Case study 14. The Bowmont Catchment

Authors: Mark Wilkinson, Steve Addy (James Hutton Institute), Luke Comins, Hugh Chalmers (Tweed Forum)

Main driver: Flood risk management and river morphology improvements

Project stage: Partially constructed (works are ongoing)

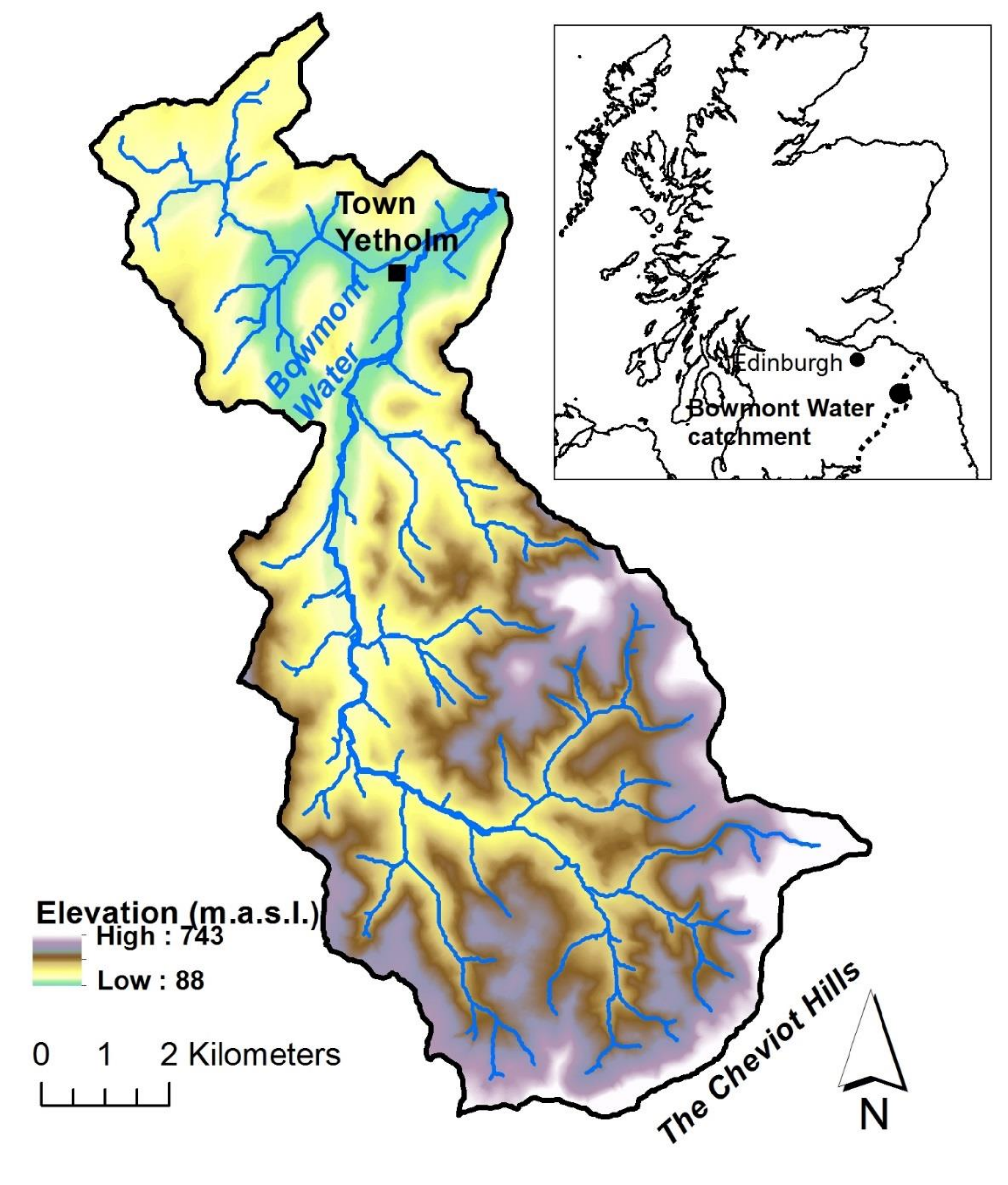
Photo 1: An avulsion on the River Glen (downstream continuation of the Bowmont in Northumberland) caused by the September 2008 flood event

Project summary:

The Bowmont Water is a tributary of the River Tweed. The valley has a history of significant flood events. Following extreme floods in 2008 and 2009, the Tweed Forum (through the Cheviot Futures initiative) began to look at more natural ways to tackle coarse sediment problems and manage flood risk. Measures such as bank protection engineered log jams (ELJs), bar apex ELJs and flow restrictors have been installed in the catchment. Alongside this, large areas of trees have been planted on the floodplains of the catchment coupled with pockets of upland planting.

Key facts:

Over the 4-year period of monitoring, 78 leaky barrier structures have been installed to capture and stabilise sediment and attenuate flows. A total of 53ha of native riparian and floodplain forest have been planted.



Map 1: The Bowmont catchment in the Scottish Borders (source: James Hutton Institute)

1. Contact details

Contact details	
Name(s):	Luke Comins, Hugh Chalmers (Tweed Forum), Mark Wilkinson (James Hutton Institute)
Lead organisations:	Tweed Forum (for measures and management) and James Hutton Institute (monitoring and research)
Partners:	Scottish Environment Protection Agency (SEPA), Scottish Government, Scottish Natural Heritage, landowners
e-mail address:	Mark.Wilkinson@hutton.ac.uk hugh.chalmers@tweedforum.org

2. Location and catchment description

Catchment summary	
National Grid Reference:	385298, 618511 (Eastings and Northings)
Town, County, Country:	Town Yetholm and Kirk Yetholm, Scottish Borders, UK
Regional Flood and Coastal Committee (RFCC) region:	Not applicable (Scottish catchment)
Catchment name(s) and size (km^2):	Upper Bowmont catchment, 86km^2
River name(s) and typology:	Bowmont Water, wandering gravel bed river
Water Framework Directive water body reference:	6885 (Solway Tweed Region)
Land use, soil type, geology, mean annual rainfall:	Land use: upland cattle and sheep grazing (pasture and rough moorland), conifer woodland and intensive game bird rearing Geology: Lower Devonian layered lavas that are overlain by glacial till on hillslopes and alluvial fill in the valley bottoms Average annual rainfall: 1,050mm

3. Background summary of the catchment

Socioeconomic/historic context

The Bowmont catchment (Map 1) is predominately rural with less than 2% of the catchment developed for buildings or roads. The main settlements along the upper Bowmont are the villages of Town Yetholm and Kirk Yetholm. A total of 475 properties are situated in the Bowmont catchment (Scottish Census 2001). Agriculture and tourism bring significant income into the area (MNV Consulting 2010).

The catchment is relatively intensely farmed by the scattered population. Due to the slope of more than 11° in certain areas of the catchment, some farming regimes such as ploughing are not possible as heavy machinery cannot be manoeuvred in these angles (Brown and Shipley 1982). The slopes are therefore critical in determining the land use of the catchment as areas are considered suitable for improved grassland (class 5) or rough grazing (class 6) (Tipping 2010).

Flood risk problem(s)

The Bowmont valley has a history of flooding and experienced 2 major flooding events in September 2008 and July 2009. Both floods caused extensive damage throughout the catchment. One of the main economic losses caused by the flooding events was the damage to large areas of arable farmland through sediment deposition, erosion and debris accumulation. Direct losses were experienced by farmers and estate businesses through the destruction of standing crops, fencing, machinery, harvested fodder and loss of animals. Cheviot Futures estimated direct costs of £2–3 million to farming and shooting businesses (Oughton et al. 2009).

The flooding events also led to damages to possessions, properties and infrastructure throughout the catchment including a bridge near Primsidemill and various roads. The 2008 flood caused approximately £670,000 worth of council repairs as well as damage to several properties including Kingfisher Cottage, Greystones and Duncanhaugh Mill (all at Duncanhaugh). Properties at Mowhaugh were damaged by the 2009 flood according to the Scottish Borders Council 2011.

In response to the September 2008 flood, parts of the Bowmont Water experienced marked gravel deposition and changes in channel planform (Photo 2). Further downstream the River Glen – the continuation of the river in Northumberland – was affected by the same floods and coarse sediment supply that partly originated in the Bowmont catchment (Photo 3).

(A) January 2007 **(B) March 2009**

Photo 2: Changes to river channel course and gravel deposition before (A) and after (B) the 2008 flood on Bowmont Water downstream of Attonburn (imagery from Google Earth)

Photo 3: An avulsion on the River Glen (downstream continuation of the Bowmont in Northumberland) caused by the September 2008 flood event. It is thought this happened in part due to excessive sediment supply from the Bowmont catchment.

Other environmental problems

The entire Bowmont catchment is largely devoid of semi-natural woodland due to centuries of domestic grazing. Apart from the direct effect of the lack of habitat, the almost complete absence of riparian woodland cover means that headwater stream sides are generally unstable. This means that the effects of heavy rainfall are made worse, as riverbanks collapse and feed more sediment into the system. Similarly, the steep headwater pasture land has a tendency to slip, causing major inputs of sediment. This leads to a wide, shallow stream morphology which is poor for salmon and trout. While the abundant gravel is good for spawning and fry numbers are good, there is very little suitable habitat for the later life stages (that is, parr). The lack of depth and cover for fish and the fact that the streams are more liable to de-water in drier periods has a negative impact on fish numbers and thus fishing, which is an important part of the local economy.

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

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

A pre-feasibility study (see MNV Consulting 2010) highlighted the flood risk and coarse sediment problems in the catchment and outlined mitigation options that could be applied to the catchment.

What was the design rationale?

This is described in the pre-feasibility study by MNV Consulting (2010). The measures were 'bespoke' to meet the design requests of all the stakeholders. However, the Cheviot Futures 2 project was keen to explore some bespoke measures (for example, ELJ leaky barrier structures) alongside more conventional restoration of riparian and headwater woodland cover to stabilise stream sides and increase the resilience of the system to extreme flood events. The Cheviot Futures 2 project worked with individual farms to draw up Farm Climate Change Resilience Plans, which addressed the risk of extreme flood and extreme drought scenarios

Work is ongoing with elements of some of these plans, including the recent approval of a significant (12ha) area of planting at Swindon Haugh in the Bowmont valley to stabilise gravels and provide woodland cover. Previous land use on this site was exacerbating the problems caused by overwintering and feeding cattle on the floodplain.

The bar apex ELJ designs were inspired by work commissioned by SEPA, which looked at similar constructions in the USA. The designs were designed to mimic naturally occurring log jam features and to help to stabilise coarse sediment movement. Two types of riverbank protection ELJs have been installed to reduce riverbank erosion and sediment inputs from these sources.

In addition, demonstrations of 4 different designs of 'green bank' protection/stabilisation were trialled at Clifton Farm in the lower part of the catchment. Wider land use change to enable the roll-out of an extensive restoration of riparian woodland in the catchment will depend on the perception of the benefits by the decision-makers, as well as the wider context of agricultural and forestry financial support from government.

Project summary	
Area of catchment (km^2) or length of river benefitting from the project:	86km^2 catchment area
Types of measures/interventions used (Working with Natural Processes and traditional):	Planting of native trees within the whole catchment landscape (predominantly floodplain and gulley planting); ELJs; hedgerow planting; ELJs, novel wooden structures and willow plantings for protecting river banks.
Numbers of measures/interventions used (Working with Natural Processes and traditional):	78 leaky barrier structures – including bar apex ELJs Flow restrictors in gullies and bank protection measures 1–2% of full catchment area planted in floodplain areas and steep valleys; 10% of Calroust subcatchment (6km^2) planted by the private landowner
Standard of protection for project as a whole:	Not applicable
Estimated number of properties protected:	Not applicable

How effective has the project been?

Owing to the small area of planting in relation to the large catchment area, it is difficult to detect the impact the measures could have had on flood peaks but it is very unlikely that there has been an effect on flood hydrology at the catchment scale. However, leaky barrier structures (bar apex ELJs) have captured small amounts of sediment, though their sediment trapping effectiveness has been limited given their small size and porous design (Addy and Wilkinson 2016) (Figure 1).

More findings from the monitored ELJ and flow restrictor measures can be found in Addy and Wilkinson (2016, 2017).

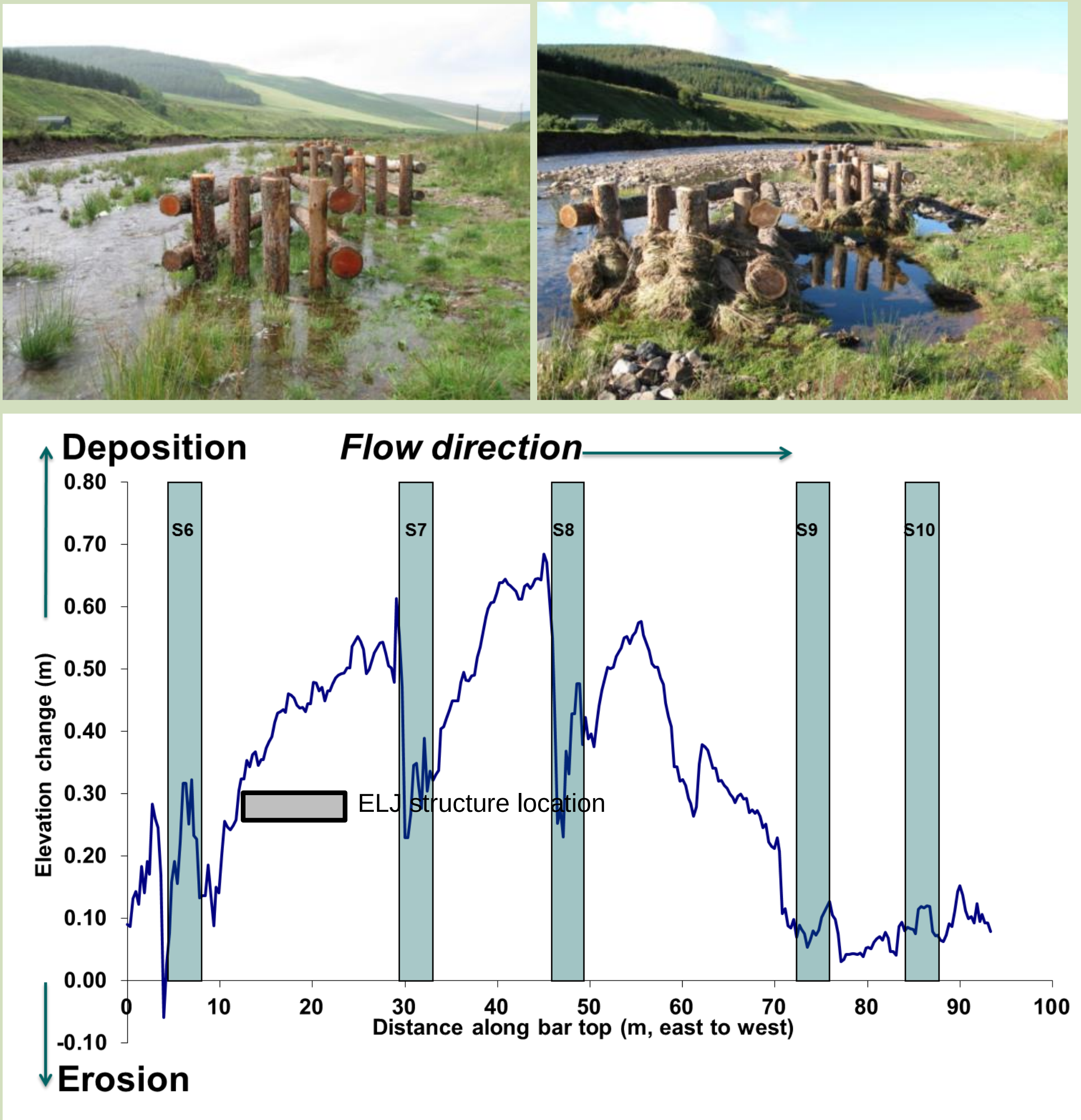


Figure 1: Top panel: Condition of bar apex ELJs on the Bowmont Water before (above left) and after (above right) a large flood (~5–10 year recurrence interval). Note the captured debris and formation of scour pockets created by the structures through re-direction of flow currents. Bottom panel: Elevation change profile showing the capture of sediment along the axis of a gravel bar in association with the ELJ locations.

5. Project construction

How were individual measures constructed?

The ELJs were constructed by a local contractor. Further details on their construction are given in Cheviot Futures (2013, 2015). Locally available larch logs of 20–40cm diameter were used to mimic a fallen tree with its root wad intact. A tractor mounted post knocker was used to pile 5 vertical logs around 1.5m into the gravel substrate; 4 horizontal logs of 4m length were attached by mild steel bars to the verticals.

Native woodland planting took place between 2010 and 2012 on 4 farms in the catchment (Venchen 8ha, Mowhaugh 5ha, Halterburnhead 40ha and Kelsocleuch 2ha) with agreement from the owners and farm tenants. The largest area was funded through the Scottish Forestry Grants Scheme, with additional funds via a carbon offset programme (Forest Carbon). Smaller areas were funded through the Cheviot Futures 2 project.

Were there any landowner or legal requirements which needed consideration?

The main river corridor is part of the River Tweed Site of Special Scientific Interest (SSSI). Permission was required from SEPA and Scottish Natural Heritage for each of the log jams and bank restoration works. Landowner negotiations included formal contracts between the owner and Forestry Commission Scotland. Other agreements were sought with farmers through the Scotland Rural Development Programme. This included a Natural Flood Management measure, 'Floodplain Management', which provided funds for 40ha of less intensive grazing of the floodplain at Attonburn Farm. This scheme ran from 2010 to 2015.

6. Funding

Funding summary for Working with Natural Processes (WWNP)/Natural Flood Management (NFM) measures	
Year project was undertaken/completed:	Implementation of measures began in 2012
How was the project funded:	Initial funding came through the Cheviot Futures initiative
Total cash cost of project (£):	£100,000+
Overall cost and cost breakdown for WWNP/NFM measures (£):	Grade control ELJs (£3,000), bank protection ELJs (£7,000), bar apex ELJs (£2,500), hedgerow planting (£1,500), timber revetment design (£3,200), Filtrexx bank protection approach (£15,000), willow spilling bank protection (£10,000) Cost of tree planting: Floodplain: £5,000 (at Venchen) Halterburnhead (£3,500 per hectare) and Mowhaugh (£5,000 per hectare) – both Forestry Grant Scheme funded; 35ha of woodland were planted at Halterburnhead. At Calroust, ~80ha was planted at a similar rate of £3,000 per hectare.
WWNP/NFM costs as a % of overall project costs:	Not applicable
Unit breakdown of costs for WWNP/NFM measures:	Not applicable

Cost–benefit ratio (and timescale in years over which it has been estimated)	Not applicable

7. Wider benefits

What wider benefits has the project achieved?

The native woodland planting has helped to add biodiversity to the catchment. This will gradually develop over the decades as the woodland canopy develops, providing food, shade and cover, particularly for woodland birds. Tree planting also contributes towards the wider climate change policy of increasing carbon capture where possible. The bank and river bed stabilisation will also contribute towards river diversity, in particular trout, eel and salmon populations, which will in turn help otter numbers.

How much habitat has been created, improved or restored?

A total of 53ha of new native woodland on riparian and floodplain zones has been planted.

8. Maintenance, monitoring and adaptive management

Are maintenance activities planned?

Tweed Forum carries out regular checks of the measures and continues to work with landowners and tenants to find ways to facilitate NFM measures in the catchment. There is no formal maintenance programme apart from the agreed requirements through Forestry Commission and Forest Carbon contracts.

Is the project being monitored?

Yes, as part of the Scottish Government Rural and Environment Science and Analytical Services Division (RESAS) funded work on 'Methods for mitigating and adapting to flood risk', The James Hutton Institute has been monitoring the hydrology and geomorphology within the catchment. It has also sought to assess the efficacy of different wooden structures for reducing coarse sediment problems which are associated with floods.

There are 12 river level monitoring stations, 3 rain gauges and 2 time-lapse cameras operational in the catchment (in a multi-scale nested design). The sites have been operational since 2012. These are complemented by a long-term flow and weather monitoring station at Sourhope (15+ years of data as part of the Environmental Change Network programme). A COSMOS soil moisture monitoring station is associated with this site. Geomorphic responses and coarse sediment movement in the river corridor have been monitored with topographical surveys, sediment tracers, photo analysis and sediment impact sensors.

Photos 4, 5 and 6 show some of this monitoring in action.

Photo 4: Surveying river morphology on Bowmont Water near Town Yetholm

Photo 5: Weather station at Sourhope

Photo 6: Downloading data from a flow monitoring station on a headwater tributary of Bowmont Water

Has adaptive management been needed?

Yes – some of the leaky barriers (the bar apex ELJs) have been displaced during large flood events. This has necessitated the removal of timbers in some cases due to concerns about bridge damage and blockage. Elsewhere the timbers have been left in the channel and damaged structures have been left in place. Fences were installed around some of the ELJs to prevent sheep from getting stuck inside them. To reduce the threat of new fence damage to planting areas, the fences are kept well away from areas where there is a high risk of damage from river erosion.

9. Lessons learnt

What was learnt and how could it be applied elsewhere?

Addy and Wilkinson (2017) drew the following conclusions.

- Managing run-off at its source on hill slopes and in valley floor pathway zones by altering land use to forest cover is likely to be the most effective means of attenuating flows or reducing coarse sediment yields. However, there is considerable reluctance to alter traditional land use on significant areas at present, though there are exceptions in the Calroust and Halterburnhead subcatchments.
- The sensitive and dynamic nature of river channels in the Bowmont catchment means any measures installed within the river corridor are susceptible to scour and washout, or being bypassed due to channel course change. Measures like ELJs, novel bank protection structures or untested measures like bunds or ponds are therefore vulnerable. Careful design of structures (using modelling approaches if possible) and consideration of river sensitivity are needed to ensure structure stability and function.
- The dynamic nature of Bowmont Water and its tributaries also means that sediment management measures like dredging are unlikely to be effective in the long term either for controlling sediment

movement or flood risk.

- The small degree of channel blockage posed by the bar apex ELJs (<10% of the channel cross-section), their locations in floodplains settings out with the active channel and the simple porous design has limited sediment capture effects (Addy and Wilkinson 2016).
- Bank protection structures like those trialled in the Bowmont valley and any other type of riverbank reinforcement, should be used with care since because: (1) they are vulnerable in such dynamic rivers; (2) allowing river bank erosion and river movement is important for letting rivers adapt to climate change; and (3) their placement may lead to undesired responses (river bed incision and transferring energy elsewhere).

The monitoring of novel ELJs and other wooden structures in Bowmont Water shows their variable effect at the reach scale and the importance of considering structure stability to ensure they function as designed. Their effectiveness at the catchment scale is impossible to measure.

Such measures require further testing and refinement if to be used successfully elsewhere. Carefully designed and placed wooden structures should be included in a suite of measures (for example, improved land management and targeted tree planting of sediment source zones) that tackle run-off and sediment problems directly.

The work carried out in the Bowmont catchment emphasises the importance of partnerships involving local communities, landowners and proactive organisations such as Tweed Forum. Large flood events galvanise landowners and farmers to work together and think beyond their farm unit to management at the catchment scale. None of the work would have happened without a dedicated, trusted intermediary facilitating the design, implementation and funding of the various measures.

10. Bibliography

ADDY, S. AND WILKINSON, M. 2016. An assessment of engineered log jam structures in response to a flood event in an upland gravel-bed river. *Earth Surface Processes and Landforms*, 41 (12), 1658-1670.

ADDY, S. AND WILKINSON, M., 2017. *The Bowmont catchment initiative: an assessment of catchment hydrology and Natural Flood Management measures. Four-year summary*. Aberdeen: James Hutton Institute.

BROWN, C.J. AND SHIPLEY, B.M., 1982. *Soil Survey of Scotland: south east Scotland*. Aberdeen: The Macaulay Institute for Soil Research.

CHEVIOT FUTURES, 2013. *Engineered log jams*. Available from: http://www.cheviotfutures.co.uk/phpdocuments/ELJ.pdf [Accessed 17 March 2017].

CHEVIOT FUTURES, 2015. *Case Study 4. Creating flow restrictors, protecting banksides. Implementing Natural Flood Management (NFM) measures. Non-technical summary.* Melrose: Tweed Forum. Available from: http://tweedforum.org/publications/pdf/nfm_non-tech_kelsocleugh4.pdf [Accessed 17 March 2017].

MNV Consulting, 2010. *Bowmont–Glen catchment initiative.* Report to the Tweed Forum.

OUGHTON, E., PASSMORE, D. AND DILLEY, K., 2009. *Cheviots flood impact study*. Report for Cheviot Futures. Newcastle: Centre for Rural Economy, Newcastle University.

TIPPING, R., 2010. *Bowmont: an environmental history of the Bowmont Valley and the northern Cheviot Hills, 10,000 BC – AD 2000*. Edinburgh: Society of Antiquaries of Scotland.

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.