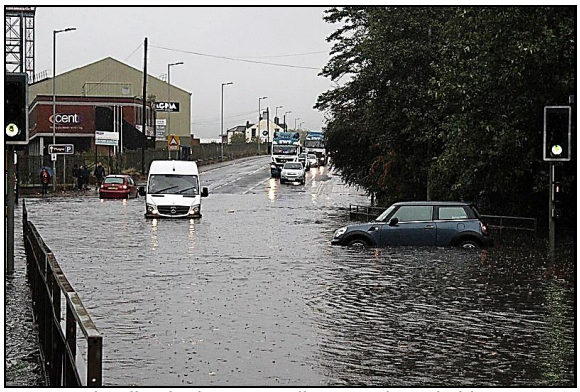
Inland flooding: a Sheffield case study

How should we respond to the increased risk of inland flooding as temperatures rise?

One of the outcomes of rising global temperatures is an increased risk of flooding. Many regions are planning flood control measures to try to mitigate this problem. This case study describes what is being planned or has been put into effect in the Sheffield region of South Yorkshire, UK.
In July 2007 the City of Sheffield experienced just one day of excessive rainfall, which resulted in disastrous floods and led to the deaths of two people, one of them a student on his way home from school.



Flooding in the Don Valley, South Yorkshire.

Following the 2007 flooding, some flood control measures were installed and others were considered, but in the winter of 2019/2020 sustained rainfall led to flooding throughout the catchment area of the River Don and its four main tributaries. Villages such as Fishlake on the Don flood plain were particularly badly affected.

Map of the River Don catchment area, with the Don itself coloured in dark blue

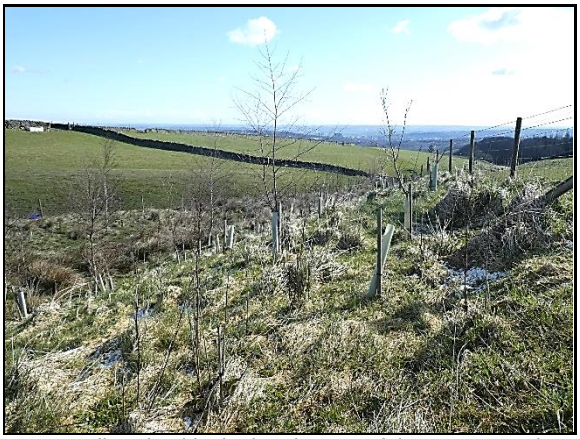
After the 2007 floods, Sheffield City Council proposed three approaches to flood risk: Slowing the Flow, Containing the Flow and Resilience. One such river to be controlled is the Porter Brook, which rises on Ringinglow Bog and joins the River Sheaf (another tributary to the Don) beneath Sheffield Railway Station in the city centre.

Slowing the Flow

Sheffield's five rivers rise in upland country and mostly flow on impermeable rock, so river levels rise quickly after heavy rain. Control measures could include:

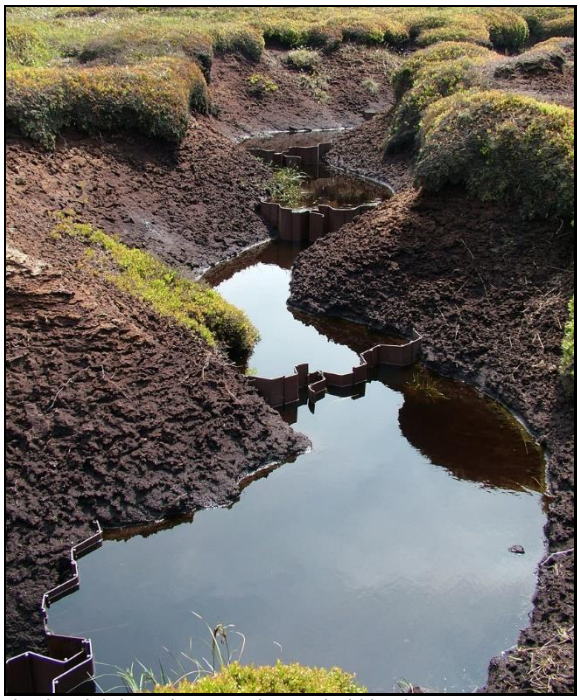
<u>Rural land management</u>:

- Tree planting can slow the run-off of water, like these saplings which were planted by local school children in the headwaters of the Porter Brook near Ringinglow.



Tree saplings beside the headwaters of the Porter Brook

- The sphagnum moss which makes up most of the peat in upland peat bogs absorbs far more water than trees. Where peat bogs have been drained to create grazing land or for grouse shooting, it is possible to stop the dried-out peat from blowing away in the wind by damming up streams across the bog, so that the moss can increase.

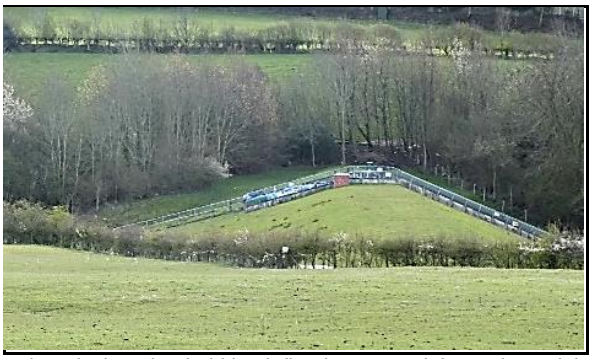


Plastic mini dams in a peat bog to hold back water to promote moss growth.

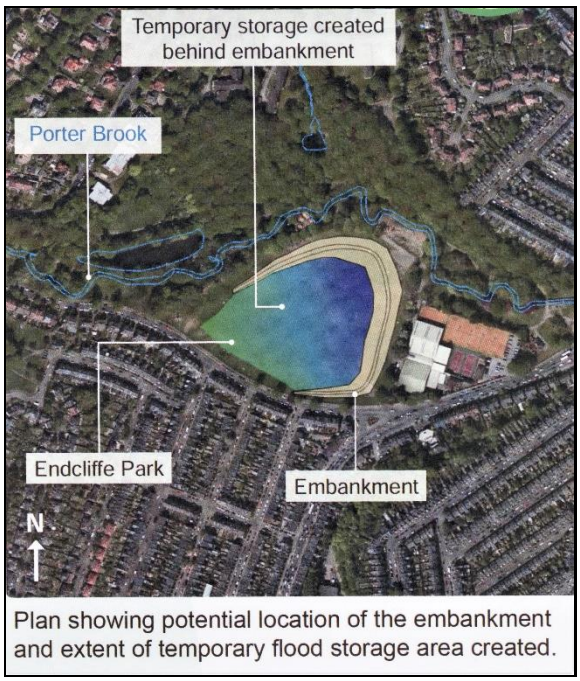
<u>Managing existing reservoirs</u>: The level of water in upstream reservoirs can be lowered in a controlled way when a bad storm is forecast, so that the reservoir will have space to hold back some of the storm water when it comes.

Redmires Reservoir in the hills to the west of Sheffield

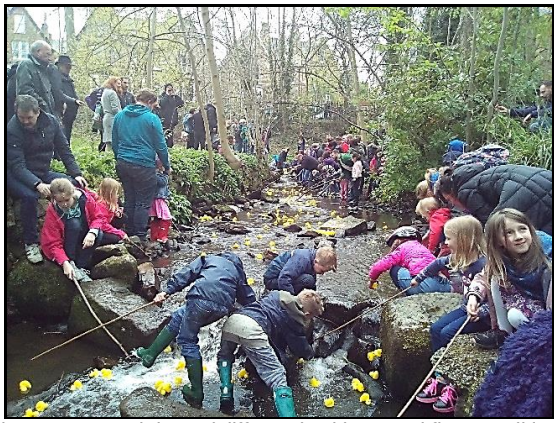
<u>Creating new storage areas</u>: In 2016, Sheffield City Council consulted the city population on plans to create temporary water storage areas in public parks and allotments lying in the tributary valleys to the River Don. Small dams across the valleys would fill with storm water and then release it gradually over several days after the storm had passed.


A dam designed to hold back flood water and then release it in a controlled way. Dronfield, near Sheffield

A related scheme would be to build embankments around wide open spaces on the valley floors, with the same purpose.



Sheffield Council's plan for an embankment in Endcliffe Park


The Porter Brook in Endcliffe Park with normal flow conditions – no sign of flooding on Duck Race Day!

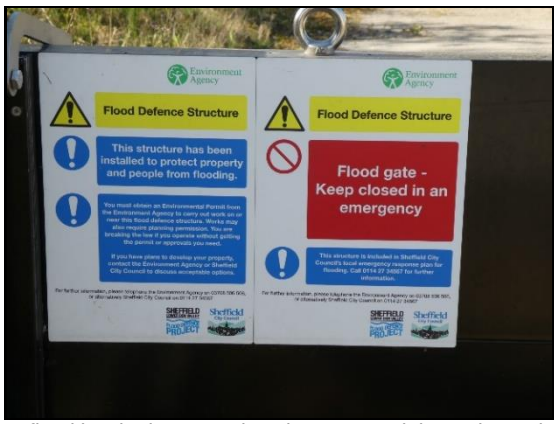
In addition to these expensive engineering solutions, community groups can build small scale structures to hold back some of the flood waters for a while. Recently, the Friends of the Porter Valley have built 'leaky dams' in the headwaters of the river, under the guidance of a Council Ranger, using fallen timber from the nearby woodland.


A 'leaky dam' constructed by volunteers

Containing the Flow

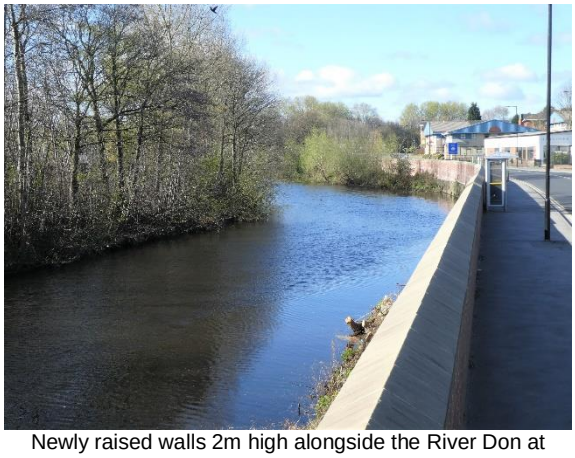
<u>Removing "pinch points":</u> This includes opening up river channels where they have previously been covered over with concrete, roads or buildings.

<u>Creating flood corridors:</u> Involves improvements to streets where flooding cannot be avoided, so that water which has overflowed can be allowed to flow safely back into the river as the level subsides.



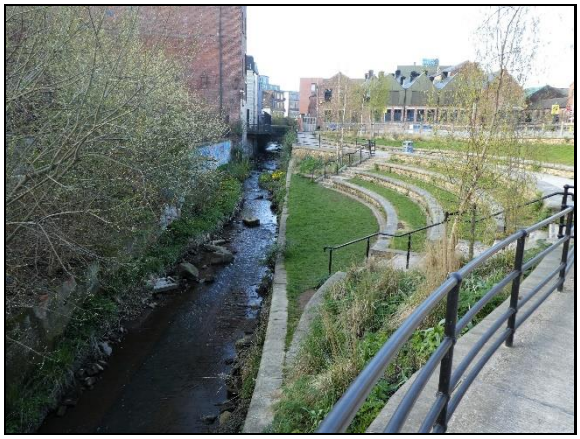
A flood barrier between the River Don and the main road, which can be opened or shut as required.

Improving flood defences: Walls can be built higher near to parts of the river where flooding occurs, to prevent it overflowing.



Newly raised walls 2m high alongside the River Don at Meadowhall.

"Pocket parks" can be created, providing a public space in normal weather, but which can flood without causing any damage in storms.



A pocket park alongside the Porter Brook, Sheffield City centre, created by removing the concrete car park which used to cover over the river.

Resilience
This means working with businesses and the community to care for the rivers themselves by clearing obstructions, and to plan for the response to flood events, including protection of property and giving adequate flood warnings.

Before any of these schemes were implemented, the City Council had to consult very widely, including official bodies such as the Environment Agency and many groups within the local community.
The descriptions mainly cover the advantages of the various schemes but there will inevitably be drawbacks. Ask students to study the proposals and invite them to suggest disadvantages which might be raised during consultation.
Then ask them to think about their own region and suggest which of the above proposals could be implemented. If they could be constructed, should they?

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The back up

Title: Flooding

Subtitle: How should we respond to the increased risk of inland flooding as temperatures rise?

Topic: A case study of flood mitigation measures affecting a flood-prone region of the UK.

Age range of pupils: 14 years upwards

Time needed to complete activity: 30 minutes or so, but more if pupils' local situation is to be researched.

Pupil learning outcomes: Pupils can:

- explain why some rivers rise quickly and flood in heavy rain storms;
- explain why flood control measures are required in the upper stretches of rivers and not on the lower flood plains alone;
- evaluate a variety of methods of flood control;
- apply a case study to their own region;
- decide whether some of the measures could and should be taken locally.

Context: The case study examines proposals for Sheffield which were implemented in time to alleviate flood damage between two major flood events, 12 years apart, and others which were not. Measures to contain the flow, i.e. removing pinch points, creating flood corridors and improving flood defences were largely successful – but only just, e.g. flood levels in November 2019 were within a few centimetres of overwhelming a major shopping mall at Meadowhall.

Some argued controversially that these "hard engineered" solutions protected Sheffield itself but exacerbated the situation in the Lower Don Valley, where Fishlake and neighbouring villages suffered disastrous flooding. The temporary dams and embankments proposed for the Porter Brook and the other four rivers were hotly debated and there has been no agreed outcome to date. Local groups would have accepted the embankment in Endcliffe Park, but two projected temporary dams upstream were objected to on the grounds of cutting off widely used recreational routes and damaging the ecology. One dam was even to have been built on an exposure of a rare band of

marine fossils in the Carboniferous Millstone Grit Series rocks. Only belated attempts have been made to plant trees or to re-wet the peat bogs in the headwaters of the rivers.

Pupils may think of such objections themselves: in addition they may suggest that some measures are very expensive and ugly; some industries and offices in a designated flood corridor would have to put up with their lower floors being flooded at times; controlling reservoir levels depends on accurate weather forecasts and may not be possible at short notice; planting trees or re-wetting peat bogs might reduce grazing land and would harm the livelihood of country people who depend on grouse shooting; there would be a lot of muddy mess in a public park after flooding had been controlled for a while by an embankment. They might also debate the wisdom of building houses on flood plains at times of increased inland flood events and rising sea levels.

Following up the activity: Find out about flooding risk in your own area and what measures have been implemented or are planned to mitigate the risk. Does your Local Authority's Plan include allowing building on flood plains?

Underlying principles:

- Increased global temperatures are leading to greater instability in the atmosphere and more frequent heavy rainstorms.
- Rivers with catchment areas on largely impermeable rocks rise quickly and are more prone to flooding than those on more permeable rocks.
- Flood mitigation measures comprise those which slow the flow of water and those which contain it.
- Flood control measures taken upstream may affect areas on flatter land downstream.
- "Hard engineered" structures are not always the most appropriate to control flooding.

Thinking skill development: Through construction, the potential impact of a flooding mitigation measure can be visualised. Discussing its impact from different perspectives will cause cognitive conflict and explanations will involve metacognition. Applying these ideas to other environments involves bridging.

Useful links: Search 'net-zero' on the Earthlearningidea website to find other Earthlearningideas relating to climate change mitigation or adaptation. Use a search engine like Google to explore the internet for more information about flooding and its control.

Resource list:

- paper copies or a screen version of this activity;
- local topographic map and where possible, geological map;
- a view from the window, or photographs of the local area.

Source: Written by Peter Kennett of the Earthlearningidea Team.

This information was as accurate as possible in summer 2022. The full list of 'net zero' emissions activities can be seen below.

Sources of images: Flooding in the Don Valley: https://commons.wikimedia.org/wiki/File:Bronagh_flooding.jpg This file is licensed under the Creative Commons Attribution-Share Alike 4.0 International license.
Map of the River Don catchment area: https://en.wikipedia.org/wiki/River_Don,_Yorkshire#/media/File:Don_(Yorkshire).png
Plastic mini dams in a peat bog: Copyright Stephen Burton and licensed for reuse under this Creative Commons Licence. (Geograph)
Endcliffe Park proposed embankment: Sheffield City Council
Other photographs by Peter Kennett

The ‘How will the ‘net-zero’ target affect your local area?’ series of Earthlearningideas

Topic			Earthlearningidea title
Introduction			How will the ‘net-zero’ target affect your local area?
Possible mitigation measures	Use alternative energy sources	Solar	Harnessing the power of the Sun
		Wave	Harnessing the power of waves
		Wind	Farming the wind: through onshore and offshore windfarms
		Tidal	Tidal energy
		Nuclear	Nuclear power - harnessing the energy of the atom
		Nuclear waste	Nuclear waste disposal
		Biofuel	Liquid biofuels: keeping our wheels turning into the future
		‘Blue’ hydrogen	Blue hydrogen: the fuel of the future? *Also:* Hydrogen of many colours
		Geothermal – hot rocks	Deep geothermal power from ‘hot dry rocks’: an option in your area?
		Geothermal – flooded mines	A new use for old coal mines
		Hydro – small scale	Small-scale hydroelectric power schemes
		Heat pumps	Heat from the Earth
		Waste – incineration	Energy from burning waste
		Waste – methane	Energy from buried waste
	Stop fuels releasing greenhouse gases	Carbon capture	Capturing carbon?
	Store energy from sources that give irregular energy supplies	Batteries	Nuclear batteries: the future?
		‘Green’ hydrogen	Green hydrogen used to even out renewable energy supplies? *Also* Hydrogen of many colours
		Hydro – storage	Matching supply and demand using stored water
		Compressed gas	Storing gas underground: What can we store? How can we do it? How will it help?
	Provide raw materials for new technologies	Electric vehicles	Electric vehicles: the way to go?
		Insulation	How do I choose the best insulation?
	Remove carbon form the atmosphere	Enhanced weathering	Speeding up nature to trap carbon dioxide
		Tree planting	Let’s plant some trees
Possible adaptation measures		Coastal flooding	How will rising sea level affect our coastlines?
		Inland flooding	Inland flooding: a Sheffield case study
		Landslides	Landslide danger
		Agriculture	The future for global agriculture