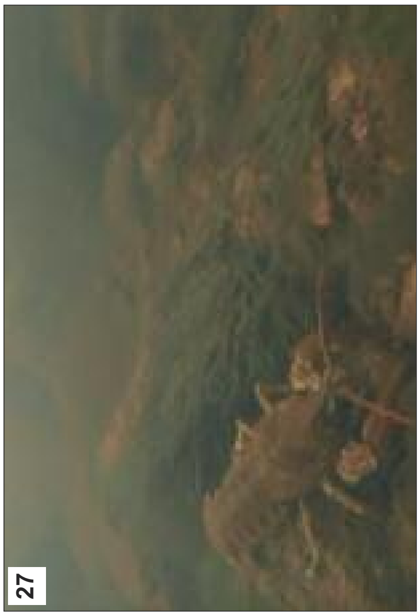
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8. Gallery captions

1	2	3
4	5	6
7	8	9

	Photo caption
1	Interest for this project was wide ranging long before the project was funded. The project board remained diverse and energetic throughout.
2	Farming amongst the wild moor land in the middle reaches of the catchment
3	The upper reaches flow through forestry into Greenlee Lough
4	Pot of Gold? Hope for a long running project?
5	A typical example of cattle poaching and collapsing banks which are prevalent along the burn and tributaries
6	An example of a forest track drain connecting with a natural water course
7	Assessing tree management in the Gorge section with land manager and contractor
8	The mound in the background is a mile castle on Hadrian's Wall. The project had to consider any impact on this protected artefact whilst planning how to manage trees and erosion along the burn
9	Aerial photograph from 1999 showing the gravels at the confluence with the South Tyne. This and much more data has been supplied by a local geomorphologist and active board member
10	The mouth of the Haltwhistle burn has been displaced downstream causing issues of access for fish. TRT consult with local angling knowledge
11	Automated sensors pick up river levels constantly
12	Fixed point photography gauging site for river levels. At one site of the burn we have both automated level measurement and citizen science photo recording for comparison. At this site the EA cleared one road arch but this was filled in again by the high flow on 23rd Dec 2014.
13	Electro-fishing surveys have been conducted with trained volunteers before and throughout the project
14	Sampling invertebrate populations following the River Fly Partnership methodology is an important element to measuring water quality changes throughout the project and as a result of our interventions
15	Local contractors repair the bank wall being sympathetic to the heritage of the burn
16	Contractors work with TRT experts to find the best position for baulk deflectors to improve attraction flows for fish
17	Utilising all available resource to model flow!
18	A local farmer is waiting for -10oC to be able to spread FYM over his fields. In the meantime project interventions prevent any nutrients reaching the burn.
19	Timber supplied by Forestry Commission have been secured as leaky dams by volunteers
20	Brash bundles constructed from overhanging branches protect an area of eroding bank
21	Remains of mining industry (ferric oxide deposits) in the upper catchment

22	Tree branches and brash not deployed for bank stabilisation provide useful habitat piles in the burn side local nature site
23	Carefully sited and anchored large woody debris helps encourage attraction flow into the main burn channel
24	Mini-diggers excavate a road bridge arch blocked with river cobbles and material
25	Haltwhistle Town Council oversaw the repair of the local amenity footpath in the gorge. Not scoped within the CRF project but supported by advice and some funds once it had happened
26	NE commission fencing to protect the burn from cattle poaching at site of WCC population
27	NWT ran a WCC workshop in the Haltwhistle burn
28	Sharing local knowledge at one of the Citizen Science sessions ran by Newcastle University
29	Reaching a wider audience via a local coffee morning and 'Why Catchments?' session
30	University researchers from a national project ' The Power and the Water ' join a local nature group on a guided walk of the project.
31	Cross generation participants explored water quality on our guided walk as part of the Haltwhistle Walking Festival
32	Farmer supervises the placement of a willow hurdle at a Diffuse Water Pollution from Agriculture workshop
33	Children from Haltwhistle Community Campus create their own Haltwhistle catchment and water cycle using plastic containers. A difficult abstract concept which made visiting the burn so much more fun!
34	Children from Haltwhistle Community Campus record what they find in the burn
35	Children from Haltwhistle Community Campus conduct a river transect
36	Using clay modelling to help children explore the nature and design of invertebrates living in the burn

9. Appendices

Appendix 9.1

Haltwhistle fish pass interpretation

History of TRT fish easements
Tyne Rivers Trust has been designing and building low cost fish passage easements since 2009. To date we have mapped dozens of obstructions and engineered better fish passage at 9 Sites. We have developed techniques to suit a range of river obstructions and these active experiments have informed the most recent works at Haltwhistle.



Stocksfield Ford and Juniper Bridge

Barriers to fish in Haltwhistle Burn
There are two major in river obstructions on the Halty Burn, Mossy Banks and Military Road Bridge Footings. These two obstructions are very different and had a combined negative effect on fish migration in this upland catchment. Environment Agency monitoring of fish stocks had discovered lower than expected fish abundances in the Halty Burn. TRT’s own electrofishing surveys confirmed this situation, but only in the upper reaches of the river. It appears that the fish populations are very sparse above, but abundant below these obstructions. This situation is likely to be due in part to the effect of these obstructions. The Mossy Banks obstruction is a former industrial mill site. The channel has been constrained with embankments on both sides of the river and a stone weir remains across the burn. Now that the mill is gone, the river bed is a wide, long and steep bedrock plain. The flow is often shallow, giving all fish species a major challenge and often leading to an aggregation of waiting fish which are susceptible to disease and poaching. The Military Road Bridge Footings are the next major and most upstream Halty impasse. A concrete stepped culvert at almost 50m long with shallow Summer and raging Winter flows, presenting difficulties for resident and migratory fish alike.


What we planned on Haltwhistle Burn
To tackle these very different problems, detailed assessment, knowledge of viable solutions and in depth understanding of local issues were key to achieving the best outcomes. At both sites we have settled on wooden baulks as the method of modifying flows to increase the window of opportunity that fish may utilise for migration. The river bed nearby gives us a lesson in how to create natural flows. This boulder strewn reach creates cascades and pools, glides and backwaters which constantly change in tandem with rain on

the fells. A fish using our easements will have negotiated this aquatic obstacle course beforehand and will hopefully find no difference between wooden or stone surroundings, so long as the flows are suitable. Our wooden baulks are merely more boulders to the fish, our careful placement mimics natures effortless design; collecting, speeding, pooling, guiding and slowing water depending upon the rivers flow. Due to the complexity of the changes in flows we generate with baulks, TRT uses an iterative design process. Whereby an initial design is carefully produced, but more emphasis is placed upon observation of the effects than rigidly sticking to the original design.

What we did on Haltwhistle Burn

We worked in a downstream direction so that we were able to see the effect we were having of river flow as we fixed our wooden baulks. This adaptive design and management is a very good way of avoiding unforeseen outcomes as it is difficult to model the effect of water with so many variables in play. TRT are very fortunate to be advised by our experienced fisheries consultant Aidan Pollard. Aidan has a unique skill set which has provided insight into fish behaviour. This experience has led us to designs with multiple access points and resting places so that all fish can vary their attempts according to river flows.

We are careful to consider the wider implications of our simple fish easements in relation to flood risk, damage to infrastructure, maintenance and effects upon ecology. We also design our baulk fixings so that these individual blocks can be modified or removed simply should it be required.

Appendix 9.2

Forest Road Drains

As part of the Haltwhistle Burn CRF project and Forest Streams project problems of connectivity forest road drains to water courses were identified.
The problems can be divided into three categories:
Road drains directly entering watercourses
Road drains culverted under a road with the drain below the road entering into a watercourse
Road drains entering scoured forest drains (which should be treated as watercourses if they have connectivity to a watercourse) which then enter a watercourse.
Connectivity of road drains to watercourses causes issues by decreasing the time from rainfall hitting the ground to getting into watercourses, increasing peak flows and related erosion events and low pH spikes. It also allows direct roots for sediment to enter watercourses especially from road surfaces and active harvesting and restocking sites. The process of re-cutting road drains also releases a lot of sediment into the draining network and, if connected, into the water course.

Guidance

From UKFS Forest and Water Guidelines

32 Avoid road drains discharging directly into watercourses.

The Forestry Commissions specification for forest road gives more detail.
From: Specification for forest roads build by outside parties.
Roadside drains & ditches
A roadside ditch shall be provided on the uphill side of a road and on both sides where the road formation is at or below the adjacent ground. Drains shall have a depth of not less than 150 mm below the formation edge and a longitudinal gradient of not less than 2%. Ditches and drains shall not lead directly into watercourses. Catchpits, settlement ponds and filters will be provided in and adjacent to the drains and culverts to avoid pollution and sedimentation of watercourses

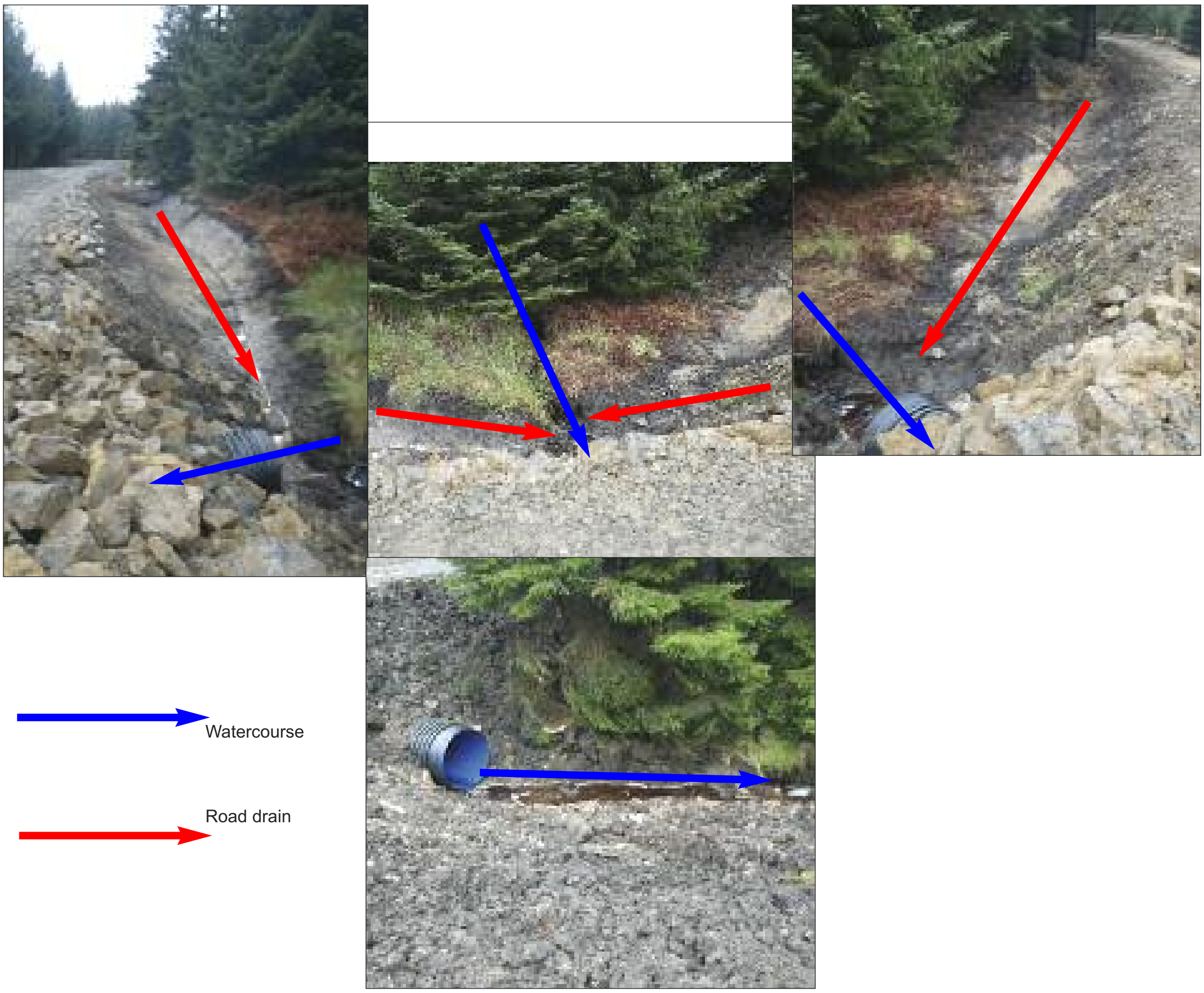
Recommendations

When creating new roads and drains; follow the specification remembering that if connected to a watercourse any existing drains (whether it be a road or forest drain) should be considered as a watercourse.

When re-cutting drains –

- Check that current roadside drains do not directly enter watercourses.
- Check that drains that take water from roadside drains do not enter watercourses.
- If drains do have connectivity then the roadside drain should not be recut until remedial work has taken place.
- Remedial work could include cut off culverts prior to the current culvert and draining the discharge into a buffer area or open land if present. If no buffer area is present then the drain may have to be discharged into a crop. The use of ponds
- Silt traps could be used as a last alternative as they may reduce the sediment but will have little effect on connectivity and there is a maintenance issue.

Example of road drains connected to watercourses in the Haltwhistle Burn catchment



New road drains, draining directly into a minor water course in Haltwhistle Burn catchment

Sediment load in Haughtongreen Burn in Haltwhistle Burn catchment below the connected drains

Appendix 9.3

Examples of Citizen Science Monitoring Techniques

TRAINING CARD: WATER QUALITY

Haltwhistle Burn river watch

Nitrates & Nitrites

Nitrates (NO_3-N) & Nitrites (NO_2-N)

What & why

Nitrates (NO_3) and nitrites (NO_2) are a form of nitrogen - a nutrient which acts as a fertiliser for aquatic plants. Excessive plant and algae growth occurs at high levels (see algae sheet for water quality impacts). Sources include agricultural fertilisers and animal manure which can easily make their way into waterbodies, e.g. when surface water flooding occurs.

Category

Chemical observation

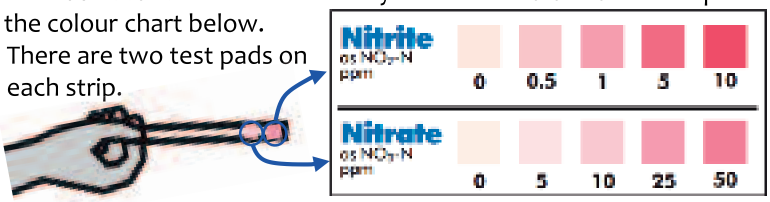
Equipment

Small plastic sample bottle • x1 LaMotte Nitrate & Nitrite Insta-test strip (2996) • Pen • Paper • Watch • Camera (optional)

Method

1. Find a safe place on the river bank where you can reach the water easily at arms length.
2. Kneel down and fill up the sample bottle – rinse it out a few times.
3. Point the top of the bottle upstream at (if possible) 0.6 of the depth (i.e. just a bit more than half way down) and fill it to the top.
4. Take one nitrate/nitrite test strip out of the packet, hold it at one end and **dip it in the water sample for 2 seconds**, then pull it out.
5. **Wait 60 seconds** then immediately match the colour of the strip with the colour chart below.
   There are two test pads on each strip.

(click on colour chart for larger copy)



6. Record your nitrate (0-50ppm) nitrite (0-10ppm) observations and note the date / time.
7. Put your water sample back in the stream and bin your test strip.

Other info

Wash your hands as soon as you return home / before eating. Be consistent with your monitoring approach and use the same location. Keep wet fingers out of the test strip bottle & store in a cool / dry place.

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Training Card: Water Quality

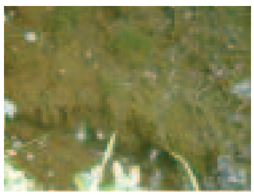
Haltwhistle Burn river watch

Algae

Algal cover

What & why	Algae represents photosynthetic plants which live suspended in the water column. Most cause odour and taste problems and because they contain **chlorophyll**, they are **green** (therefore it is easy to spot them visually). If widespread, algal blooms can cause waterbodies to clog up, reduce light penetration, lower dissolved oxygen levels and consequently affect aquatic life, especially fish. This problem is often known as eutrophication. In rural environments, eutrophication is often associated with **intensive farming** and nutrient enrichment (high levels of fertiliser).
Category	Biological observation
Equipment	Visual assessment: • Pen • Paper • Watch • Camera (optional)
Method	1. Stand at the side of the river at your monitoring location in a safe place on the bank or footpath (you don't need to enter the water) 2. Visually look for any algae within the waterbody – can you see any green clusters? 3. Choose your answer out of the 3 categories:

(click on images for larger copy)

1) None	2) Some	3) Abundant
		

4. Record your algae observation number (1, 2, or 3), date and time.

Other info	Be consistent with your monitoring approach and use the same location.

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Appendix 9.4

Project Contributors

Organisation / Interested Stakeholder Group	Representatives
AMS Partnership	Martin Stark
Countryside Matters	Allen Telford, Jason Telford
Environment Agency	Eva Diran, Shona Holland, David Kirkland, Jerry Gallop
Forestry Commission	Graham Gill, Tom Dearnley
George Dodds and Co	George Dodds
Hadrian's Wall Heritage Limited	John Scott
Haltwhistle Anglers	David Stobart
Haltwhistle Flood Action Group	David Cadwgan, Vic Fleming
Haltwhistle Town Council	Alan Sharp
Independent Flood Resilience consultant	Lynne Dunleavy
National Trust	Andrew Poad, Eric Wilton
Natural England	Heather York
Newcastle University	Eleanor Starkey, Geoff Parkin, Paul Quinn, Andy Large
Northumberland County Council	Aaron McNeil
Northumberland National Park Authority	Derek Proudlock, Tim Bell, Jen Hewitson
Northumberland Wildlife Trust	Steve Lowe, Kevin O'Hara
Northumbrian Water	Brian Lillie, Hazel Leah
Reeltime Fishing Services	Aidan Pollard
Riparian land owners / occupiers	Colin Mills, Susan Craig, Tom Howard, Michael Jameson
River Watch Group - Haltwhistle	Martin Stark - Champion
Tyne Rivers Trust	Malcolm Newson, Susan Mackirdy, Ceri Gibson, Graham Holyoak, Paul Atkinson, Kim Storey, Mairi Hextall
Whistle Art Stop	Alison Raimes