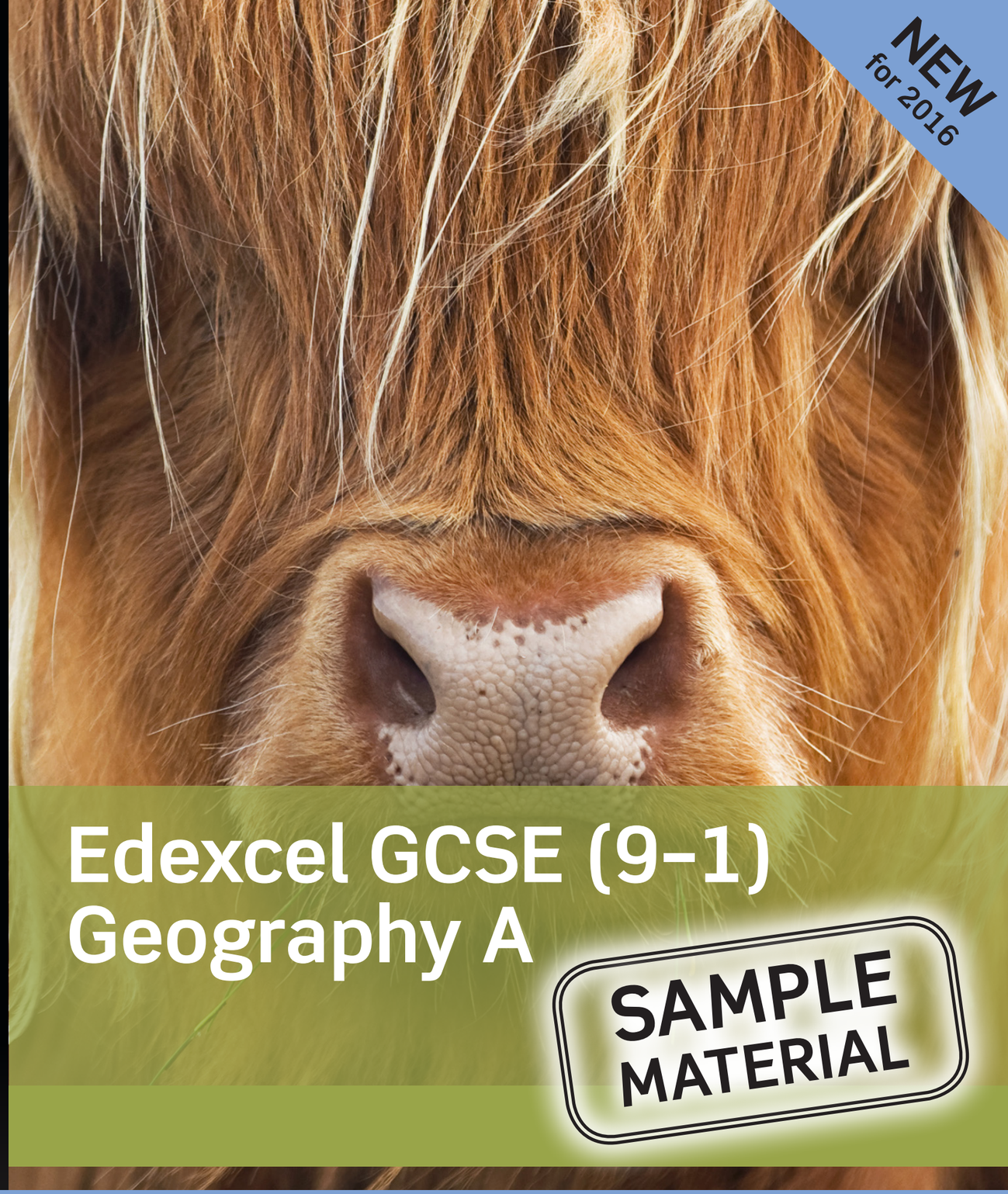

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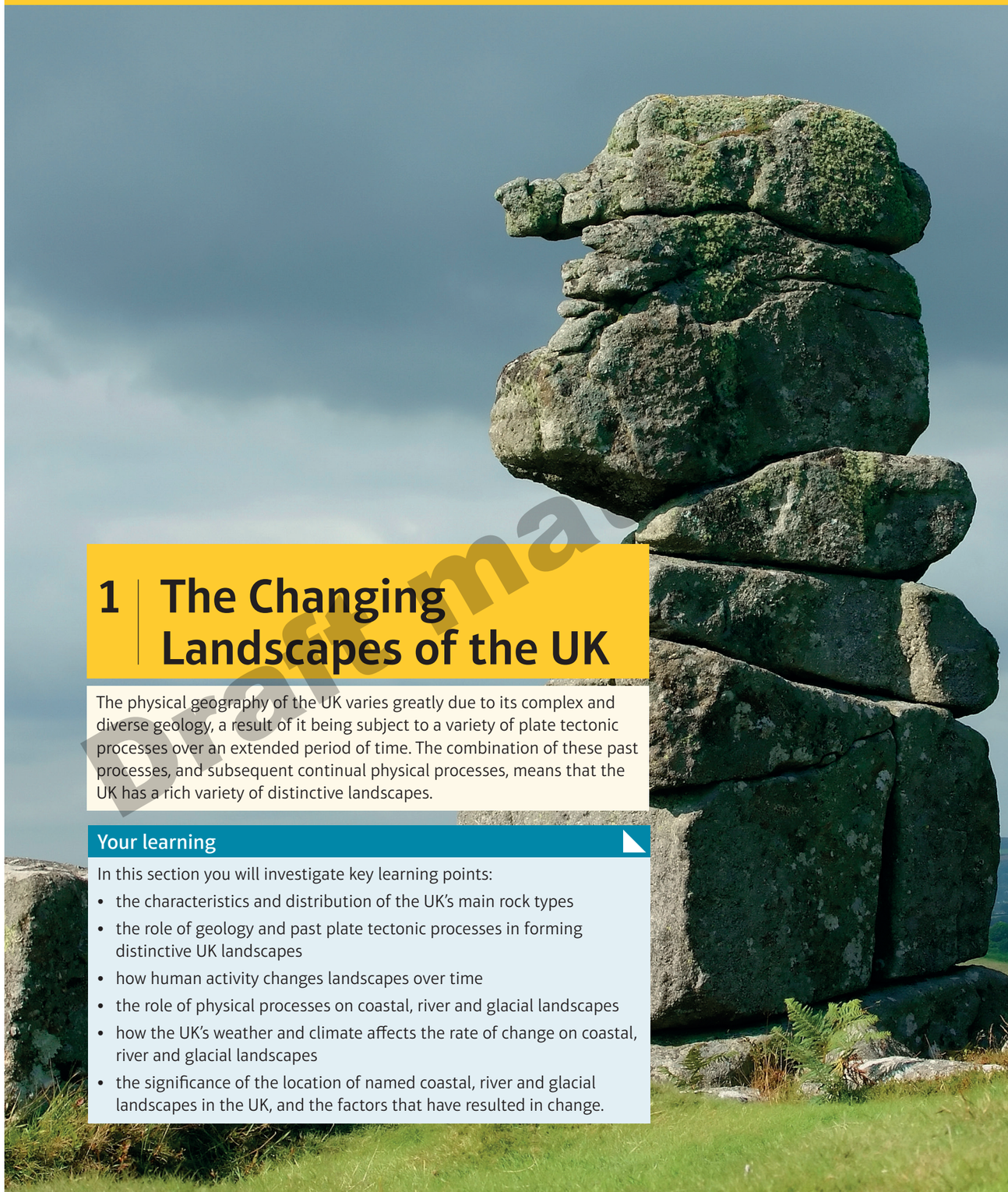


1 | The Changing Landscapes of the UK

The physical geography of the UK varies greatly due to its complex and diverse geology, a result of it being subject to a variety of plate tectonic processes over an extended period of time. The combination of these past processes, and subsequent continual physical processes, means that the UK has a rich variety of distinctive landscapes.

Your learning

In this section you will investigate key learning points:

- the characteristics and distribution of the UK's main rock types
- the role of geology and past plate tectonic processes in forming distinctive UK landscapes
- how human activity changes landscapes over time
- the role of physical processes on coastal, river and glacial landscapes
- how the UK's weather and climate affects the rate of change on coastal, river and glacial landscapes
- the significance of the location of named coastal, river and glacial landscapes in the UK, and the factors that have resulted in change.

1B River Landscapes and Processes

Drainage basins and river processes

Learning objectives

- To know the different processes that change river landscapes
- To understand the main processes operating in river channels
- To understand how geology and erosion, transport and deposition interact to form distinctive river landforms

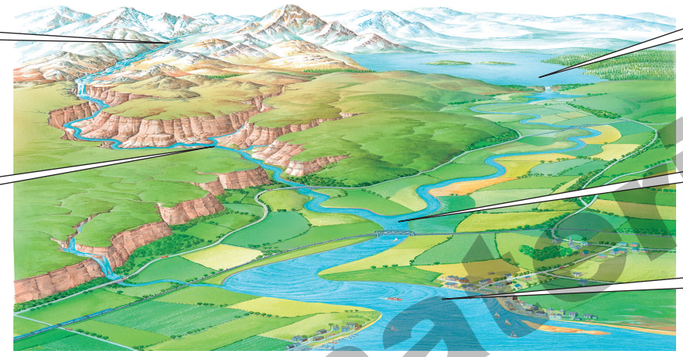


Figure 1 The drainage basin

A **drainage basin** is the area of land drained by a river and its **tributaries**. When it rains, much of the water usually finds its way into rivers eventually, either by moving across the surface or by going underground and moving through the soil or the rock beneath.

Figure 1 shows the location and definition of the key features of a drainage basin.

Exam-style question

Describe **one** way chemical (acid rain) weathering might have an impact on river landscapes.

(**2 marks**)

Exam tip

A good answer will link together two descriptive points that give the details of the process.

Command word

When asked to **describe** a physical process you should give the main characteristics.

The impact of processes on river landscapes

Different processes in the drainage basin act to change the river landscape.

Weathering is the breakdown and decay of rock by natural processes, usually acting on the river valley sides. The three key weathering processes that can affect river valleys are:

1. **Physical (freeze thaw)** – this happens when rainwater enters cracks or gaps in the rock and then freezes if temperatures drop below zero. The water expands as it turns into ice and then exerts pressure on the rock, causing it to break into smaller pieces.
2. **Chemical (acid rain)** – all rain is slightly acidic. If the air is polluted by factories and vehicles, it can become more acidic. When rain falls on rocks, the acid in it can react with weak minerals, causing them to dissolve and the rock to decay.
3. **Biological weathering** – the roots of plants, especially trees, can grow into cracks in a rock and split the rock apart.

Mass movement is the movement of rocks and soil downslope due to gravity, helped by weaker rocks, steep slopes and heavy rainfall. Mass movements can be very slow – only a few millimetres a year – or sudden and rapid. The types of mass movement that affect river valleys include:

1. **Soil creep** – where individual particles of soil move slowly down a slope.
2. **Sliding** – where material moves rapidly downslope in one go, for example in a landslide. In a **slump**, the material often rotates as it moves.
3. **Flows** – where masses of soil or rock, usually mixed with water, flow like liquid downhill.

The material moves down valley sides and collects at the bottom, where a river may then erode it. This makes the slope steeper, causing more mass movement.

River erosion involves the action of water wearing away the rocks and soils on the valley bottom and sides. Rivers have most energy for eroding and transporting **sediment** when there is a large amount of water and a steep gradient. Four key erosion processes can affect river valleys:

1. **Hydraulic action** – this results from the sheer force of the water hitting the river bed and banks and wearing them away. This action is particularly important during high-**velocity** flows.
2. **Abrasion** – this is caused by material carried in the river rubbing against the bed and banks of the channel, so wearing them away. Overall, abrasion causes most erosion.
3. **Solution** – river water is slightly acidic, so it can dissolve some rocks and minerals in contact with the river. Limestone and chalk are most affected.
4. **Attrition** – sediment particles carried in the river collide with each other, causing the edges to be knocked off. The continued collision of particles in the river causes them to become rounder and smaller downstream.

Activity

1 Create a mind map to represent the physical processes that cause changes to river landscapes. On your mind map, include:
   - **a** the definition of each physical process with a suitable drawing
   - **b** an explanation for how each physical process will cause a river landscape to change.

Tip When creating your mind map, use a colour code to represent erosion, weathering and mass movement processes.

Transportation of load in a river

A river picks up and carries material as it flows downstream. The four types of **transportation** processes are shown in Figure 2.

Deposition

When a river no longer has enough energy to carry its load, **deposition** occurs. As the river's **discharge** and velocity reduce, the heaviest material is deposited first, for example after flooding.

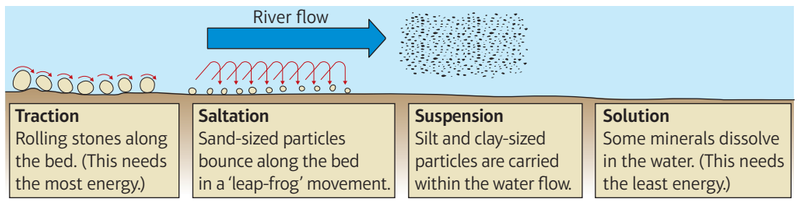


Figure 2 River transportation processes

1B River Landscapes and Processes

Figure 3 Interlocking spurs in the upper course of a river

Exam-style question

Explain how waterfalls are formed from the interaction of different processes. **(4 marks)**

Exam tip

When answering a formation question, you must include an explanation of how the processes lead to the landform. An **annotated** sketch is a useful way of explaining a complete sequence of processes.

How do river processes form distinctive landforms?

Interlocking spurs

Near their **source**, rivers are small and do not have a lot of power. They tend to flow around valley side slopes, called spurs, rather than being able to erode them. The spurs are left interlocking, with those from one side of the valley overlapping with the spurs from the other side. You can see these **interlocking spurs** labelled in Figure 3.

Waterfalls and gorges

A **waterfall** is formed along a river when a band of hard, more resistant rock lies over a band of soft, less resistant rock. The river erodes the less resistant rock at a faster rate, gradually undercutting the more resistant rock. The continued erosion of the soft rock by abrasion and hydraulic action causes an overhang of the hard rock. Eventually, the hard rock cannot support its own weight and collapses under the force of gravity. The force of the falling water and abrasion by large, angular boulders leads to erosion of the river bed and the formation of a **plunge pool**. As the soft rock continues to be eroded and the hard rock collapses, a steep-sided **gorge** is formed as the waterfall retreats upstream. Gorges form in hard rocks, where **vertical erosion** by rivers is dominant.

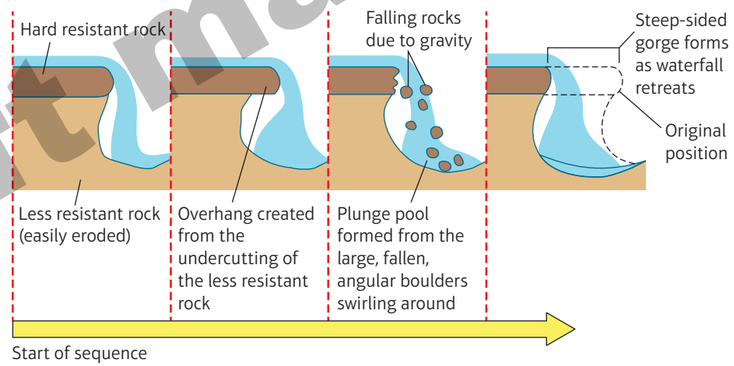


Figure 4 The stages in the formation of a waterfall

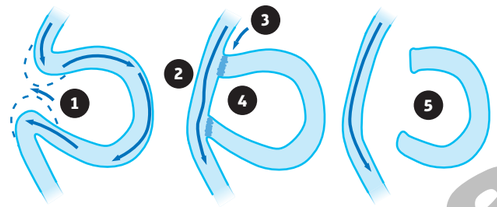
Figure 5 A meander bend on the River Dee in Cheshire

Meanders

Meanders are bends in a river's course, commonly found on a river's **flood plain**. The flow of the water swings from side to side, directing the line of maximum velocity and the force of the water towards the outside of the bend. This results in **lateral erosion** by undercutting and an outer, steep bank is formed. This is called a **river cliff**. On the inside of the bend the velocity and force of the water is less, leading to deposition and the formation of a gently sloping bank, known as a **slip-off slope**. The material deposited is called a **point bar** and is characteristically curved in shape. Due to erosion and deposition, the **cross section** of a meander is asymmetrical – steep on the outside of the bend, gentle on the inside.

Oxbow lakes

As a meander bends and develops, its **neck** becomes narrower. Eventually the river may erode right through the neck, especially during a flood. Water then flows through the new, straight channel and the old bend is abandoned by the river. Deposition at the neck seals off the bend, which gradually begins to dry up, leaving behind a horseshoe-shaped lake (Figure 6).



1. Narrow neck of the meander is gradually being eroded.
2. Water now takes the quickest route.
3. Deposition takes place, sealing off the old meander.
4. The meander neck has been cut through completely.
5. Oxbow lake – left behind when meander completely cut off.

Figure 6 Formation of an oxbow lake

Flood plains

A flood plain is the flat area of land either side of a river in its lower course. It is formed by erosion and deposition. Lateral erosion on the outside bends of meanders means they **migrate** across the valley floor and can erode the valley sides, so the valley floor becomes wide and flat. During floods, the flood waters spread out across the valley floor. As they slow down, with less energy for transport, the river deposits fine sediments called **alluvium**.

Levees

Levees are natural embankments of sediment formed along the banks of rivers that carry a large load and occasionally flood. In times of flood, water and sediment come out of the channel as the river overflows its banks. As it overflows, the river immediately loses velocity and energy and deposits the larger and heavier sediment first, on its banks. Repeated flooding causes these banks to get higher, forming levees.

Activity

Study Figure 5.

1 Draw a sketch of the meander bend shown in Figure 5. On your sketch label the key geographical features, for example river cliff.

2 Annotate your sketch to:

- **a** describe the key features
- **b** explain how different processes interact to produce these key features.

Checkpoint

Now it is time to review your understanding of the processes that interact to create landforms and change river landscapes.

Strengthen

S1 Think about weathering, slope processes and erosion. Which of these involve movement? Which happen mainly on valley sides?

S2 Put these river processes in the right order: deposition, erosion, transportation.

Challenge

C1 Summarise the formation of a flood plain in no more than 125 words. You must include: a description of the formation, key features, processes and an explanation. Underline in a different colour where you have explained.

C2 In the same way, summarise how oxbow lakes are formed.

C3 Classify the landforms on pages 4–5 into those formed mainly by erosion, mainly by deposition, or by both.

Case Study – The River Dee (Afon Dyfrdwy)

Learning objectives

- To know the changes in a river's valley and river processes between its upper, middle and lower course
- To recognise river landforms on OS maps at different scales
- To be able to interpret contour patterns and draw contour cross sections from OS maps

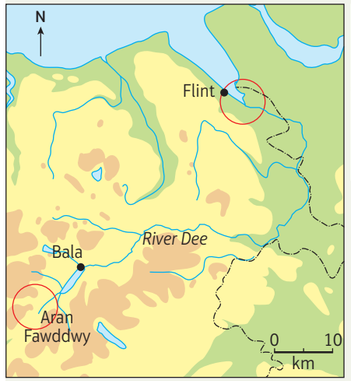


Figure 7 Map of the River Dee catchment

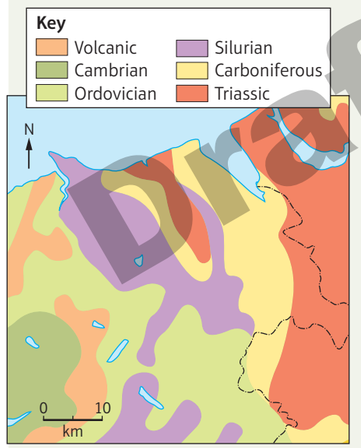


Figure 8 Geology map of the River Dee catchment

Did you know?

The River Dee is thought to be about three million years old.

The long profile

Geographers divide a river and its valley into the upper, middle and lower course. A river's **long profile** shows the height and distance downstream from the river's source to its **mouth**. It is a curved shape, steeper near the source and flatter near the mouth.

The upper course

The source of the River Dee is 460 metres above sea level on the slopes of Dduallt in Snowdonia National Park, North Wales. Here the average annual rainfall exceeds 3000 mm and **runoff** is high from the steep upland slopes. The geology is mainly hard igneous rocks, which are very resistant to erosion. Near the source, the channel is narrow, shallow and full of angular stones, so friction with the bed and banks slows the river down. In the upper course the river erodes vertically, cutting down into the landscape and forming a **V-shaped valley** with steep slopes, where processes such as sliding and slumping take place.

The middle course

As the River Dee leaves its upland area and flows downstream, the valley becomes wider and flatter, creating areas of flood plain, and its gradient decreases. The river now erodes sideways through lateral erosion as well as downwards, and there is some deposition, for example on the inside bends of meanders. Sooner or later the sediments will be eroded by the river again, so they become smaller and more rounded, and transported further downstream. As more tributaries join the River Dee, its discharge increases.

The lower course

In the lower Dee valley, the climate changes, with average annual rainfall less than 750 mm. The river flows through softer rocks, such as sandstones, towards Chester. Lateral erosion creates a wide valley with a flat bottom. The river channel also widens. Because it is deep and smooth, there is less friction with the river bed and banks, so the river's velocity is greatest. More tributaries increase the Dee's discharge. Here, lateral erosion and transportation continue and the muddy river water shows its **sediment load** is high. This encourages deposition, for example at the river mouth where the flow is checked by the sea. After 110 km the River Dee reaches its mouth in the Irish Sea between Wales and the Wirral Peninsula. This part of the river near Chester is called the **estuary** because it is affected by tides.

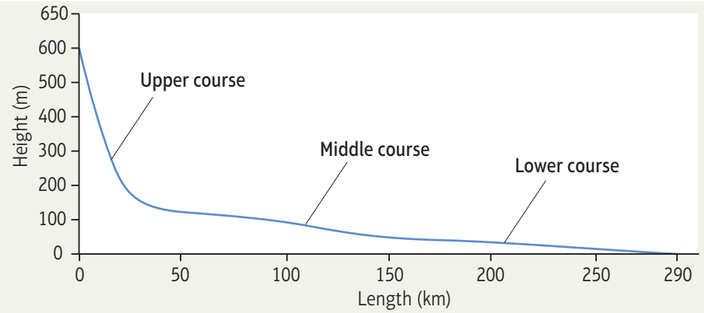


Figure 9 The long profile of the River Dee

Like most rivers, the characteristics of the River Dee change as it flows downstream. Geographers use Bradshaw's Model to summarise how these change between the upper, middle and lower course (Table 1).

Table 1 Characteristics of the River Dee: Bradshaw's Model

Characteristic	Definition	Change from source to mouth
Width	The distance from one bank to the other	Increases
Depth	The distance from the surface of the water to the river bed	Increases
Velocity	How fast the water is flowing	Increases
Discharge	The volume and speed at which water flows through the river channel	Increases
Gradient	The steepness of the river bed	Decreases
Channel roughness	How rough the river's bed and banks are	Becomes smoother, so less friction
Sediment size and shape	The material (sediment, debris) carried by the river	Becomes smaller and rounder

Activity

1 Draw a copy of Figure 9. Annotate the profile to show how the following change between the Dee's upper, middle and lower course:
   - **a** the gradient of the river channel and valley
   - **b** the width and depth of the river channel
   - **c** where vertical and lateral erosion are most important
   - **d** where friction with the bed and banks is highest and lowest.

2 Re-read the text on pages 4–5. On your profile, add details of the river landforms you would expect to find in each part of a river valley.

3 Draw a sketch map of the River Dee catchment (Figure 7). Using evidence from the text, label the upper, middle and lower course. Then annotate your sketch map with details of:
   - **a** differences in geology and climate in the Dee Valley
   - **b** where valley slopes are steepest and slope processes are most active.

4 Explain why the Dee's velocity and discharge increase downstream from its source to its mouth.

5 Use what you know about the geology of the Dee catchment and valley and river processes to explain why the river is usually clear near the source but muddy near the mouth.

Exam-style question

Study Figures 10 and 11. Which of the following is the best description of the River Dee on **each** map? **(2 marks)**

A A mountain stream near its source

B A river meandering across its flood plain

C A river flowing through a steep-sided valley

D A lowland river close to its mouth

Exam tip

If you check the map carefully, this type of question is usually straightforward. But watch out for choices which are nearly correct, but not quite right.

Investigating river landscapes using OS maps

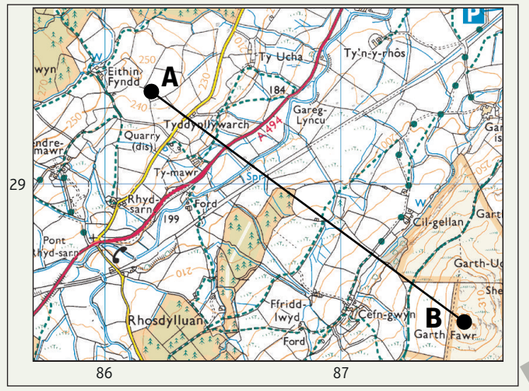


Figure 10 Extract from 1:25,000 OS map of the River Dee south west of Lake Bala

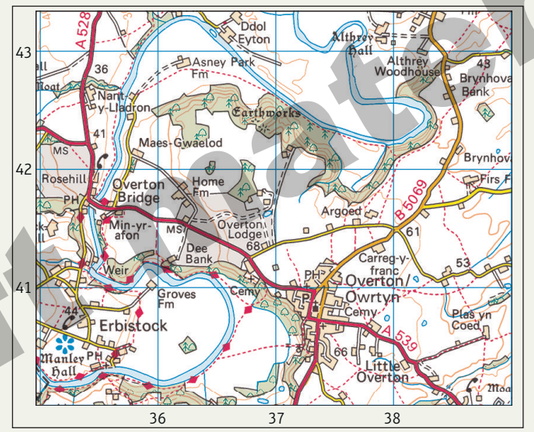


Figure 11 Extract from 1:50,000 OS map of the River Dee near Erbistock, Wrexham

Activity

1 Study Figures 10 and 11.

2 Choose one grid square from **each** map that includes the river. Draw two squares with sides 50 mm in your notes, then sketch the course of the channel across each.

a Decide whether the maps are of the upper, middle or lower course. Write a title for each sketch map including this information and its location.

b Annotate details about the river channel, for example its width and shape as it flows through the river valley.

c Look back to pages 4–5, then use map evidence to identify landforms in each part of the Dee Valley. Label them on your sketch maps, or list them with grid references.

How to draw a contour cross section

Contours are lines joining places of equal height above sea level. They also tell us how much the land slopes.

- Contours that are close together on the map show where the land slopes steeply.
- Contours further apart on the map show gentle slopes.
- Areas with few contours, or none at all, are flat: there is little or no gradient.

Drawing a cross section through the contour lines shows what the landscape looks like (Figure 12).

1 Choose where you are going to make your cross section. Place a strip of paper across the contour lines on the map.

2 Mark on the strip of paper each place where a contour line crosses it. Label the heights of the contours on your paper.

3 Make the horizontal axis the same length as your strip of paper.

4 The vertical axis is the height of the land from the lowest point to the highest point on the cross section.

5 Use the information on your strip of paper to plot the heights on the graph paper.

6 Join the dots and label some of the landscape features.

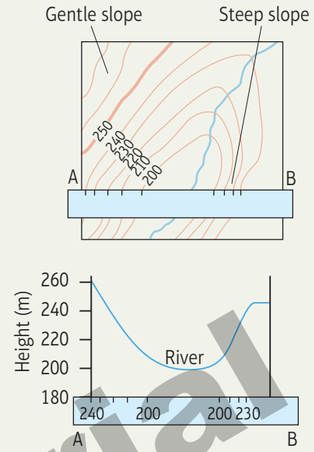


Figure 12 How to draw a contour cross section

Activity

1 Read the information about contours and then look again at Figures 10 and 11.

a Find areas of flat land, gentle slopes and steep slopes on the two maps.

b Describe the steepness of the valley sides and floor in each part of the River Dee.

2 Re-read 'How to draw a contour cross section' above.

a Draw a contour cross section between points A and B on Figure 10. Annotate details of the valley height and slopes, and the river channel.

b Choose and draw a cross section of a contrasting part of the river valley from Figure 11, and add similar details.

c Write a paragraph comparing the two contour cross sections, and what they show about different parts of the Dee Valley.

Checkpoint

Now it is time to review your understanding of landscapes and processes in different places along the long profile of the river.

Strengthen

S1 Describe the shape of a typical long profile of a river.

S2 Describe the differences in contour patterns you would expect to see on an OS map of the upper and middle course of a river.

Challenge

C1 Match these river landforms with the section(s) of a river's course where they are most likely to appear: levee, flood plain, interlocking spurs, meander, oxbow lake.

C2 Summarise the reasons for changes in the shape of a river's valley as it flows from source to mouth.

Changes in the Dee catchment

Learning objectives

- To know how people and the environment interact, causing change in the Dee Valley
- To understand the physical and human causes of flooding
- To understand the effects of flooding on people and the environment, and why the risk of flood is increasing

Figure 13 Flood embankments on the channelised section of the River Dee at Chester

Activity

1 Re-read pages 6–7 about the resources of the Dee Valley.

- **a** Make three lists: economic, environmental and social resources (some may be in more than one category).
- **b** Describe the impact a growing population may have on the resources of the Dee Valley.

2 Give examples of human activities which may reduce, and may increase the River Dee's discharge.

As you have found out, natural processes are constantly changing the River Dee and its valley. Like most UK rivers, they have also been used and changed by people for centuries. Today the River Dee and its valley are important resources for people and the environment.

- Ninety-four per cent of the catchment is rural, including forestry, sheep farming and pasture in the upper valley, and dairy farming and arable farming in the lower valley.
- The river is an important source of water for approximately three million people in Wales and north-west England.
- The river supports large areas of important habitats, including those for rare plant and wildlife species such as the otter and water vole.
- The River Dee and its estuary are famous for commercial and recreational fishing.
- Parts of the catchment, such as the Snowdonia National Park, contain beautiful landscapes which are popular for recreation and tourism.
- Key communication routes run alongside the River Dee, including the Chester to Holyhead railway line, as well as the A55 and the A483 primary roads.

With a growing population, particularly in urban parts of the catchment, pressure on the Dee Valley is likely to increase. A major problem is the increasing flood risk.

Human factors changing the river

In the summer the Dee's natural flow does not provide enough water to meet the demand from people and industry. Growing demand in the 1960s led to a number of **reservoirs** being built to store water during the winter months. One of the reservoirs, Llyn Celyn, can collect 327,000 cubic metres of water a day. A second reservoir, Llyn Brenig, collects 800,000 cubic metres of water a day and can hold 60 million cubic metres in total. These reservoirs help control the river's flow, and can reduce its discharge.

Near Bangor-on-Dee in the middle course of the river, earth embankments are used to protect farmland and properties from flooding. A land drainage pumping system at Worthenbury Meadows helps to remove excess flood waters.

Between 1972 and 1976, 8 km of the River Dee underwent **channelisation** between Chester Weir and its estuary to improve navigation (Figure 13). This change to the river's course resulted in increases to its velocity and discharge.

Physical factors changing the river

The UK's climate is naturally variable from year to year. In particular, the amount and intensity of rainfall has a direct effect on river flows. In periods of drought, river flows are low; by contrast, heavy rainfall and high surface runoff cause high river flows, when most erosion and transportation occur.

In future, climate change could lead to more variable weather, including an increased flood risk across the whole Dee catchment. In the Dee Estuary, rises in sea level will add to the flood risk.

Predicting the risk of flooding in the Dee catchment

The Environment Agency is responsible for managing the risk of flooding in England, as well as protecting the environment and water quality. It has produced a River Dee Catchment Flood Management Plan. By 2100, the plan predicts an increased risk of flooding caused by:

- increasing population – more people will be in areas at risk
- urban development and changes in land use, causing increased runoff
- climate change, including 20% increase in river flows, and a one metre sea level rise.

Together, these factors will increase the number of properties in the catchment at risk from a 1% flood event from 4200 to 6400, with most impact on Chester.

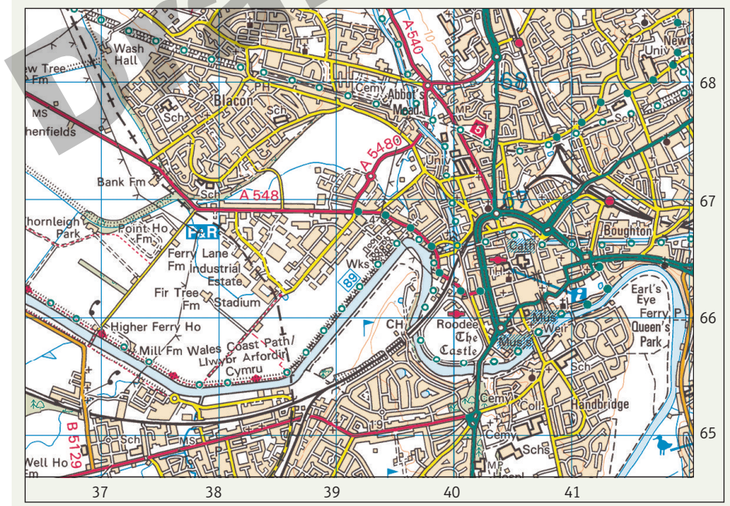


Figure 14 Extract from 1:50,000 OS map of the River Dee at Chester

Did you know?

You can download flood maps from the Environment Agency website. The Environment Agency uses probability to talk about how likely it is that a flood of a particular size will happen. A **1% flood event** has a 1 in 100 chance or greater of happening each year, or a probability of 0.01.

Activity

Study Figure 14 and an atlas.

1 Describe where the places with the biggest increase in flood risk are and explain this pattern.

2 Draw a sketch map of Figure 14.

- **a** Label one or more areas of flood plain.
- **b** Identify and label one area where development on the flood plain puts property at risk, and one type of land use suitable for the flood plain.
- **c** Label where there are flood embankments and where the River Dee has been channelised.

3 You have learned about physical short- and long-term changes in the Dee catchment.

- **a** Storms and droughts are short-term events: describe how they affect river processes.
- **b** Climate change is a long-term change: summarise its likely effects in the Dee catchment.

Figure 15 Flooding in Bangor on the River Dee, 2011

Activity

Study Figure 16.

1. Use the scale to estimate the size of the flooded area in Figure 16.
2. Identify **three** ways the river flooding might affect people living in the areas shown in Figure 16.
3. The South Downs is an upland area. Explain how the relief and different rock types affect the pattern of flooding.

Did you know?

A total of 4.6 million people in the UK are at risk from river or coastal flooding. Building on flood plains has put 2.3 million properties at risk of flooding.

Activity

Study Figure 17.

1. Classify the different effects of flooding in the UK into social, environmental and economic effects.
2. Which of the four flood events do you think is the odd one out? Explain carefully why you think it is different from the other three. Then find a different odd one out, or a different reason.

The causes and effects of flooding in the UK

River flooding is a natural hazard that has affected people and the environment in the UK for centuries. It can be made worse by human activities. Since 1998, significant flooding has occurred somewhere in the UK every year, and sometimes twice in a year. The average annual cost of damage from flooding is between £500 million and £1 billion.

Physical causes of flooding

A river floods when it overflows its banks causing water to spread out onto nearby land. A number of physical factors can lead to rivers flooding.

1. **Intense rainfall** – during periods of heavy rainfall, the soil and rocks can quickly become saturated. As **infiltration** is reduced, water flows over the surface and into the river at a faster rate.
2. **Duration of rainfall** – long periods of rainfall cause the soil to become saturated and prevent further infiltration of rainwater, leading to increased surface runoff.
3. **Snow melt** – in some places a lot of snow falls during the winter months. When temperatures rise above zero in the spring, all the snow that has built up melts, releasing large volumes of **meltwater**.
4. **Rocks** – different rock types in the catchment can affect flooding. **Permeable** rocks such as chalk allow water to soak in, so reducing surface runoff. **Impermeable** rocks such as clay do not allow water to pass through them, so rainwater will run off the surface and straight into the river channel (Figure 16).
5. **Relief** – water reaches the river channel much faster where slopes are steeper.

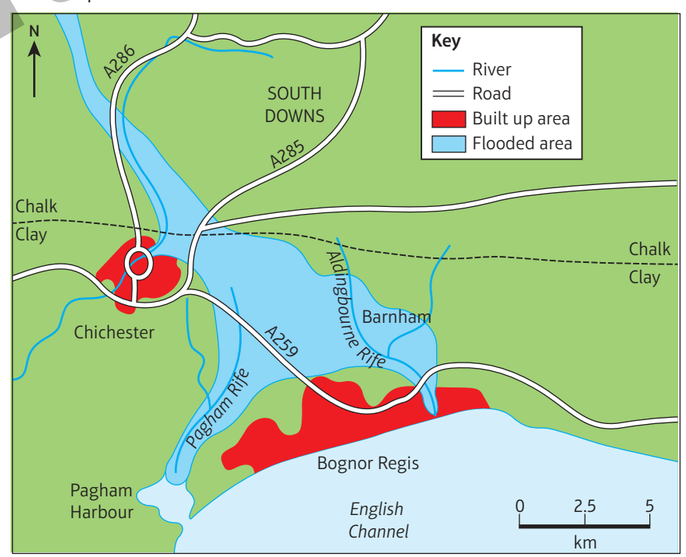


Figure 16 A map showing the areas affected by the flooding near Chichester

Human causes of flooding

1. **Deforestation** – vegetation collects, stores and uses water from rainfall: this is called **interception**. Plant roots also encourage water to pass into soil and rock, so vegetation reduces runoff: if it is removed, more water can reach the river channel more quickly.
2. **Urbanisation** – in towns and cities, rainwater will not infiltrate the hard, impermeable surfaces of concrete and tarmac. This causes the water to run off immediately into drains and river channels.

Climate change

Although any single flood event cannot be linked to climate change, most scientists think that a warmer climate is making extreme weather more likely. Warmer air can hold more water. One factor in a number of recent events is a change in the behaviour of the **jet stream**, which has brought more intense storms across the UK. In turn, this change in the jet stream may be linked to rising Arctic temperatures. Scientists believe these intense storm events, which would have previously occurred once in 100 years, are now more likely to happen once every 80 years in southern England.

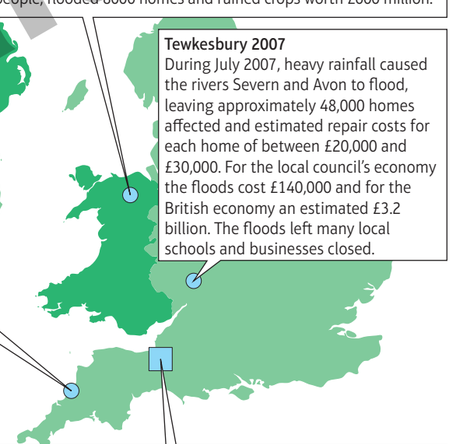
The effects of flooding on people and the environment

Floods can have wide-ranging environmental, economic and social effects. Figure 17 shows some recent flooding events and the effects these had.

UK November 2012
In 2012, it rained persistently from April to November. Between 21 and 24 November, a series of low-pressure systems crossed the UK, bringing strong winds and intense rain that fell on saturated ground, causing immediate surface runoff and flooding. North Wales, Cumbria and South West England were badly hit. 2012 was England's wettest and Wales' third wettest year on record, causing flooding in many parts of the UK that killed nine people, flooded 8000 homes and ruined crops worth £600 million.

Boscastle 2004
On 16 August 2004, a month's worth of rain fell in one day, leaving the small village of Boscastle in ruins. Around 100 homes and businesses were destroyed and 75 cars were washed into the sea. The tourist industry was significantly affected, with the Wellington Hotel's lower floor unrecognisable and many local businesses destroyed. The devastation caused by the floods left many local residents struggling to deal with what they had experienced during that day.

Tewkesbury 2007
During July 2007, heavy rainfall caused the rivers Severn and Avon to flood, leaving approximately 48,000 homes affected and estimated repair costs for each home of between £20,000 and £30,000. For the local council's economy the floods cost £140,000 and for the British economy an estimated £3.2 billion. The floods left many local schools and businesses closed.



Somerset 2014
During January and February 2014 in Somerset, persistent heavy rainfall resulted in disruption to transport (road and railway) because the flood waters took around 12 weeks to reduce. A total of 1000 hectares of farmland were left under water and six farms, including their animals, had to be evacuated. In the villages of Moorland and Fordgate homes were destroyed and local residents were evacuated because of fear for their safety.

Figure 17 Flood events in England and Wales

Checkpoint

Now it is time to review your understanding of the causes of flooding and the effects on people and the environment.

Strengthen

- **S1** Draw a concept map of the physical and human causes of flooding. Then add details of the causes, the links between them and any examples of relevant flood events from these pages.
- **S2** What is the difference between short- and long-term effects of flooding? Provide one or more examples of each.
- **S3** Give examples of suitable and unsuitable uses of land in flood plains.

Challenge

- **C1** Describe how human activities can increase and reduce the flood risk in a catchment like the River Dee.
- **C2** Turn a 1 in 100 flood into a percentage. Which is more likely to flood: land with a 1 in 100 or 1 in 1000 chance of flooding?
- **C3** Explain why climate change makes flooding more likely over time, but cannot be blamed for a single flooding event, for example, the Somerset floods in 2014.

The UK's increasing flood risk

Learning objectives

- To know why the risk of flooding in the UK is increasing
- To understand and be able to interpret the features of storm hydrographs
- To be able to construct a hydrograph and calculate the lag time

The flood risk in the UK is likely to increase in future. The main reasons are changes to land use, an increasing population and changes to weather patterns, particularly linked to climate change. For example, in December 2013 and January 2014, the UK experienced the wettest two-month period of rainfall since 1910. This led to the ground becoming saturated, causing high runoff and increased river discharge. The River Thames recorded its highest discharge for over 60 years. Figure 18 illustrates the difference between the previous and the most recent highest recorded rainfall.

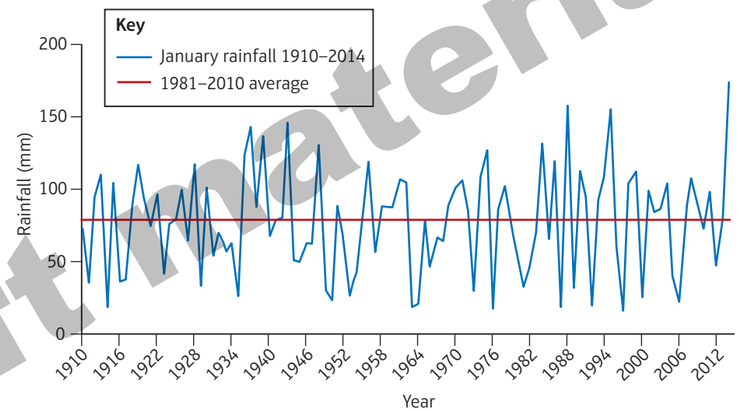


Figure 18 Rainfall in south-east and central southern England, 1910–2014

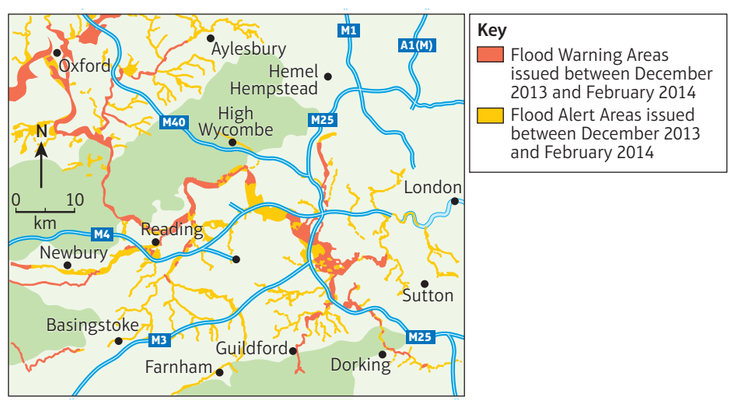


Figure 19 Flood warning and alert areas along the River Thames, January 2014

Activity

Study Figure 18.

1. Which year experienced the lowest January rainfall?
2. What is the difference between rainfall levels for 1988 and 2014?
3. Other than 1988 and 2014, which other year had a similar high level of rainfall?
4. Study Figure 19.
   - **a** Work out the length of the Thames between Oxford and Reading.
   - **b** Describe the distribution of flood warning and flood alert areas along the River Thames, using geographical language.
5. Some scientists think the weather is becoming more extreme, perhaps linked to climate change. What evidence from the text and Figure 18 supports/does not support this idea?

Storm hydrographs

A **hydrograph** shows how a river responds to a storm event. Figure 20 shows the relationship between rainfall (as a histogram) and the river discharge (as a line graph) for the River Severn in the record-breaking floods of July 2007. The discharge of a river is measured in cubic metres per second (cumecs).

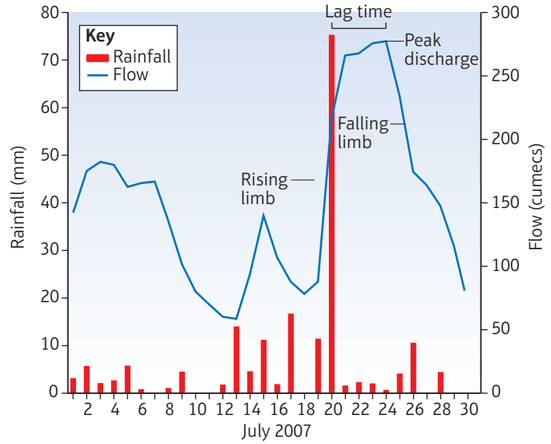


Figure 20 Flood hydrograph of the River Severn at Bewdley, July 2007

A hydrograph has a number of key features including:

- the **rising limb**, which represents the rapid rise in water after a period of heavy rainfall
- the **lag time**, which is the difference between the time of the heaviest rainfall and the point at which the river contains the largest amount of water
- the **falling limb**, which shows the reduction in the amount of rainfall reaching the channel.

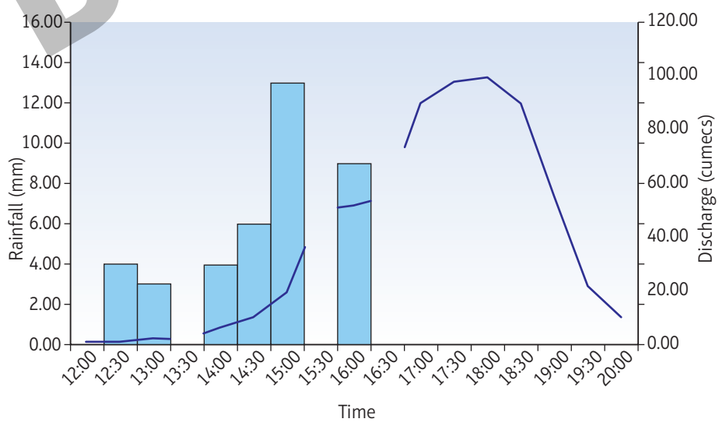


Figure 21 Flood hydrograph of the River Valency at Boscastle, 2004

Activity

Study Figure 21.

1. Copy and complete the flood hydrograph using the data below.

Time	13.30	15.30	16.30
Rainfall (mm)	10	15	3
Discharge (cumecs)	2	50	55

2. Label the rising limb, the lag time and the falling limb.
3. Calculate the lag time.
4. Compare the hydrographs for the River Severn and Boscastle. What are the similarities and differences between the two floods?

Managing flood risk

Learning objectives

- To know how the Environment Agency manages flood risk
- To understand the advantages and disadvantages of different techniques used to manage rivers and reduce flood risk
- To understand how river management techniques can lead to change in river landscapes

The Environment Agency manages the risk of flooding in England by:

- reducing the chances of a flood happening by managing rivers and land use, controlling development in flood plains and building flood defences
- reducing the impact of flooding by helping people prepare for flooding and giving flood warnings.

Flood defences

The Environment Agency works out where flood defences would be most effective in preventing floods, and where they would not cause environmental damage. In the past, people controlled floods by **hard-engineering** methods, often building defences out of concrete. However, these methods are expensive and do not reduce the risk of flooding in other parts of the catchment, and some may even increase it.

Table 2 Advantages and disadvantages of hard-engineering techniques

Advantages	Disadvantages
Embankments (levees) – high banks built on or near riverbanks	
They stop water from spreading into areas where it could cause problems, such as housing. They can be earth and grass banks, which blend in with the environment.	Flood water may go over the top, and then get trapped behind them. They can burst under pressure, possibly causing even greater damage.
Channelisation – this involves deepening and/or straightening the river	
This allows more water to run through the channel more quickly, taking it away from places at risk.	Water taken downstream may put other places at risk. It does not look natural.
Flood relief channels – extra channels can be built next to rivers or leading from them	
The relief channels can accommodate high flows so that a river will not overflow its banks.	They can be unsightly and may not be needed very often. Costs can be high.
Dams and reservoirs – barriers constructed to hold back water in artificial lakes	
They are long-lasting and can also be used to produce hydro-electric power (HEP) and provide a local water supply. They can be used for water sports.	They are expensive to build and can cause the displacement of people and ruin the environment. Some lakes suffer from the growth of algae.

Longer term, **soft engineering** may be the answer, using a more natural approach to managing floodwater. This approach aims to create space for floodwater in the landscape, which also reduces the risk of flooding in other areas. Soft defences are usually cheaper, need little maintenance and often provide habitats for wildlife.

Table 3 Advantages and disadvantages of soft-engineering techniques

Advantages	Disadvantages
Washlands – areas on the flood plain that are allowed to flood	
These give a safe place for floodwater to go and help slow floodwaters down. This also improves a river's natural sedimentation processes – the soil structure in the flood plain is restored, making it more efficient at storing water.	Allowing land to flood may limit the use of the land, for recreation for example, or mean a change of land use, for example a change in farmland.
River restoration – restoring the river's original course	
Restoring rivers to a more natural course by taking away embankments aims to slow them down, for example by restoring meanders. Natural rivers are more attractive and create natural habitats for wildlife.	Some flood banks are often still needed, and like flood-plain retention, changes in land use may bring some disadvantages.
Flood-plain zoning – governments allocate areas of land to different uses, according to their level of flood risk	
Flood risk management aims to prevent building homes and businesses in high risk zones. Here, uses such as open space for leisure and recreation are allowed because flooding would be less costly.	These may not be the best places for the different activities in terms of public accessibility. Flood plains are attractive places to build.

Land-use management

The way land is used and managed in a river's catchment has a significant impact on the risk of flooding. Changes in land use such as deforestation and urbanisation increase the amount and speed of surface runoff and river discharge. By contrast, improving land use aims to help rainwater infiltrate into the soil and slow runoff, for example:

- **afforestation** helps reduce the flood risk because woodland intercepts rainfall, and tree roots encourage infiltration of water
- managing farmland can reduce runoff, for example by avoiding overgrazing by animals, and ploughing across slopes rather than downhill
- managing drainage in urban areas more sustainably helps reduce flash flooding, for example by increasing green areas and building ponds to store runoff.

Exam-style question

Describe the differences between soft and hard engineering. **(4 marks)**

Exam tip

It is important when you are asked to describe the differences that you use connective words such as 'whereas' to form descriptive sentences.

Activity

1. Summarise the main costs and benefits of hard and soft engineering, adding examples of different techniques.
2. Using three shades, colour-code your notes to show which costs and benefits are economic, environmental and social.
3. Explain why zoning and land-use management may be a useful way of managing flood risk in the long term.
4. Look again at the different techniques for hard and soft engineering and land-use management. Thinking about the Dee Valley, can you put them into a rank order?

Reducing the impact of flooding

Figure 22 Flooding around the village of Moorland on the Somerset levels, 2014

Sometimes flooding is inevitable, as in 2012, 2013 and 2014. Then the Environment Agency tries to reduce the impact on people, land and property. Through its website and the news, the Environment Agency provides an up-to-date overview of potential areas at risk, using flood warning feeds, a live flood warning map and a three-day flood risk forecast. There are three warning levels: flood alert; flood warning and severe flood warning (Figure 23).

Figure 23 The Environment Agency flood warnings

The Environment Agency and local government and agencies work together to educate people about the hazards of living in flood risk areas. They use television, the internet, leaflets, helplines and training exercises to make people aware of what they should do before, during and after a flood. Advice for homeowners includes the following:

- lay tiles on the ground floor and use rugs instead of fitted carpets
- raise the height of electrical sockets to 1.5 metres above ground floor level
- fit stainless steel or plastic kitchens instead of chipboard ones
- position any main parts of a heating or ventilation system, such as a boiler, upstairs
- fit removable door barriers and non-return valves to all drains and water inlet pipes
- replace wooden window frames and doors with synthetic ones.

Local government will only give planning permission to build properties near a river if a full flood risk assessment has been completed. The new laws set out by the government in 2010 state that all new properties built near rivers need to be flood resistant.

Activity

Look back at your learning in this topic. Examine why the River Dee Valley is prone to flooding. Give an example of its impact and a way in which it can be managed.

what to do in an emergency

Listen to and act on the advice of the emergency services. Follow these simple steps to stay safe.

1. Gather essential items together either upstairs or in a high place.
2. Fill jugs and saucepans with clean water.
3. Move your family and pets upstairs, or to a high place with a means of escape.
4. Turn off gas, electricity and water supplies when flood water is about to enter your home if safe to do so. DO NOT touch sources of electricity when standing in flood water.
5. Keep listening to local radio for updates or call Floodline 0845 988 1188.
6. Flood water can rise quickly, stay calm and reassure those around you. Call 999 if you are in danger.

Important! Flood water is dangerous

- Avoid walking or driving through it.
- Keep children and vulnerable people away from it.
- Wash your hands thoroughly if you touch it.

Figure 24 Advice on what to do if flooding occurs

Command word

Examine questions ask you to break something down into its different parts. Here you could explain how different physical and human processes contribute to the flood risk on the Dee, then link these to their impact and ways to manage the floods.

Checkpoint

Now it is time to review your understanding of how flood risk management can reduce the chances of flooding, and its impact.

Strengthen

S1 Give two reasons why people in the UK will be at greater risk of flooding in future.

S2 Summarise the advice for homeowners living in a flood risk area.

S3 Explain why planners have strict rules about new development in flood plains.

Challenge

C1 Describe the environmental benefits of soft engineering techniques.

C2 Summarise how the Environment Agency tries to reduce the impact of flooding. Categorise the activities into short, medium and long term.

C3 Compare engineering techniques and land-use management. Which do you think are most likely to reduce the flood risk in places like the Dee Valley in future?

River Landscapes and Processes

Rivers shape the world. The majority of people live on or close to major rivers and we all depend on the food grown on their flood plains. We use rivers for transport, power, water, food and recreation. Rivers are also dangerous; more people are killed by river flooding than by any other natural disaster.

Checklist

You should know:

- ☐ the drainage basin terms – watershed, confluence, tributary, source and mouth
- ☐ the physical processes of erosion, mass movement and weathering
- ☐ the characteristics of a river profile and how these change from the source to the mouth
- ☐ how the UK's weather and climate affect river processes and impact on landforms and landscapes
- ☐ how erosion processes and geology influence the development of river landforms such as interlocking spurs, waterfalls and gorges and river cliffs
- ☐ how depositional processes cause the formation of point bars, flood plains and levees
- ☐ how the interaction of deposition and erosion cause the development of river landforms such as meanders and oxbow lakes
- ☐ why human activities and changes in land use affect river processes and impact on river landscapes
- ☐ the physical and human causes of river flooding
- ☐ how river flooding affects people and the environment
- ☐ the advantages and disadvantages of different defences used on UK rivers
- ☐ how one named distinctive river landscape has been formed and the most influential factors in its change.

Which key terms match the following definitions?

a The area of land drained by a river and its tributaries.

b The breakdown and decay of rock by natural processes.

c The movement of material down a slope due to gravity.

d The speed at which a river flows, often measured in metres per second.

e A type of erosion where particles carried by rivers are worn down as they collide with each other, becoming smaller and rounded.

f A wide, flat area of land either side of a river in its middle and lower course.

g Using artificial structures to prevent river or coastal flooding.

h A bend formed in a river as it winds across the landscape.

i The starting point of a stream or river, often a spring or a lake.

j A diagram showing the shape of a landscape as if cut through sideways.

To check your answers, look at the Glossary on pages 30–31.

Preparing for your exams

River Landscapes and Processes

Question 1 *Explain **one** physical and **one** human cause of flooding.* *(4 marks)*

Student answer

One cause of flooding is deforestation. This causes flooding because removing the trees reduces interception, causing more rainwater to reach the river channel faster.

A second cause of flooding is urbanisation. This is where humans build near rivers, using hard, impermeable materials. This causes flooding because the rainwater will not infiltrate into the concrete, causing the rainwater to run-off into the river channel at a quicker rate.

Verdict

Part 1 is correct – the answer has identified a correct cause, 'deforestation', and explained the reason why this causes flooding – 'reduces interception'.

Part 2 is incorrect. Whilst the human cause is correct, the question asks for **one** physical and **one** human cause of flooding. The student should have explained a physical cause of flooding.

Exam tip

The student has not answered the question being asked. Reading the question through at least a couple of times can help avoid this sort of mistake. Underlining key words can also help you to focus. Finally, if at all possible, leave time to check back on your answers to make sure you really have answered the questions being asked in each case.

Question 2 *Examine how different river processes work together in the formation of a meander.* *(6 marks)*

Student answer

A meander is a bend in a river's course, which is often found in the lower course of a river. The formation of a meander results from a combination of erosion and deposition processes. On the outside of the bend the water is deeper and the current is flowing with greater speed. The force of the water causes undercutting of the bank through abrasion, which is where material carried in the river rubs against the bed and banks of the channel, causing a river cliff to form. On the inside of the bend the water is flowing at a much slower velocity. More friction and therefore less energy means that deposition occurs on the inside of the river bend. Over time sediments are deposited, forming a point bar and slip-off slope and eventually a floodplain.

Verdict

This answer precisely answers the question, by examining the physical processes that work together to form a meander. It includes key geographical features relating to meanders.

Exam tip

Once again it is important to answer precisely the question being asked – in this case you need to examine the interaction of physical processes to form a meander. You will need to learn the key features of landforms, the physical processes and how these cause the formation. Good answers will also include accurate use of geographical terms.

Learning objectives

- To understand how to conduct a geographical investigation of change in river valleys and channels
- To know how to choose enquiry questions, fieldwork methods and data sources for a river investigation
- To know how to present, analyse and evaluate data collected from a river investigation

Activity

1 Using your knowledge of the changes in the long profile of the River Dee, create another two key questions that would help you to answer the main task question.

2 Using your wider geographical knowledge, suggest the results you would expect for your chosen key questions based on a typical river profile. Refer to Bradshaw's Model.

F The enquiry question

When conducting a geographical enquiry, it is important to have a purpose. One way to do this is to ask a task question.

For this enquiry on rivers, the task question is:

How do the river valley and channel characteristics vary along the River Dee?

To help answer the task question, geographers next devise some key questions. These help to provide a focus for the enquiry.

For this task, one of the key questions is:

Does the width and depth of the river channel increase as the river flows downstream?

F Locating the study

It is important to provide maps showing where the investigation is located. You should include maps at a local and a national scale, plus detailed maps showing your survey or data collection sites. You can then use your location and survey site maps to give a detailed overview of the place in which your investigation will take place. This part of your enquiry helps set the scene.

Figure 25 River Dee at Llanuwchllyn, near Site 4

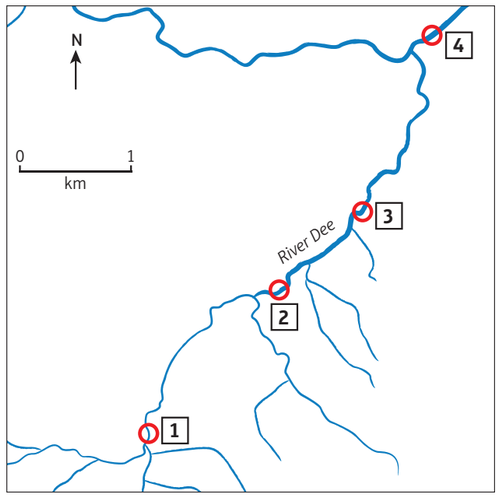


Figure 26 A student's sketch map of survey sites on the upper River Dee

F Methodology

Once you have decided on some suitable key questions and located your investigation, the next stage is to choose the methods you will use to collect your data. Geographers use both **primary data** (data that is collected first hand) and **secondary data** (data that has already been published). In your investigation, you should choose at least three **quantitative** (using numbers) methods, for example measuring the width of a river, and one **qualitative** (descriptive) method, for example a field sketch.

For each method, it is important that you decide where and how you will collect the data and why the data collected will help to answer the overall task question. You cannot collect data from every part of the river or measure every pebble in its bed, so you need to sample.

- **Random sampling** – data is collected by chance. An example might be picking up stones from the river bed at random with your eyes closed.
- **Systematic sampling** – the locations of the sites are found at equal intervals from each other. An example might be to measure the depth of the river every 0.25 metres across its width.
- **Stratified sampling** – is used when the study area has significantly different parts. An example might be measuring the discharge just below every confluence.

An example of how to present your methodology is shown in Table 4.

Table 4 Measuring the width and depth of a river (quantitative method)

Method	Outline of method	Purpose of method	Recording
Measuring the width and depth of the river. *Sample measurements collected at Sites 1–4. Each site is located where a tributary joins the River Dee.*	*We found a suitable representative point at each site. We measured the width from one bank to the other with a tape measure.* *To measure the depth, at 0.25 metres intervals I placed a metre ruler into the water until it reached the river bed.*	*We chose this method to investigate how the width and depth of the river changes as it flows downstream – so we are trying to prove Bradshaw's theory.*	*On a tablet, we set up a simple spreadsheet for the width and depth at each of the four sites. We entered the data directly in the field.*

When you investigate the changing river processes, it is also important to find out how people and rivers interact, for example in an area of beautiful landscapes or at risk of flooding. One method you could try to survey the thoughts of local people is to conduct a questionnaire. When deciding on a questionnaire, you should consider the following.

- What questions will allow you to collect the information that you need for your investigation?
- Will the questions be open (allowing people to offer opinions) or closed (for example, yes or no)?

Did you know?

You can use interactive geology maps from the British Geological Survey (BGS) to support your fieldwork. Use the Geology of Britain viewer on the BGS website to find a map for anywhere in the UK.

Exam-style question

Is a questionnaire about people's opinions a qualitative or quantitative method? **(1 mark)**

Did you know?

Timing how long an orange takes to float for 5 or 10 metres downstream is an easy way to measure river velocity. However, rivers flow faster near the surface, so the results need to be multiplied by 0.85 to allow for the friction along the river bed and banks.

Activity

1 What do you think are the advantages and disadvantages of recording river channel data directly into a spreadsheet on a tablet?

2 Make a blank copy of Table 4.

   a Choose **two** investigations from the following: river landscape, velocity and discharge, gradient and bedload. Discuss what you could find out about them, how you could do so and why they will help with answering the main task question.

   b For each investigation, describe the methods and explain how and why you would conduct and record them. Use a highlighter to identify where you have explained how you would carry out the methods.

3 You have been asked the following key question, 'How do river processes affect people living in the catchment?' Create a questionnaire that would enable you to gather the information you need to answer this key question.

Exam-style question

Study Table 6. Calculate the cross-sectional area of the River Dee at Sites 1–4. **(2 marks)**

Exam tip

Calculate the cross-sectional area by multiplying channel width by mean depth.

Command word

When asked to **calculate** you work with numbers to answer a problem. You must show your working and do not forget to include the unit (e.g. m^2) in your result.

Now that you have decided on the methods you will use to collect your data, you need to produce a risk assessment with your teacher's guidance before you collect and record your data. In your risk assessment, you should consider: the potential risks, the severity of each risk – on a scale of 0 (low) to 10 (high) – and how the risk can be managed. An example is shown in Table 5.

Table 5 Risk assessment

Risk	Severity rating	Management
Slipping on rocks	6/10	Take care before entering the river and listen to the teacher

Table 6 River Dee channel data collected by a geography student

Channel variable	Site 1	Site 2	Site 3	Site 4
Width (metres, m)	3.30	4.10	6.20	8.80
Mean depth (m)	0.17	0.19	0.28	0.37
Cross-sectional area (m^2)				
Velocity (m/s)	0.08	0.09	0.10	0.13
Discharge (m^3/s)	0.04	0.06	0.15	0.36

F Data presentation

Once you have collected your data, you then need to decide how to present it. Geographers use a range of graphical techniques to present their findings. For your investigation, you should aim to produce a number of simple and sophisticated techniques. A sophisticated technique is one that uses at least two variables to represent the data. An example of this would be located graphs of data for the river at different sites. Techniques that could be used to present information for the River Dee include:

- flow-line maps to show velocity or discharge (see Figure 27)
- annotated photographs/field sketches of the river landforms
- river channel profiles
- located proportional circles of mean sediment size
- a GIS map with located photographs and channel data for different sites.

Presenting data on river velocity and discharge

The students measured river velocity at four sites, then calculated the discharge. Figure 27 shows an example of how the students presented their discharge data for the River Dee in a flow-line map.

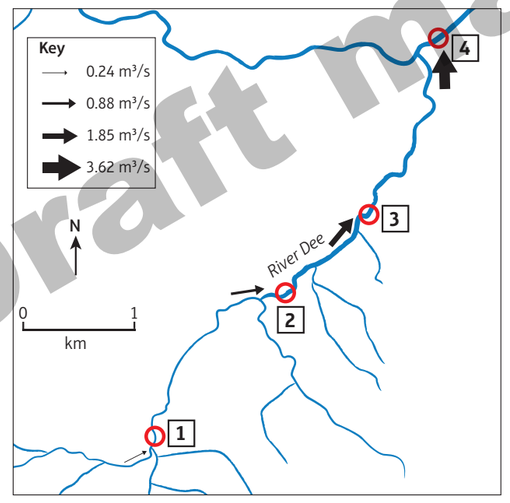


Figure 27 Flow-line map showing discharge on the River Dee

Activity

1 Study Table 6. Describe the changes in the velocity and discharge of the River Dee from Site 1 to Site 4, and give reasons for them.

Tip Remember to make reference to the map as well as the data, use geographical terminology and explain how the data links to geographical theory.

2 The students decided to investigate four more sites on the River Dee, downstream to Chester. They obtained depth and discharge figures from two web pages: 'Environment Agency – River and sea levels' and 'National River Flow Archive'.

   a What type of data is this: primary or secondary; qualitative or quantitative?

   b The students downloaded a catchment map from one site. Describe one simple and one sophisticated way they could use this map in their study.

F Analysis and conclusions

The next stage of the enquiry is to analyse the data collected to begin answering your key questions. When analysing the data, it is important to:

- **describe** the general trends from your data – for example, 'The width of the river increases travelling downstream'
- **make comparisons** using data – for example, 'The width of the river is greatest at Site 4, measuring 8.80 metres, a difference of 5.5 metres from Site 1'
- **explain** the patterns of your data with links to geographical theory – for example, 'The width of the river has increased because of lateral erosion of the banks due to attrition, hydraulic action and other processes'.

Read the extract below from an analysis a student wrote about data collected along the River Dee. The student gave a structured response with:

- reference to the figure and data (red)
- use of geographical terminology and theory (green)
- an explanation of their data and links to geographical theory (yellow).

The velocity of the River Dee increases from Site 1 to Site 4 as predicted by Bradshaw's Model. As you can see in Table 5, the mean velocity at Site 1 was 0.08 m/s and increased to 0.13 m/s at Site 4. This shows an overall mean velocity increase of 0.05 m/s. The reason the mean velocity increases is that as the width and depth of the river increases there is less friction against the bank.

Activity

1 Discuss the two paragraphs showing the student's analysis and conclusion. For **each** paragraph decide: what is good about it, how it might be improved or developed, anything that you think should be added. Justify your decisions.

2 Rewrite the **second** student paragraph with your suggested improvements.

Once you have analysed your data using the structure above, you need to write a conclusion for each key question as well as the overall task question. When writing your conclusion, it is important to:

- focus on your task question and key questions: what did your investigation find out?
- summarise your findings from the data you collected and presented and link each finding to the evidence
- point out any anomalies in your data – these are results that are very different from what you expected: you might try to explain them
- refer back to any theory that related to your investigation; for rivers, you should refer to the Bradshaw Model.

You then need to write your overall conclusion to the task question, in this case: 'How do the river valley and channel characteristics vary along the River Dee?'

Read the extract below from a conclusion written by a student.

The purpose of my investigation was to find out if my chosen valley and channel characteristics vary along the River Dee. I can conclude that as the River Dee flows downstream, the width and depth of the river increases, the bedload alters in size and roundness, and the mean velocity and discharge increase. My data generally supports the Bradshaw Model with only a few anomalies identified.

F Evaluation

The final part of the enquiry is to evaluate your investigation. Here you think about how well you answered the task question or theory, and how you could improve or develop the process. The key questions below will help you review your data collection methods, results and conclusions.

- How successful and useful were your methods for sampling and collecting data? Could they be improved?
- How accurate were your results? Did your data collection methods affect the results?
- Did missing or inaccurate data make the study unreliable or affect your conclusions?

Activity

1 Read the students' reflections in Figure 28. Discuss which ones are about:

- **a** strengths and weaknesses in the study
- **b** the accuracy of the data
- **c** missing data or the size of the sample.

2 Suggest how the data collection methods could be improved if other students repeated the study.

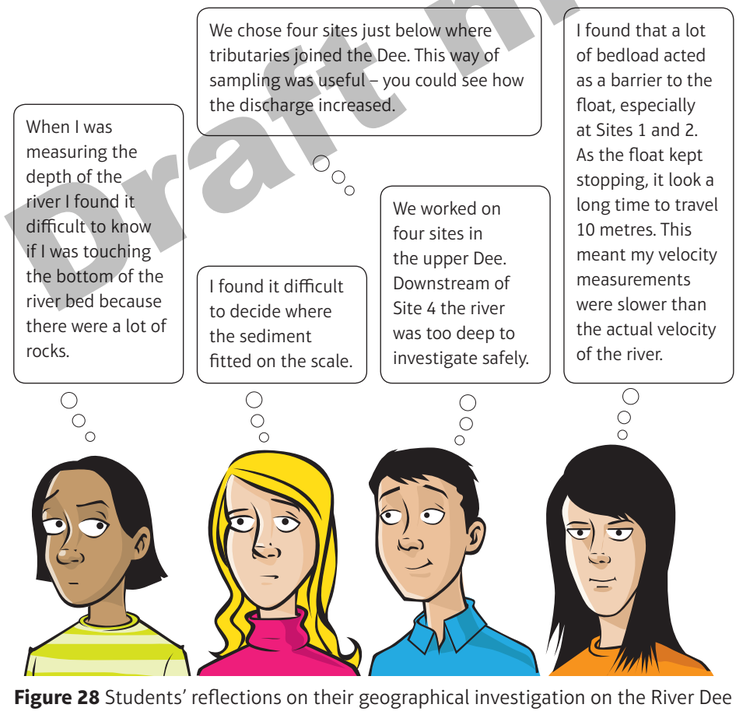


Figure 28 Students' reflections on their geographical investigation on the River Dee

Checklist

Now it is time to review your understanding of how to plan and conduct an investigation into change in river valleys and channels.

Strengthen

S1 With a partner, note down **two** things you can remember about each of the following: the enquiry question, locating the study, presenting data and evaluation.

S2 Classify the following into simple and sophisticated presentation techniques: flow-line map, bar graph, located pie graph, multiple-line graph, pie graph.

S3 Explain why it is important that a student's conclusion is linked to their task question.

Extend

C1 Think about what you know about random, systematic and stratified sampling. Note down an example of how each could be used in a river investigation.

C2 Write out example(s) of the methods below, deciding if they are qualitative or quantitative, primary or secondary, and the strengths and limitations of information gained from each of them:

- **a** method(s) to measure river discharge
- **b** method(s) to record river landforms and landscapes
- **c** method(s) to investigate the impact of river processes on local people
- **d** method(s) to investigate a flood risk in the whole river catchment.

Writing geographically: a clear, well-structured answer

Every response you write needs to be clearly written and clearly structured. To achieve this, you need to **signal that your answer is relevant** and **signal the sequence and structure of your ideas**.

Learning objectives

- To understand how to use key noun phrases and verbs from the question to make sure you answer it
- To able to write a clear opening sentence beginning with a subject–verb construction
- To understand how to use adverbials to link your ideas and signal their sequence and structure.

Definitions

Noun: a word that describes an object, idea, person, place, etc., e.g. *wind*.

Noun phrase: a phrase including a noun and any words that modify its meaning, e.g. *south-westerly, prevailing wind*.

Verb: a word that describes an action (Chemicals *poured* into the river), incident (Something *happened*) or situation (The rock *is* sedimentary).

Adverb(ial): a word or phrase that can modify a verb, adjective or another adverb; often used to link ideas in a text, e.g. *suddenly, all of a sudden, therefore, firstly*.

How can I make sure I am answering the question?

Look at this exam-style question in which key noun phrases, verbs and adverbials are highlighted:

Describe how physical processes work together to form a spit. **(8 marks)**

Now look at the first sentences of two different responses to this question:

Student A *The formation of a spit occurs due to a number of physical processes working together.*

Student B *First, the wind moves the waves up the beach at an angle.*

1. Which student signals most clearly that their response is going to answer the question?
2. Write a sentence or two explaining your choice.

How can I signal the structure and sequence of my answer?

When explaining, describing or analysing a concept, you can use adverbials to link your ideas:

Similarly… For example… However… Therefore… Consequently… In conclusion…

When you explain or describe a process, such as the formation of a spit, you can use adverbials to signal a series of events over time:

Firstly… Secondly… Then… Next… Meanwhile… After several years… Over a period of time… Eventually… Finally…

THINKING GEOGRAPHICALLY

3. Now look at Student A's response to the exam-style question on page 28. How many adverbials have they used to link their ideas and explain the process they are describing? Make a note of them all.

The formation of a spit occurs due to a number of physical processes working together. Firstly, the south-westerly prevailing wind causes the waves' swash to push sediment up the beach at an angle. The backwash then brings material back down the beach at right angles to the coast, under the force of gravity. The swash and backwash process results in a zigzag movement of material along the coastline, known as longshore drift. The direction of longshore drift transports sediment from west to east over a period of time.

When there is a change in the direction of the coastline, usually because of an estuary, the transported material is deposited offshore. Over time this build-up of material causes a spit to form, stretching across from the headland in an easterly direction. The estuary limits the growth of the spit due to the deep waters and currents. As the spit grows, sheltered waters develop behind the spit causing finer sediments to settle and these begin to fill in the area, eventually leading to the development of a saltmarsh. Finally, the spit becomes curved towards the north of the estuary due to the river currents and secondary wind direction.

Did you notice?

Adverbials can be positioned at a number of different points in a sentence.

4. At which point in Student A's sentences are most of the adverbials positioned?
5. Choose one sentence from Student A's answer in which an adverbial is used. Experiment with repositioning the adverbial at different points in the sentence. What impact does it have on the clarity of the sentence?

Improving an answer

Look at Student B's response to the exam-style question on page 28.

First, the wind moves the waves up the beach at an angle. The swash pushes the sediment onto the beach and the backwash brings the sediment back down the beach. The sediment moves in a zigzag pattern along the coastline in an easterly direction. At the end of the coastline the material is deposited and builds up to form a spit. Winds cause the spit to curve and a saltmarsh develops behind it.

6. Rewrite Student B's response aiming to:

- use key words in the first sentence to signal clearly that the answer is relevant to the question
- use adverbials to signal clearly the sequence of events you are describing.

Glossary

1% flood event a 1% flood event has a 1 in 100 chance or greater of happening each year, or a probability of 0.01

abrasion this type of erosion is caused by rivers, glaciers or waves picking up sediments and rubbing them against rocks in the bed and banks, valley or cliffs

afforestation the planting of trees where there were none before, or they had been cut down

alluvium fine sediments which are deposited by rivers

annotate to add notes and explanations to a photograph, map or diagram

attrition this type of erosion is where particles carried by rivers or waves are worn down as they collide with each other, so they become smaller and rounded

channelisation the deepening and/or straightening of a river to allow it to carry more water

confluence the point where two rivers meet

contour a line on a map joining places of equal height above sea level

cross section a diagram showing the shape of a feature or landscape as if it was cut through sideways

deposition a process where sediments are dropped by the river, glacier or waves that carried them

discharge the volume of water flowing in a river, measured in cubic metres per second (cumecs)

drainage basin the area of land drained by a river and its tributaries

estuary the mouth of a river which broadens into the sea and is affected by tides

flood plain a wide, flat area of land either side of a river in its middle and lower course

gorge a steep, narrow valley with rocky sides

hard engineering strategies using artificial structures (e.g. concrete) to prevent river or coastal flooding

hydraulic action this results from the sheer force of moving water wearing away the river bed and banks, or waves wearing away sea cliffs

hydrograph a graph showing changes in a river's discharge and rainfall over time

impermeable rocks that are impermeable, like clay, do not allow water to pass through them

infiltration the process whereby water soaks into the soil and rock

interception the process where vegetation catches rainfall on its leaves and branches

interlocking spur an area of higher land jutting out of steep valley sides in a river's upper course

jet stream a fast-moving current of air in the upper atmosphere

lateral erosion erosion where a river cuts sideways into its banks

levee a raised bank of sediment along the side of a river

long profile the shape and gradient of a river bed from source to mouth

mass movement the movement of material down a slope due to gravity

meander a bend formed in a river as it winds across the landscape

meltwater water coming from melting snow or glacier ice

migrate the process of movement of people or of features such as meanders

mouth the point where a river leaves its drainage basin and reaches the sea

neck the narrow strip of land between the two closest banks of a meander

permeable rocks that are permeable, like chalk, allow water to pass through them

plunge pool a hollow under a waterfall created by erosion and filled by water

point bar sediment laid down on the inside of a meander bend where the river flows slowly

primary data data that you collect first hand

qualitative data without numbers based on people's opinions or ideas, e.g. an interview or field sketch

quantitative data which contains numbers and figures, e.g. a pedestrian count

random sampling data that is collected so each has an equal chance of being selected, e.g. by using random numbers

reservoir an artificial or man-made lake used to store large volumes of water for industrial and domestic purposes

river cliff a steep section of river bank, caused by fast-flowing water eroding the outside of a meander

river erosion the action of water wearing away the rocks and soil on the valley bottom and sides

runoff water running across the land surface *or* the proportion of rainfall that flows in rivers

secondary data data that has been collected and published by someone else

sediment material such as mud, sand and pebbles carried and deposited by rivers or waves

sediment load the sediment particles carried by a river

slip-off slope the gentle slope on the inside of a meander bend formed by deposition

soft engineering strategies using natural resources and people's knowledge to reduce the risks of river or coastal flooding

solution the process where some rock minerals slowly dissolve in water, which is slightly acid

source the starting point of a stream or river, often a spring or a lake

stratified sampling data that is collected from different parts of a population, e.g. different age groups

systematic sampling data that is collected at regular intervals, e.g. every 500 metres

transportation the movement of sediment by rivers, glaciers or waves

tributary a stream or small river that joins a larger one

urbanisation the increase in the percentage of people living in towns and cities, causing them to grow

velocity the speed at which a river or glacier flows; river velocity is often measured in metres per second

vertical erosion downward erosion of the river bed

V-shaped valley a valley with a V-shaped cross section formed by river erosion

waterfall a point in a river's course where it falls vertically

watershed the boundary separating two drainage basins, often a ridge of land

weathering the breakdown and decay of rock by natural processes acting on rocks on cliffs and valley sides

Acknowledgements

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