Section 1.2 Activities

1 Compare the river regimes of the Gloma (Norway), Shannon (Ireland) and Rhine (Switzerland). Suggest reasons for their differences.
2 Table 1.4 shows precipitation and runoff data for a storm on the Delaware River, New York. Using this data, plot the storm hydrograph for this storm. Describe the main characteristics of the hydrograph you have drawn.
3 Define the terms *river regime* and *storm hydrograph*.
4 Study Figure 1.11, which shows the impact of urbanisation on storm hydrographs. Describe and explain the differences in the relationship between discharge and time.

Table 1.4 Precipitation and runoff data for a storm on the Delaware River, New York

Date	Time	Duration of rainfall	Total (cm)
29 September	6 a.m.	12 hours	0.1
29 September	6 p.m.	12 hours	0.9
30 September	6 p.m.	24 hours	3.7
30 September	12 p.m.	6 hours	0.1
		Total	**4.8**

Date	Stream runoff (m^3/s)
28 September	28.3 (baseflow)
29 September	28.3 (baseflow)
30 September	339.2
1 October	2094.2
2 October	1330.1
3 October	594.3
4 October	367.9
5 October	254.2
6 October	198.1
7 October	176.0
8 October	170.0
9 October	165.2 (baseflow)

1.3 River channel processes and landforms

Erosion

Abrasion (corrasion) is the wearing away of the bed and bank by the load carried by a river. It is the mechanical impact produced by the debris eroding the river's bed and banks. In most rivers it is the principal means of erosion. The effectiveness of abrasion depends on the concentration, hardness and energy of the impacting particles and the resistance of the bedrock. Abrasion increases as velocity increases (kinetic energy is proportional to the square of velocity).

Attrition is the wearing away of the load carried by a river. It creates smaller, rounder particles.

Hydraulic action is the force of air and water on the sides of rivers and in cracks. It includes the direct force of flowing water, and cavitation – the force of air exploding. As fluids accelerate, pressure drops and may cause air bubbles to form. Cavitation occurs as bubbles implode and evict tiny jets of water with velocities of up to 130m/s. These can damage solid rock. Cavitation is an important process in rapids and waterfalls, and is generally accompanied by abrasion.

Corrosion or solution is the removal of chemical ions, especially calcium. The key factors controlling the rate of corrosion are bedrock, solute concentration of the stream water, discharge and velocity. Maximum rates of corrosion occur where fast-flowing, undersaturated streams pass over soluble rocks – humid zone streams flowing over mountain limestone.

There are a number of factors affecting rates of erosion. These include:

- load – the heavier and sharper the load the greater the potential for erosion
- velocity – the greater the velocity the greater the potential for erosion (see Figure 1.13)
- gradient – increased gradient increases the rate of erosion
- geology – soft, unconsolidated rocks such as sand and gravel are easily eroded
- pH – rates of solution are increased when the water is more acidic
- human impact – deforestation, dams and bridges interfere with the natural flow of a river and frequently end up increasing the rate of erosion.

Erosion by the river will provide loose material. This eroded material (plus other weathered material that has moved downslope from the upper valley sides) is carried by the river as its load.

Global sediment yield

It is possible to convert a value of mean annual sediment and solute load to an estimate of the rate of land surface lowering by fluvial denudation. This gives a combined sediment and solute load of 250 tonnes/km² per year – that is, an annual rate of lowering of the order of 0.1 mm per year. There is a great deal of variation in sediment yields. These range from 10 tonnes/km² per year in such areas as northern Europe and parts of Australia to in excess of 10 000 tonnes/km² per year in certain areas where conditions are especially conducive to high rates of erosion (Figure 1.12). These include Taiwan, New Zealand's South Island and the Middle Yellow River basin in China.

In the first two cases, steep slopes, high rainfall and tectonic instability are major influences, while in the last case the deep loess deposits and the almost complete lack of natural vegetation cover are important. Rates of land surface lowering vary from less than 0.004 mm per year to over 4 mm per year. The broad pattern of global suspended sediment is shown on the map and it reflects the influence of a wide range of factors, including climate, relief, geology, vegetation cover and land use.

Load transport

Load is transported downstream in a number of ways:

- The smallest particles (silts and clays) are carried in suspension as the suspended load.
- Larger particles (sands, gravels, very small stones) are transported in a series of 'hops' as the saltated load.
- Pebbles are shunted along the bed as the bed or tracted load.
- In areas of calcareous rock, material is carried in solution as the dissolved load.

The load of a river varies with discharge and velocity. The capacity of a stream refers to the largest amount of debris that a stream can carry, while the competence refers to the diameter of the largest particle that can be carried.

Deposition and sedimentation

There are a number of causes of deposition, such as:

- a shallowing of gradient, which decreases velocity and energy
- a decrease in the volume of water in the channel
- an increase in the friction between water and channel.

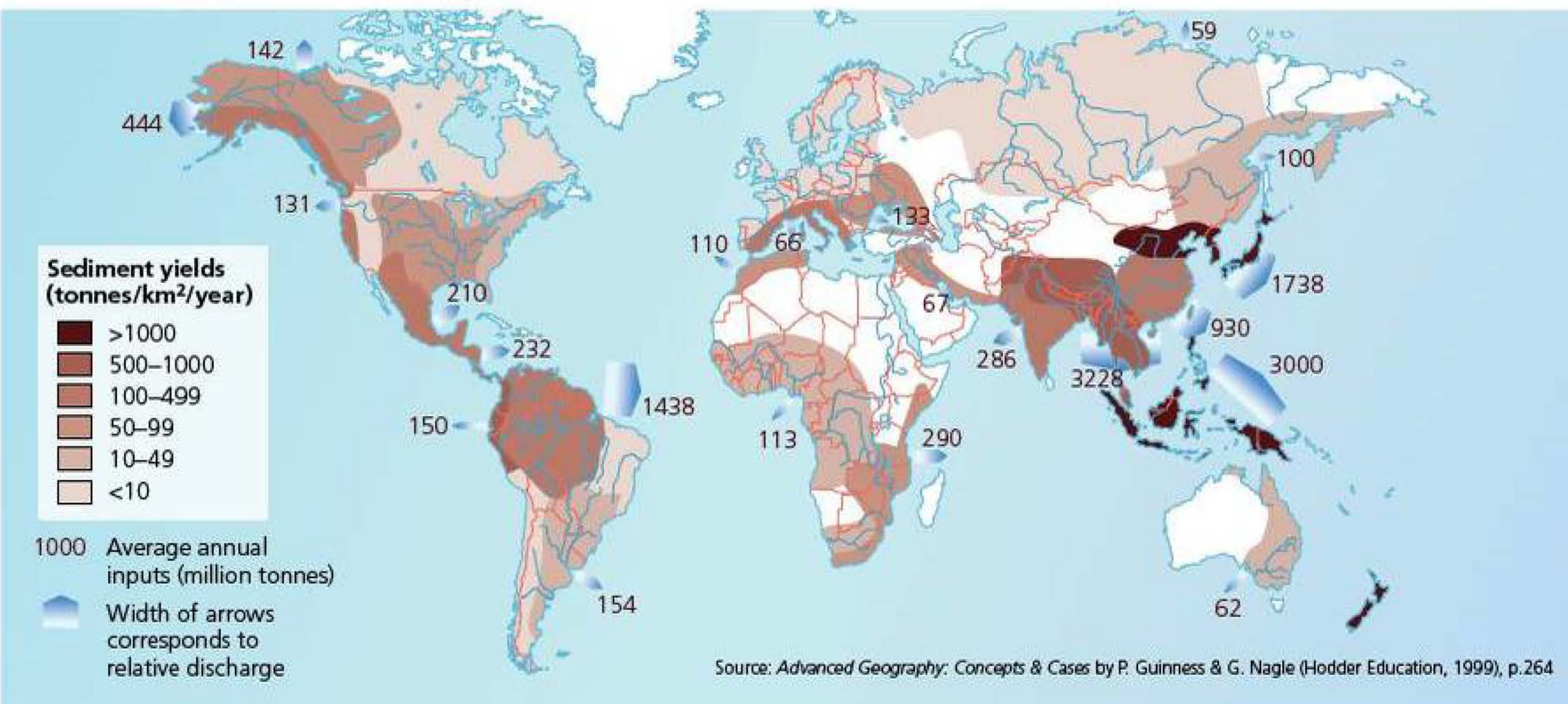
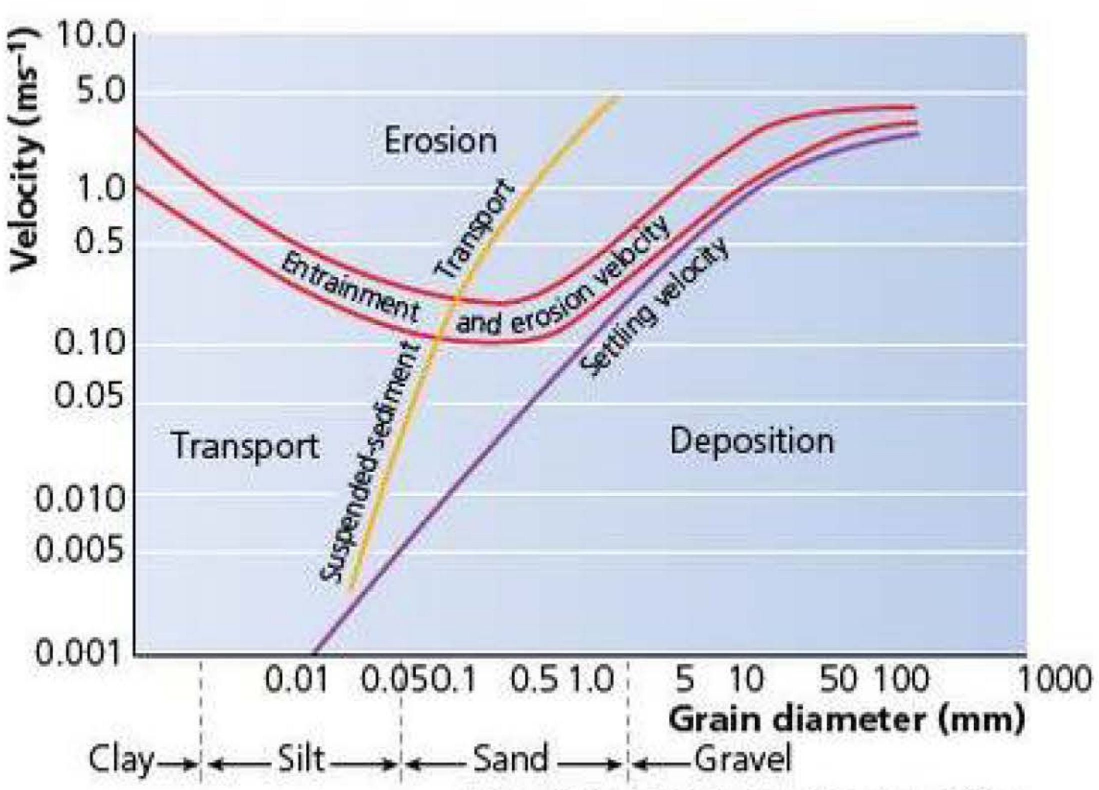


Figure 1.12 Global sediment yield

The Hjülstrom curve

The critical erosion velocity is the lowest velocity at which grains of a given size can be moved. The relationship between these variables is shown by means of a Hjülstrom curve (Figure 1.13). For example, sand can be moved more easily than silt or clay, as fine-grained particles tend to be more cohesive. High velocities are required to move gravel and cobbles because of their large size. The critical velocities tend to be an area rather than a straight line on the graph.



Source: *Advanced Geography: Concepts & Cases* by P. Guinness & G. Nagle (Hodder Education, 1999), p.263

Figure 1.13 Hjülstrom curve

There are three important features on Hjülstrom curves:

- The smallest and largest particles require high velocities to lift them. For example, particles between 0.1 mm and 1 mm require velocities of around 100 mm/s to be entrained, compared with values of over 500 mm/s to lift clay (0.01 mm) and gravel (over 2 mm). Clay resists entrainment due to its cohesion; gravel due to its weight.
- Higher velocities are required for entrainment than for transport.
- When velocity falls below a certain level (settling or fall velocity), those particles are deposited.

Section 1.3 Activities

Study Figure 1.13.

1 Describe the work of the river when sediment size is 1 mm.
2 Comment on the relationship between velocity, sediment size and river process when the river is moving at 0.5 m/s^{-1}.

River flow

Velocity and discharge

River flow and associated features of erosion are complex. The velocity and energy of a stream are controlled by:

- the gradient of the channel bed
- the volume of water within the channel, which is controlled largely by precipitation in the drainage basin (for example bankfull gives rapid flow, whereas low levels give lower flows)
- the shape of the channel
- channel roughness, including friction.

Manning's Equation

$Q = (AR^{2/3}\,S^{1/2})/n$

where Q = discharge, A = cross-sectional area, R = hydraulic radius, S = channel slope (as a fraction), n = coefficient of bed roughness (the rougher the bed the higher the value).

As water flows over riffles, for example, there are changes in cross-sectional area, slope and hydraulic radius. Slope and velocity increase but depth decreases. Discharge remains the same.

Manning's 'n'

Mountain stream, rocky bed	0.04–0.05
Alluvial channel (large dunes)	0.02–0.035
Alluvial channel (small ripples)	0.014–0.024

Patterns of flow

There are three main types of flow: laminar, turbulent and helicoidal. For laminar flow, a smooth, straight channel with a low velocity is required. This allows water to flow in sheets, or laminae, parallel to the channel bed. It is rare in reality and most commonly occurs in the lower reaches. However, it is more common in groundwater, and in glaciers when one layer of ice moves over another.

Turbulent flow occurs where there are higher velocities and complex channel morphology such as a meandering channel with alternating pools and riffles. Bed roughness also increases turbulence, for example mountain streams with rocky beds create more turbulence than alluvial channels. Turbulence causes marked variations in pressure within the water. As the turbulent water swirls (eddies) against the bed or bank of the river, air is trapped in pores, cracks and crevices and put momentarily under great pressure. As the eddy swirls away, pressure is released; the air expands suddenly, creating a small explosion that weakens the bed or bank material. Thus turbulence is associated with hydraulic action.

Vertical turbulence creates hollows in the channel bed. Hollows may trap pebbles that are then swirled by eddying, grinding at the bed. This is a form of vertical corrasion or abrasion and given time may create potholes (Figure 1.14). Cavitation and vertical abrasion may help to deepen the channel, allowing the river to down-cut its valley. If the down-cutting is dominant over the other forms of erosion (vertical erosion exceeds lateral erosion), then a gulley or gorge will develop.

Figure 1.14 Potholes as seen by the areas occupied by water (dark patches)

Horizontal turbulence often takes the form of helicoidal flow, a 'corkscrewing' motion. This is associated with the presence of alternating pools and riffles in the channel bed, and where the river is carrying large amounts of material. The erosion and deposition by helicoidal flow creates meanders (Figure 1.15). The thalweg is the line of maximum velocity and it travels from outside bank to outside bank of the meanders. The main current strikes the outer bank and creates a return flow to the inner bank, close to the channel bend. The movement transports sediment from the outer bank to the inner bank where it is deposited as a sand bar.

Channel types

Sinuosity is the length of a stream channel expressed as a ratio of the valley length. A low sinuosity has a value of 1.0 (that is, it is straight) whereas a high sinuosity is above 4.4. The main groupings are straight channels (<1.5) and meandering (>1.5). Straight channels are rare. Even when they do occur the thalweg (line of maximum velocity) moves from side to side. These channels generally have a central ridge of deposited material, due to the water flow pattern.

Braiding occurs when the channel is divided by islands or bars (Figure 1.16). Islands are vegetated and long-lived, whereas bars are unvegetated, less stable and often short-term features. Braided channels are formed by various factors, for example:

- a steep channel gradient
- a large proportion of coarse material
- easily erodable bank material
- highly variable discharge.

Braiding tends to occur when a stream does not have the capacity to transport its load in a single channel, whether it is straight or meandering. It occurs when river discharge is very variable and banks are easily erodable. This gives abundant sediment. It is especially common in periglacial and semi-arid areas.

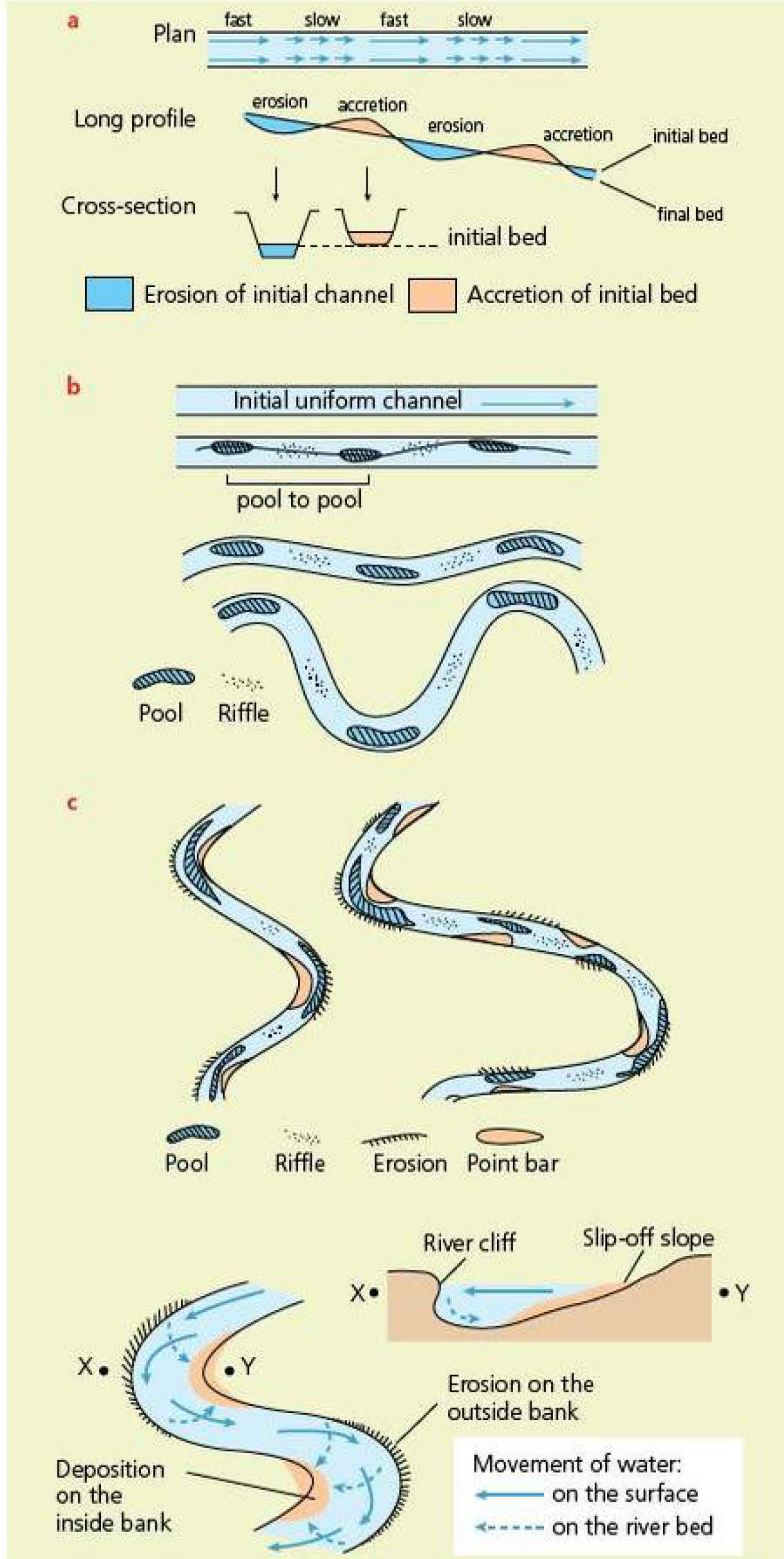


Figure 1.15 Meander formation

Braiding begins with a mid-channel bar that grows downstream. As the discharge decreases following a flood, the coarse bed load is first to be deposited. This forms the basis of bars that grow downstream and, as the flood is reduced, finer sediment is deposited. The upstream end becomes stabilised with vegetation. This island localises and narrows the channel in an attempt to increase the velocity to a point where it can transport its load. Frequently, subdivision sets in.

Figure 1.16 A braided river, Mýrdalsjökull, Iceland

Meanders

Meanders are complex (Figure 1.15). There are a number of relationships, although the reasons are not always very clear. However, they are *not* the result of obstructions in the floodplain. Meandering is the normal behaviour of fluids and gases in motion. Meanders can occur on a variety of materials, from ice to solid rock. Meander development occurs in conditions where channel slope, discharge and load combine to create a situation where meandering is the only way that the stream can use up the energy it possesses equally throughout the channel reach. The wavelength of the meander is dependent upon three main factors: channel width, discharge and the nature of the bed and banks.

Meanders and channel characteristics

- Meander wavelengths are generally 6–10 times channel width and discharge.
- Meander wavelengths are generally 5 times the radius of curvature.
- The meander belt (peak-to-peak amplitude) is generally 14–20 times the channel width.
- Riffles occur at about 6 times the channel width.
- Sinuosity increases as depth of channel increases in relation to width.
- Meandering is more pronounced when the bed load is varied.
- Meander wavelength increases in streams that carry coarse debris.
- Meandering is more likely on shallow slopes.
- Meandering best develops at or near bankfull state.

Natural meanders are rarely 'standard'. This is due, in part, to variations in bed load; where the bed load is coarse, meanders are often very irregular.

Causes of meanders

There is no simple explanation for the creation of meanders, and a number of factors are likely to be important.

- **Friction** with the channel bed and bank causes turbulence, which makes stream flow unstable. This produces bars along the channel, and a helicoidal flow (corkscrew motion), with water being raised on the outer surfaces of pools, and the return flow occurring at depth.
- **Sand bars** in the channel may cause meandering.
- **Sinuosity** is best developed on moderate angles. There is a critical minimum gradient below which straight channels occur. At very low energy (low gradient), helicoidal flow is insufficient to produce alternating pools and riffles. In addition, high-velocity flows in steep gradient channels are too strong to allow cross-channel meandering and the development of alternating pools and riffles. In such circumstances, braided channels are formed.
- **Helicoidal flow** (corkscrewing) causes the line of fastest flow to move from side to side within the channel. This increases the amplitude of the meander.

Change over time

There are a number of possibilities:

- Meanders may migrate downstream and erode river cliffs.
- They may migrate laterally (sideways) and erode the floodplain.
- They may become exaggerated and become cut-offs (ox-bow lakes).
- Under special conditions, they may become intrenched or ingrown.

Intrenched and ingrown meanders

The term incised meanders describes meanders that are especially well developed on horizontally bedded rocks, and form when a river cuts through alluvium and into underlying bedrock. Two main types occur – intrenched and ingrown meanders. Intrenched meanders are symmetrical, and occur when down-cutting is fast enough to offset the lateral migration of meanders. This frequently occurs when there is a significant fall in base level (generally sea level). The Goosenecks of the San Juan in the USA are classic examples of intrenched meanders. Ingrown meanders are the result of lateral meander migration. They are asymmetric in cross-section – examples can be seen in the lower Seine in France.

Landforms

Meanders

Meanders have an asymmetric cross-section (Figure 1.15b). They are deeper on the outside bank and shallower on the inside bank. In between meanders they are more symmetrical. They begin with the development of pools and riffles in a straight channel and the thalweg begins to flow from side to side. Helicoidal flow occurs, whereby surface water flows towards the outer banks, while the bottom flow is towards the inner bank. This causes the variations in the cross-section and variations in erosion and deposition. These variations give rise to river cliffs on the outer bank and point bars on the inner bank.

Pools and riffles

Pools and riffles are formed by turbulence. Eddies cause the deposition of coarse sediment (riffles) at high velocity points and fine sediment (pools) at low velocity. Riffles have a steeper gradient than pools, which leads to variations in subcritical and supercritical flow, and therefore erosion and deposition.

Riffles are small ridges of material deposited where the river velocity is reduced midstream, in between pools (the deep parts of a meander).

Braided rivers

A braided river channel consists of a number of interconnected shallow channels separated by alluvial and shingle bars (islands). These may be exposed during low flow conditions. They are formed in rivers that are heavily laden with sediment and have a pronounced seasonal flow. There are excellent examples on the Eyjafjörður in northern Iceland.

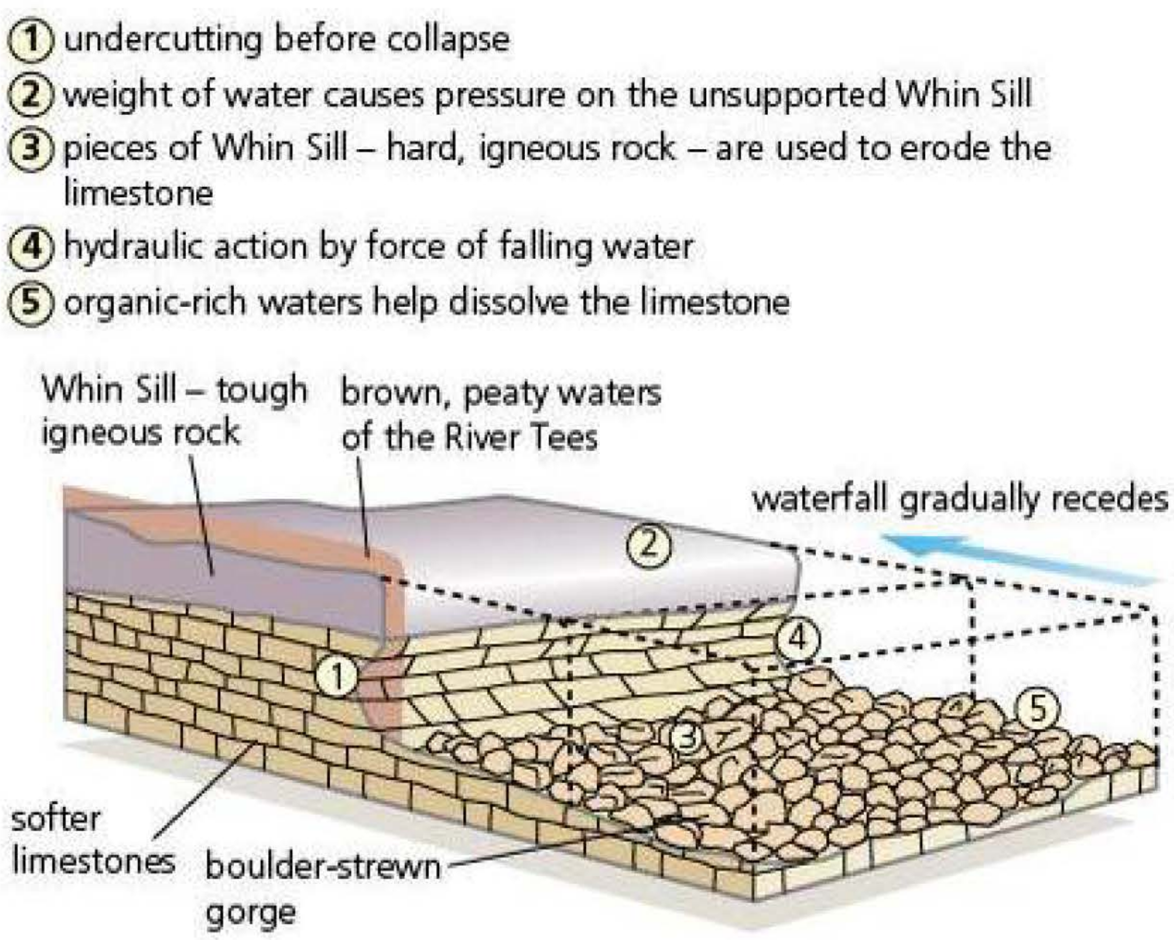
Section 1.3 Activities

Study Figure 1.15.

1 Compare the main characteristics of river cliffs with those of point bars.
2 Briefly explain the meaning of the term *helicoidal flow*.
3 Describe and explain the role of pools and riffles in the development of meanders in a river channel.

Waterfalls and gorges

Waterfalls occur where the river spills over a sudden change in gradient, undercutting rocks by hydraulic impact and abrasion, thereby creating a waterfall (Figures 1.17 and 1.18). There are many reasons for this sudden change in gradient along the river:



Source: Goudie, A. and Gardner, R., *Discovering Landscapes in England and Wales*, Unwin 1985

Figure 1.17 Waterfall formation

- a band of resistant strata such as the resistant limestones at Niagara Falls
- a plateau edge such as Victoria Falls on the Zimbabwe–Zambia border
- a fault scarp such as at Gordale, Yorkshire (UK)
- a hanging valley such as at Glencoyne, Cumbria in the UK
- coastal cliffs.

The undercutting at the base of a waterfall creates a precarious overhang, which will ultimately collapse. Thus a waterfall may appear to migrate upstream, leaving a gorge of recession downstream. The Niagara Gorge is 11 kilometres long due to the retreat of Niagara Falls.

Gorge development is common, for example where the local rocks are very resistant to weathering but susceptible to the more powerful river erosion. Similarly, in arid areas where the water necessary for weathering is scarce, gorges are formed by periods of river erosion. A rapid acceleration in down-cutting is also associated when a river is rejuvenated, again creating a gorge-like landscape. Gorges may also be formed as a result of:

- antecedent drainage (Rhine Gorge)
- glacial overflow channelling (Newtondale, UK)
- the collapse of underground caverns in Carboniferous limestone areas
- surface runoff over limestone during a periglacial period
- the retreat of waterfalls (Niagara Falls)
- superimposed drainage (Avon Gorge, UK).

Figure 1.18 Axara waterfall, Iceland

Case Study: Niagara Falls

Most of the world's great waterfalls are the result of the undercutting of resistant cap rocks, and the retreat or recession that follows. The Niagara River flows for about 50 kilometres between Lake Erie and Lake Ontario. In that distance it falls just 108 metres, giving an average gradient of 1:500. However, most of the descent occurs in the 1.5 kilometres above the Niagara Falls (13 metres) and at the Falls themselves (55 metres). The Niagara River flows in a 2 kilometre-wide channel just 1 kilometre above the Falls, and then into a narrow 400 metre-wide gorge, 75 metres deep and 11 kilometres long. Within the gorge the river falls a further 30 metres.

The course of the Niagara River was established about 12 000 years ago when water from Lake Erie began to spill northwards into Lake Ontario. In doing so, it passed over the highly resistant dolomitic (limestone) escarpment. Over the last 12 000 years the Falls have retreated 11 kilometres, giving an average rate of retreat of about 1 metre per year. Water velocity accelerates over the Falls, and decreases at the base of the Falls. Hydraulic action and abrasion have caused the development of a large plunge pool at the base, while the fine spray and eddies in the river help to remove some of the softer rock underneath the resistant dolomite. As the softer rocks are removed, the dolomite is left unsupported and the weight of the water causes the dolomite to collapse. Hence the waterfall retreats, forming a gorge of recession.

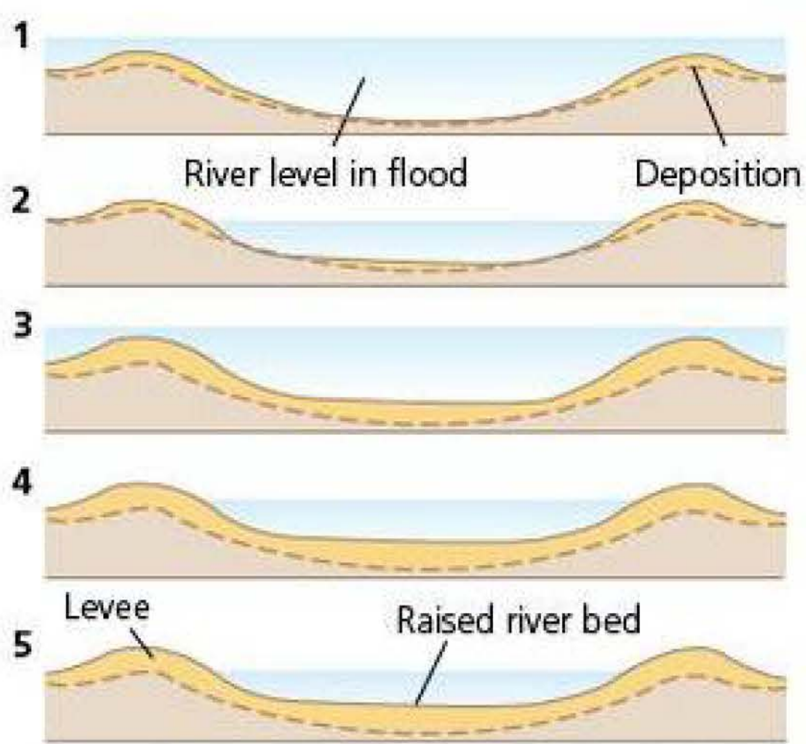
In the nineteenth century, rates of recession were recorded at 1.2 metres per year. However, now that the amount of water flowing over the Falls is controlled (due to the construction of hydro-electric power stations), rates of recession have been reduced. In addition, engineering works in the 1960s reinforced parts of the dolomite that were believed to be at risk of collapse. The Falls remains an important tourist attraction and local residents and business personnel did not want to lose their prized asset!

Section 1.3 Activities

Draw a labelled diagram to show the formation of a waterfall.

Levees, floodplains and bluffs

Levees and floodplain deposits are formed when a river bursts its banks over a long period of time. Water quickly loses velocity, leading to the rapid deposition of coarse material (heavy and difficult to move a great distance) near the channel edge. These coarse deposits build up to form embankments called **levees** (Figure 1.19). The finer material is carried further away to be dropped on the **floodplain** (Figure 1.20), sometimes creating **backswamps**. Repeated annual flooding slowly builds up the floodplain. Old floodplains may be eroded – the remnants are known as terraces. At the edge of the terrace is a line of relatively steep slopes known as **river bluffs**.



1 When the river floods, it bursts its banks. It deposits its coarsest load (gravel and sand) closest to the bank and the finer load (silt and clay) further away.
2, 3, 4 This continues over a long time, for centuries.
5 The river has built up raised banks, called levees, consisting of coarse material, and a floodplain of fine material.

Figure 1.19 The formation of levees

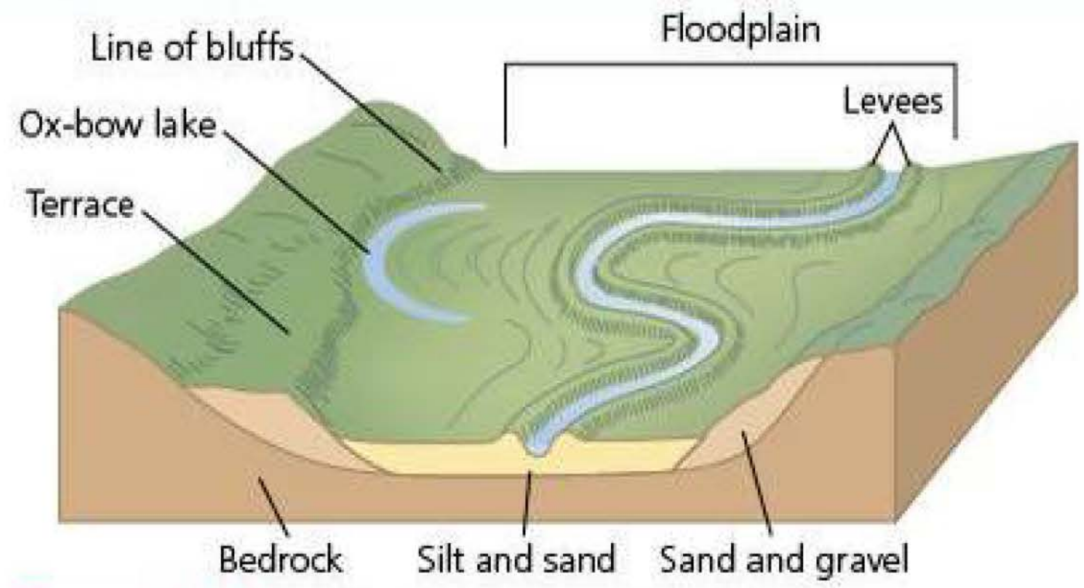
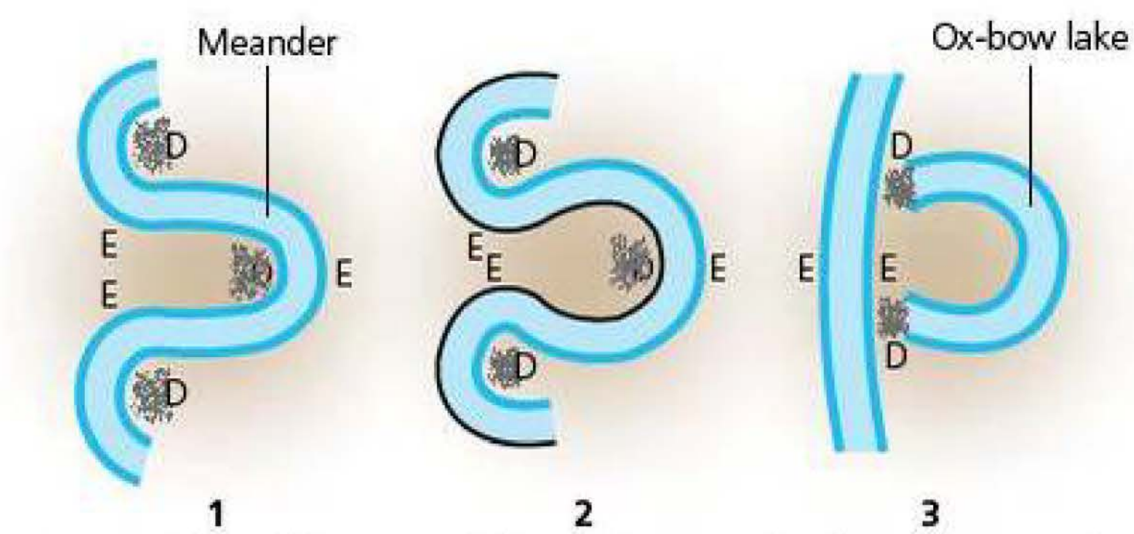


Figure 1.20 Floodplains, levees and bluffs

Ox-bow lakes

Ox-bow lakes are the result of both erosion and deposition. Lateral erosion, caused by helicoidal flow, is concentrated on the outer, deeper bank of a meander. During times of flooding, erosion increases. The river breaks through and creates a new steeper channel. In time, the old meander is closed off by deposition to form an ox-bow lake.

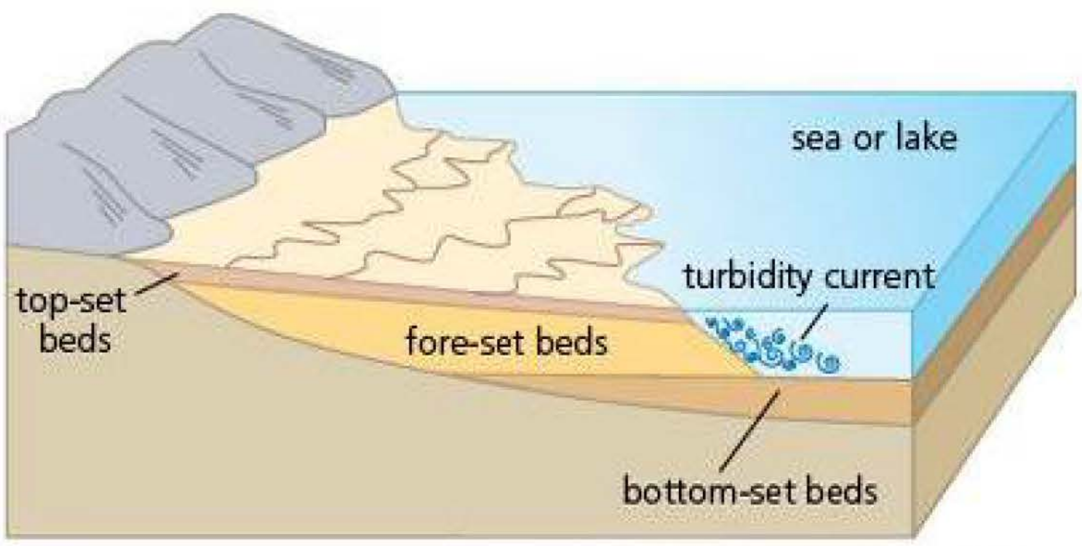


1 Erosion (E) and deposition (D) around a meander (a bend in a river).
2 Increased erosion during flood conditions. The meander becomes exaggerated.
3 The river breaks through during a flood. Further deposition causes the old meander to become an ox-bow lake.

Figure 1.21 Formation of an ox-bow lake

Deltas

Deltas are river sediments deposited when a river enters a standing body of water such as a lake, a lagoon, a sea or an ocean (Figure 1.22). They are the result of the interaction of fluvial and marine processes. For a delta to form there must be a heavily laden river, such as the Nile or the Mississippi, and a standing body of water with negligible currents, such as the Mediterranean or the Gulf of Mexico. Deposition is enhanced if the water is saline, because salty water causes small clay particles to flocculate or adhere together. Other factors include the type of sediment, local geology, sea-level changes, plant growth and human impact.



Source: *Advanced Geography: Concepts & Cases* by P. Guinness & G. Nagle (Hodder Education, 1999), p.268

Figure 1.22 Model of a simple delta

The material deposited as a delta can be divided into three types:

- Bottomset beds – the lower parts of the delta are built outwards along the sea floor by turbidity currents (currents of water loaded with material). These beds are composed of very fine material.
- Foreset beds – over the bottomset beds, inclined/sloping layers of coarse material are deposited. Each bed is deposited above and in front of the previous one, the material moving by rolling and saltation. Thus the delta is built seaward.
- Topset beds – composed of fine material, they are really part of the continuation of the river's floodplain. These topset beds are extended and built up by the work of numerous distributaries (where the main river has split into several smaller channels).

The character of any delta is influenced by the complex interaction of several variables (Figure 1.23):

- the rate of river deposition
- the rate of stabilisation by vegetation growth
- tidal currents
- the presence (or absence) of longshore drift
- human activity (deltas often form prime farmland when drained).

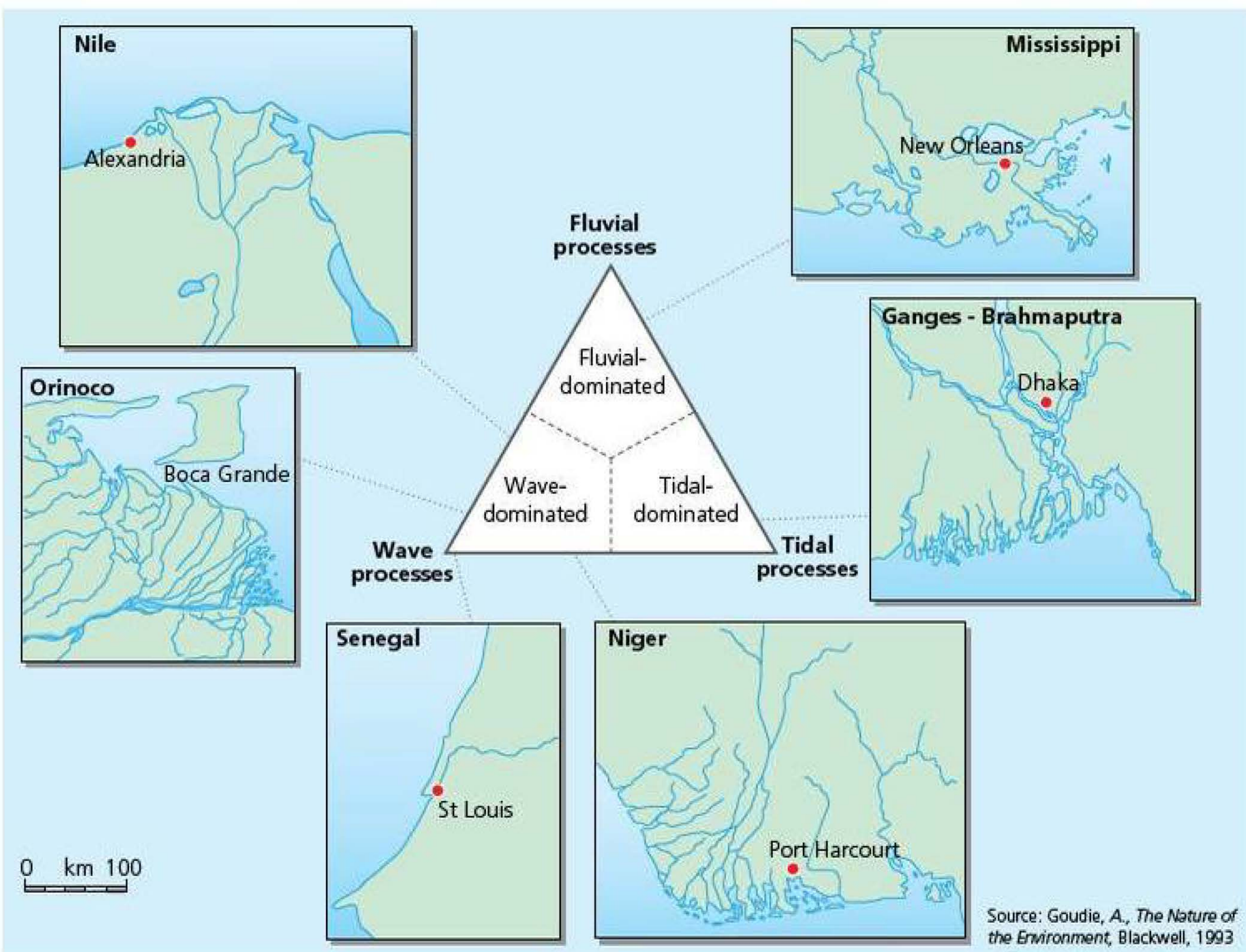


Figure 1.23 River delta shapes related to river, wave and tidal processes

There are many types of delta, but the three 'classic' ones are:

- **Arcuate delta**, or fan-shaped – these are found in areas where regular longshore drift or other currents keep the seaward edge of the delta trimmed and relatively smooth in shape, such as the Nile and Rhône deltas.
- **Cuspate delta** – pointed like a tooth or cusp, for example the Ebro and Tiber deltas, shaped by regular but opposing gentle water movement.
- **Bird's-foot delta** – where the river brings down enormous amounts of fine silt, deposition can occur in a still sea area, along the edges of the distributaries for a very long distance offshore, such as the Mississippi delta.

Deltas can also be formed inland. When a river enters a lake it will deposit some or all of its load, so forming a **lacustrine delta**. As the delta builds up and out, it may ultimately fill the lake basin. The largest lacustrine deltas are those that are being built out into the Caspian Sea by the Volga, Ural, Kura and other rivers.

Case Study: The future of the Nile delta

The Nile delta is under threat from rising sea levels. Without the food it produces, Egypt faces much hardship. The delta is one of the most fertile tracts of land in the world. However, coastal erosion is steadily eroding it in some places at a rate of almost 100 metres a year. This is partly because the annual deposits from the Nile floods – which balanced coastal erosion – no longer reach the delta, instead being trapped behind the Aswan High Dam. However, erosion of the delta continues, and may be increasing, partly as a result of **global warming** and rising sea levels. The delta is home to about 50 million people, living at densities of up to 4000 people per km^2.

The Intergovernmental Panel on Climate Change has declared Egypt's Nile delta to be among the top three areas most vulnerable to a rise in sea level. Even a small temperature increase will displace millions of Egyptians from one of the most densely populated regions on Earth.

The delta stretches out from the northern reaches of Cairo into 25 000 km^2 of farmland fed by the Nile's branches. It is home to two-thirds of the country's rapidly growing population, and responsible for more than 60 per cent of its food supply. About 270 kilometres of the delta's coastline is at a dangerously low level and a 1 metre rise in the sea level would drown 20 per cent of the delta.

The delta is also suffering from a number of environmental crises, including flooding, coastal erosion, salinisation, industrial/agricultural **pollution** and urban encroachment. Egypt's population of 83 million is set to increase to more than 110 million in the next two decades. More people in the delta means more cars, more pollution and less land to feed them all on, just at a time when increased crop production is needed most.

Saltwater intrusion is destroying crops. Coastal farmland has always been threatened by salt water, but salinity has traditionally been kept at bay by plentiful supplies of fresh water flushing out the salt. It used to happen naturally with the Nile's seasonal floods; after the construction of Egypt's High Dam, these seasonal floods came to an end, but a vast network of irrigation canals continued to bring enough fresh water to ensure salinity levels remained low.

Today, however, Nile water barely reaches the end of the delta. A growing population has extracted water supplies upstream, and what water does make it downriver is increasingly polluted with toxins and other impurities.

The impact of **climate change** is likely to be a 70 per cent drop in the amount of Nile water reaching the delta over the next 50 years, due to increased evaporation and heavier demands on water use upstream. The consequences for food production are ominous: wheat and maize yields could be down 40 per cent and 50 per cent respectively, and farmers could lose around $1000 per hectare for each degree rise in the average temperature.

While politicians, scientists and community workers are trying to educate Egyptians about the dangers of climate change, there is confusion over whether the focus should be on promoting ways to combat climate change, or on accepting climate change as inevitable and instead encouraging new forms of adaptation to the nation's uncertain future.

Egypt's contribution to global carbon emissions is just 0.5 per cent – nine times less per person than for the USA. However, the consequences of climate change are disproportionate and potentially disastrous.

The scale of the crisis – more people, less land, less water, less food – is overwhelming. As a result, many now believe that Egypt's future lies far away from the delta, in land newly reclaimed from the desert. Since the time of the pharaohs, when the delta was first farmed, Egypt's political leaders have tried to harness the Nile. The Egyptian government is creating an array of canals and pumping stations that draw water from the Nile into sandy valleys to the east and west, where the desert is slowly being turned green. The Nile delta may well become history – as a landform and for the people who live and work there.

Section 1.3 Activities

1 Outline the main conditions needed for delta formation.
2 Suggest reasons for the variety of deltas, as shown in Figure 1.23.
3 a Outline the natural and human processes that are operating on the Nile delta.
  b Comment on the advantages and disadvantages for people living in the delta.