Presentation commentary

Title: An introduction to flooding

Slide 2: Types of flooding

The most common forms of flooding in the UK are:

- Surface water
- River
- Goundwater
- Coastal flooding.

The first part of this presentation briefly explains each of these types of flood event before moving on to examine the causes and management of river flooding in more detail.

Source of photo: Shrewsbury © Andy Owen

Slide 3: Surface water floods

Surface water floods can occur almost anywhere, including in towns and cities. They usually occur after periods of heavy rainfall.

The growth of towns and cities has increased the risk of flooding. Cities are full of impermeable surfaces – surfaces that water cannot soak into such as tiles, bricks, concrete and tarmac.

Slide animation:

- Without artificial drains under roads, they would flood every time it rains because the rain water would not be able to soak away into the ground.
- However, sometimes these drains become blocked or they simply cannot cope with a sudden, heavy downpour of rain. Then the roads quickly fill with shallow water – which is called surface water flooding.

Surface water flooding causes delays and disruption to transport. Cars break down in surface flood water so streets have to be closed to traffic. Railway stations and tube stations may need to close until the flood water goes down. Floods in London forced tube stations to close for 141 hours between January and September 2021. London Fire Brigade took over 1,000 emergency calls on 12 July and 25 July during severe surface water flooding.

Source of data: https://www.london.gov.uk/press-releases/assembly/zack-polanski/stations-closed-for-141-hours-after-flooding

Source of photo: https://upload.wikimedia.org/wikipedia/commons/thumb/3/3c/July_2021_London_floods_-_North_Circular_at_South_Woodford.jpg/800px-July_2021_London_floods_-_North_Circular_at_South_Woodford.jpg

Slide 4: River floods

River floods occur after heavy rainfall or after prolonged periods of rain. The river channel is like a conveyor belt, carrying water downhill towards the sea. After heavy rain the amount of water carried down the river channel increases and the level of water rises. Eventually, the capacity of the channel is exceeded – meaning that there is no space left in the channel to carry the water. Consequently, some water spills out of the channel – a process described as

the river bursting its banks. This causes flood water to spread across land beside the river channel.

In this photo, you can see the River Severn in Shrewsbury which has flooded across a footpath and into the playing fields of a school. Notice the lifebelt on a stand which is surrounded by flood water. This lifebelt is normally on dry land next to the river.

Slide animation:

- The blue shape shows roughly where the river channel is and the blue arrow shows the direction that the river is flowing.

Source of photo: Shrewsbury © Andy Owen

Slide 5: Groundwater flooding

Groundwater is water that is stored in pore spaces, which are small gaps, in the soil and rocks beneath our feet. Pore spaces near the ground's surface are usually full of air but pore spaces deeper down are saturated with water – which means the ground acts like a giant sponge. The upper surface of this groundwater store is called the water table.

The water table is not found at a fixed depth. In the summer the water table tends to fall. One reason for this is that water is pumped out of the groundwater store by water companies and farmers.

Slide animation: However, in the winter and spring the water table tends to rise as the pore spaces are refilled by winter rainfall. If the water table reaches ground level, water will appear at the surface and flooding can happen. This happens most often:

- After long periods of heavy rain
- In parts of the UK where the geology is chalk, sandstone or gravel.

Source of photo: Image of groundwater flooding at Great Shefford, Berkshire in 2014. Source: https://assets.publishing.service.gov.uk/media/606f16e78fa8f57356118b3c/GW_flooding_at_Great_Shefford.jpg

Slide 6: Coastal flooding

All of the flood events we have seen so far occur after heavy rain – and they can occur almost anywhere in the UK. Coastal flooding is quite different. It only occurs in coastal regions of the UK where the land is only slightly higher than sea level. Coastal parts of Lincolnshire, Norfolk and Essex in the east of England are particularly at risk.

This photo shows the town of Blakeney in Norfolk. The coastline is about 2km away – you can see a low ridge of sand dunes in the distance near the top of the photo. Between Blakeney and the sand dunes is a salt marsh. This is a very flat area of muddy land. A river channel flows across the salt marsh. Fishing boats have used this river channel to get to the sea for hundreds of years.

Slide animation:

- Twice a day the high tide comes in from the sea. The rising and falling of the tides is a daily process caused by the gravitational effect of the moon. The height of the hide tide varies slightly each day on a natural cycle. The greatest difference between high tide and low tide occurs just after a full moon – this is called the spring tide. In this second photo you can see how a spring tide has almost submerged most of the flat salt marsh.

Source of photos: Blakeney, Norfolk © Andy Owen

Slide 7: [Coastal flooding – no title]

Coastal flooding occurs when a spring tide occurs at the same time as low pressure is crossing the UK. Low pressure brings cloud, wind and rain. It also has a strange effect on sea water – it makes the level of the sea bulge upwards a little. So, if there is low pressure over the North Sea at the same time as a spring tide, then coastal areas such as Blakeney can suffer from coastal flooding. Sea water rises and begins to come inland. Since low pressure is usually accompanied by strong winds, the high tide can have large waves on top of it – raising the level of the sea even higher – and the wind can blow the waves onshore.

This photo shows a spring tide flooding the coast road at Blakeney. The air pressure was not low when the photo was taken.

Slide animation:

- The building on the opposite side of the coast road is at risk of coastal flooding. The water level laps against the bottom of the wall during a spring tide. But if the spring tide coincides with low air pressure, then this and other buildings in Blakeney are flooded.
- The plaques on the outside of the building show the height of past coastal floods. Notice that someone has fitted flood defences to the window to prevent flood water getting into the building.

Source of photos: Blakeney, Norfolk © Andy Owen

Slide 8: Flooding in the news

Flooding is often in the news. People lose their lives in the worst flood events. The Home Office reported over 11 deaths in England in the year 2019–2020: the highest number on record. Severe floods in Germany and Belgium made headline news across Europe in July 2021. At least 205 people were killed. It is estimated that the damage caused by these floods cost 30 billion euros to repair.

However, floods don't have to be life threatening to make headline news: even small floods can cause damage to homes, businesses and schools and threaten people's health and feeling of well-being.

Source of data:

- https://www.gov.uk/government/news/counting-the-costs-of-flooding
- https://www.dw.com/en/german-floods-up-to-30-billion-needed-for-recovery-fund/a-58807147
- Photo of Shrewsbury © Andy Owen
- Photo of Ahrweiler https://upload.wikimedia.org/wikipedia/commons/thumb/6/6d/Consequences_of_the_floodings_in_Ahrweiler%2C_Germany.11.jpg/800px-Consequences_of_the_floodings_in_Ahrweiler%2C_Germany.11.jpg

Slide 9: Impacts of flooding

It is difficult to live in a home or use a building that has been flooded with water. You should turn off the gas and electricity because there is a risk of gas leaks and electrocution – so that means there is no heating. Also, flood water is often contaminated with raw sewage – so you should avoid getting flood water on your skin.

This means that it is very difficult to continue using flood-damaged buildings, such as schools and homes, until the flood water has gone down and the property has dried out. The cost of repairing the damage caused by flooding to homes and businesses is huge: flood damage cost the UK £333 million between November 2019 and March 2020.

Flooding in 2015– 2016 was estimated to cost the UK economy £1.6 billion.

Source of data:
https://www.gov.uk/government/publications/flood-and-coastal-risk-management-national-report/flood-and-coastal-erosion-risk-management-report-1-april-2019-to-31-march-2020#flood-risk

Slide 10: What do we mean by vulnerability?

Floods can cause physical, emotional and economic harm. Vulnerability is a measure of how much harm could be caused during a flood.

Some land uses are also more vulnerable to the effects of flooding than others. This is because flood water does relatively little damage if it floods a green space in the city such as an urban park but it can cause a lot of physical and economic harm if it enters a care home, a school, a shop or other businesses.

The photo on the left shows a theatre in Shrewsbury next to the River Severn during flooding in January 2021. It is very vulnerable to the economic impacts of flood damage so it is protected from flood water by a flood wall and flood gates.

The photo on the right shows flood water spilling across a bowling green (on the right of the picture) and across tennis courts (on the left). The level of vulnerability of these land uses is relatively low because the flood water is not doing much harm to people or property.

Source of photos

- Both photos © Andy Owen

Slide 11: Is the risk of flooding increasing?

Records of rainfall (or precipitation) have been kept at some locations in England since 1766. As time has gone by, more weather stations – places that record the weather conditions every day – have been set up across England and Wales. These records are known as the EWP (England and Wales Precipitation) series and the data allows us to see whether patterns of rainfall are changing.

This graph shows rainfall intensity – the annual average amount of rainfall that fell per day (on days that had at least 1mm of rainfall) across England and Wales in the period 1960-2020. The trend, in black, shows a slight increase in intensity between 1960 and 1990. Since then, the intensity of rainfall has fluctuated but the five biggest peaks on the graph occur after 2020.

Source of data:

- https://blog.metoffice.gov.uk/2014/02/14/met-office-rainfall-records-how-far-do-they-go-back-and-what-can-they-tell-us/
- https://rmets.onlinelibrary.wiley.com/doi/epdf/10.1002/joc.7285

Slide 12: Winter rainfall

This graph takes a much longer-term view of how the UK's weather is changing. It shows the total amount of rainfall in each season since records began in 1766. Each season shows a fluctuation and overall, the total amount of rainfall hasn't really changed very much.

Slide animation:

- However, if we look at just the line for winter rainfall an interesting trend can be seen. This line shows a clear increase in winter rainfall. The wettest winter on record was in 2014, and 2016 was the eighth wettest on record.

Source of data:

- https://rmets.onlinelibrary.wiley.com/doi/epdf/10.1002/joc.7285

Slide 13: Climate change

The increase in winter rainfall may be an effect of climate change and a lot of research is currently being done to try to understand the effects of climate change on the UK's weather patterns. Models suggest that, as the Atlantic Ocean gets warmer, we might expect more rain and more intense rainfall during the winter months. If so, research suggests that the risk of flooding will increase. This map, produced by researchers at Heriot-Watt University, Edinburgh, suggests that all regions of the UK will face a greater risk of flooding – especially Scotland, Wales and the northern and western parts of England.

Source of data:

- https://www.sciencefocus.com/news/uk-flooding-could-increase-by-15-35-per-cent-by-2080/

New section: Slide 14: Why do rivers flood?

Slide 15: The drainage basin

To understand why rivers flood we need to understand how water moves through any drainage basin. When it rains, only a tiny proportion of the rain falls directly into rivers. Most rain falls onto the land and from here it gradually drains into the nearest river.

The diagram shows flows of water through a typical drainage basin.

Slide animation:

- Some water flows over the surface, over the ground and into the river. This is called overland flow and it happens when rainwater cannot soak into the soil, for example, when the soil is made of clay or when air spaces in the soil are already full of water from heavy rain in previous days.
- On most occasions some rain does enter the soil. This water moves slowly downhill between the soil particles – a process known as throughflow. Eventually some of this water will join the water that is flowing down the river.
- Some water percolates deeper into the ground and enters the bedrock beneath the soil where it can be stored for long periods of time. This water slowly moves downhill and, eventually, some of it enters the river.

The movement of water through the drainage basin means that the amount of water in a river increases for a while after the rain has fallen. The time gap between the rainfall and the river going into flood is known as the lag time.

Slide 16: Lag times – rivers

This diagram is an example of a flood hydrograph – a type of graph that shows how the amount of water flowing down a river changes after a heavy rainstorm. The horizontal axis shows time – usually marked in hours or days – depending on the duration of the flood.

Slide animations:

- This hydrograph shows the amount of rainfall as a bar. The axis for this bar is on the right of the diagram – so this graph shows that 30 mm of rainfall fell in a period of just over one hour.
- The amount of water flowing down the river is shown with a line on the hydrograph. The amount of water in the river is sometimes measured by its depth – in metres. However, another way to measure flow is in cubic metres of water per second (m^3/s – or cumecs). In this graph there are 4 m^3/s of water flowing down the river when the rainfall begins. While the rain is falling the amount of water in the river hardly changes. This is because very little of the rain falls into the river itself. Most falls into the drainage basin and it takes time to get into the river. However, soon after the rain stops the amount of water in this river begins to increase – we call this the rising limb of the graph. During this period of time the water in the river is getting deeper until it floods over the bank.
- The maximum amount of water flowing down the river is shown by this part of the graph. This is the peak discharge and it is about 23 m^3/s on this hydrograph.
- The length of time between the rainfall and the peak discharge is the lag time. In this example, the lag time is about three and a half hours. Lag times vary from one river to another. It depends on several factors, including the size and geology of the drainage basin. It is important to know the lag time because it gives people time to prepare for the flood that is coming.
- This part of the graph – the falling limb – shows the river gradually going back to normal after the flood.
- The baseflow is water that feeds into the river from the rocks in the drainage basin. Rocks release water into the river very steadily throughout the year and the amount of baseflow only rises a little, and very slowly, even after a big rainfall event.

Slide 17: Physical factors

Flooding depends on a number of physical factors which include location, relief, geology, weather and climate change. For example, the risk of being affected by a flood increases when these factors combine: for example, if you live close to a river in a location that experiences an unusual amount of rain. In the next two slides we will examine how geology affects flooding.

Source of photos:

- Photo © Andy Owen

Slide 18: Geology

Geology is a major influence on how quickly water flows through a drainage basin. Some rocks act like a sponge – chalk is a good example. When rain falls into a drainage basin that is made of chalk a lot of the rain soaks into the ground where it can be stored for long periods of time in the porous chalk. Eventually, the water emerges from a spring which supplies the river with water. This process is slow and steady so the river is unlikely to flood.

Other rocks are impermeable – meaning that water finds it hard to soak into the ground. Clay, slate and granite are all good examples. After a heavy rain storm most of the water runs over the ground and enters the river. This process is quick, meaning that the river is likely to flood.

On this map you can see that the drainage basin of the River Thames is made of two main rock types. The chalk is porous. It acts like a sponge and releases water slowly into the River

Thames and its tributaries. The mudstone and clay layer is impermeable. Water runs off these rocks and straight into the river – creating the risk of flooding.

Source:
https://www.researchgate.net/figure/Thames-River-Basin-UK-geographical-context-and-location-of-the-West-Thames-National_fig1_325058125

Slide 19: Geology influences lag times

This graph shows how geology affects the behaviour of two rivers. Each is a tributary of the River Thames. The horizontal axis shows the months of the year and the green bars at the bottom of the graph represent rainfall in 2000.

Slide animation:

- The black line shows the amount of water in the River Lambourn. This river has a chalk drainage basin. Notice how the line is very steady – it rises and falls steadily and seems to be unaffected by the rainfall shown by the green bars. This river is fed steadily by baseflow as water gradually seeps into the river from the chalk. It is unlikely to flood.
- The red line shows the amount of water in the River Ock. The source of this river is a spring in the chalk, so some water is constantly fed into the river from water stored in the chalk. However, the river flows across a clay valley. You can see how the red line fluctuates up and down. Each peak in the red line corresponds with a rainfall event. This river responds quickly and dramatically to rainfall – this type of river is sometimes described as a 'flashy river'. There is a short lag time so there is not much time to prepare for the flood.

Source:

- https://nrfa.ceh.ac.uk/uk-river-flow-regimes

Slide 20: Human factors

We have seen how physical factors, such as geology and the amount of winter rainfall, affect the amount of flooding. Human factors can also affect whether flooding may be likely.

Slide animation:

- The way we farm the land; the growth of towns and cities; the planting or removal of trees, the drainage of upland moors; and artificial changes to river channels can all make flooding more or less likely.
- Climate change, as we have already seen, increases the risk of flooding and human activities such as burning fossil fuels cause much of the climate change that we experience today.

New section: Slide 21: Flood management

Slide 22: Channel maintenance

River channels are like the gutters on a house: they need to be clear so that water can flow easily. If the gutters and downspouts of a house become blocked with leaves they stop working – and river channels are similar. The amount of water that a river can carry – its capacity – can be reduced if the river channel is full of silt, vegetation or litter and this may add to the flood risk.

Slide animation:

- Rivers carry a lot of sand, silt and mud as they flow along. Over time, some of this sediment is deposited on the bed of the river where it can build up into a thick layer.

- This thick layer of sediment reduces the capacity of the river channel – meaning there is less space for the water to flow. Now, when any extra rain enters the river, the chance of a flood occurring is increased.

To reduce the risk of flooding, the Environment Agency and land owners maintain river channels using a number of strategies. These include:

- removal of blockages: river channels can become blocked by fallen trees and by litter dumped illegally (such as shopping trolleys and old fridges). Fallen trees that become caught by the piers of a bridge, like in the photo, will act like a dam – blocking the flow of water and causing a flood, perhaps weakening the structure of the bridge. All of these blockages need to be removed periodically.
- managing vegetation: grass, shrubs and trees along the river channel need to be cut and maintained – especially where they are growing in the river channel and reducing the capacity of the channel to carry water at a time of flood.
- dredging: using a digger to dredge out some of the sediment from the bed of the river. This increases the capacity of the river channel – leaving more space for the water to flow.

Source:

- Photo: © Andy Owen

Slide 23: Hard engineering – straightening/deepening

Sometimes rivers are made deeper, wider or straighter to reduce the risk of flooding and protect the lives of people who live nearby. These photos show diggers removing rock from the channel of the River Valency in Boscastle, Cornwall. Boscastle suffered a terrible flood in August 2004 when 200mm of rainfall fell in just four hours. The flood was very destructive. 150 people had to be rescued by a fleet of helicopters.

The Environment Agency designed a flood defence scheme for Boscastle which cost £4.6 million and took two years to complete (2006–8). Downstream of Boscastle, the channel was widened, deepened and straightened. The wider, deeper channel has a greater capacity so it holds more water. Water moves quickly through the straightened channel so that water now flows quickly and efficiently down the channel and away from the town before it can cause a flood.

Source:

- All photos © Andy Owen

Slide 24: Hard engineering – walls and floodgates

The Environment Agency has built flood walls in many towns and cities to prevent flood water damaging homes and businesses. The flood wall in Keswick is 1.3km long and combined with 1.1km of embankment, these defences work together to manage river flows through the town. There is also 65m of culvert, 3 floodgates, 1 stoplog gate to divert water flow, a surface water pumping station and numerous valves on drainage outfalls to manage the flow of water.

In Shrewsbury the flood walls were built in 2004 to protect Frankwell – an area that includes homes, offices, shops and a theatre which you can see in the photo. The walls themselves are 3 metres high – high enough to stop water spilling over the top during normal and heavy rainfall. These walls are built on steel sheet foundations that are sunk 16 metres into the ground. These steel sheets prevent groundwater seeping up from the river and into the streets behind.

You can see flood gates in the wall. These are only closed when a flood is forecast. At other times they are left open so that people can have access to the river bank.

Source:

- Shrewsbury photo © Andy Owen
- Keswick photo © Environment Agency

Slide 25: Temporary (demountable) flood defences

The Environment Agency also uses temporary flood defences, known as demountable flood barriers, to hold back flood water when the river level rises. These barriers are erected when a flood has been forecast.

For most of the year, when there is no risk of flooding, the barriers are kept in storage. On the left you can see a tractor and trailer which has delivered demountable flood barriers to Frankwell in Shrewsbury because the river levels are rising and a flood has been forecast. The barriers are fixed to metal plates that are permanently bolted to the ground. On the right, two engineers are checking that a section of demountable barriers is working correctly.

Source:

- All photos © Andy Owen

Slide 26: Soft engineering – leaky dams

There are two main aims of soft engineering:

- to slow the flow of water as it travels through the drainage basin
- secondly, to create places where water can be stored in the upper part of the drainage basin

The Environment Agency use a number of strategies to do this – including leaky dams - and they describe these strategies as 'working with nature' or natural flood management.

Leaky dams are made of wood. Tree trunks or branches are laid across the river channel – usually a series of three or more dams a few metres apart. Normally the river water passes under the wooden dam. But, when the river is full of water after heavy rain, the leaky dams slow down the flow of water and encourage some water to spill out onto the floodplain where it is stored. Leaky dams delay the passage of flood water downstream, allowing sediment to settle out, and reduce flood risk in towns or cities further downstream.

Source of photo:

- https://www.ice.org.uk/ICEDevelopmentWebPortal/media/Disciplines-Resources/Case%20Studies/slowing-the-flow.jpg

Slide 27: River restoration

This photo shows the Swindale Beck in the Lake District. The river was straightened in the early 1800s so that the fields next to the river could be used for grazing. In 2018 the Environment Agency and its partners restored the river channel to a more natural meandering form. If you look carefully, you can see the old straight channel and the new meandering one in this photo. Water now moves much more naturally and slowly along the river channel. This helps to reduce the risk of flooding further downstream, in the town of Penrith.

Source of photo:

- Swindale Beck https://restorerivers.eu/wiki/images/thumb/3/3b/Swindale-2.jpg/800px-Swindale-2.jpg

Slide 28: How river restoration works

Over the last 200 years many of England's rivers have been straightened and widened. Embankments and walls have been built to try to prevent flooding. However, we now realise

that some of the changes made to rivers in the past are not helpful for people or the environment. By straightening rivers, for example, water is pushed down a river unnaturally quickly. By straightening rivers in the past we may have actually increased the risk of flooding further downstream. Nowadays, the Environment Agency tries to work with nature – so, in many places, rivers that were altered in the past are being restored to a more natural form.

Slide animation:

- A wide straight river channel is very efficient. Water moves down it quickly. If there is somewhere further downstream that is vulnerable to flooding then all of this water will arrive there quickly and could cause a serious flood.
- By contrast, a natural river channel has lots of meanders. Water moves down this channel much more slowly. If there is too much rainfall then the river will flood here – reducing the threat of flooding further downstream.

Slide 29: Flood planning and preparedness

No matter how much we try to control rivers we cannot prevent every flood. So, if you live or work somewhere that is vulnerable to flooding it is important to have a flood plan so that you know exactly what to do if a flood has been forecast.

The Environment Agency issues flood warnings when a flood is forecast for rivers and the sea – so if you live somewhere that is vulnerable to flooding you must understand what the three levels of warning mean.

Slide animation: The other thing you can do is make a personal flood plan. This means thinking about things like:

- How you can stop flood water entering your house and where to get sandbags
- Putting important documents somewhere safe where they can't be affected by flood water
- Knowing how to turn off the electricity, water and gas supplies
- And planning how to protect your furniture and other goods, for example, by making a list of items that could be moved upstairs if a flood warning has been given.

Source of image:

- https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/444659/LIT_4112.pdf