TOPIC 3
Landscapes formed by water

3.1 Overview
Numerous videos and interactivities are embedded just where you need them, at the point of learning, in your learnON title at www.jacplus.com.au. They will help you to learn the content and concepts covered in this topic.

3.1.1 Introduction
Water is one of the most powerful agents in creating landscapes. If you have ever been caught outside in a heavy downpour, walked through a fast-flowing creek, or been dumped in the surf, then you have felt and seen the energy of flowing water. It can knock you off your feet, move buildings and carve huge holes in the Earth’s surface. Landscapes created by water are found everywhere.
3.2 Which landscapes are formed by water?

3.2.1 How does water change landscape features?

A torrent of gushing water can shift rocks, remove topsoil or shape river valleys. Gentle rain can change the chemical structure of any surface material, making it more likely that soil will be transported by the next heavy shower. In cold climates, frozen water in glaciers works like a slow-moving bulldozer to erode land and create unique landscape features. Once fresh water has made its way to the ocean, the power of waves creates coastal landscape features.

As you saw in topic 2, landscapes are predominantly changed or created by two processes: erosion and deposition. Water is one of the most powerful agents of change, causing erosion and deposition, and thereby breaking up, moving and repositioning material across the Earth’s surface. In figure 2 you can see the power of water as it rushes over a rockface and carves pools in its hard surface. You may have seen pools of a similar shape carved by waves in rocky coastal landforms.
As water makes contact with landscapes, it can change the shape and size of its features or landforms (figures 2 and 3). The coastal landscape that you see today is not the same as it was hundreds or thousands of years ago. Figure 1 is a photo of the Twelve Apostles, located on the coast of south-western Victoria. The name suggests that there may once have been twelve pillars of rock, or stacks, visible along this stretch of coastline. In the foreground you can see the remnants of two quite recently collapsed stacks. Even these stacks were once joined to the cliffs as part of the mainland. This highly erodible coastline has been constantly altered by many years of rainfall and wave action on the soft limestone cliffs. The resulting coastline has seen much creation and destruction of stacks over time.
3.2 Activities

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember

1. Landscapes are in a state of continual change.
   (a) Which two natural processes powered by water are most responsible for continually changing landscapes?
   (b) How are these two processes linked?

Explain

2. Where would figures 1 and 2 be placed on the landscape depicted in figure 3? Explain.
3. Explain how the water cycle and the formation of landscapes are interconnected.

Discover

4. Use your research skills to create a list of world water facts on the following:
   (a) the biggest glacier
   (b) the longest river
   (c) the biggest wave
   (d) the highest waterfall
   (e) the widest river
   (f) the biggest ocean
   (g) a world water fact of your choice.
   Show on a map where each is located.
3.3 What is coastal erosion?

3.3.1 How are coastal landscapes eroded?

The coast is the zone or border between land and ocean. It is in this collision zone that the movement of sea water and the impact of the ocean on the land together create coastal landscapes. Coastal landscapes have landforms that are common to coastlines in different places around the world because they are built up or worn away in similar ways.

Powerful ocean waves crash onto rocky coastlines, wearing away the cliff base between the high and low tide marks. In figure 1 in subtopic 3.2, showing the Twelve Apostles, the most powerful wave impact on this coast would be to the seaward side of the stacks or rock pillars. Wave impact has progressively knocked over some stacks, and the rock that they were made from has eroded into sand, which now forms part of the beach at the cliff base.

Coastal erosion is mostly caused by waves moving sand and other material and energy to and from the beach. For example, you may have seen sand being churned up by the waves when you have been at the beach. The waves that wash on to the beach are called swash. Waves returning down the beach into the sea are called backwash. A powerful ocean swell created by offshore storms forms destructive waves. These are the waves that produce good surf, and dump you while you are swimming. As these waves rush back into the sea, the force of the water and sand they carry can make it difficult for you to get back onto the beach. Destructive waves often have a powerful backwash that can carry beach sand offshore. Figure 1 shows backwash filled with sand that is being moved from the beach.

Predict

5. Many landscapes change rapidly; for example, the Twelve Apostles. With a partner or group, discuss another example of a landscape that has been shaped by the power of water. Do you think the changes to the landscape have been positive or negative? To what extent should people try to stop the changes caused by water?

6. Water can be considered one of the most important architects of desert landscape features. After looking at the images on this page, try to explain how you think water can change the landscapes of arid or desert environments.

7. Identify three possible ways that people can change the flow of water, either across the surface of the Earth or along the coast. Predict how you believe this may alter landscape features. Examples may include the use of river water for irrigation or the construction of a marina.
However, not all aspects of coastal landscapes are solely created by the power of water. Other physical processes can also greatly affect the coastal landscape; for example, the tectonic force of earthquakes and volcanoes; changing sea levels; and human activities such as building roads, ports and houses, and damming rivers.

**Which coastal landscape features are created by erosion?**

Features such as cliffs, headlands, bays, caves and stacks are all landforms found along an eroding coastline (figure 2). These features are formed by wave action and rainfall, which attack the cliffs and find points of weakness that are then eroded. Water running off a cliff face can carry eroded material into the sea below. When waves hit the cliff face, they undercut the base of the cliff to form a notch. As the notch increases in size, the undercut section of the cliff becomes unstable and falls into the sea.

Destructive waves can also alter a sandy coastline. They can remove sand from a beach, destroy the vegetation on dunes, and remove management features designed to protect landscape features.

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**FIGURE 2** Coastal landforms created by erosion

Rushing water can cause the roof of a cave to collapse, forming a blowhole. Blowhole

Erosion between high and low tide undercuts rocks, and a rock platform develops. Wavecut platform, Stack

Erosion of softer rock can create a bay. Erosion of softer rock can create a bay

Stacks used to be part of the headland or coast but have resisted erosion. Stacks used to be part of the headland or coast but have resisted erosion

Over time, caves on either side of a headland can erode to form an arch. Over time, caves on either side of a headland can erode to form an arch

Headlands are formed when hard rock resists erosion. Headlands are formed when hard rock resists erosion

Rock is undercut and sections fall, creating a cliff. Rock is undercut and sections fall, creating a cliff

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**3.3 Activities**

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

**Remember**

1. What are three physical processes that have influenced the creation of coastal landforms?
2. What are three human activities that have influenced the creation of coastal landforms?

**Explain**

3. Create an annotated diagram that explains the difference between swash and backwash.
4. Place the following landforms in the order in which they would be created:
   (a) arch, cave, headland, stack
   (b) blowhole, cave, cliff.
Discover
5. Watch the Stack formation weblink and/or the Clifed Coast weblink in the Resources tab. Take note of the process of erosion of a cliff face.
6. In a small group, create your own claymation or stop-motion movie, Prezi, or animated PowerPoint to show the changes that happen to a cliffed coast eroding to form a notch, cave, arch and stack.
7. Find an image of a sandy coastline that has recently been affected by destructive waves. Explain the process that has occurred. Use the terms swash and backwash in your explanation.

Predict
8. Most Australians live within an hour’s drive of the coast, and many people either spend regular holidays on the coast or move to the coast in their retirement, for a ‘sea change’. How might the continually changing coastal landscape (as seen in figure 2) affect coastal housing and popular holiday places? Brainstorm this with a small group.
9. Identify, using a sketch map, how several of the changes identified in question 8 might affect the coastal landscape of your favourite beach.
10. Do you think people will still feel the same way about a coastal landscape such as the Twelve Apostles when only two or three are still standing? How might the changing landscape affect the value or pleasure people get from visiting this place? Write a short paragraph to comment.

Think
11. Rising sea levels, whether they are a naturally occurring process or have resulted from human activity, will affect coastal landscapes. Use a diagram, with annotations, to explain how rising sea levels could change two of the landforms illustrated in figure 2.

3.4 Which coastal landforms are created by deposition?

3.4.1 How are depositional coastal landforms formed?

Not all waves are destructive. Some waves gently lap the shoreline. Smaller, gentler waves that carry less energy than destructive waves are known as constructive waves. The movement of these waves towards the land is more likely to push material such as sand and shells and deposit them on the beach, building new coastal features.

A beach is a good example of a depositional coastal landform (figure 1). Sand has been deposited and built up over a period of time. Constructive waves build coastal landscape features by repositioning wave-born materials to also create spits, sand dunes and lagoons.

The coastal features created by deposition can be created only when material is brought onshore by the swash of constructive waves. The construction material is in the form of sand, shells, coral and pebbles.
The source of the construction material may come from eroding cliffs, from an offshore source, or from rivers which, when they enter the sea, dump any material they were transporting.

This construction material is then shaped by prevailing winds. Figure 2 illustrates the cross-section of a beach formed when there is plenty of sand being pushed onshore by the swash. This construction material is dried by the sun and blown inland to create dunes.

Beach material can also be shifted by waves, which get their energy from the wind. The wind influences or directs the angle that waves move towards the coast. Waves come from the direction of the prevailing wind. This means that waves often move towards the shore at an angle, and their swash pushes any material they are carrying onto the beach at an angle. As the backwash of the wave returns to the sea, its path takes the shortest possible route down the beach towards the water. This action is known as longshore drift, and it is shown in figure 3. Longshore drift moves material along the beach in a zigzag pattern that follows the direction of the prevailing wind. Longshore drift moves sand along the beach and creates spits and bars. If the prevailing wind changes direction, then so does the direction of longshore drift.

**Figure 1** Depositional landforms: coastal landforms created by deposition.

**Figure 2** The formation of sand dunes.

1. Sand is moved to the beach in the swash.
2. The wind blows the sand from the beach to the foredune.
3. These grasses are adapted to cope with exposure to salt, sun and wind-blown sand.
4. Small plants and shrubs grow to form a backdune where there is more protection from wind and salt.
5. The area between the dunes is known as the interdune corridor or swale.
FIGURE 3 The process of longshore drift.

3.4 Activities
To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. Where does the material come from that builds beaches?
2. Either scan and enlarge a copy of figure 4 or draw a sketch of it, then label or annotate it to identify the depositional landform features of this coastal landscape.

Explain
3. The formation of sand dunes cannot happen unless there is plenty of sand in the swash to allow them to grow. Use the information in figure 2 to provide the evidence for you to agree or disagree with this statement.
4. How is weather involved in the formation of sand dune environments?

Discover
5. Use your atlas plus the internet to locate and name places in Australia that have the following coastal landforms: a spit, a beach with dunes, a bay, a headland (point, cape or promontory) and an estuary. Find four examples of each landform and mark them on a map. You could create a Google map of your results, with links to images of each feature.

CASE STUDY
The Murray mouth, South Australia
The Murray River is Australia’s most important river and the world’s sixteenth longest river.

When water for home use and irrigation in the Murray–Darling Basin is not balanced by rainfall, the amount of water that reaches the river mouth decreases. This means that the deposition of longshore drift is stronger than the trickle of water reaching the mouth. In 2009, $24 million was allocated by the Federal government to dredge the mouth of the river in an effort to keep it open.
3.5 How are coasts changed?

3.5.1 Who uses the coast?

Coasts are very popular places for people to live near and visit. The first Europeans to Australia arrived by sea, and the first areas inhabited by the Europeans were within coastal landscapes. However, the increasing popularity of coastal environments can result in crowding, pollution, a loss of habitat, and the building of permanent structures in zones that should be allowed to undergo the natural changes of a coastal landscape.

Aboriginal peoples and Torres Strait Islander peoples travelled from what is now Asia to the north, first settling along the coast. They enjoyed coastal food resources, such as fish, shellfish and sea birds; nearby forest resources for food and shelter; and the moderate coastal climate. Figure 2 shows a coastal landscape feature built by Indigenous peoples. Centuries of regular camps in these dunes resulted in the construction of a midden from the discarded shells of meals of oysters and cockles. To encourage sustainable harvesting of coastal resources, the top layer of the midden showed the next visitors what had been eaten most recently. They would then know to eat something else and not overuse a single food source.
There are many thousands of similar sites in all Australian states and in other countries. They are evidence of the use and habitation of coastal landscapes by people for thousands of years.

Since 1788, the coastline of Australia has been used as:

- the main highway linking Australian cities to other places in Australia
- a place to dispose of liquid and solid waste
- a holiday playground
- a resource for fishing
- a place for mining
- a very popular scenic area.

**CASE STUDY**

**Cape Woolamai**

Cape Woolamai, Phillip Island is a well-known surf beach location in south-eastern Victoria. The Cape is pounded by the westerly swells off Bass Strait on its southern coast, and the Eastern Passage, entrance to Western Port Bay, protects its northern coast. Cape Woolamai was created when a build-up of sand joined the coast to a small granite outcrop with a tombolo or narrow sandy isthmus. This sandy environment was stabilised by many centuries of vegetation growth.

Tourists, surfers and beach goers have used this place for many years and their use has affected the landscape quality. Walking and driving on the dune vegetation has resulted in vegetation destruction and a number of blowouts along the dunes. The surf beach access tracks have eroded, with sand being blown inland and depleting the beach of sand. On the more protected northern side, sand surfing has destroyed vegetation. As can be seen in figure 3, a large section of dune vegetation has gone. People on surfboards skimming down the dune have caused this vegetation loss. The popularity of this place has seen the addition of an access road, large car park, boardwalks and protective fencing in an attempt to manage landscape degradation.
3.5.2 Why does a coast need to be managed?

The popularity of a coastal location, and the many competing ways people use it, means that it must be looked after to protect it from damage caused by overuse (see figure 1).

Coastal landscapes can also be changed by wave action from strong winds. The roads and buildings located on both rocky and sandy coasts are vulnerable to damage from attack by destructive waves.

However, it is possible to manage or protect the natural and built features of coastal landscapes from the physical processes that strive to alter them.

3.5 Activities

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. Why is it important for people to manage their use of the coastal landscape?
2. List as many examples of coastal use and management as you can identify in figure 1.

Explain
3. How did Indigenous Australian peoples protect the features of the landscape along the coast?
4. Why does the material that a coastal landscape is made from affect the ability of water to shape it? Compare a cliffed coast like the Twelve Apostles to a surf beach with dunes. Refer to subtopics 3.2 and 3.4.
5. Carefully look at figure 3 and identify the evidence of human impact on this place.
6. How would the landscape management strategies of building a road, car park, boardwalks and protective fences reduce future landscape degradation of the dunes at Cape Woolamai?

Think
7. Describe the interconnection between sand surfing and vegetation loss on the Cape Woolamai dunes.
8. Write a paragraph to explain how attempts to reduce or manage coastal landscape destruction could reduce the recreational experience of visitors.

3.6 What differences exist in coastal landforms between places?

3.6.1 How do coastal landforms differ?

Although coastal landforms can be similar in different parts of the world, they can also be very different. Some differences are climatic and some are geomorphic. Coastal landscapes are created by the interconnections between the sculpting power of the oceans, coastal topography and the material that is available to sculpt.

Limestone stacks, such as the Twelve Apostles in Victoria (figure 1, subtopic 3.2), have been shaped by the power of the Southern Ocean. Similar stacks have been formed by the erosive power of the waters off the coast of Thailand (figure 1) and along the Portuguese and Welsh coasts.

The Gippsland Lakes in south-eastern Victoria are a network of coastal lakes and lagoons fed by six rivers but they are often cut off from the sea by a barrier of silt. The Gippsland Lakes are at the mouth of the Mitchell, Avon, Thompson, Latrobe, Nicholson and Tambo Rivers. When there is little rainfall, the rivers flow slowly and deposit sediment in the lakes. This, along with the longshore drifting of the sea current in Bass Strait, creates lakes by moving sediment to seal the lakes with offshore barriers. After heavy rainfall the level of water in the Lakes rises and the barrier breaks, allowing access of fresh water to the sea and salt water into the Lakes. This lake system had an artificial entrance cut by humans in the late 1800s to allow fishing boats into and out of the Gippsland Lakes and to reduce the chance of algal blooms.
In south-eastern Iceland the melting Vatnajökull glacier (figure 2) flows into the Atlantic Ocean through a glacial lake. This glacier once flowed directly into the sea, but a warming local climate has meant that the glacier’s snout is now 1.5 kilometres inland. The melting ice has created the large 18-square-kilometre glacial lake named Jökulsárlón. Since the climate is cold and the sunshine has little heat, the large chunks of ice that fall from the glacier remain as slowly melting icebergs. These icebergs float in the lake until they become small enough to roll down a channel into the sea. During winter the lake freezes and traps the icebergs until the summer thaw. Humans have created a narrow channel to link Jökulsárlón with the sea. This channel is designed to reduce the chance of summer floods and to protect the major highway that brings tourists to this beautiful place.

These two coastal lakes have formed in very different places, with different climates, but the geomorphic process of deposition has meant that human intervention has been required to allow their waters to flow into the sea.

3.6 Activities

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. What material are the Twelve Apostles and Ko Tapu rock both made from?

Explain
2. How has climate changed the entrance of the Vatnajökull glacier into the sea?
3. Describe the way that the geological process of deposition has changed the Gippsland Lakes and Jökulsárlón.

Discover
4. Use the internet to collect at least six images of limestone stacks from different places in the world.
5. Attach these images to a Google map to create a global distribution of limestone landscapes.
6. Describe the similarities and differences between the images.

Predict
7. The Vatnajökull glacier is expected to have melted within 80 years. What might this place look like when there is no longer a glacier? Draw a sketch map to explain your answer.
8. Look at a map of the Gippsland Lakes. Predict how they might look if part of the barrier washes away during a huge storm. Draw a sketch map to explain your answer.
3.7 How are coasts managed?

3.7.1 How can a coast be managed?

It is possible to reduce or slow the change to coastal landscapes if we understand the physical processes and human activities that cause it. While it is not possible to change the speed and direction of the wind or the number of months each year when destructive waves reach a shoreline, it is possible to redistribute or trap the sand shifted by storm waves or longshore drift. It is also possible to protect coastal houses and roads using barriers to reduce the direct impact of waves.

Some of the most common structures built to protect coastal landscapes and manage change are sea walls and breakwaters, as seen in figure 1, or rock barriers and groynes as seen in figure 2.

Do these management strategies always work?

An integrated strategy like the one designed for Adelaide’s beaches has a much better chance of protecting existing coastal landscapes (particularly the beaches) and structures built nearby, because it has taken into account the prevailing wind conditions, as well as the movement of sand. If a structure like the groyne in figure 2 is built on a beach, it will certainly trap sand on the side that interrupts the direct flow of the longshore drift. But this structure will also reduce the flow of sand to beaches further along the coast, on the other side of the groyne. Building a sea wall or breakwater may interrupt the flow of longshore drift and actually silt up the mouth of the harbour it is protecting. A sea wall can deflect the power of waves and increase erosion on an unprotected part of the nearby coast, or reduce the erosion of material from a cliff face that had been replenishing sand on the local
beaches. Coastal management is quite a tricky issue. Do you manage to protect the existing coastal landscape or do you manage to allow the action of wind and waves to create a naturally evolving landscape?

3.7.2 Adelaide’s coast

CASE STUDY

Managing Adelaide’s living beaches

The problem: The beautiful sandy beaches closest to Adelaide are under constant threat from erosion. Figure 4 identifies the problem. For the past 7000 years the beaches south of Adelaide have been eroding, and the prevailing winds from the south-west have driven this material northwards. This longshore drift has removed material from the south and relocated it in North Haven, where a peninsula has grown and a large dune system has been created. For the past 30 years the beaches in the south have been replenished by adding truckloads of sand. The plan is to find a better way to manage Adelaide’s beaches by reducing the cost of moving sand.

The solution: Adelaide’s Living Beaches Strategy. Figure 5 illustrates the solution. Although sand will still need to be recycled from north to south, the plan is to use a pipeline instead of trucks to do most of the transportation. The pipeline will extend along the coast and will send sand back to the southern end of the beach. Figure 3 shows sand being discharged at the southern end of the beach. A series of structures such as breakwaters and groynes will be built in several places to trap sand at important locations. Fewer trucks will be used, and it is expected that the cost of beach restoration will be reduced.
3.7 Activities

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Remember
1. How do groynes and sea walls help to manage or protect a coastal landscape?
2. Draw a diagram to explain your answer to question 1. Refer to figure 3 in subtopic 3.4 to help with your diagram.

Explain
3. Describe what will happen to Adelaide’s southern beaches if they stop being replenished with trucks of sand.

Discover
4. Research another example of coastal landscape management. Identify why the management strategies were put in place and comment on their success. Examples of places that would be good to research include Cape Woolamai, the Gold Coast, Melbourne bayside beaches, Polder coastline of the Netherlands, Bondi, Cottesloe, Venice Beach or Waikiki.

Think
5. Imagine that you own a holiday house that is built on coastal dunes within 15 metres of the beach. After a powerful storm, the beach in front of your house is eroded and your house is now only five metres from the sea. What are your options? Work out a series of strategies that you could implement which may save your house from falling into the sea. Include diagrams to illustrate your plan.
6. Identify the strengths and weaknesses, for your house and your neighbours’ houses, of the management proposal you created to answer question 5 above.
7. (a) Refer to figure 4. Describe the changes that have occurred to Adelaide’s coastline over the past 7000 years.
   (b) Refer to figures 3 and 5. Describe the changes the Living Beaches strategy has made to the Adelaide coastline and the reasons for these changes.

Deepen your understanding of this topic with related case studies and questions: Managing coasts

3.8 How do I undertake coastal fieldwork?

3.8.1 Your fieldwork task

The best way to understand the physical processes and human activities that affect a specific coastal landscape is to visit it. A fieldwork activity will allow you to put the knowledge you have gained in the classroom into practice. Your fieldwork will also allow you to enjoy the coastal landscape in magnificent 3D.

Any coastal landscape would be suitable to investigate. Once a fieldwork site has been identified, there is quite a lot of planning that you should do before you get there.

What is your fieldwork task?
Your task is to identify the landforms and dynamic nature of a coastal landscape and to recognise and assess the influence of people on it.
In class

1. Prepare a base map of the fieldwork site or sites. On this base map, mark in the location of the coastal landscape’s natural features (such as beach, rock, dunes, water, vegetation) and human features (such as seawall, groyne, steps, lawn, shelter, jetty). Using Google Maps or a topographic map is an excellent way of identifying the specific details of the coastal landscape.

2. Looking at the aerial shot on Google Maps will also allow you to see the pattern of the waves as they move to the shore. Does it look as if longshore drift is occurring on the day this image was taken?

On your field trip

What do you need to do at the coast to collect your information?

It is good to work in groups to collect your data in the field. It is then possible for some students to take measurements and some to record. Sharing tasks means that there will be others with whom to discuss what you have recorded. On returning to class you can pool your observations. You will need recording sheets, pencils, a digital or phone camera, tape measure, compass and maybe a clinometer. You could also collect information using data logging equipment, a GPS locator, weather recording equipment and notepads. Your group should decide what equipment is the most practical and relevant for collecting the data you need.

![FIGURE 1 The information you need to collect at your fieldwork location.](image-url)
You may not be able to return to your fieldwork site, which means your data needs to be very detailed.

- Always record the location of the information on your map.
- Take photos of the coastal landscape, including the landforms and human structures.
- Measure distances and heights.
- Draw field sketches to remind you of details. Even when you have photographed something, a field sketch allows you to annotate the diagram so that you can remember important characteristics about how it was formed or the direction of longshore drift. Do not worry if you are not a gifted artist, as there are apps that allow you to convert your photos to sketches when you get back to class.
Back in class

Now that you have collected your information in the field, you need to present your findings about the coastal landscape you visited.

There are many ways that you could present this information. Your fieldwork report could be presented as a poster, website, PowerPoint presentation, booklet, blog, movie, news report or podcast. Consider using Google Maps and uploading images of the sites you visited. You will need to present the data you collected and describe your findings.

3.9 SkillBuilder: Constructing a field sketch

WHAT ARE FIELD SKETCHES?

Field sketches are drawings completed during fieldwork — geography outside the classroom. Field sketches allow a geographer to capture the main aspects of landscapes in order to edit the view, focusing on the important features and omitting the unnecessary information.

Go online to access:
- a clear step-by-step explanation to help you master the skill
- a model of what you are aiming for
- a checklist of key aspects of the skill
- a series of questions to help you apply the skill and to check your understanding.

![FIGURE 1 Field sketch of Cape Schanck](source)

**Source:** © Geography Teachers’ Association of Victoria Inc. Interaction, journal of the GTAIV, June 1998. Illustration redrawn by Harry Slaghekke.

![FIGURE 4 Students on a fieldwork trip, measuring the slope of a sandy beach.](source)

**Watch this eLesson:** Watch this video to learn how to construct a field sketch.
Searchlight ID: eles-1650

**Try out this interactivity:** Use this interactivity to learn how to construct a field sketch.
Searchlight ID: int-3146
3.10 What’s in a rip?

3.10.1 What is a rip current?
The movement of water within the coastal landscape can be hazardous to people as well as to coastal landforms.

If you have ever walked along a surf beach, you know about the uneven power of waves as the water returns to the ocean. This backwash can either be a gentle, non-threatening flow or it may be so powerful that it can be difficult for you to remain standing. The powerful flow of water returning to the sea is called **undertow**. If the seabed adjacent to the beach has an even slope, then the undertow is relatively harmless. Water returns to the sea and washes ashore in the next wave. Undertow can also take material from the beach and deposit it in the wave zone. If the seabed adjacent to the beach has an uneven topography, or shape, the undertow will be more threatening.

Where the flow of an undertow is concentrated, as occurs in a gap between offshore sandbars, or in a deeper seabed channel, this may result in the formation of a **rip current**. A rip current, or rip, is a strong current that runs offshore from the beach. If you are caught in a rip, it feels as if you are in a fast-moving river channel being whisked out to sea. The fast-moving water erodes a deep channel in the sea bed.

3.10.2 How do you identify a rip?
Before you swim at a surf beach, it is important to try to identify the location of possible rips. If the beach is patrolled by surf lifesavers, the yellow and red flags will be placed in a rip-free part of the beach. Looking at figures 1 and 3, you can see that the sea where the rip current is found is actually different from the sea on either side of it. Typically, where there is a rip current, the sea looks calmer, with surface ripples indicating a flow of water away from the beach. The waves are not as big and the water may be a
darker colour because it is deeper. The calmer water often tricks swimmers into thinking that this is a safer place to swim.

3.10.3 What should you do if you are caught in a rip?

Rips do not actually pull you under the water, but being caught in a rip current causes many people to drown on our beaches each year. Figure 3 shows that a rip will not take you far out to sea, although it will take you offshore very quickly. If the waves are large, then the speed of the rip will be faster and more dangerous.

If you are caught in a rip, the most important thing to do is not to panic. Do not try to swim against the rip, because even the strongest swimmer will get tired. Most drownings at Australian beaches occur when the beach is not being patrolled. This means that the best way to avoid the hazard created by a rip current is to swim between the flags at a patrolled surf beach.

3.10 Activities

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. How is undertow different from a rip current?
2. What colour are the flags used by lifesavers to identify the safe part of a beach for swimming?
3.11 How does water form river landscapes?

3.11.1 Moving water

Erosion, transportation and deposition by running water are the main processes that create our landscapes. Some rivers, such as the Gordon River in Tasmania, are perennial; some, such as Coopers Creek in Queensland, are intermittent; others, such as the Colorado River in the United States, have eroded amazing landforms like the Grand Canyon.

Water is always on the move. It evaporates and becomes part of the water cycle; it rains and flows over the surface of the Earth and into streams that make their way to a sea, lake or ocean; and it soaks through the pores of rocks and soil into groundwater.

3.11.2 River systems and features

A river is a natural feature, and what we see is the result of the interaction of a range of inputs and processes. All parts of the Earth are related to the formation of river landscapes. This includes the lithosphere (rocks and soil), the hydrosphere (water), the biosphere (plants and animals) and the atmosphere (temperature and water cycle). Changes can happen quickly and over a very long period of time. Changes at one location along a river can have an effect at other locations along the river.

Water flows downhill, and the source (the start) of a river will be at a higher altitude than its mouth (the end). As the water moves over the Earth’s surface, it erodes, transports and deposits material.
The volume of water and the speed of flow will influence the amount and type of work carried out by a river. A fast-flowing flooded river will erode enormous amounts of material and transport it downstream. As the speed or volume of the water decreases, much of the material it carries will be deposited.

**FIGURE 2** A river system

**FIGURE 3** (a) Long profile of a river — a view along its length. The slope of the river tends to get flatter and the riverbed gets smoother as it moves downstream. (b)–(d) Cross-sections showing the shape of the river channel and valley at three points along the river. Arrows indicate the main direction of erosion.

**Watershed**
A river gathers its water from a region known as its drainage basin, or catchment (figure 4). The boundary of this region is identified by mountain tops, hilltops or any land that is slightly higher than surrounding land. This is known as the watershed, and it is the point that divides the direction of water flow.
River formation

Even the biggest rivers begin with water from rain or melting snow in mountains or hills. This water has collected in tiny depressions called rills. These rills grow larger when they collect more water, and when they combine they begin to look like streams. Many streams contribute to a river (see figure 2).

Upper course

Waters in a river channel flow over steeper slopes in the upper reaches. The force of rushing water on a steep slope cuts downwards and creates a V-shaped valley. The river then tends to follow a fairly straight course (see figure 3).

Waterfall

When a river meets resistant rock, a waterfall can occur (see figure 5). If the river has to cross bands of resistant rock, rapids will form. The turbulent water flow in rapids is called white water. A plunge pool forms at the base of a waterfall when rocks and soil moved by the fast flowing water erode the banks and base of the river.

Tributary

A river or stream that adds or contributes water to the main river is known as a tributary (see figure 6). The place where two rivers join is called the confluence.
Meanders
On flatter land, a river is wider than it is in the hills, and water added from tributaries has increased its volume (see figure 3). Much of the erosion is in a sideways direction, and the valley of a river is much wider. Sideways erosion causes meanders (curves) along its course (see figure 7). Over time, a meandering river will change the path it follows, as some bends become more obvious and some disappear. A meander that is cut off is called an oxbow lake.

Floodplains
Flooding over thousands of years creates floodplains. During a flood, the water flows over the banks of the river. Once outside the river, it slows down and deposits the alluvium it was transporting. This alluvium is often very fertile (see figure 2). These regions are highly suitable for farming and settlement (see figure 8).

River mouth
Deltas are found at the mouths of large rivers, like the Mississippi. A delta is formed when the river deposits its material faster than the sea can remove it. The material is a mix of mud, sand and clay. The river will sometimes split up into smaller streams to find its way through the deposited material. These little streams are called distributaries. We recognise three main shapes of delta: fan shaped, arrow shaped and bird-foot shaped. The shape is influenced by tides, ocean waves and the volume of sediment and river water.

Sometimes a river will have a wide mouth, where fresh water and salt water mix. This is known as an estuary.

FIGURE 6 Tributaries of the Darling River which, in turn, is a tributary of the Murray River.
3.11 Activities

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

**Remember**
1. Refer to figure 1 and compare the **scale** of Australia’s longest river with the world’s longest river.
2. Sketch the long profile shown in figure 3 and label the source, the mouth and the direction the river flows.
3. What feature, other than water, has to be present for waterfalls and rapids to form? Refer to figure 5.

**Explain**
4. Explain how rivers are part of the water cycle.
5. Why do people settle and farm on floodplains?

**Discover**
6. Identify a river that flows through the capital city in one state or territory in Australia. Describe its source, any tributaries, and its mouth.
7. After some rain, investigate an area of bare ground on a small slope near school or home. Sketch the pattern that the rills have made. Identify the watershed and catchment for each rill.
8. Using Google Earth or an atlas, find the Nile delta, the Ebro delta and the Mississippi delta. Draw a sketch and write a short description of the shape of each delta, presenting your findings in a table.

**Predict**
9. Refer to figure 8. Sketch a diagram to show the course of the meandering Murray River. Mark in the course that the river used to take. Predict and label where the next oxbow lake might form. Show the possible future course of the river.
10. What do you think will happen to deltas if sea levels rise?
11. Predict the changes that will occur to the waterfall in figure 5. Justify your answer.

**Think**
12. Produce a flowchart or animation to explain the formation of an oxbow lake, a delta, a waterfall or rapids.
13. Refer to the paragraph about meanders and to figures 3 and 7. Sketch a cross-section (like figure 3) of a river at a meander. This will show the shape of the riverbank on each side of the river. What are the advantages and disadvantages of living on each side of the river?
14. What changes will occur along a river if there is unusually high rainfall in its upper course? Think in terms of erosion and deposition.

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**learnon RESOURCES — ONLINE ONLY**

- **Try out this interactivity:** River carvings: Use this interactivity to learn how rivers shape our landscapes.
  Searchlight ID: int-3104
3.12 How are river landscapes managed?

3.12.1 Mississippi River

Rivers are vital. Plants and animals depend on their waters for survival. People also rely on rivers for their waters and have diverted rivers for flood control, irrigation, power generation, town water supplies, waste disposal and recreation.

The mighty Mississippi River is approximately 3700 kilometres long and is the second longest in the United States. It flows through 10 states (see figure 1). The drainage basin, or catchment, for the river covers 40 per cent of the country, and includes all or part of 31 states and two Canadian provinces. The drainage system is made up of thousands of rivers and streams, including the Missouri.

Importance of the river

The Mississippi has been a major contributor to the economic growth of the United States.

- It is important for transporting goods, such as fuel, coal, gravel, chemicals, steel, cement and farm produce. The barges on the river are able to connect to ocean shipping at Baton Rouge in Louisiana.
- It supplies water for cities and industries and irrigation for farming.
- Much of its floodplain has been cleared for farmland.
- The river basin also supports natural biodiversity. It has many species of mussels, 25 per cent of all fish species in North America, and over 300 species of birds that use the river during migration and breeding.

![FIGURE 1 The Mississippi drainage basin](image)
Floods

The river has created the geographical characteristics that have always attracted settlement. The source of the river is at an altitude of 450 metres above sea level, and the river drops in altitude very quickly. The last 1000 kilometres of the river’s journey is through a wide floodplain that is the result of many floods over hundreds of years. Under natural conditions, the river had high water levels in early spring and much lower levels by early autumn.

Floods are a major issue for businesses, homes and farms. There have been many significant floods; for instance, in 1849, 1850, 1882, 1912, 1913, 1927, 1983, 1993 and 2011. After the floods of 1927, the Mississippi River and Tributaries Project was set up with the goal of preventing destructive floods and keeping the river open for navigation.

River management

The Mississippi River and Tributaries Project uses many strategies to manage the river. The aim is to satisfy the needs of farming, towns, industry, transport and ecosystems. There are many dams to control water levels in the river.

Management issues

• The strategies are expensive.
• Continuous dredging is needed.
• Levees are being built higher — some now seven metres high — and it is hard work to make sure they don’t leak or break.
• Water is powerful and the river still wears away at weak points along the banks.
• If a levee breaks or if water goes over the top, flood damage can be very bad.
• The floodplain does not receive much sediment from the river.
• The river water is not as clean as it used to be.
• Natural habitats are damaged by dredging or concreting.
• The delta is decreasing in size.
3.12 Activities
To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. Refer to figure 1 and name key tributaries of the Mississippi River. In which general direction does the Mississippi flow from its source to its mouth?

Explain
2. Why is the river important to the United States? Classify each reason as one or a combination of the following: social, economic or environmental.

Discover
3. How close will Baton Rouge be to the sea in 2100?
4. Use the Land loss in the Mississippi delta weblink in the Resources tab. Which parts of the delta have been most affected by erosion?
5. Use the Mississippi River watershed weblink in the Resources tab to watch a video about the river. What do you notice about the scale of the watershed and the location of the Mississippi River?

Predict
6. What do you think would be the main management strategies on the Mississippi River during a year of heavy rainfall? What do you think would be the main management strategies during a drought?

Think
7. Do you agree or disagree with the following statement? 'A strategy implemented in one part of the river will have an impact on another part of the river.' As you find evidence from this topic, place it in a table, or under subheadings. Write a conclusion based on your findings.

3.13 Which landscapes are formed by ice?
Access this subtopic at www.jacplus.com.au

3.14 Do all rivers flow to the sea?
3.14.1 Okavango River
Some rivers do not reach the sea. The Okavango River in Africa has created an inland delta, its water finally disappearing into ancient salt pans.

This perennial river has its source in the highlands of Angola, flows roughly south-east for about 1000 kilometres, passing along the Namibian border, to its delta in Botswana. Very little rain is added to the river in Botswana and it takes about a month for the water to flow from its source to the delta. The delta doubles in size when it floods in the dry season. This makes it an oasis in the Kalahari Desert.

The delta region contains many islands and is fairly flat. When the volume of the river increases, the water slowly spreads out with some of the water making it as far as the Makgadikgadi Salt Pans. A lot of water is lost from the delta through very high rates of evaporation.
FIGURE 1 Location of Okavango River and delta

FIGURE 2 Average temperature and rainfall for Huambo, Angola (1990–2012). This region provides nearly all the water to the Okavango River.

FIGURE 3 Plants and animals have adapted to cope with changes in water level.

FIGURE 4 The desert landscapes near the Okavango delta.

FIGURE 5 The Makgadikgadi Salt Pans are at the end of the river.

FIGURE 6 The average temperature and rainfall for Maun, in Botswana (1990–2012); it has much less rain than Huambo.

FIGURE 7 When the Okavango enters Botswana it is a wide meandering river.
3.14.2 Diamantina River

CASE STUDY
The Diamantina River flows into Kati Thanda–Lake Eyre

The Diamantina River in Australia is an intermittent river about 900 kilometres long, with its source in Queensland and its mouth in inland South Australia at Kati Thanda–Lake Eyre. It is one of the rivers in the catchment of Kati Thanda–Lake Eyre. Some local rain adds to the water in the lake, but most of the water comes from cyclones and tropical rain in northern Queensland. Water can take three to 10 months to flow all the way to the lake. There are a few permanent waterholes along the river and there can be many dry years between the short periods when the river flows.

The temperatures in the catchment are high and only a small fraction of the Queensland rain reaches the lake. Water seeping into the soil also reduces the level of the lake. About once every eight years there is significant water in the lake. Kati Thanda–Lake Eyre is in an arid environment. The wet and dry periods influence the patterns of life of flora and fauna.

FIGURE 9 The river divides into many small channels.

FIGURE 10 Average rainfall and temperature at Swords Range (1990–2012), the source of the Diamantina River.

FIGURE 11 The desert environment surrounding the lake.

FIGURE 12 Average temperature and rainfall at Kati Thanda–Lake Eyre (1990–2012). The lake is in a hot, dry region.

FIGURE 13 Birds fly long distances to breed and feed on the fish life in the water.

FIGURE 14 High temperatures lead to high evaporation of water, leaving a very salty mixture behind.

FIGURE 8 The location of the Diamantina River.
3.14 Activities

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. What is the difference between the average annual rainfall at the source and the mouth of the Diamantina River?
2. Describe the distribution of rain in a year at Huambo and at Swords Range.
3. Refer to figures 7 and 9 and describe the difference in the shape of the river channel.

Explain
4. Distinguish between a perennial river and an intermittent river.
5. How is it possible that the Okavango delta floods in the dry season?
6. Refer to figures 3 and 13 and compare the flora and fauna at the mouth of each river.
7. How does high temperature lead to water loss?

Discover
8. In which hemisphere are the Okavango and Diamantina Rivers?
9. In which continent is each river?
10. What is a cyclone? Name another place in Australia that is affected by cyclones.
11. Find out about one species that flourishes at Kati Thanda–Lake Eyre when the lake has water. How has this species adapted to the environment? What other species is it relying upon?

Predict
12. The Okavango is the only permanent source of water in Namibia. What would happen to the delta environment if Namibia diverted water from the river as it flows along its border? Think about the possible impact on people, on the environment and on the economy.
13. Changes to the climate are likely to make the Kati Thanda–Lake Eyre region hotter and drier. What impact will this have on the environment of the lake and the native species that flourish there?

Think
14. Compare the Okavango River and the Diamantina River. Present your findings in a visual manner to show similarities and differences. Consider characteristics such as the location of the river, length of river, rainfall at source, rainfall at mouth, perennial or intermittent nature, environment surrounding mouth, speed of flow, evaporation rate at mouth, water added along course, fauna at mouth, flora at the mouth, shape of the river channel and final end point of the river.
15. The Okavango Delta and Kati Thanda–Lake Eyre are both popular tourist destinations. Provide two reasons why you think people are attracted to these places. Which one has a permanent tourism industry? How is this possible? When would be the best time to visit each location?
3.15 SkillBuilder: Reading contour lines on a map

WHAT ARE CONTOUR LINES?
Contour lines drawn on the map join all places of the same elevation (height) above sea level. Contour maps are used to show the relief (shape) of the land and the heights of the landscape. Maps with contour lines show the relief of the land and help people to identify features.

Go online to access:
• a clear step-by-step explanation to help you master the skill
• a model of what you are aiming for
• a checklist of key aspects of the skill
• a series of questions to help you apply the skill and to check your understanding.

FIGURE 1 How contour lines show the shape of the land.

3.16 Review

3.16.1 Review
The Review section contains a range of different questions and activities to help you revise and recall what you have learned, especially prior to a topic test.

3.16.2 Reflect
The Reflect section provides you with an opportunity to apply and extend your learning.
Access this subtopic at www.jacplus.com.au