UNIT 1

Physical and human geography

Topic 1.1 Rivers, floods and management

Things to learn

- ★ **The drainage basin hydrological cycle.** You should know the meaning of the following key terms: precipitation, transpiration, evaporation, interception, throughfall, stemflow, surface storage, overland flow, vegetation storage, infiltration, soil water storage, throughflow, channel storage, percolation, groundwater storage, groundwater flow (base flow), runoff.
- ★ **The water balance.** You should know the meaning of the following key terms: inputs (precipitation), outputs (runoff and evapotranspiration), water surplus, soil moisture utilisation, soil moisture recharge.
- ★ **The storm hydrograph.** You should know the meaning of the following key terms: discharge, base flow, rising limb, receding limb, lag time
- ★ **Long profiles and the factors that determine their shape; the progression to the graded profile**
- ★ **Valley cross profiles and the factors determining their shape**
- ★ **Potential and kinetic energy**
- ★ **Changing channel characteristics.** You should know the meaning of the following key terms: channel cross profile, roughness, discharge, efficiency, hydraulic radius, velocity, wetted perimeter, braided channels.
- ★ **Landforms of fluvial erosion: waterfalls/rapids, gorges, potholes, meanders and oxbow lakes.** For each of these features you should be able to **describe** the following: shape, size (dimensions), composition, its relationship with other features (its position on the river), and the detailed processes that formed it.
- ★ **Landforms of fluvial deposition: floodplain, levée, delta.** For each of these features you should be able to **describe** the following: shape, size (dimensions), composition, its relationship with other features and the detailed processes that formed it.
- ★ **The capacity and competence of a river; the spatial variations in load**
- ★ **The effects of river rejuvenation: knickpoints, waterfalls, river terraces, incised meanders.** For each of these features you should be able to **describe** the following: size (dimensions), shape, its position within the river system and the rejuvenation processes that formed it.
- ★ **The physical and human causes of flooding in general, including deforestation and urbanisation**
- ★ **The impacts of flooding in general**

Things to understand

In every physical section it is important that you understand the link between the shape/appearance of a landform and the processes that formed it. Taking the example of a river pothole, you should understand the following sequence of processes:

- ★ A cylindrical hole is drilled into the rocky bed of a river by turbulent high-velocity water loaded with pebbles.
- ★ These pebbles are trapped in slight hollows where vertical eddies in the water are strong enough to allow sediment to grind a hole in the rock by abrasion.
- ★ In addition, any small crack in the hollow is widened by hydraulic action.
- ★ As a result, the pebbles are gradually rounded and reduced in size by attrition. Potholes are found in the upper valley, which lies well above base level giving more potential for downcutting.

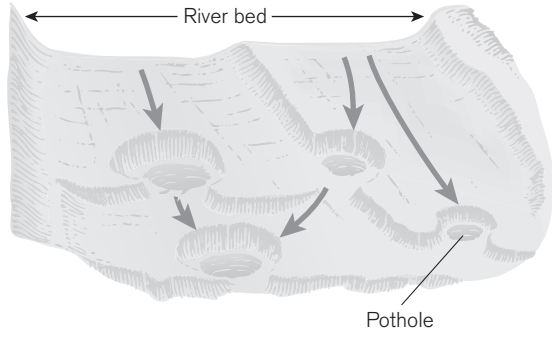

Figure 1.1 The formation of river potholes

The factors affecting water balance. You should be able to understand the interrelationships between inputs into the drainage basin, the outputs from the basin, the various ways in which water is stored within it, and the transfers of water from one part of the basin to another.

Factors affecting river discharge. You should be able to understand antecedent rainfall, intensity and duration of rainfall, snow, porosity/permeability of soil/rock, drainage basin size/shape, slopes, vegetation cover, land use and urbanisation.

Processes of fluvial erosion. You should be able to understand hydraulic action, abrasion, attrition, corrosion. You should be able to use alternative words to demonstrate you understand them — for example, scraping, scouring and rubbing for 'abrasion'.

You must be clear in the meaning of these terms and of how they operate in a river context.

Processes of transportation of the river load. You should be able to understand traction, suspension, saltation, solution. You should be able to use alternative words to demonstrate you understand them — for example, rolling for 'traction'.

The Hjulström curve. This shows how erosion, transport and deposition are related to changes in velocity. It is a complicated graph, and you should be able to appreciate how differing river velocities impact on the load of a river.

Why and how rivers deposit their load. You should be able to understand the factors that cause rivers to deposit their load — for example, reduced gradient, reduced discharge, and variations in the size of load received.

The causes of rejuvenation. You should be able to understand the factors that cause sea level to lower, relative to the level of the land.

You should be able to understand how each of these aims to control flooding in general.

Flood prediction. You should be aware of how hydrologists try to forecast the likelihood of future floods, including magnitude and frequency analysis.

Flood management strategies:

- ★ Hard engineering strategies: dams, embankments and levées, channel straightening, channel enlargement, flood-relief channels (diversion spillways) and flood-storage reservoirs.
- ★ Soft engineering strategies: afforestation, land-use zoning and management, wetland and river bank conservation, river restoration and weather forecasting.

Key case studies

- ★ The causes and impacts of river flooding in two recent events taken from contrasting areas of the world should be covered. One example could be taken from the UK or another developed country such as the USA (e.g. Mississippi flooding), and the other from a developing country such as Bangladesh or Mozambique. Make sure you examine the impacts from a range of aspects, such as social, economic and environmental.
- ★ Detailed studies should be undertaken of at least one flood-management scheme involving hard engineering and one involving soft engineering. Be sure of the relative advantages and disadvantages of each of the schemes you have studied.

Testing your knowledge and understanding

Hints

2 On a simple level, think of what is coming into the basin and what is going out. In terms of the water, work out where it might go.

5 What happens after the soil has reached field capacity?

The **answers** to the **questions** are on pages 74–76

1 What is a drainage basin?

2 What are the inputs and outputs of the drainage basin hydrological cycle?

3 Explain what is meant in the drainage basin by 'interception'.

4 What do you understand by the term 'base flow'?

5 Study Figure 1.2, which shows a water budget graph (water balance). Which shading would you use for the area left blank on the right-hand side of the diagram (between the precipitation and potential evapotranspiration lines)? Explain your choice.

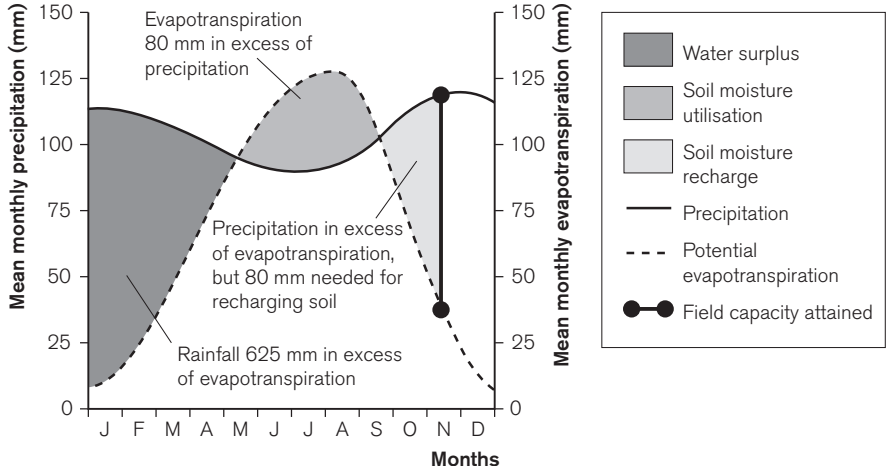

Figure 1.2 Water balance

Hints

6 River discharge is a volume. What two pieces of information do you need to calculate that volume?

8 For **c** think of the effect on running water of the given features. Do they slow the water down or do they speed it up. For **d**, you are looking for the cause of the flood on this river.

6 How would you measure river discharge?

7 What factors can affect river discharge?

8 Study Figure 1.3, which shows a storm hydrograph for the River Calder on 6 July 2006 and answer the following questions:

- **a** What was the lag time?
- **b** How far above base flow was the peak discharge?
- **c** How did the steep slopes, impermeable geology and the sparse woodland cover of the Calder catchment contribute to the shape of the hydrograph?
- **d** What information on Figure 1.3 shows another factor important in the shape of the hydrograph?

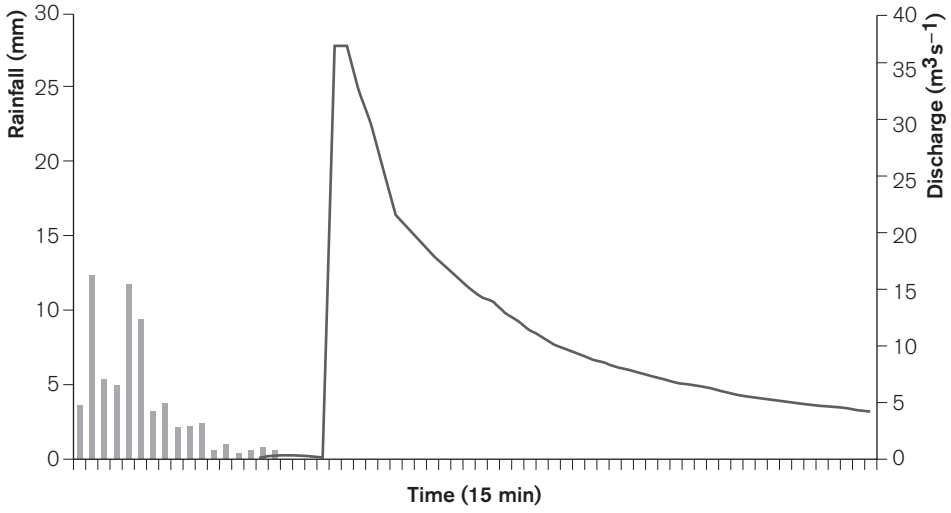

Figure 1.3 Storm hydrograph for River Calder, 6 July 2006

9 By which processes do rivers erode?

10 Define the terms 'capacity' and 'competence' in the context of river transport.

11 How do rivers transport their load?

12 Why do rivers deposit their load?

13 Study Figure 1.4, which shows the changes in sediment roundness on a section of the River Aire in Yorkshire.

- **a** Describe the changes in the roundness of sediment along the section.
- **b** How could the changes that occur around 8 kilometres be explained?

Hint

13 For **b**, if angular fragments dominate again, they cannot have been changed from rounded fragments (as angular are changed into rounded by the passage downstream), so where did they come from?

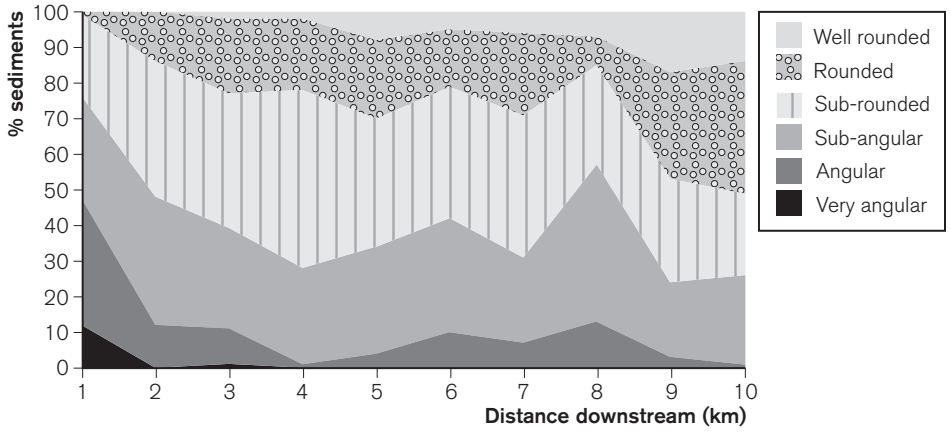

Figure 1.4 Downstream changes in sediment roundness on the River Aire

14 How can variations in the long profile be explained?

15 How does the changing shape of a river's channel affect its efficiency?

16 Calculate the hydraulic radius of the two channels shown in Figure 1.5. Which channel is more efficient?

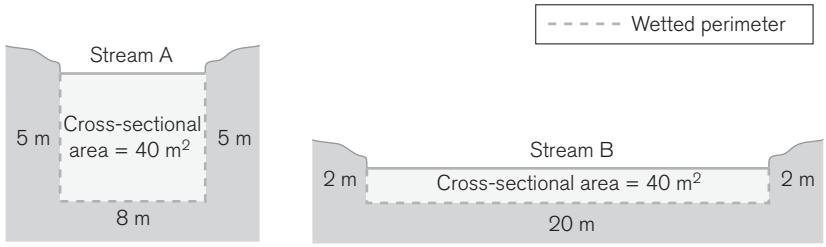

Figure 1.5 Channel shape

Hint

17 If a channel is rough as opposed to smooth, how does that affect the water in it?

17 How does channel roughness affect a river?

18 Explain the formation of braided channels.

19 How do rivers form floodplains?

20 Explain the formation of a delta.

21 Explain what is meant by 'river rejuvenation'.

22 How are incised meanders formed?

23 What are the physical causes of river flooding?

24 How can human activities lead to river flooding?

25 How can floods be predicted?

Hint

26 For a full answer you need to make the contrasts based on categories such as housing, agriculture, industry, transport, water/power supplies, loss of life, disease, and overall, the cost. You might also consider the impact on different members of society.

26 Compare the impacts of a major flood in two contrasting areas of the world.

27 In terms of responses to a flood problem, what do you understand by 'hard engineering' solutions?

28 How are 'soft engineering' solutions better for a river system than solutions based upon hard engineering?

29 Figure 1.6 describes a major flood event, which took place in Hull in June 2007. What was the impact of the flood upon the city of Hull?

On 25 June Hull received 96 mm of rainfall in 2 hours, almost one-sixth of its average annual precipitation. This resulted in extensive flooding of the city, engulfing over 7000 residential properties and 1300 businesses. One person died. By 12 July, thousands of insurance claims had been received for flood damage to properties, at an estimated cost to insurers of £250 million, but it was estimated that 2000 families had no contents' insurance. The local council, in defiance of government policy, did not have flood insurance for its properties; some 3500 council houses and 12 schools suffered severe damage as a result of the floods. Special assistance was provided by the local council to those affected who were elderly or disabled and those families with children below school age, whether insured or not. £18 million was earmarked by Hull City Council for repairs to affected homes. For the first time ever, the national government agreed to pay compensation to uninsured individuals.

Figure 1.6

30 How may global warming affect rivers and drainage basins?

Topic **1.2** Cold environments

Things to learn

- ★ **The global distribution of cold environments including polar (marine and land), alpine, glacial and periglacial.** You should know the meaning of each term, the areas where they are to be found (both today and in the past) and the actual and relative size of each at the present time.
- ★ **The glacier as a system; how the glacial budget works and the types of ice flow within the system.** You should know where the following operate within the system: rotational flow, compressional flow, extension flow and basal sliding; the differences in flow between warm- and cold-based glaciers.
- ★ **Landforms of glacial erosion: corries, arêtes, pyramidal peaks, glacial troughs, hanging valleys, ribbon lakes and roches moutonnées.** For each feature you should be able to **describe** the following: shape, size (dimensions), position within the glacial area (i.e. its relationships with other features), orientation and the detailed processes that formed it. Know examples of the major landforms.
- ★ **The ways in which glaciers transport debris to include: on the top (supraglacial), within the ice (englacial) and underneath the ice (subglacial)**
- ★ **Landforms that result mainly from glacial deposition: drumlins and moraines (terminal and recessional).** For each feature you should be able to **describe** the following: shape, size (dimensions), composition, position within the glacial area (i.e. its relationship with other features), orientation and the detailed processes that formed it.
- ★ **Landforms that result from fluvioglacial processes: meltwater channels, eskers, kames, outwash plains (including kettle holes).** For each feature you should be able to **describe** the following: shape, size (dimensions), composition (if applicable), position within the periglacial area (i.e. its relationship with other features), orientation and the detailed processes that formed it.
- ★ **A description of the permafrost**
- ★ **The major landforms that result from the processes of periglaciation: nivation hollows, ice wedges, patterned ground, pingos and solifluction lobes.** You should be able to **describe** each feature in terms of shape, size (dimensions), composition, (if applicable), position within the periglacial area, orientation and link it closely with the processes that produced it.
- ★ **The traditional economy of the tundra and its recent changes/adaptations**
- ★ **Early resource exploitation in the tundra by outsiders (sealing and whaling) and recent developments in the area such as oil exploitation, fishing and tourism**
- ★ **The concept of a fragile environment and why the tundra should be considered as such; wilderness areas and why they are considered to be important**
- ★ **Sustainable development**
- ★ **Conservation, protection and sustainable development in Antarctica**

This should, in particular, make reference to the activities of the indigenous population and how they formed sustainable economies.

This should also include some knowledge of the Southern Ocean, the seas that surround Antarctica.

Things to understand

In every physical section it is important that you understand the link between the shape/appearance of a landform and the processes that formed it. Taking the example of a corrie, you must be able to understand the following:

- ★ initial hollow — formed by the process of nivation
- ★ steep backwall — result of frost shattering and plucking by ice
- ★ deep hollow — result of rotational movement of ice within the corrie and the debris obtained through frost shattering and plucking carrying out abrasion
- ★ rock lip — the result of the over-deepening of the hollow
- ★ possible moraine on lip — deposited during deglaciation as the glacier 'retreated' into corrie

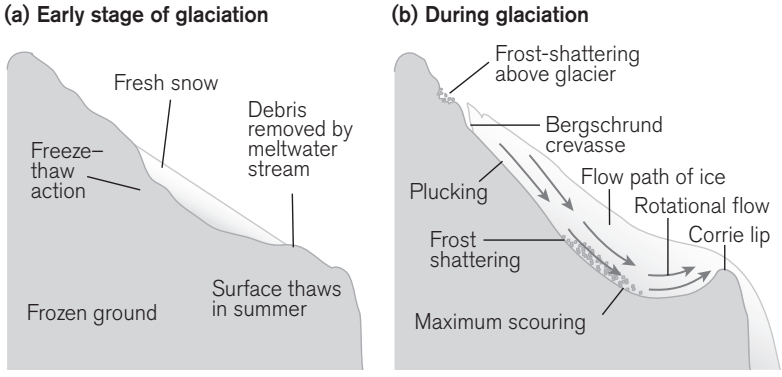

Figure 1.7 The formation of a corrie

Accumulation and ablation within the glacial budget. You should understand how the balance between the inputs into the system (accumulation) and the outputs (mainly ablation) affects the state of a glacier and its movement. You should also understand how, in temperate glaciers, there is a negative balance in summer and the reverse in winter.

Types of ice flow: rotational, compressional, extensional and basal sliding. It is important to understand how these types of flow occur and the impact that each has upon the work of the glacier — for example, erosion and deposition.

Processes of glacial erosion: abrasion and plucking. You should understand in detail how these two processes work and the effect that they can have on the glacial landscape. You should also understand how these processes are responsible for the features of glacial erosion such as corries, arêtes, pyramidal peaks, glacial troughs and hanging valleys. The detail expected is shown in the corrie example.

The process of frost shattering. You should understand how this process contributes material to enable a glacier to carry out the process of abrasion.

Again, it is important to understand the link between the detail of the feature and the exact process bringing it about.

The transportation of debris by a glacier. You should understand the various methods of transportation (supraglacial, englacial and subglacial) and why material is carried in that position.

Glacial deposition. You should understand the difference between lodgement and ablation till and where you find each of these in the glacial landscape. You should also understand the formation of drumlins and moraines.

The processes connected with fluvioglaciation, including the role of glacial meltwater. You should understand how fluvioglacial processes formed eskers, kames, kettle holes and the outwash plain.

Periglacial processes. You should understand how periglacial processes operate and, in particular, how they cause specific landforms. This should involve frost shattering being responsible for scree and blockfields, nivation for nivation hollows, solifluction for lobes, frost heave for stone stripes and polygons and ground contraction for ice wedges. You should also understand how wind and water action can affect the periglacial landscape.

Human activity. You should understand how people in modern times are able to cope with the difficult physical conditions presented by the tundra and how it can be possible for development to be sustainable.

Key case studies

- ★ Antarctica and the Southern Ocean, including the exploitation of the seas and the development of tourism should be covered. Contemporary issues should be considered involving conservation, protection, development and sustainability in this wilderness region.
- ★ Detailed studies should also be made of other aspects of human involvement in the tundra. Some suggested topics are the Trans-Alaska oil pipeline, the economy of the indigenous populations of northern North America and northern Eurasia, and the Arctic National Wildlife Refuge (ANWR) with particular reference to the oil industry.

Testing your knowledge and understanding

1 Where would you find ice sheets at the present day?

2 What do you understand by the term 'snow line'?

Hint

3 Try to work out which slope will be warmer.

3 On European mountains, on which side (north or south) is the snow line higher in summer? Explain your answer.

4 Explain the formation of 'neve' (firn).

5 Describe three types of ice flow associated with valley glaciers.

6 Look at Figure 1.8 which shows the effect of ice movement on a flexible pipe inserted vertically into a glacier. Using the diagram and your own knowledge, explain why the pipe has deformed in the way it has.

The **answers** to the **questions** are on pages 76–79

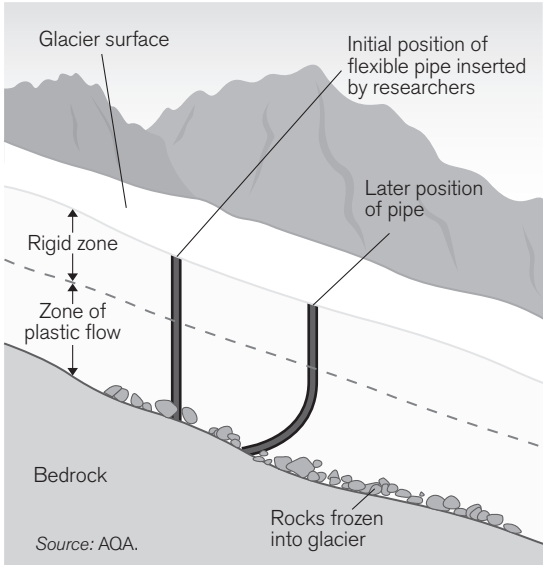

Figure 1.8 Ice movement