CASE STUDY 2

Beaver wetland in farmland upstream of a flood-prone village

KEY THEMES OF INTEREST

Cost versus benefits of Flood Alleviation

Flood attenuation and slowing the flow

Impacts on agriculture

Management of dam to limit impacts on highway

Large tree felling management

Overview of site and beaver behaviour

- Beavers established a territory in a tall herb fen habitat, adjacent to a mixed organic farm. The farm comprises some Grade 1 arable land, improved pasture and lower grade grasslands, upstream of a village at risk of flooding.
- The site supports six dams including the main channel dam which now extends to 60 m in width across the floodplain. >1000 m^2 of standing water has been created with complex wetland and multi-thread channels exposing former river-channel gravel beds throughout the floodplain (0.08 ha).
- This site represents a unique opportunity to study both the costs and benefits of beaver activity due to the negative impacts on productive farmland and flood risk benefits to a downstream settlement.

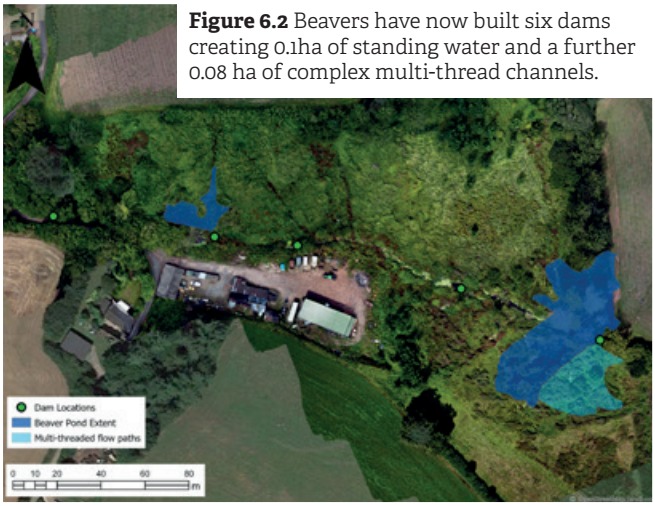


Figure 6.2 Beavers have now built six dams creating 0.1ha of standing water and a further 0.08 ha of complex multi-thread channels.

Beaver population

Beaver activity was first noticed here in 2016 by the grazier and trapping confirmed the presence of a single young female beaver in March 2017. A male beaver was subsequently trapped in February 2018. The following January a yearling was trapped, confirming successful breeding in 2018.

Beavers reached this site after travelling up a 300 m long, open, concrete aqueduct, demonstrating that beavers are able to navigate throughout a watercourse network, even if the watercourse appears to be inhospitable.

Cost versus benefits of flood alleviation

Benefits - flood attenuation

The beaver dam complex is 300 m upstream of a flood-prone village which has been monitored by the Environment Agency since 2009. This time series dataset has established a comprehensive understanding of flood risk over seven years before beaver colonisation. 52 properties in the village are at risk of flooding from the brook and other surface water sources, including both pluvial (rainfall/surface water) and fluvial (stream) flooding.

Since 2000 there have been four flood events in the village

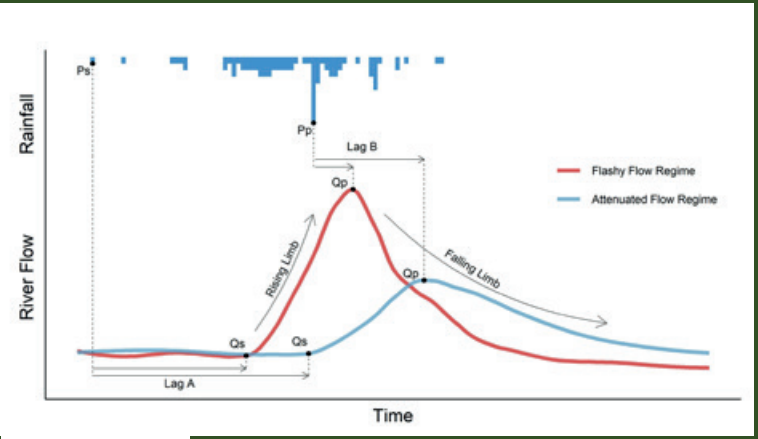


Figure 6.3 A schematic hydrograph showing the different elements of an attenuated flood hydrograph.

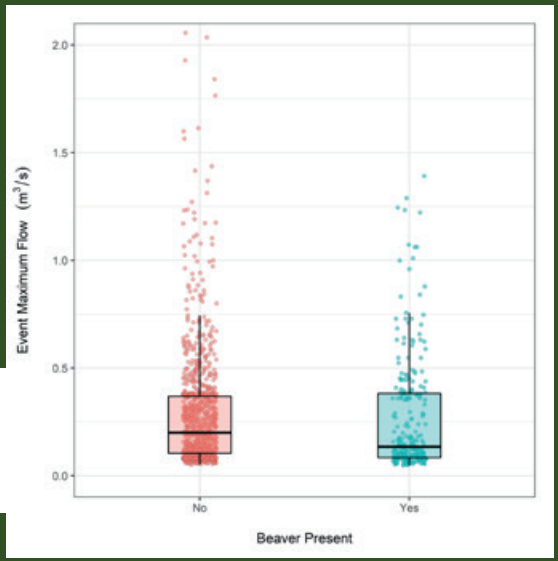


Figure 6.5 Peak flows before (red) and after (blue) beavers impacted the hydrology.

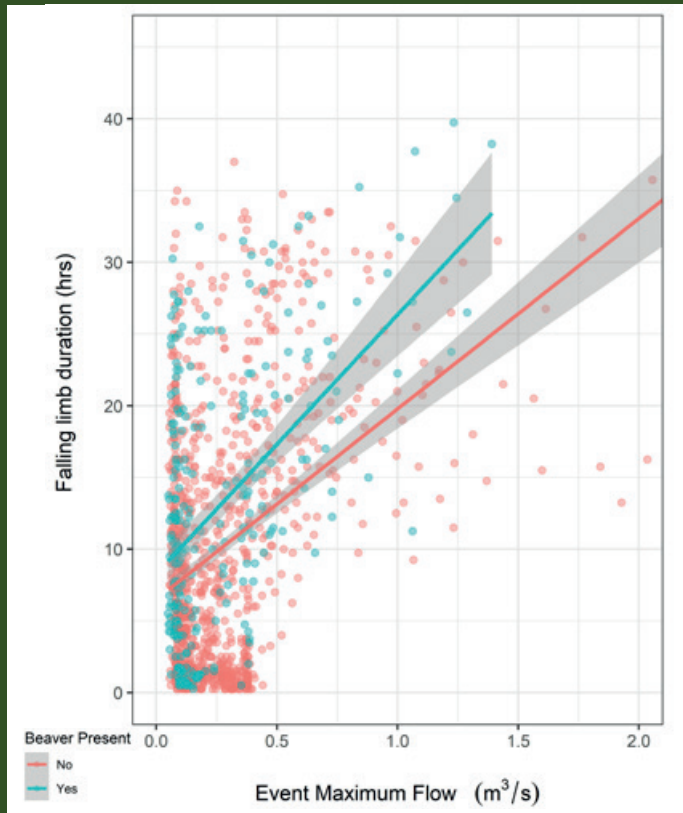


Figure 6.6 Relationship between maximum flow and the time taken for flows to return to a normal (base) flow for hydrological events before (red) and after (blue) beaver dams were constructed. After beavers constructed dams, the time taken for river flows to fall from their peak to base flow was, on average, greater than before dams were constructed. This indicates that water is being released from the beaver ponds more slowly, attenuating downstream flow.

which affected between two and five properties. According to publicly available data held by the Environment Agency, the River Otter area more broadly was subject to 166 flood alerts and warnings between January 2006 and December 2018[1].

The six beaver dams alter the hydrology locally by impounding water upstream and pushing water out onto the floodplain that was previously disconnected from the channel, due to historical deepening and straightening of the stream. The ponds cover 1000 m^2, with an average depth of approximately 0.7 m. Thus, the beaver dams hold water on the floodplain, pushing it sideways and releasing the water slowly, rewetting surrounding areas and creating a complex wetland environment.

In addition, the time that the water takes to flow into the site following rainfall and furthermore, the time that it takes to leave has also altered. Falling limb recession (the time it takes water to subside or leave the site) is longer, demonstrating that the flood hydrograph is attenuated (or flattened) by the presence of the beaver dams.

When compared with the detailed records of flood flows before beaver damming, more recent floods have been attenuated, taking longer to move through the site and demonstrating lower peak flow levels. The data show this effect persists even after large rainfall events and following periods of prolonged wet weather. This is because beavers have created a huge storage area within the floodplain above the village, routing water via complex flow-paths and increasing the roughness of the flow surface. Before beaver damming, water flowed at speed through the straightened and deepened channel.

The East Devon Catchment Flood Management Plan (CFMP)[2] for this area recommends "more natural river processes, creation of wetland habitats, and the reconnection of rivers with their floodplains" to mitigate flooding. The possible costs avoided have been assessed under ten hypothetical scenarios using the funding calculator for flood and coastal erosion risk management grant-in-aid allocation, a tool which is used in Environment Agency assessments and is openly available on the UK Gov website[3].

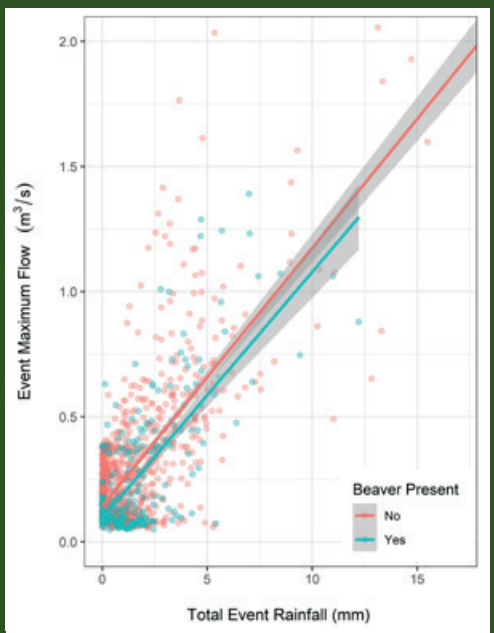


Figure 6.4 Relationship between total rainfall and maximum flow for hydrological events before (red) and after (blue) beaver dams were constructed. After beavers constructed dams, downstream flows were more likely to be lower for a given amount of rainfall.

Scenario	Details	Moderate Risk	High Risk	Very High Risk	Pre-Inflation			Post-Inflation		
					Benefit Per Year	**5 Year Benefit**	10 Year Benefit	Benefit Per Year	**5 Year Benefit**	10 Year Benefit
Properties Currently At Risk		***7***	***38***	***5***						
1	One moderate risk property downgraded to low risk	6	38	5	£150	£750	£1,500	£163	£815	£1,631
2	One high risk property downgraded to moderate risk	8	37	5	£450	£2,250	£4,500	£489	£2,446	£4,892
3	One very high risk property downgraded to high risk	7	39	4	£750	£3,750	£7,500	£815	£4,076	£8,153
4	All moderate risk properties downgraded to low risk	0	38	5	£1,050	£5,250	£10,500	£1,141	£5,707	£11,414
5	All high risk properties downgraded to moderate risk	45	0	5	£17,100	£85,500	£171,000	£18,588	£92,939	£185,877
6	All very high risk properties downgraded to high risk	7	43	0	£3,750	£18,750	£37,500	£4,076	£20,381	£40,763
7	All moderate and high risk categories downgraded one risk category	38	0	5	£18,150	£90,750	£181,500	£19,729	£98,645	£197,291
8	All high and very high risk categories downgraded one risk category	45	5	0	£20,850	£104,250	£208,500	£22,664	£113,320	£226,640
9	All properties downgraded one risk category	38	5	0	£21,900	£109,500	£219,000	£23,805	£119,027	£238,053
10	All properties downgraded to low risk	0	0	0	£30,600	£153,000	£306,000	£33,262	£166,311	£332,622

Table 6.2 – Potential weighted annual average damage costs avoided by the reduction of flooding by beavers under hypothetical scenarios[4]. As there are other surface water flows which contribute to flooding, it is thought that Scenarios 1 to 6 are more likely as a result of beaver impact.

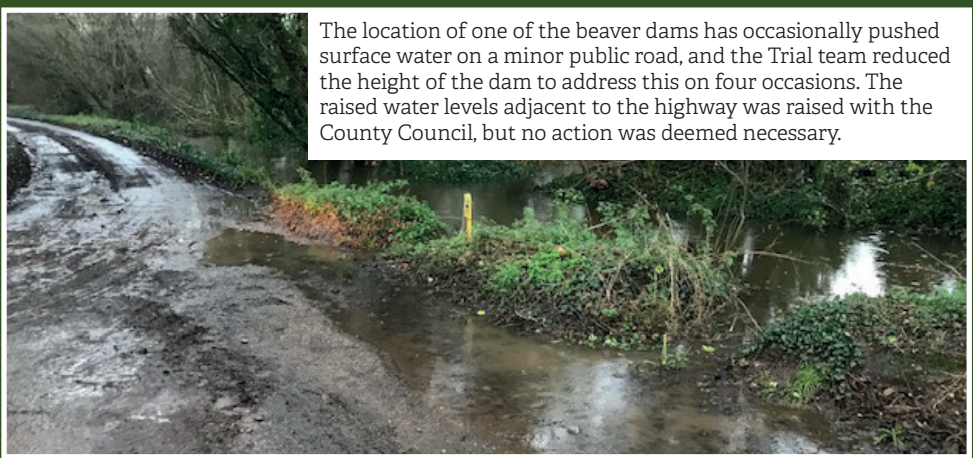
Costs - Impacts on agriculture

One impact of this additional water storage on the land was elevated water levels in the corner of a Grade 1, organic potato field, preventing the planting of 0.4 ha of first early seed potatoes (a high value crop) under a 5-year rotation. The costs of this waterlogging were £1,495 (profit foregone) and £600 for seed potatoes unplanted (used for cattle fodder)[5]. If the same area of field was affected the following year, this would impact upon a cash crop of spring barley leading to an estimated £227 gross margin loss[5]. For future avoidance of such costs, removal of 0.4 ha of the field from agriculture has been recommended.

Additionally, the corner of a pasture field and a ford became submerged / waterlogged making them practically impassable to machinery and livestock. This ford was moved to a different location to reconnect access between the two sides of the valley at a one-off cost of £900.

The landowner allowed the beavers to fell five poplar trees (one of which fell onto the farmer's fence), at a removal cost of £200.

Water flowing around the original beaver dam and across the floodplain, came back into the stream through an important gateway used for farm access. Rather than interfere with the flows, the decision was made with the farmer to move the gateway further downstream.



The location of one of the beaver dams has occasionally pushed surface water on a minor public road, and the Trial team reduced the height of the dam to address this on four occasions. The raised water levels adjacent to the highway was raised with the County Council, but no action was deemed necessary.

Due to raised water levels, 0.4 ha of Grade 1 agricultural land was impacted, preventing access by heavy machinery used to grow organic potatoes.

Large tree felling management

Prior to the arrival of the beavers, the majority of the failing poplar plantation that covered the wetland was proactively felled to prevent trees falling on an overhead powerline. However, approximately 10 large poplar trees were retained, and one of these has been felled by beavers onto the perimeter stock fencing. This is one of the few sites in the Trial where large trees are being felled, and on this site, the management response has been to allow the beavers to fell trees unrestricted. Protection measures can be used to prevent beavers gnawing trees, or trees can be proactively felled in a desired direction to prevent potential damage.

Flood Alleviation Cost-Benefit Analysis

As the potato field is in a 5-year cropping rotation with two high value crops, we have assessed the costs over five years against the benefit of the potential 5-year weighted annual average damage cost avoided. We used figures which account for inflation until 2018.

The estimated total potential gross margin loss from the two cash crops in the waterlogged field (organic first early potatoes and organic spring barley) was £1722. If just one property at high flood risk is downgraded to moderate risk as a result of the beavers' activity, the estimated benefit is £2446 over five years[4], thus there would be an estimated net gain of £724 over five years. If one property at very high risk is downgraded to high risk as a result of beavers, the estimated benefit is £4076, thus the net benefit in this instance is estimated to be £2304 over five years.

With the additional one-off costs at the site included (potato seed unplanted, ford relocation and felled poplar removal) the estimated economic cost is raised to £3422. This is below the estimated benefit for one very high-risk property being downgraded to high risk[4], with a net benefit of £654 over five years.

Therefore, if at least one very high-risk property has been downgraded by one flood risk category as a result of beaver activity, the economic benefits of reduced flood risk have outweighed the economic costs at this site. The benefit margin would increase if and where the number of properties where flood risk category has been reduced increases (see Table 6.2).

NB. It is important to note that it is crucial to develop innovative mechanisms to address the imbalance between those who derive benefit from the presence of beavers (e.g. local residents at risk of flooding and insurance companies) and incur no costs and those who are exposed to ongoing costs and derive little or no benefit.

Farmer perspectives

"Population is growing, demand on food is growing, world population is growing, diminishing natural resources out there, are all absolute facts of life. You can't deny any of that. So we do have to be mindful that food production has to be protected and kept going, but obviously it is important that we have a balanced view of that with not only protecting our natural habitat but also enhancing it as well. So I think having the two together is really good."

Public perceptions

An exploratory study was conducted via an online questionnaire. In the community downstream of the beavers 303 properties were invited to participate, 15 of whom did so (4.95% return rate). Comments received included the following:

"It appears to be a means of using nature to solve the problem of flood risk and may well reduce the need to use more expensive and perhaps more environmentally damaging engineered solutions."

"I would have thought that flood reduction by beavers would be minimal, and unreliable – to say the least."

"I believe this could be a fantastic opportunity to increase animal biodiversity in the area and is a positive measure that is environmentally friendly that can reduce flood risk."

"If it reduces flooding downstream, does that mean there may be flooding elsewhere?"

1. Environment Agency. Historic Flood Warnings. https://data.gov.uk/dataset/d4fb2591-f4dd-4e7f-9aaf-49af94437b36/historic-flood-warnings (2019).
2. Environment Agency. *East Devon Catchment Flood Management Plan.* (2008).
3. Environment Agency. Funding calculator for flood and coastal erosion risk management grant-in-aid allocation. https://www.gov.uk/government/publications/fcrm-partnership-funding-calculator (2014).
4. Penning-Rowsell, E. *et al. Flood and Coastal Erosion Risk Management I A Manual for Economic Appraisal.* (Taylor & Francis Group, 2014).
5. Lampkin, N., Measures, M. & Padel, S. 2017 *Organic Farm Management Handbook.* (Organic Research Centre, 2017).