What could Natural Flood Management offer?

and how might it be developed at a catchment scale – emerging evidence from the Eddleston Water.

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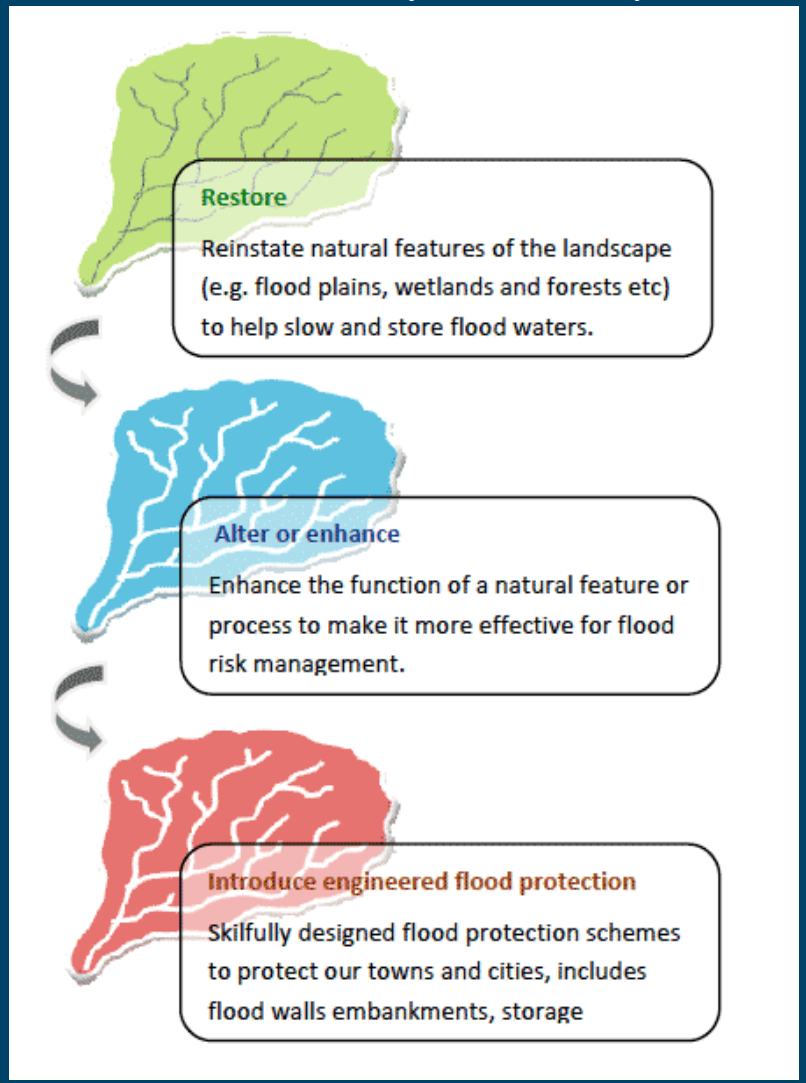
Introduction to Natural Flood Management (NFM)

- ***NFM*** **consists of different types of measures and in different locations within a catchment, which can help reduce flood risk and can also deliver other benefits for communities and wildlife**

- **NFM is part of a *Catchment Management* approach that recognises we cannot only build walls downstream at the location where floods do most damage, but also need to manage flood sources and pathways. All about improving *Flood Resilience at a time of Climate Change***

NFM does *NOT* replace traditional flood defences
NFM is *NOT* Re-wilding

Taking a whole Catchment Approach - Sources, Pathways and Receptors



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NFM aims to *work with* local landowners & the character of the landscape to suggest potential locations to 'slow the flow', temporarily store floodwaters and improve river habitats

block upland ditches

plant riparian woodlands

install high-flow log restrictors

re-meander channel

remove flood banks

create flood storage ponds

BUT how does one do it? - and do we have the evidence this works?

Eddleston Water – Project Aims

a) To assess the ***effectiveness of NFM measures*** to **reduce flood risk**

b) To assess the ***impact of NFM restoration*** on **habitats and species**

c) Work ***with landowners*** and the local community to maximise the benefits to them, **while** **sustaining farm businesses**

Long-term partnership study *2010* →

- **Managed by Tweed Forum**, with Scottish Government, Scottish Borders Council, SEPA & University of Dundee and British Geological Services
- **Advisory group:** NFU, Scottish Land & Estates, Forest & Land Scotland, NatureScot, Tweed Foundation
- **Scottish Government & EU funding,** with public & private sector support *£2.9m +*
- Based on a detailed ***Hydrological & Ecological*** **monitoring network**

Field data and Flood models **'learning by doing'**

What did we do at the start?

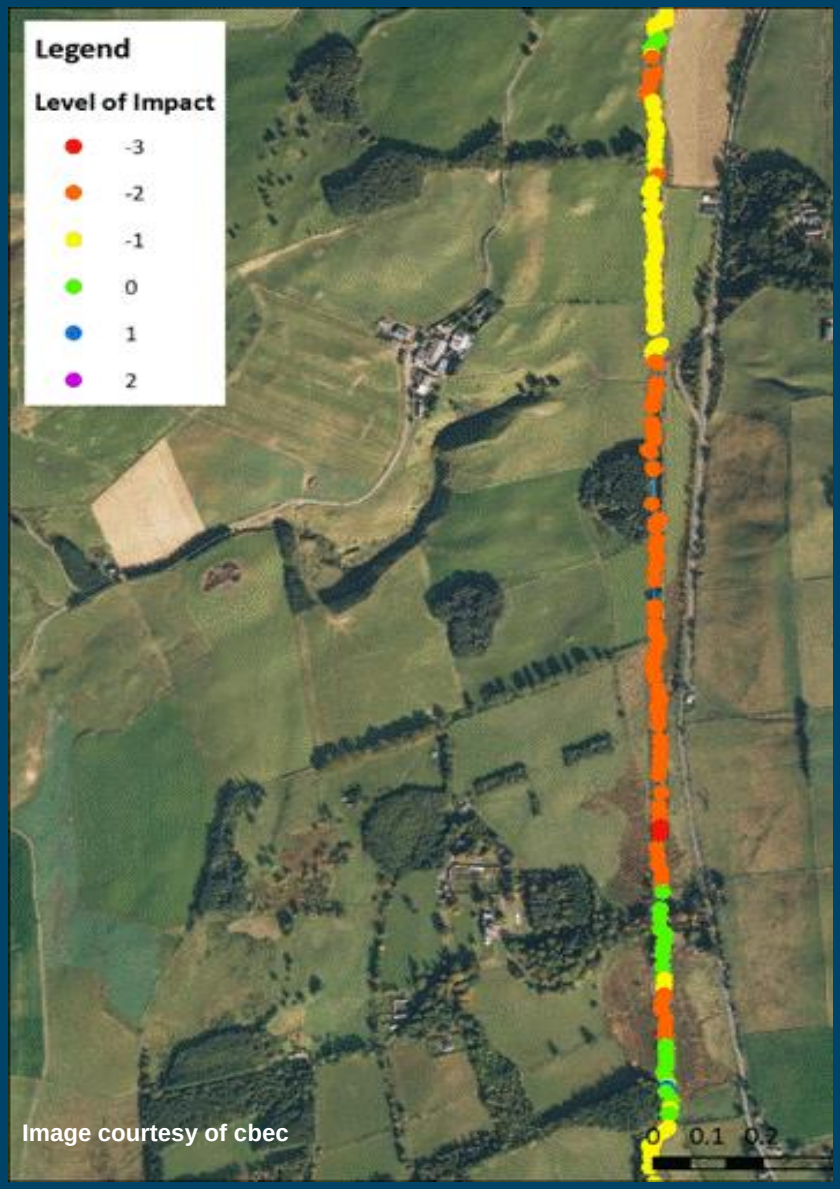
- Surveyed current state of the river environment - *before doing anything*

- Set up our Monitoring Networks:
  - Hydrology – rain gauges, river levels, surface water flows
  - Groundwater – soil moisture probes
  - River morphology – in stream habitats
  - Ecology – fish and aquatic invertebrates

- Talked with local land managers, farmers and foresters – seeking their advice and ideas as to what and where NFM measures might be implemented

- Looked for funding to 'make the NFM package'

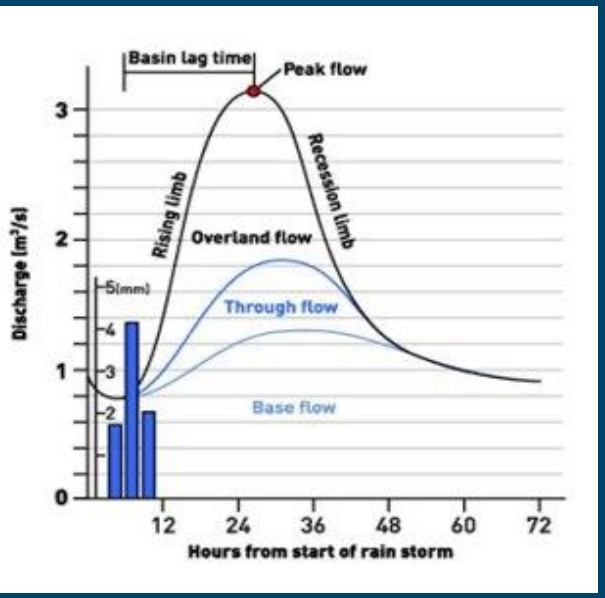
- Implemented the NFM measures



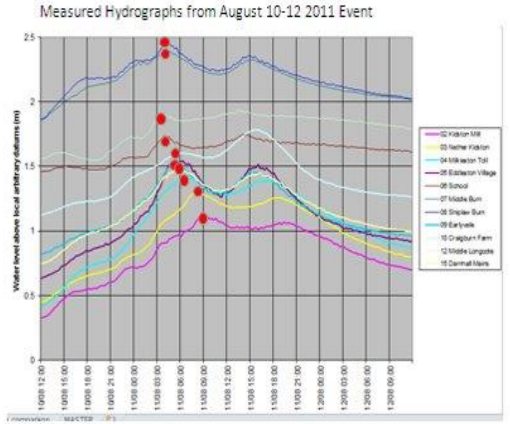
Cringletie - Lake Wood stretch showing impact of past work on the river channel and banksides. Red & orange lengths potential good sites for NFM

Set up a comprehensive Monitoring Network

Hydrology



Aim to lower the peak flow



Tracking a single storm down the catchment

Aim:

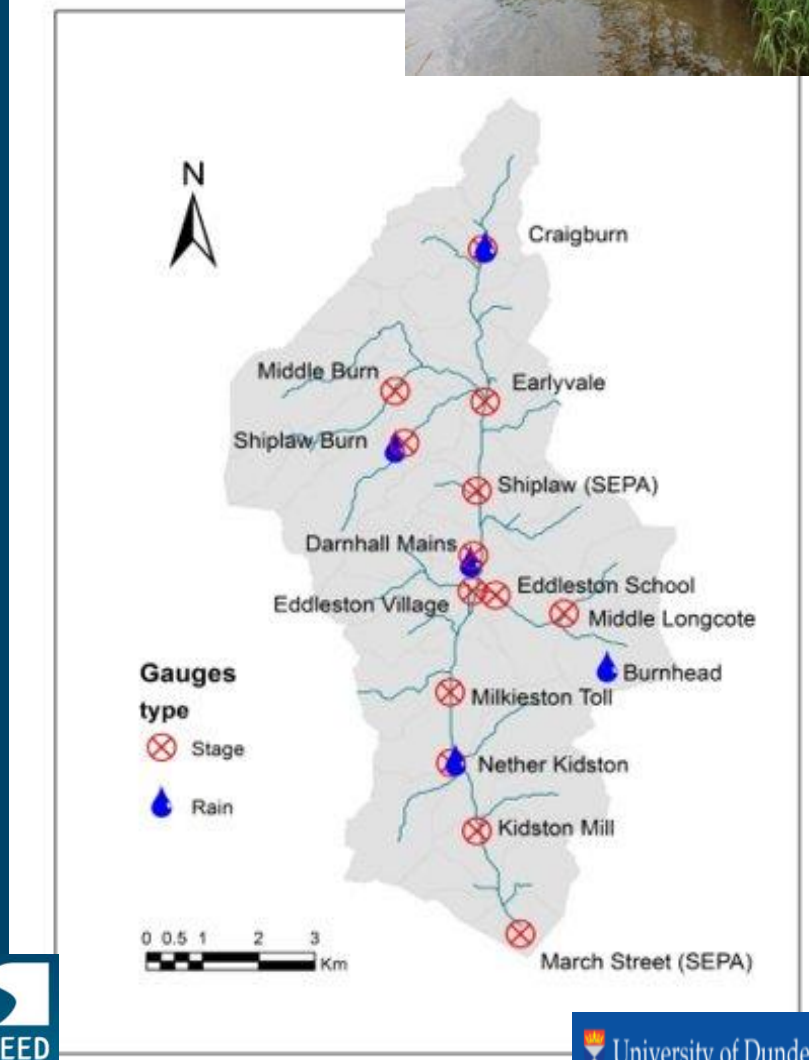
to identify how and where flood runoff is initiated and how floods then move downstream, causing flooding

Installed:

Very detailed Hydrometric network in 2010 to record river and pond levels and flood flows.

Groundwater boreholes

Weather stations



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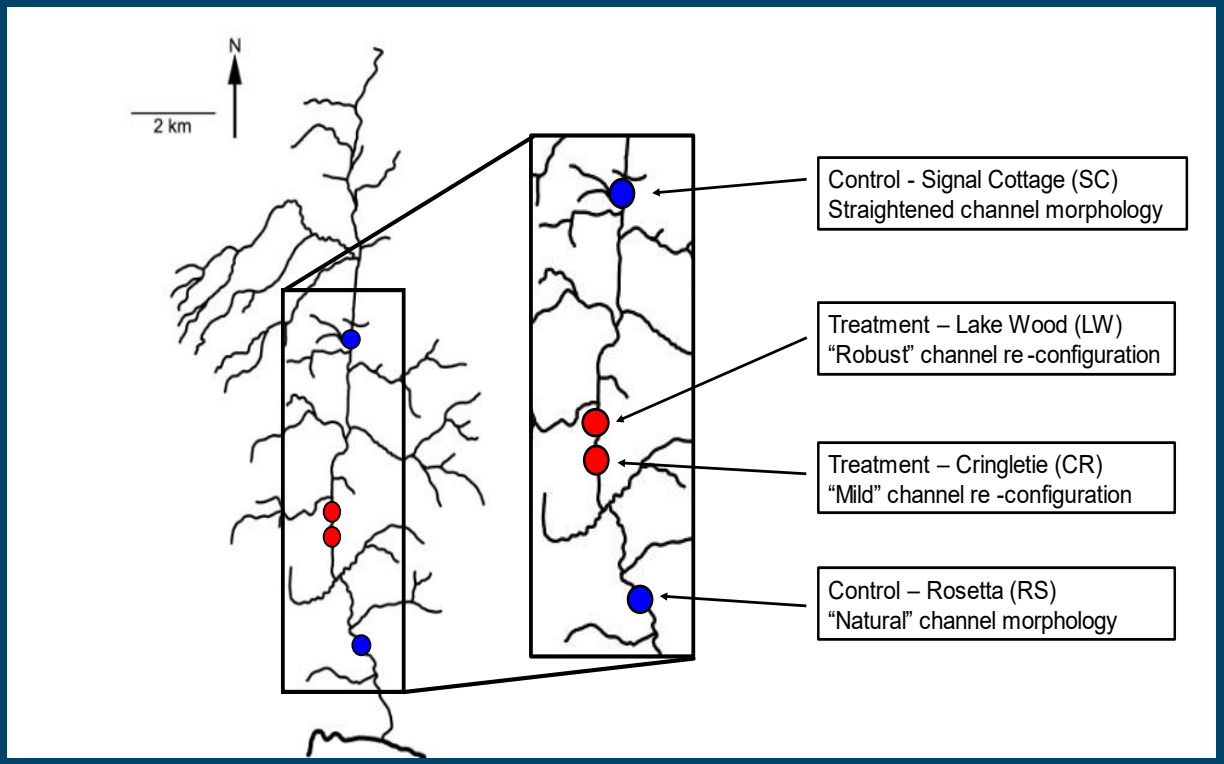
Monitoring changes in Ecology and River Habitats

Before / After / Control / Impact survey design used **to assess the impact of re-meandering once straight channels on aquatic macroinvertebrates and fish**



Before-After-Control-Impact design

Sediment and **Ecological** sampling undertaken at same locations

2012 - pre works
2013 - pre works
meanders
2014 - analysed
2015 - analysed
2017 - analysed
2019 - analysed
2021 – part analaysed + an e-DNA trial
2023 - surveyed

Channel re-configuration completed in July Cringletie & Sept Lake Wood 2013

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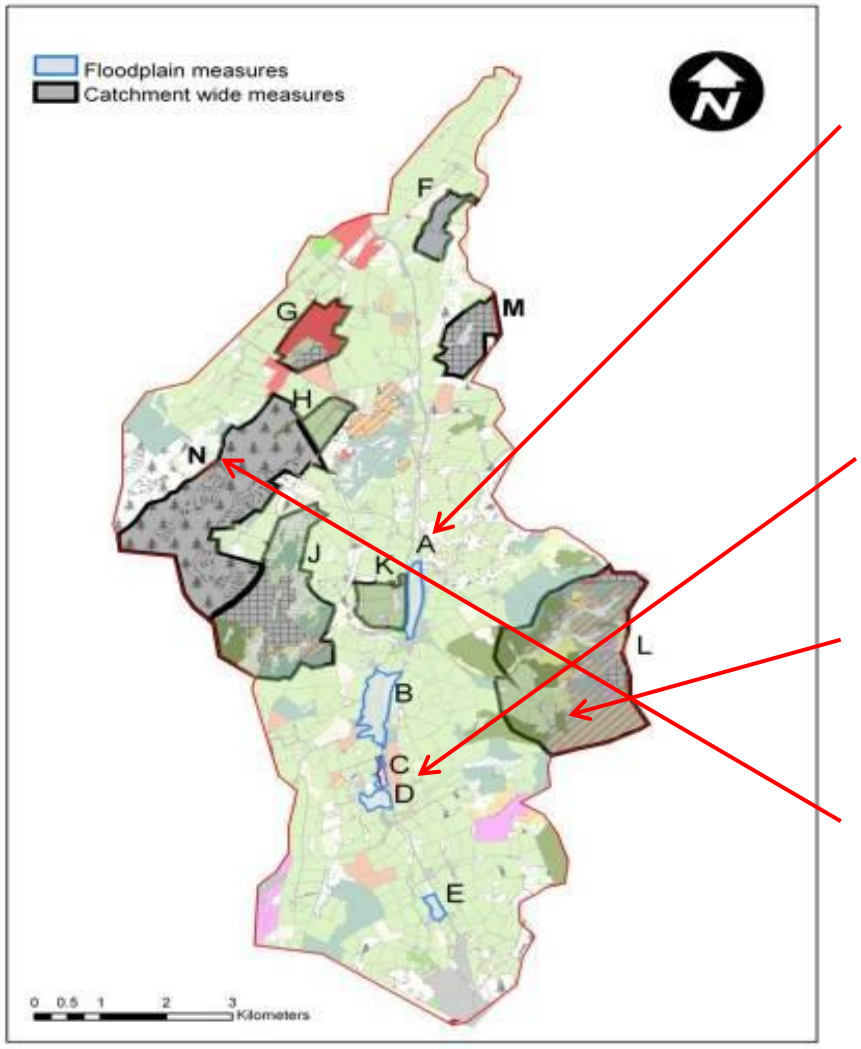
Veritas Ecology

University of Dundee

APEM

Scoped *potential* options to *reduce flood risk* and *restore the river* across the *whole* catchment



Potential options/measures:

A: breach/set back embankments, new fence margins, riparian & wet woodland

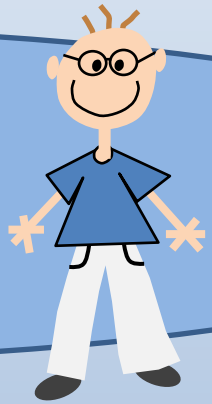
C: **re-meander channel**

L: Reduced stocking density, **tributary woodland, floodplain forest**

N: create ponds, wetlands, riparian woodland block ditches, **engineered log jams**

Target list of potential restoration opportunities – from *policy-makers*, *researchers*, *landowners* & *local communities*

Trusted intermediary



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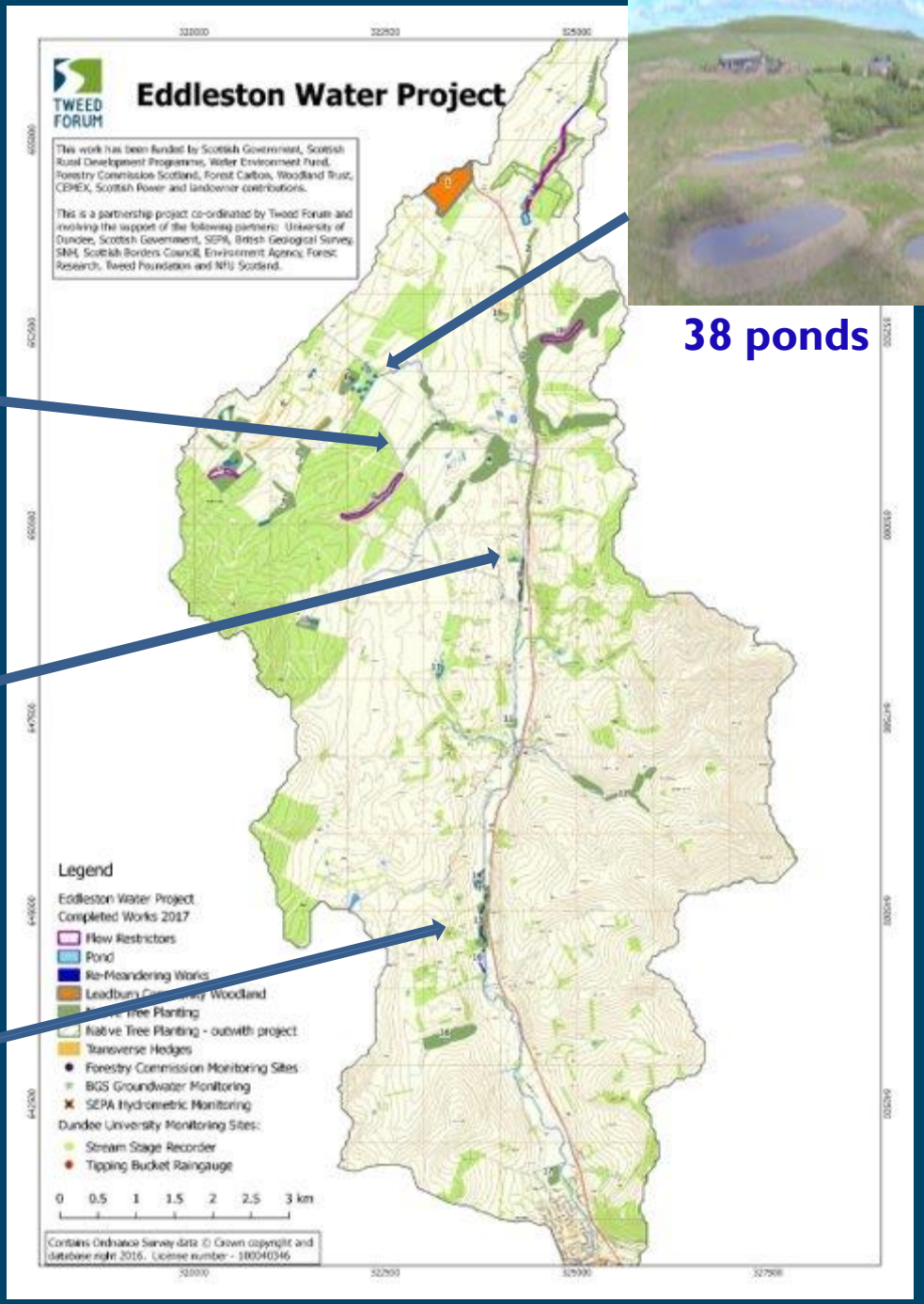
Land Managers - Changes on the ground

NFM Measures implemented

116 high-flow log restrictors

330k native trees (207ha)

3.5km new meanders



38 ponds


Cringletie
Re-meandering on the Eddleston Water
Exact channel design and location depends on hydrological analysis, historical analysis and landowner agreement
Milkieston
Lake Wood, Wormiston
dotted line denotes the old course

Log Jams / Leaky Barriers / Woody structures

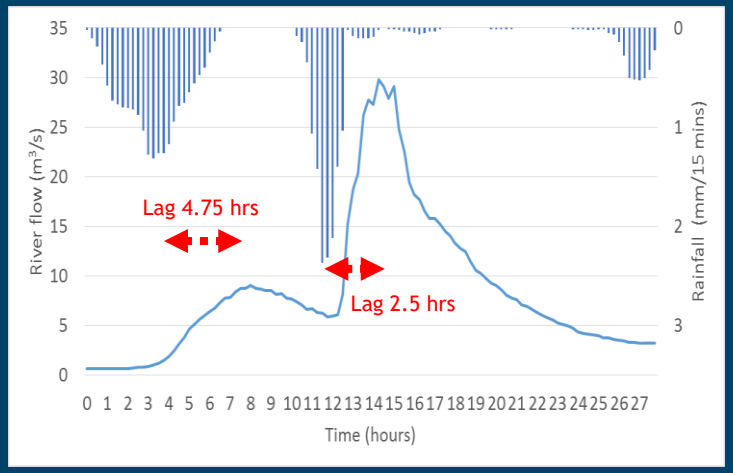
207 ha of riparian woodland created
330,000 native trees planted
25km fencing erected

Kidston Burn, Nether Kidston

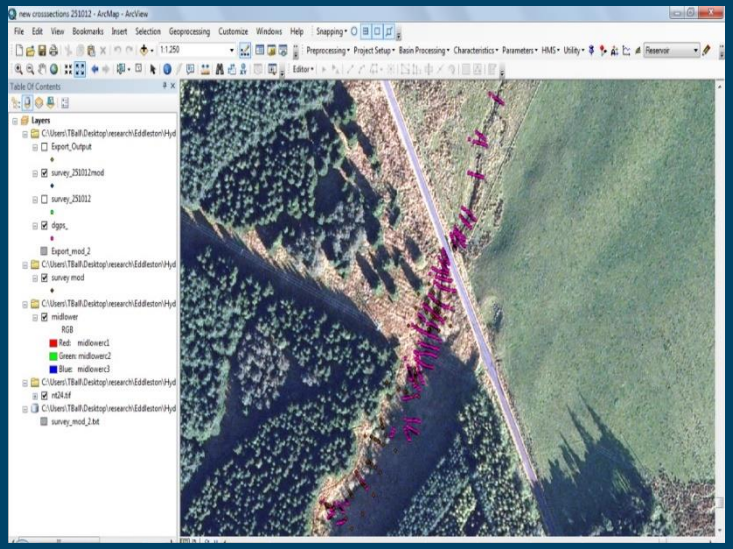

38 Leaky Ponds Created
28,355 m²
Ruddenleys

Do NFM measures reduce flood risk?

High-flow log structures placed in headwater streams can *temporarily store* surface waters and *delay peak floods in small catchments*

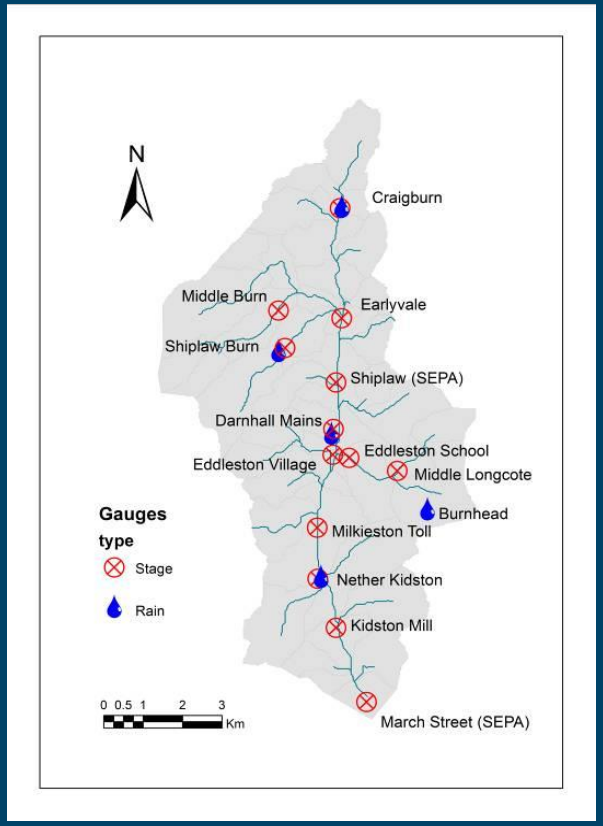


'Lag time' has increased by 2 - 7 hours in the headwater sites with flow restrictors in catchments of up to 25 km2 (delays also seen in catchments up to 36 km2).



<u>In upper catchment:</u>

- The **flood peak has reduced** by c30% post NFM measures (and 8% in lower catchment)
- The **high flow frequency** has decreased by 50%. (even the downstream 69km2 catchment gauge shows a 29% decrease in high flow frequency).



Log Structures, High flow restrictors and Beaver Dams ……..

High-flow Log structures produce minimal ecological benefits

water flows unhindered, except temporary backing up in high flow, good for flood risk reduction.

High-flow log structures, Middle burn, Eddleston

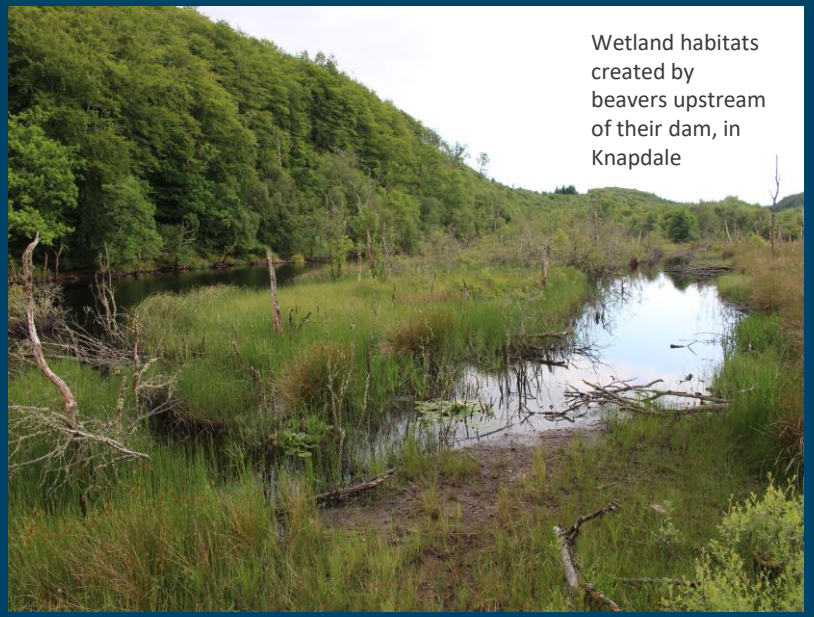
Often described as '***ecosystem engineers***', **Beavers** do have the potential to improve habitats and mitigate climate change.

- 1st official release Knapdale 2009, but reports on Tay since 2003. Scottish population now >2,000, forecast to reach 10k by 2030

Beaver activity can markedly change ecosystem structure

Creation of dams & ponds, and other beaver activities shown to:

- ***attenuate flood flows***, reducing peak discharge by 30%, total discharge by 34% and increasing lag times by 29%
- ***Improve wetland habitats*** - in plot trials, mean plant species richness increased by 46%, cumulative no. species by 148% with corresponding increases of 71% in heterogeneity.
- with evidence also for ***reduced sediment, nitrogen and phosphate***.



Wetland habitats created by beavers upstream of their dam, in Knapdale

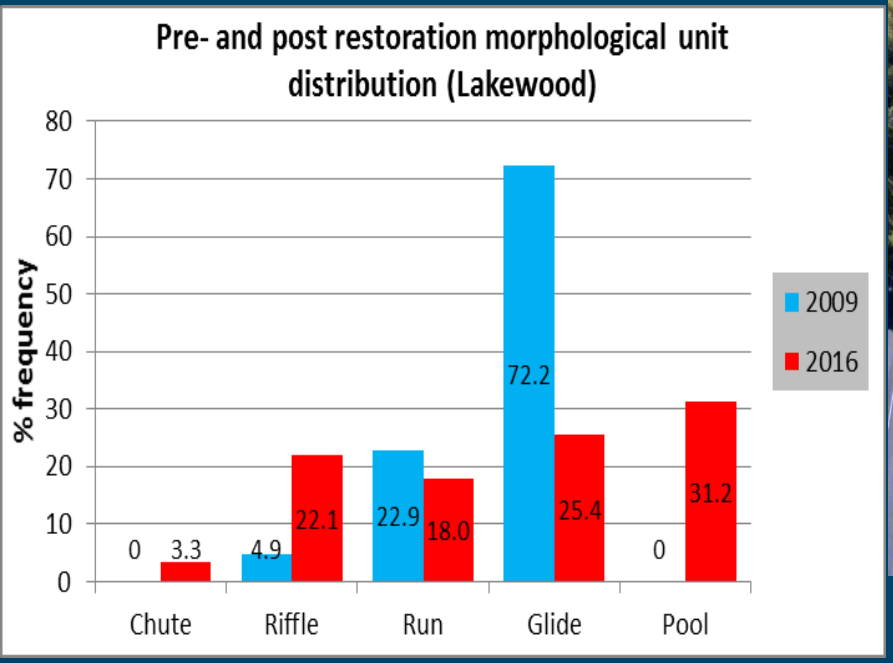
BUT:

Beavers build dams where *they* want to! Sites and impacts may not be acceptable, causing damage to property, land use and infrastructure

PS – there are no beavers in Eddleston (yet)

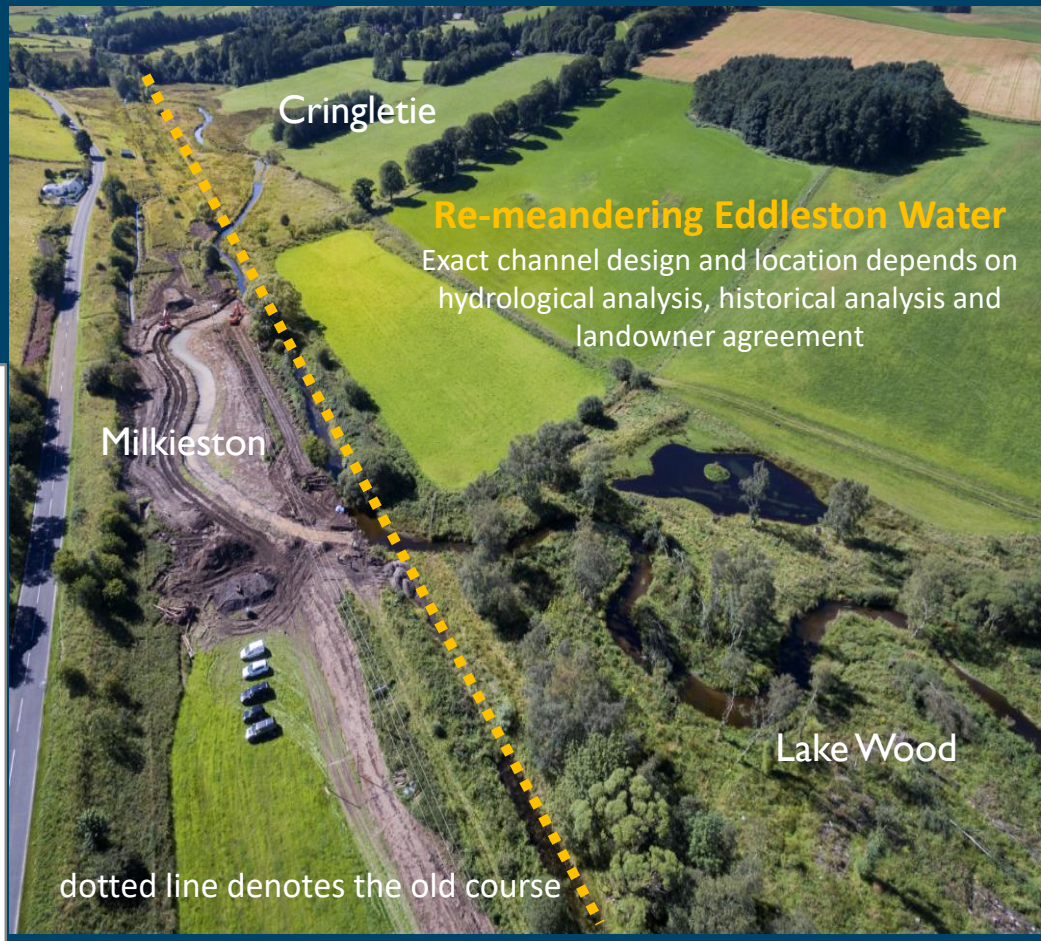
Does remeandering the river channel improve it for wildlife?

- New meanders add 8-46% more channel
- New channels have an increase in overall physical diversity of habitats
- Meandering is followed by a significant increase in the extent of active bar features in the channel and rapid recolonisation by invertebrates and fish



Pre- and post- restoration morphological unit distribution. Numbers represent percentage cumulative length of each morphological unit

Eddleston Water was straightened and embanked 200 years ago



Re-meandering undertaken in 2013 of the Eddleston Water

Re-meandering improves in-stream habitats

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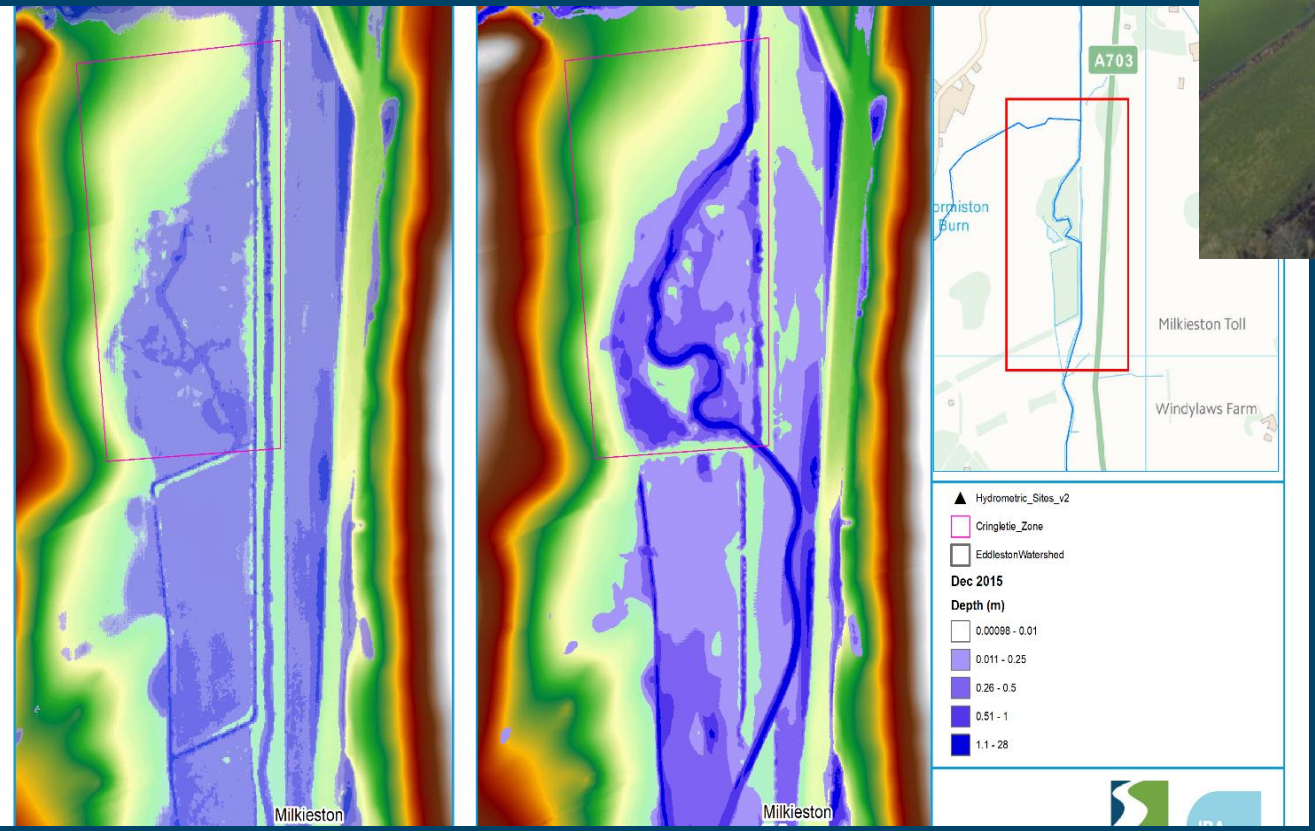
Does remeandering improve flood storage

Re-connecting river to the floodplain can improve flood storage locally



Calculated impact of NFM re-meandering on floodplain storage

Change in flood storage with channel being remeandered 2012-2015

Storage on the Floodplain increases 6% (8,700m^3 to 9,216m)

However, meandering alone staying within high embankments and with no temporary storage on the adjacent floodplain only adds c 2% extra storage

TWEED FORUM

Do new ponds effectively store flood waters?

We have created 36 Ponds in upstream 'source areas'

- Measurements of pond levels show **ponds in the *upper catchment can readily store water***, *providing 'quick wins'*
- But this is only effective in small sub-catchments
- Modelling shows that this will only have a *relatively small effect on total catchment runoff* at this scale

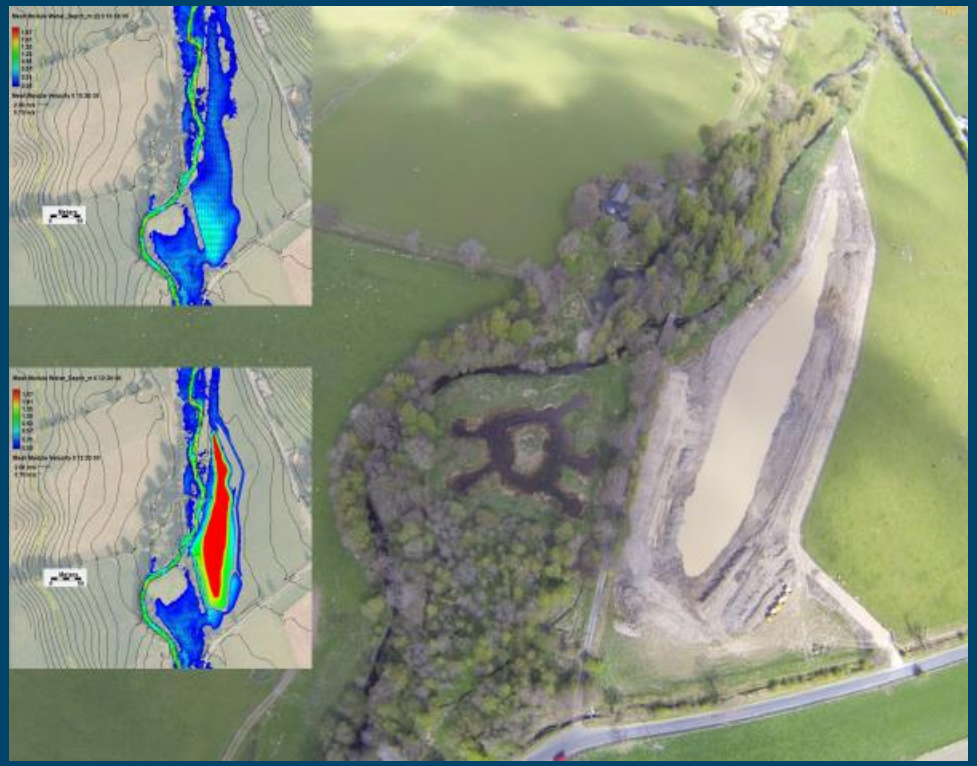
Ponds in the upper catchment at Ruddenleys

Ponds are designed to always hold some water, but also have a large 'freeboard' enabling them to temporarily store greater volumes in times of flood

TWEED FORUM

What about bigger ‘ponds’ on the floodplain?

- ***M***odelling of the potential impact of a series of larger ponds on the floodplain linked to the river suggests that five such ponds in series could *locally reduce the discharge peak by c 18-20% and theoretically delay it by up to 6 hours.*
- *But once full, they are full!*
- ***And floodplain ponds would occupy some of the best farmland***



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Are the flood ponds any good for wildlife?

Creating ponds for temporary storage of flood water leads to significant enhancement of catchment biodiversity

- Surveys of ***macroinvertebrate communities*** in 12 ponds in 2021 show that the mean richness of NFM ponds (27.5 families) was similar or better than that found in many other 'natural' or conservation ponds across UK.

- Work in 2023 on ***odonata (dragonflies***) shown that Pond creation for NFM has strengthened catchment dragonfly populations. Pond creation has increased habitat availability and all recorded species of dragonflies are now found at more sites.

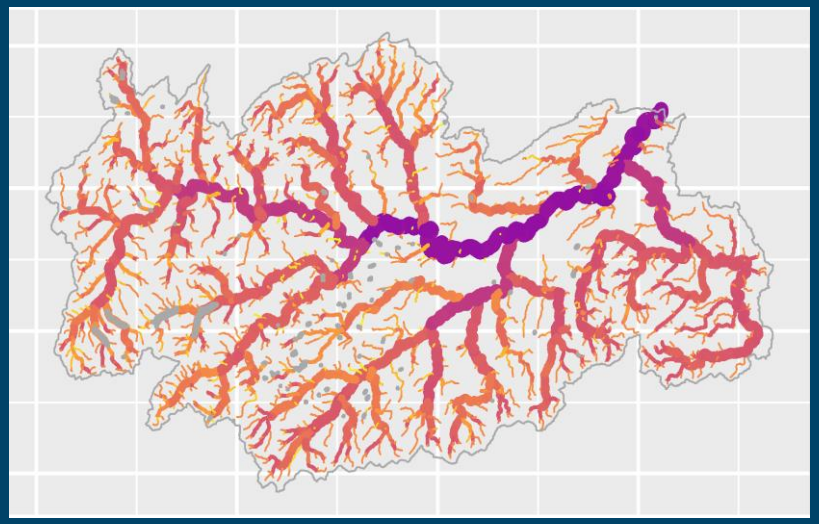
Does woodland planting help flood reduction and wildlife?

Landscape scale tree planting could reduce rapid runoff in the uplands and improve infiltration into soil and groundwater – UK tree canopy annual rainfall interception loss is c.17-45%

Tree shade can dramatically reduce water temperatures.

- Model of landscape-scale tree planting shows up to 20% reduction in peak flood flows and flood peaks delays of 45 mins
- Infiltration of rainfall measured under mature broadleaf woodland is ***5-8 x*** that under grazed pasture or conifers

Eddleston: -planted c 330,000 native trees over 207 hectares



- Riparian Woodland planting at four specific sites, were shown to have ***significantly lowered localised water temperatures,*** particularly in summer months, with one site, Craigburn Farm exhibiting a 1.5°C decrease in daily maximum water temperatures after modification

Summary

Different NFM measures can reduce flood risk - through both *temporarily storing* surface waters and *delaying the peak floods*, as well as through increased surface roughness and groundwater connectivity

This needs *the* ***widespread application of many types of approach throughout the whole catchment***

NFM measures ***work best in small catchments*** **and** ***in response to lower level flood events.*** They will not stop flooding in major events. NFM will be most effective in short-duration events.

NFM is about reducing risks overall ***in combination with other methods*** taking a whole catchment approach, not just downstream defences

NFM measures provide ***additional benefits to wildlife*** and also water quality, carbon, recreation, fishing, access, etc.

The ***economic value*** of the flood damages avoided and multiple benefits of restoration measures can be ***demonstrated***

Are NFM measures good value for money?

We can assess the impact of NFM measures as flood damage avoided

Flood risk reductions due to NFM measures can be valued in terms of Flood Damages avoided to downstream properties and communities using standard HM Treasury Green book methods

NFM measures already implemented show a positive net present value (NPV) of **£950k** from flood damages avoided

For a hypothetical maximum use of NFM in the catchment this could increase to £2,850k (NPV taken over 100yrs).

TWEED FORUM

Are NFM measures good value for money?

We can also assess the value of other benefits (ecosystem services) these same NFM measures provide

Using best practice methods, the total value of all other benefits (ecosystem services) delivered by current NFM measures is estimated at £4.2 million (NPV)

Benefit category	Actual NFM implemented (£k)	Additional NFM (£k)
Amenity	1,489	3,724
Biodiversity and ecology	627	4,594
Carbon sequestration	717	4,857
Education	383	383
Flows in watercourse	365	2,678
Water quality and pollution	628	1,424
Total	4,201	17,660

For a hypothetical maximum use of NFM in the catchment this could increase to approximately £17.7 million NPV.

One take home message is that:

The total value of other benefits delivered by NFM across the catchment are 4x larger than the flood damages avoided benefit alone.

Thank you

With thanks to the funders, supporters, and most of all the communities, landowners, farmers and foresters involved in the work on Eddleston covered in this presentation, as well as Scottish Government, Tweed Forum, Scottish Environment Protection Agency, University of Dundee and EU Interreg North Sea Region *Building with Nature*

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For information on the **Eddleston Water Project** see:
http://www.tweedforum.org/projects/current-projects/eddleston