IN THE KNOW

Rivers and the Water Cycle

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Accurate and reliable background information to underpin your geography lessons

Introduction

Water is constantly on the move; water from melting glaciers and water held in the ground gets channelled into tiny streams that grow and join up with other streams to form rivers. Rivers form a major part of the Water (Hydrological) Cycle; rivers are responsible for transferring water to the oceans. River landscapes are often beautiful and changeable, and provide many examples of physical geography at work.

The Water Cycle

Evaporation (when liquid turns to vapour) from oceans, lakes, soil and vegetation loads the atmosphere with water vapour (a gas). Where water vapour rises over warm land or mountains, or is pushed up by cool, denser, air meeting warmer air, it cools down causing condensation to occur around particles of dust or pollution, forming water droplets and clouds. Tiny water droplets in clouds collide and grow in size. Once big enough to overcome gravity they fall as precipitation (rain, snow, sleet or hail). Tall clouds where strong uplift occurs (giving turbulence experienced in flight) allow larger raindrops to form before falling. When it falls, much precipitation is intercepted by vegetation (the surface of leaves) and is evaporated straight back into the atmosphere, especially if rainfall is light and the temperature is warm. Some water will drip off, and through, vegetation and infiltrate the soil. Once in the soil it will percolate down into the ground to become ground water. If the ground becomes saturated, water will run off the surface, gathering into tiny streams and feeding into bigger streams and rivers. Some water is taken up by the roots of vegetation and transpired back into the atmosphere through the leaves. Figure 1 shows the cycle of water.

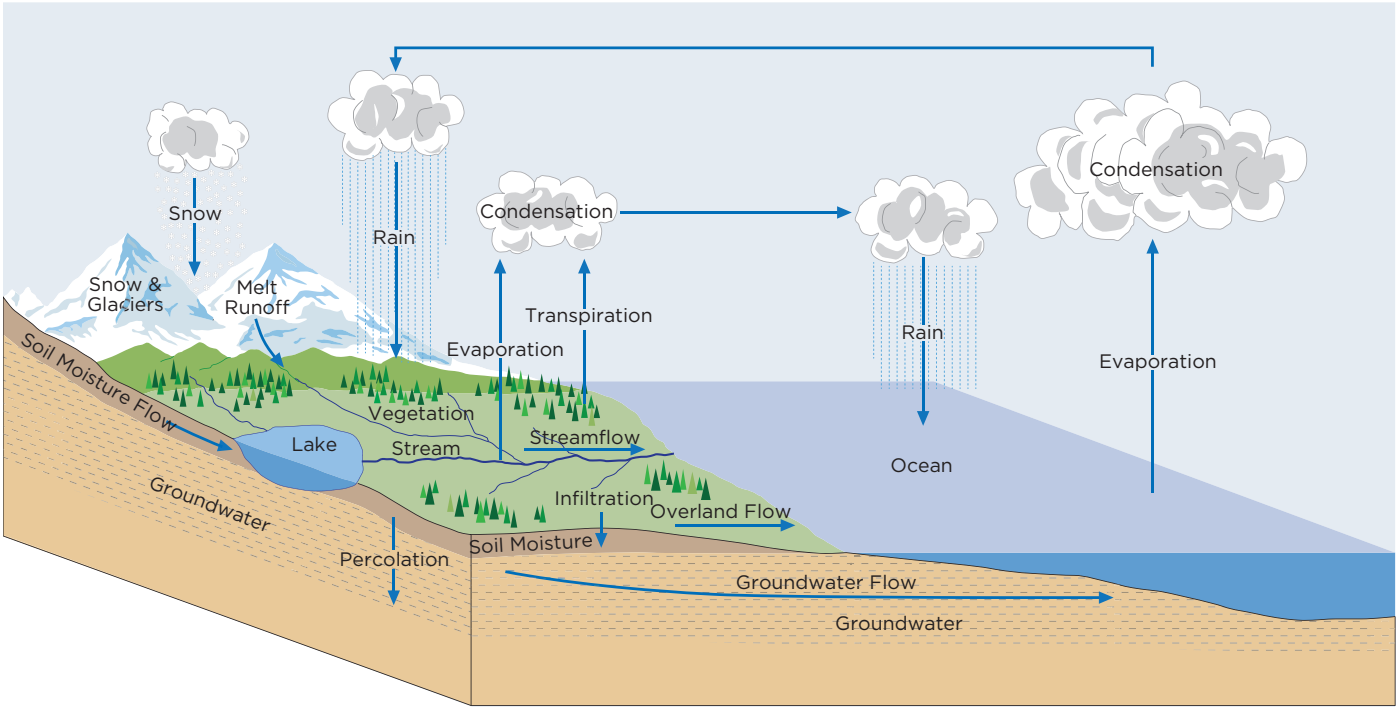


Figure 1: The Water (Hydrological) Cycle.

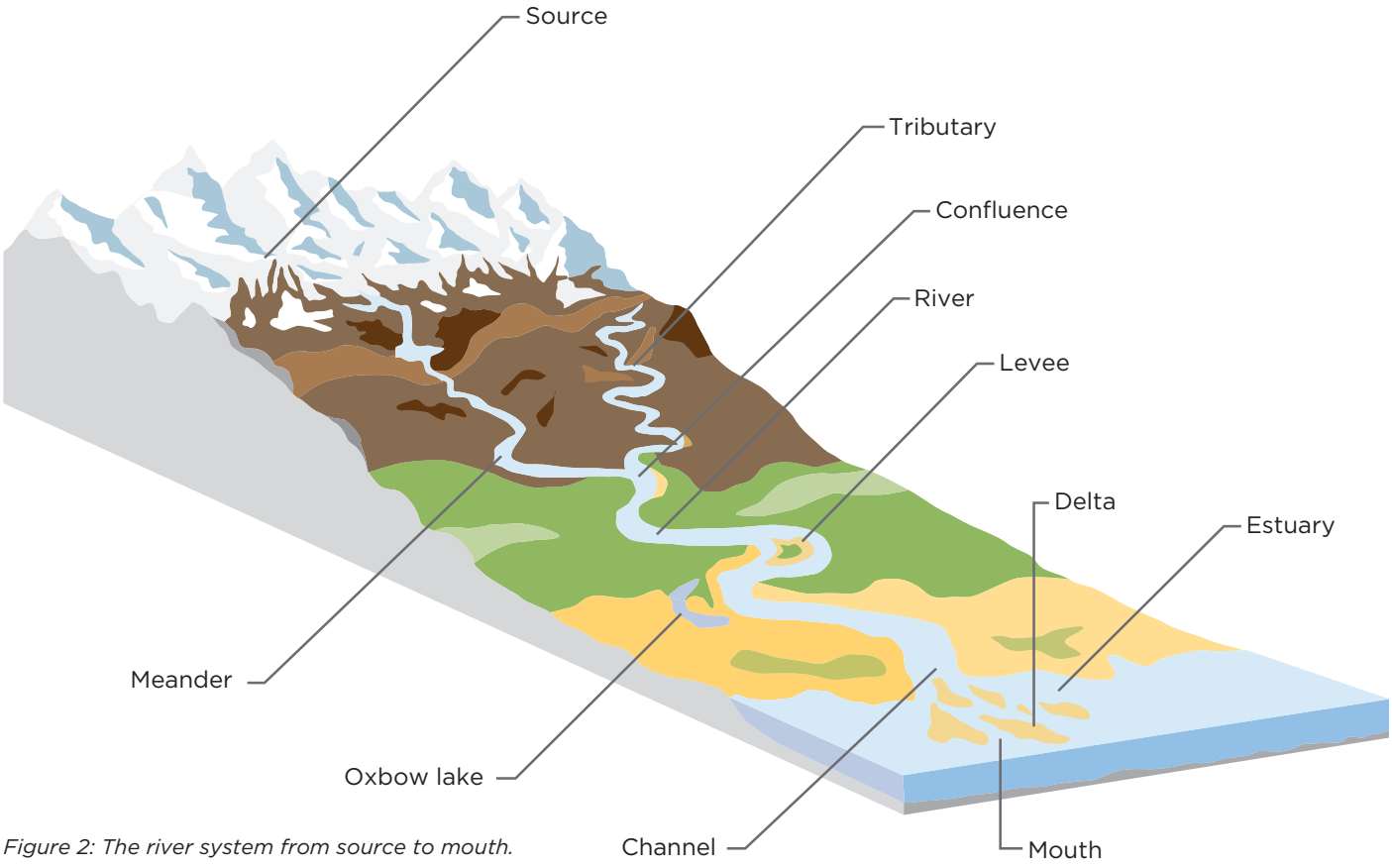


Figure 2: The river system from source to mouth.

Rivers

The river system diagram (Figure 2) shows how all rivers start at their source and flow downhill gradually increasing in size before ending at the mouth where they discharge into a lake or sea.

FACT The five longest rivers in the UK are:

		Length (km)	Source	Mouth
1.	River Severn	354	Plynlimon, Mid Wales	Severn Estuary
2.	River Thames	346	Thames Head near the hamlet of Kemble, Gloucestershire	North Sea, Southend-on-Sea
3.	River Trent	297	Trent Head Well, Biddulph Moor Staffordshire	Humber Estuary
4.	River Great Ouse	230	Wappenham in Northamptonshire	King's Lynn, the Wash
5.	River Wye	215	Plynlimon, Mid-Wales	Severn Estuary

How does water end up in a river?

Runoff (the draining away of water from the land's surface) is a rapid transfer of water to a river and can result in the river rising quickly. Runoff, also known as overland flow, is common in urban areas covered in impermeable surfaces. When water falls on vegetation, dripping off leaves or flowing down stems it infiltrates the soil and slows down the passage of water to rivers, resulting in a lag or delay in the river rising after a precipitation event.

The river or storm hydrograph (Figure 3) shows how a river's discharge responds to a precipitation event and the characteristics of the drainage basin. A steep and high peak may be produced by intense rain on dry soil in a drainage basin with steep slopes, well-drained soils and few trees, or in an urban river. A gentle and low peak could be produced by moderate rainfall or where forests and woodland are abundant with delayed transfers and high interception and transpiration losses.

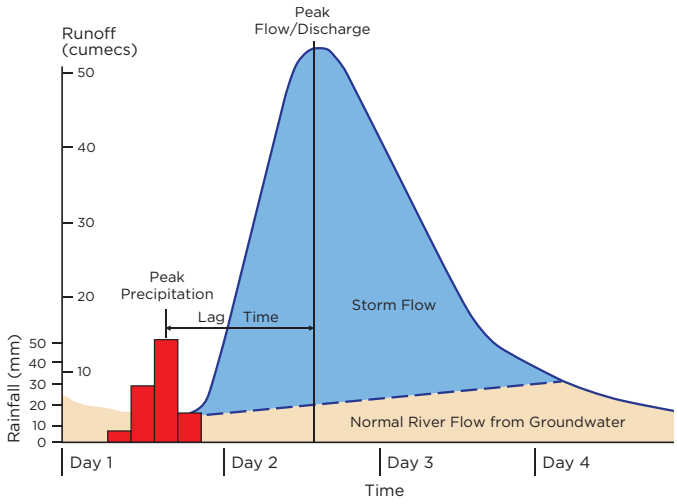


Figure 3: A storm hydrograph shows how the river's discharge responds to a precipitation event.

The difference between a river process and feature

River processes are the actions that the flow of water and the load it carries have on the landscape, whereas river features are the parts of the river landscape that stand out in a landscape giving it its distinctive characteristics and look.

River features

River features are the landforms produced by the flow and energy of the water as well as the erosional movement of sediment or the deposition of the sediment. Typically, these will change along the long profile/course of the river from source to mouth.

The Upper Course, typically but not always, has deep, narrow, V-shaped valleys with interlocking spurs or land, turbulent streams, large bedload of rocks and boulders, rapids, pools and waterfalls (Figure 4). The Middle Course has deeper valleys, emerging floodplains and meanders, a deeper channel and faster more efficient flow. The Lower Course has a wide-open valley, low relief, looping meanders and finally the muddy sediment-rich estuary.

River processes

Processes are generally erosional, involving the wearing away of the channel, its bed and sides (this will also involve movement of the eroded material). Erosional slope processes will operate on valley sides carrying further material into the river, which can then be transported away. Deposition is also a process, which creates associated features.

River processes are most significant or powerful at times of high energy and flood discharge, dragging and rolling bedload along the channel (traction) with destructive power; the processes of hydraulic action and cavitation are constant forces at work. Conversely, at times and in areas of low energy and still waters, suspended sediment will settle to create muddy areas of sediment, common in pools and estuaries.

Rivers transport their load in a number of ways. In solution (dissolved in the water), suspension (peat, soil and clays hanging in the water giving it a muddy or peaty colour after heavy rainfall), saltation (dislodging and picking up then dropping sands and gravels) and traction (rolling larger boulders along the bed of the river) (Figure 5). The greater the discharge the greater the energy, and the more load that is transported the more erosion occurs.

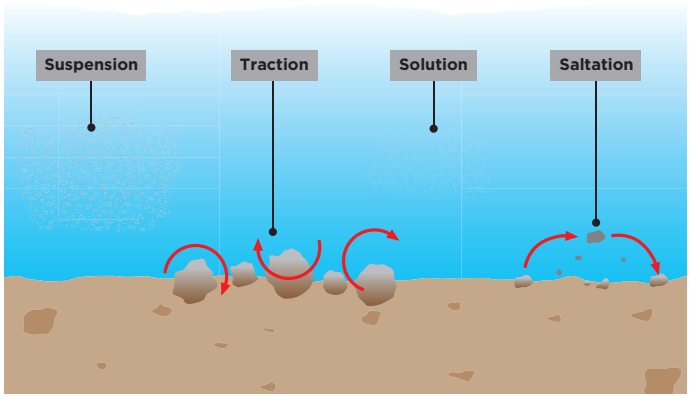
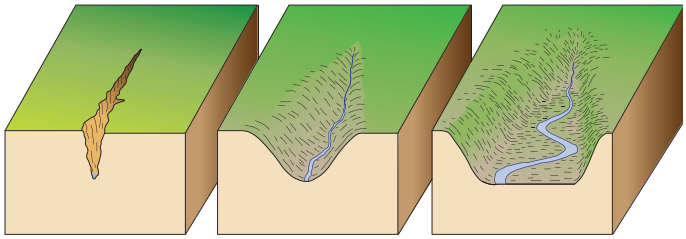


Figure 5: Methods of transportation within rivers.

Figure 4: A typical upper course on the River Dane on the Cheshire Staffordshire border, showing steep "V" shaded valley slopes and a narrow river channel with large bedload. Photos: Ben Steel

Erosional features

Erosional features, including the channel itself, are seldom perfectly straight unless created by humans to speed up the flow of water. Channels can be braided like hair if flowing through islands or bars of loose sediment, but are often a single winding and meandering course. Often the channel will flow through a series of riffles (shallow rocky areas) into pools of deeper water. Valleys can be steep and narrow if cut into harder rocks in mountain areas and much more gently sloping but vastly wide in lowland areas (Figure 6). A meandering channel will widen the valley it forms as it erodes laterally from side to side.



The river cuts down and deepens its valley.

The river widens its valley as it deepens it.

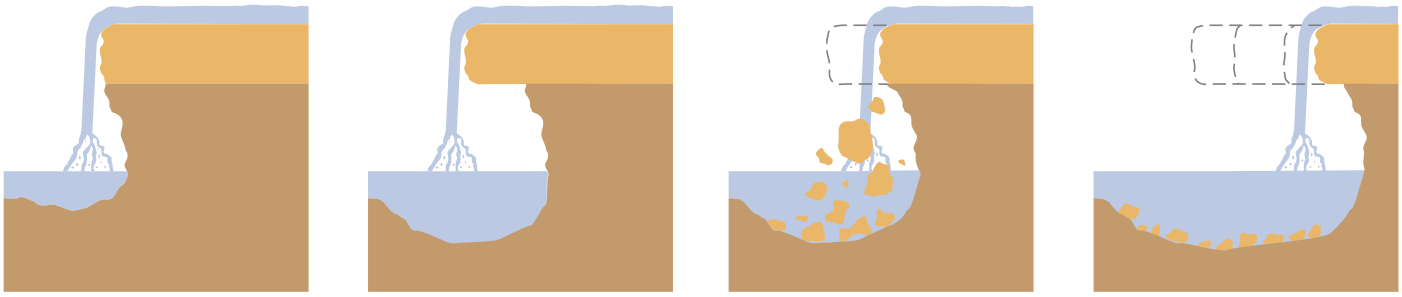
The river continues to widen its valley.

Figure 6: Erosion processes wear away the rock in different ways to form valleys.

Gorges are spectacular, narrow, and deep; often channelling a very fast powerfully flowing river through a narrow cleft in hard rock. Waterfalls can be spectacular steps in the long profile/course of a river, where the river encounters an area of resistant rock, which it is not yet able to erode. As the waterfall gradually erodes this resistant rock upstream, a gorge may be formed (Figure 7).

A channel will often meander. While the fastest flowing water on the outside of its bends may erode a steep bank or river cliff, the slower flow on the inside may deposit a river beach or point bar (Figure 8). The result is that the whole river channel will shift across the floodplain, if not prevented from doing so by river management. Where a meander becomes very tortuous it can cut through its own outside bend, where flow and energy are at their strongest; leaving the meander cut off as an oxbow lake (Figure 9).

Figure 8: Eroded river cliff on the outside of the meander and deposited bar/beach on the inside on the River Greta, North Lancashire. Photos: Ben Steel.



1. Waterfalls typically form in the upper stages of a river. They occur where a band of hard rock overlies a softer rock. Falling water and rock particles erode the soft rock below the waterfall, creating a plunge pool.

2. The soft rock is undercut by erosional processes such as hydraulic action and abrasion creating a plunge pool where water and debris swirl around eroding the rock through corrosion further deepening it and creating an overhang.

3. Hard rock overhang above the plunge pool collapses as its weight is no longer supported.

4. Erosion continues and the waterfall retreats upstream leaving behind a gorge.

Figure 7: The formation of a waterfall.

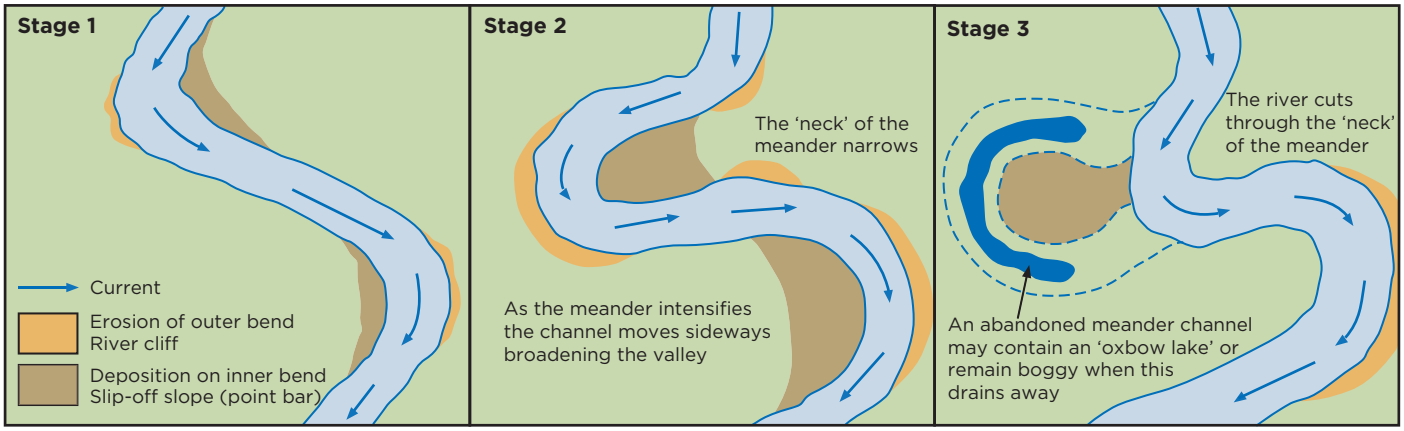


Figure 9: Meanders and ox-bow lakes.

Depositional features

Depositional features include floodplains. Each time the river floods, a wide flat expanse of silt or alluvium smothers the flooded area in layer upon layer of deposited sediment.

A change to a wetter climate can give a river more water and the associated erosional power may cut down through the floodplain to create steps or river terraces in the floodplain (Figure 10).

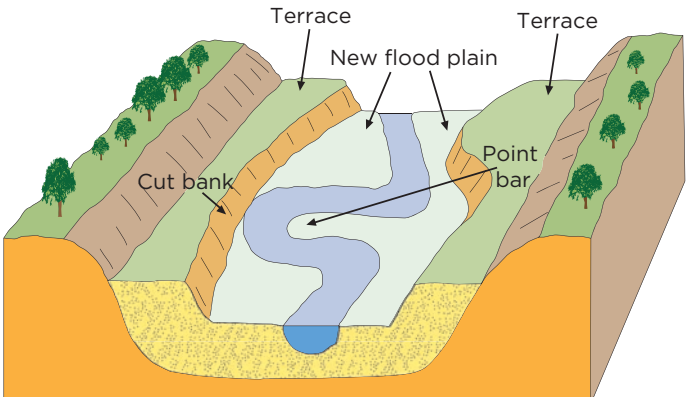


Figure 10: How floodplains can be eroded to create river terraces.

River bars/beaches are features on the inside of meanders where flow is low and material is deposited. A river delta is a triangular shaped area of deposits, intersected by distributaries, where the river slows as it reaches the mouth and loses the energy required to transport its load.

What happens when a river floods?

In times of heavy rain when the discharge of flow becomes too much for the channel, water will overtop the banks and a river will flood (in a flash flood this will happen in less than six hours after the onset of the precipitation event). Typically, water, sediment (alluvium) and flotsam debris will spill across the floodplain. More sediment tends to be deposited alongside the channel and can form long low ridges of sediment (levees). Floodplains can remain inundated with water for long periods after a flood event until the water has eventually drained into the land. Flooded properties can be left with thick deposits of muddy alluvium, larger sediments and other debris after flood water has drained away. A river in full flood is extremely powerful with its erosional force at its maximum. It is in times of flood when river landscapes and features can change significantly with channels shifting, banks collapsing and valleys widening and deepening.

River habitats

There are about 90,000 km of rivers in the UK, providing a rich variety of habitats for plants, flies, invertebrates, fish and birds in their channels and adjacent wetlands and floodplains.

Rivers support species that depend on permanent running water; salmon and other fish that need clean gravels to spawn on, stoneflies and mayflies that depend on constant high oxygen levels and cool water, river mosses, dragonflies, the invertebrate-eating Dipper, the beautiful Kingfisher and, in clean rivers, crayfish and Pearl Mussels. Habitats will vary according to the depth, velocity, water pH and quality. An alkali river in an area of upland limestone will support different species to a deeper, sediment-rich, meandering lowland river.

FACT In an account of the great Lynmouth flood. North Devon 15-16 August 1952, a storm with heavy rainfall, combined with already saturated soil and flood debris, led to the flooding of the village and a total loss of 34 lives. Witnesses described a terrifying rumbling noise as giant boulders were set in motion by the force of the water.

Glossary

Alluvium – Material deposited by a river (sand-silt and mud).
Attrition – A process of erosion whereby the load rubs against itself. Sediment becomes smaller and more rounded.
Bank – the margin or side of a river. Undercutting of the bank, especially on the outside of the meander can lead to slumping of alluvial material into the channel where it is carried away.
Bedload – the material carried by a river through traction or saltation along the river bed.
Cavitation – an erosional process caused by the force of exploding air bubbles in turbulent flow and plunge pools below waterfalls. (The process seems insignificant but is very powerful and constant, potentially cracking solids and preparing particles for removal.)
Channel – the shaped land that the river flows in.
Confluence – where two rivers meet, combining their flow.
Corrasion/Abrasion – where the load of a river drags, scrapes and erodes its bed and sides, mainly effective during high flow flood events.
Corrosion – a process of erosion caused by solution, especially important in limestone landscapes.
Cumecs – cubic metres per second.
Delta – an area of deposition found at the mouth of the river that is triangular in shape and hence named after the Greek letter.
Discharge – the amount/volume of water flowing in a river. Usually measured in cubic metres per second (cumecs).
Distributaries – small channels that divide and split deltas. The opposite of a tributary.
Drainage Basin – the area of land drained by a river and its tributaries. The land use in the drainage basin and how it is managed will affect whether a river will flood or not.
Erosion – the process of wearing away and removal of material mainly in the river channel and along the bank. Erosion includes solution, corrosion, cavitation and also fluid stressing (the force of water on softer banks).
Estuary – a drowned river valley, where the river flows into the sea. Often tidal and an area of mudflats and alluvial deposits.
Flood hydrograph – a graph with bars to show rainfall and a line to show discharge showing how a river responds to different amounts of rainfall.
Gorge – a narrow steep-sided valley caused by a waterfall eroding backwards (e.g. Niagara) or by powerful vertical erosion maybe combined with uplifting landscapes (e.g. Grand Canyon)
Hydraulic power – a process of river erosion caused by the force of the water.
Lag time – the time between the peak rainfall and peak discharge after a rainfall event. A short lag time and high peak is a 'flashy' response and can lead to flooding.
Levee – an elevated ridge at the side of the channel, raised above the floodplain. These are formed naturally as the river floods and deposits sediment close to the channel but are often artificially built as a flood defence.
Meander – a bend or loop in the river - usually in the middle or lower course
Mouth – where a river enters the sea or a lake, the river flow slows, loses its energy and often deposition occurs.
Oxbow lake – a classic landform whereby a near circular meander is cut off by erosion on the outside bends and the river takes the shorter cut-off path, leaving a lake when a meander is sealed off by deposition.
Plunge pool – a deeper pool below a waterfall eroded by the force of the water and corrosion.
Saltation – particles picked up and bounced off each other, causing them to travel along a riverbed.
Solution – the dissolving of solid rocks by water. Most important in limestone (calcareous) areas with water that is weakly acidic.
Source – the starting point of a river; the source of the highest tributary.
Traction – boulders rolling along the river bed.
Tributaries – small rivers or streams, which flow into a larger river; these will begin as springs as water seeps out of the ground water.
V-shaped valley – shape of a river in the upper course with steep sides and narrow base.
Velocity – the speed of a river's flow, measured by distance divided by time.
Water (Hydrological) Cycle – the cycle of water between the air, land and sea.
Waterfall – a step in the river channel, usually where the river crosses a band of hard rock and cannot erode it easily.
Watershed – high ground that surrounds a drainage basin.

Further ideas, links and resources to support your teaching of rivers and the water cycle can be found at: **www.geography.org.uk/investigating-rivers-and-water-cycle-at-key-stage-1-2**

 ISBN 978-1-84377-435-8.
Published by The Geographical Association, 160 Solly Street, Sheffield S1 4BF.
Company number 07139068.
Website: www.geography.org.uk.
The Geographical Association is a registered charity: no 1135148.