Case study 9. Eddleston Water Project

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Main driver: Natural Flood Management

Project stage: Monitoring

Photo 1: Aerial photo of the Eddleston Water project (source: Tweed Forum)

Project summary:

The Eddleston Water project (Photo 1 and Map 1) in the Scottish Borders north of Peebles has been running for 7 years. Its aim is to test the effectiveness of various Natural Flood Management (NFM) measures in a heavily altered upland catchment of 70km^2. The project also examines how to improve river ecology, including the Water Framework Directive classification as the main river was extensively straightened in the late 1700s, alongside maintaining sustainable farming within the catchment. To date, 3 sections of river with a total length of 2,000m have been remeandered, with the latest completed in autumn 2016. A total of 80 flow restricting log jams have been installed in strategic locations in the upper catchment and 66ha of native riparian woodland has been planted, along with 20 stormwater ponds. Further planting, flow restrictors and ponds are under negotiation. The catchment is undergoing intense hydrological (including groundwater) and ecological monitoring to quantify the effects of these various measures. The project has recently been awarded funding through the European Union's Interreg North Sea Region international project, Building with Nature, which will enhance the monitoring effort considerably.

Key facts:

The essence of the project is gathering reliable and convincing data from a detailed monitoring network to provide evidence of the effectiveness of NFM and habitat restoration measures. Modelling supports this observational approach.

Since works began the watercourse has been upgraded from 'bad' status under the Water Framework Directive to 'moderate'. This has been achieved largely by targeting degraded reaches to improve their hydromorphology including remeandering, channel improvements, weir removal and bankside planting.

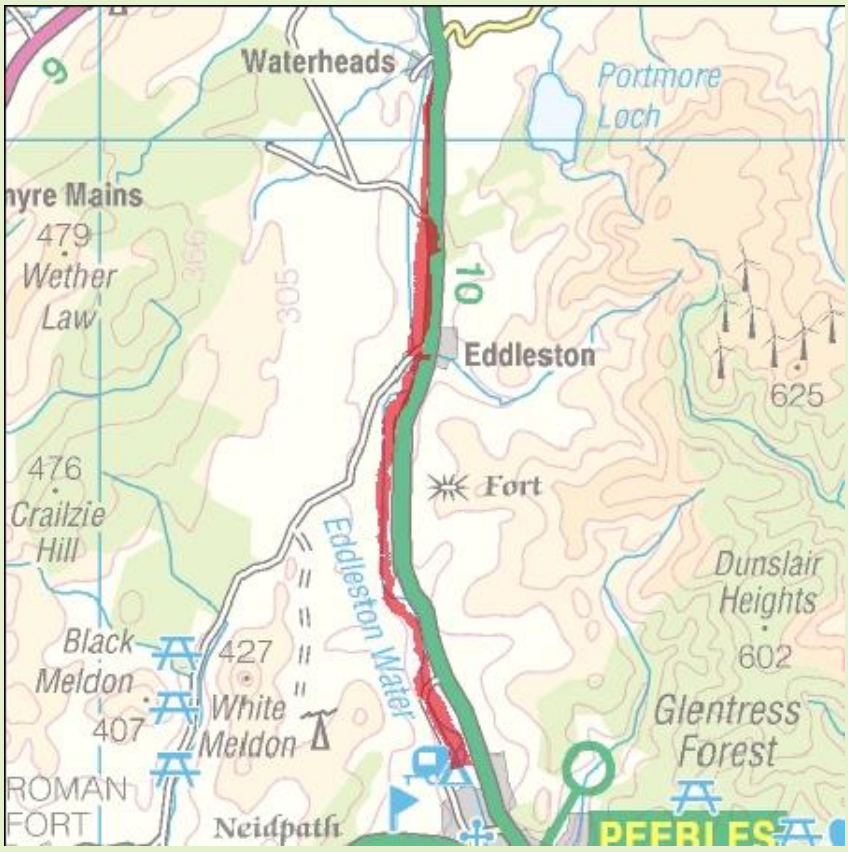
The measures have yet to be tested in a really significant flood event, but the following have been demonstrated.

- Established broadleaf woodlands on hillslopes provide areas of increased capacity for rainfall infiltration and arrest run-off generation during flood-producing storm events.
- There is no evidence from this study that coniferous plantations or new broadleaf plantations offer the same increase in soil permeability and therefore run-off attenuation.

Further targeted studies would be required to provide further evidence to back up these statements.

Cost–benefit analyses show positive ratios for NFM planting and improved ecosystem services.

The role of a trusted intermediary is essential in working with land managers and integrating NFM measures into a working landscape.



Map 1: Eddleston Water (source: SEPA)

1. Contact details

Contact details	
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2. Location and catchment description

Catchment summary	
National Grid Reference:	NT 23815 44761
Town, County, Country:	Eddleston, Scottish Borders, Scotland
Regional Flood and Coastal Committee (RFCC) region:	Scottish Borders
Catchment name(s) and size (km^2):	Eddleston, 70km^2
River name(s) and typology:	Eddleston Water, Shiplaw Burn, Fairydean Burn, Longcote Burn, Cowieslinn Burn – short reaches of mountain

	bedrock channels, extensive wandering gravel streams with artificially straightened reaches
Water Framework Directive water body reference:	Eddleston Water 5307 Cowieslinn Burn 5308
Land use, soil type, geology, mean annual rainfall:	Agricultural, brown forest earths and non-calcareous gleys Ordovician greywackes overlain by Quaternary gravel, silts and sands Average annual rainfall: up to 1,500mm

3. Background summary of the catchment

Socioeconomic/historic context

The Eddleston Water is a tributary of the River Tweed in the Scottish Borders and flows through the towns of Eddleston and then Peebles for around 20km, where it joins the main river. In Peebles, the river is known locally as 'The Cuddy' which is a Scot's word for 'horse'. This may reflect the fact that tanning of hides took place on the Cuddyside. Hides were cleaned and worked on over trestles, known as 'cuddies'. Skinworks and tanneries were common on the Tweed. During the latter part of the 18th century, the river was severely straightened (the majority of the main stem) to accommodate a new toll road, causing the overall length of the river to decrease by over 6km. This had the effect of providing more land for agriculture, which continues to be the catchment's main land use. Part of the Eddleston Water falls under the Tweed River Special Area of Conservation (SAC), making it imperative that any works are carried out in a sensitive manner in consultation with SEPA and Scottish Natural Heritage. Over the years habitat loss, drainage, agricultural intensification, rail and housing development, and forestry have modified the catchment to a high degree, with knock-on effects on its hydrology, morphology and ecology.

Flood risk problem(s)

Peebles lies at the confluence of the River Tweed and the Eddleston Water, and has a well-documented history of flooding. The last major event occurred during December 2015 and January 2016 when the Tweed burst its banks, resulting in damage to several properties and a care home having to be evacuated. The Eddleston Water itself flows through an area of Peebles known as 'Cuddyside' which has experienced flooding in 4 out of the past 6 years (Photo 2). Five miles north of Peebles lies the village of Eddleston, which has also experienced multiple flood events in recent years.

SEPA's flood risk assessment puts 527 properties at risk in Eddleston and Peebles, as well as large areas of productive agricultural land, from flooding of the Eddleston Water in a 1 in 200 year event. Alongside flooding issues, the Eddleston catchment was also classed as being of 'bad ecological status' under the Water Framework Directive in 2009 due to its artificially straightened channel and relatively poor habitat for aquatic life. A 'multiple benefits' approach was therefore adopted whereby any NFM measures put in place would also enhance the ecological status of the river and provide other ecosystem services.

Other environmental problems

As mentioned above, the Eddleston Water was classified as being of 'bad ecological status' under the Water Framework Directive in 2009. Since then it had been upgraded to 'moderate', mainly due to changes to the river hydromorphology through the NFM measures introduced.

Water quality is generally good, though occasional incidences of diffuse pollution from agricultural activities are being experienced and investigated. The Eddleston Water is an important spawning and nursery habitat for salmonids, but the quantity and quality of habitat has been greatly reduced by the loss of sinuosity and diversity as a result of the channelisation process. There has been little recovery

to the planform in over 200 years, partly because the railway was built next to the river and thus giving the river even less room to move.

Photo 2: Flooding on the Eddleston W**ater in Peebles in 2010**

4. Defining the problem(s) and developing the solution

What evidence is there to define the flood risk problem(s) and solution(s)

In 2009, Dundee University and cbec eco-engineering UK undertook a scoping study to investigate the potential to introduce NFM measures to reduce flood risk, including where and what these might be. The Eddleston Water was chosen partly because it is not currently a priority for any form of urban flood protection, making NFM the only realistic flood protection option in the short term.

Modelling from SEPA showed that 521 properties in Peebles, 61 in Eddleston and 7 rural dwellings are at risk from a 1 in 200 year flood event. Furthermore, current projections for rainfall patterns over the next century suggest a 10–30% increase in winter precipitation in the Scottish Borders, which will be reflected in the flows of south-facing tributaries in the Tweed catchment. Thus, the Eddleston Water currently poses a risk to over 500 homes, and coupled with the effects of climate change, is likely to pose a greater threat in the future. Given the absence of any urban flood defences and the fact that this is likely to remain the case for the foreseeable future, NFM appears to be the most viable option for the Eddleston catchment.

What was the design rationale?

From its inception, the project has adopted an empirical approach, focusing on gathering detailed data both before and after new NFM measures were introduced. The monitoring strategy is based on a comprehensive network of river gauging stations, automated weather stations, fluvial audits, aquatic and macrophyte monitoring, and groundwater studies. It is split between detailed (before–after–control–

impact style) studies of individual NFM measures and whole catchment impacts. All interventions have been accurately costed. In addition, full catchment habitat and ecosystem services have been measured (including historical studies) and studies made of the attitudes of farmers and other stakeholders to NFM.

In addition to the data provided by the very detailed monitoring network (on which the project design was based), the work is supported by detailed flood modelling at ID and 2D level. This is conducted at catchment scale and at the level of individual measures to examine effects of NFM measures such as woody log jams and pond creation. Computer modelling has also been used to good effect when designing works, especially those which require a SEPA Controlled Activities Regulations licence.

The project adopted a 'multiple benefits approach, whereby any NFM measures introduced should, where possible, also address the ecological degradation of the Eddleston Water and vice-versa. To this end, 15 types of NFM measures were identified by Dundee University as appropriate for potential development in the Eddleston Water (see Table 1). These were then targeted at those areas where they would have greatest impact.

Table 1: Summary of NFM measures

Measure	Function
Plant trees on hillslopes, riverbanks and floodplain margins	Increase shade and food supply for salmonids and increase biodiversity. Stabilise river banks.
Fence channel margins or set existing fences back from channel	Reduce tramping by stock at channel margins, thereby reducing erosions and release of fines.
Remeander channel	Improve habitat for salmonids by creating new pools, riffles and glides and increase biodiversity
Install flow deflectors	Create artificial pools and riffles to improve habitat where remeandering is not possible.
Remove river works such as bank protections and weirs	Promote development of a more natural morphology.
Breach/remove embankment or set back from banks	Provide temporary flood storage and improve habitat via episodic inundation of floodplain.
Plant broadleaf woodland on floodplain	Increase roughness, flatten flood hydrograph and increase biodiversity.
Introduce large woody debris	Increase roughness, flatten flood hydrograph and locally improve habitat.
Reduce stocking densities on grassland	Reduce compaction of soils, improve soil structure and increase infiltration.
Plant riparian woodland on tributaries	Increase infiltration and storage of water in the soil.
Plant transverse woodland strips	Increase infiltration and storage of water in the soil.
Create ponds/wetlands with extra freeboard to store stormwater	Raise local water table and increase surface and groundwater storage.
Maintain paths	Reduce area of surface which generates overland flow and sediment.
Block drainage ditches	Slow down transmission of water from slopes to channel.
Block tile drain	Slow down transmission of water within soil to channel.

Project summary	
Area of catchment (km^2) or length of river benefitting from the project:	70km^2
Types of measures/interventions used (Working with Natural Processes and traditional):	Remeandering, flow restricting log jams, native tree planting (riparian, hillslope, floodplain and transverse strips), storage ponds, removing artificial banks
Numbers of (types of) measures/interventions used (Working with Natural Processes and traditional):	8
Standard of protection for project as a whole:	All NFM measures
Estimated number of properties protected:	527

How effective has the project been?

From its inception, the Eddleston Water project identified one of its key drivers as the need for empirical evidence on the benefits of NFM for flood management and biodiversity. Despite still being at a relatively early stage, the project has shown a marked improvement in river ecology which resulted in the Eddleston Water being upgraded from 'bad' in 2009 to 'moderate' in 2016 under the Water Framework Directive. This is primarily due to the restoration of the channel meanders and associated works to the channel and banksides, as well as native tree planting. Over 2km of river have been remeandered, which resulted in an extra 300m of watercourse being created. Baseline surveys of aquatic plants, aquatic invertebrates, hydrology and hydrogeomorphology were made. In addition, salmonid surveys were carried out before the project began and a new set of surveys will be conducted in the near future to determine the effect the works have had on fish populations. Surveys in 2014 to 2016 showed the presence of salmon redds and otters in the remeandered sections of river. Although a quantified account of ecological improvement on the Eddleston Water will require further work, it is clear from site visits that the new habitats created are being occupied by salmonids.

A hydrometric network of 12 stream gauges, 1 weather station and 4 rain gauges was established in 2011. It has collected data on the nearly 30 high water events since the first measures were implemented in 2011. As yet, these show no significant effect on the travel time or peak flow magnitude at a catchment scale, though this is to be expected given that NFM measures such as native tree planting will take some time to have a measurable effect. The flow restricting log jams in the top of the catchment (in the Middle Burn subcatchment) are expected to delay peak flow delay by up to 70 minutes compared with those without. Monitoring is in place to capture whether these modelled benefits are realised and early indications that the modelled predictions are correct. On the community engagement side, the project was credited by local residents and the press for preventing the Eddleston Water from flooding during the severe winter floods of 2015 to 2016, although local weather conditions on the Eddleston Water will also have contributed.

A total of 12 piezometers have been installed in a floodplain aquifer to monitor groundwater response to flood events and to investigate the controls on groundwater flooding. Three years of data show that groundwater levels across much of the floodplain are closely coupled to river stage, but that nearer to the hillslope they are coupled to rainfall and soil moisture. Persistent groundwater flooding can occur at the floodplain–hillslope boundary. Two hillslope transects were instrumented in autumn 2016 to monitor the effectiveness of established shelter belts on the partitioning of surface and subsurface flow.

Although primarily an empirical project, modelling has also been performed to estimate the potential gains from NFM on the Eddleston water. A lumped rainfall–run-off model was developed with the model structure being related to catchment characteristics (land use, geology and soils) and a calibration period of data was collected. Once the calibration and uncertainty analyses were deemed satisfactory for the baseline condition, the model was run with a design rainfall storm volume and an intensity profile as recommended by the Flood Estimation Handbook, and different scenarios were run for various land use changes. The modelling indicated that floodplain roughness could be the most effective means of

flood management, with peak flows reduced by up to 23% when combined with the enhanced storage and infiltration associated with dense forest cover. Continued monitoring will demonstrate whether these theoretical gains can be realised

5. Project construction

How were individual measures constructed?

cbec eco-engineering UK was commissioned to design the remeandering sections. The work was carried out by local contractors, Glendinning Groundworks. Flow restricting log jams were installed by Tweed Forum staff and native tree planting carried out by local forestry contractors.

How long were measures designed to last?

Remeandering, removal of artificial banks, native woodland planting and storage ponds are all designed to be permanent features. High flow restricting log jams will last around 10 years, but all of these have native trees planted closely to the log jam, with the idea being that once the log jam has rotted, it is likely that new recruits from fallen saplings/trees will be added to continue to slow high flows in these headwater streams.

Were there any landowner or legal requirements which needed consideration?

The project has always relied on landowner cooperation and works have all been carried out voluntarily with the landowners' consent. To date, 25 farmers and landowners have been involved and 19 have hosted measures on their land. As stated above, the project has emphasised a multiple benefits approach and creating good landowner relations has very much been a part of this. Most woodland planting areas are covered by Forestry Commission contracts (which require woodland cover to be permanent) and some have agreements with carbon brokers for periods of up to 60 years. The remeandering has involved multiple landowners where the river has formed the march between properties and there is also essential infrastructure to think about including roads and electricity/water supplies. This has added a degree of complication and Tweed Forum is currently handling any liability issues with regards to subsequent planform changes.

6. Funding

Funding summary for Working with Natural Processes (WWNP)/Natural Flood Management (NFM) measures	
Year project was undertaken/completed:	2009-present
How was the project funded:	Scottish Government, Building with Nature (Interreg) SEPA, Scottish Borders Council, SNIFFER, Forestry Commission Scotland, Environment Agency, Dundee University, Woodland Trust, Cheviot Futures 2, Scottish Power, CEMEX, Scottish Rural Development Programme, Forest Carbon and Landowner Contributions
Total cash cost of project (£):	£1.4 million
Overall cost and cost breakdown for WWNP/NFM measures (£):	Scoping: £49,000 Set up and initial monitoring: £306,000 Capital works: £723,300

	Design feeds:£81,100 Ongoing monitoring: £205,600 Project management: £80,000
WWNP/NFM costs as a % of overall project costs:	100%
Unit breakdown of costs for WWNP/NFM measures:	Not available – could be calculated
Cost–benefit ratio (and timescale in years over which it has been estimated):	As above

7. Wider benefits

What wider benefits has the project achieved?

The upgrading of the Eddleston Water from 'poor' to 'moderate' under the Water Framework Directive has demonstrated the improvement to biodiversity and water quality brought about since the project began. Confirmed salmon redds and otter tracks suggest that biodiversity has improved since remeandering took place. Repeating the surveys for invertebrates, macrophytes and geomorphology will show the effectiveness or otherwise of the project. The salmon fishery of the Tweed is worth a total of over £24 million a year to the local economy and supports over 500 jobs, so any improvement to fish habitat is important.

How much habitat has been created, improved or restored?

- Riparian new native woodland: 142ha (~200,000 trees)
- Leaky ponds: 22 (8,155m^2)
- Transverse hedges: 2,305m
- High flow restricting log jams: 101
- 2.2 km of river remeandered
- 2.900m of floodbank removed

8. Maintenance, monitoring and adaptive management

Are maintenance activities planned?

Main stem river works and repairs will be maintained where appropriate.

Is the project being monitored?

A hydrometric network has been set up across the catchment, making it one of the most heavily monitored watercourses in the UK. The network includes stream gauges, weather station, rainfall gauge and time-lapse cameras. The Tweed Foundation will carry out salmonid surveys to quantify the effect that works have had on local populations. Tree planting sites are being surveyed every couple of years and any dead saplings replaced to satisfy Forestry Commission contract requirements.

Has adaptive management been needed?

A small section of the remeandered site was undercut during a high water event, resulting in the

rootwads being lifting out of position. This section has been repaired and, in subsequent sites, rootwads have been installed with large boulders weighing down the ends to reduce the risk of undercutting causing the rootwad to lift out of position.

9. Lessons learnt

What was learnt and how could it be applied elsewhere?

The study is still in its early years and new empirical data are added to the science evidence base for NFM with each rainfall event and flood. However, experience to date has shown that:

- restoration of the catchment can be undertaken alongside the continuation of sustainable farming and livelihoods, working through a trusted intermediary to identify opportunities, engage with land managers and facilitate works
- the consent process is currently unwieldy and does not help facilitate NFM measures (there is often the need for planning consent, controlled activity consent and designated site approval)
- the use of sympathetic, local contractors who are pragmatic and flexible makes it much easier to carry out larger scale works such as remeandering effectively
- different NFM measures can reduce flood risk through increased rainfall interception, increased evapotranspiration, temporary storage of surface waters and delaying peak floods, as well as through increased roughness and groundwater connectivity
- appreciable flood risk reduction through NFM is only likely to be achievable through the widespread application of many types of approach throughout the entire catchment
- NFM measures to reduce flood risk and habitat enhancement measures to improve ecological condition (including Water Framework Directive ‘ecological status’) provide a wide range of additional benefits and ecosystem services
- appraisal of NFM measures show a positive net present value from riparian planting
- economic appraisals should consider benefits for NFM beyond just flood risk reduction to enable policymakers to make decisions reflecting the true net present value of investment in NFM

10. Bibliography

See http://tweedforum.org/projects/current-projects/eddleston_publications

Project background

This case study relates to project SC150005 'Working with Natural Flood Management: Evidence Directory'. It was commissioned by Defra and the Environment Agency's Joint Flood and Coastal Erosion Risk Management Research and Development Programme.