Water in the world

A resource is anything we use to satisfy a need or a want. Resources we use from the natural world are called environmental resources. All life on Earth depends on these environmental resources to survive. The water we drink, the Sun we depend on for light and warmth, the soil we use to grow our crops, and the trees we rely on to produce the oxygen we breathe are all environmental resources. As the world's population grows, we continue to place more and more pressure on these resources. The availability of many of these environmental resources (including oil, forests, and of course, fresh water) is becoming increasingly uncertain.

chapter 2

Source 1 Hindus in India believe that bathing in the holy waters of the Ganges River gives them spiritual blessings.

2A

How is water an environmental resource?

1 Which environmental resources do we need to survive?
2 How are the people in the photograph using the Ganges River as a resource?

2B

How does water connect and affect places?

1 How do you think the Ganges River connects places in India?
2 List three ways that water from the Ganges River might be used.

2C

How much water do we have?

1 Water covers about 70 per cent of the Earth's surface. Why, then, do we have a shortage of water to drink and to wash in?
2 Where do you think the wettest and driest places in Australia might be found?

2D

How do we manage water?

1 Why do you think the Ganges River is difficult to manage?
2 Make a list of strategies that you personally would put in place to use less water?

2.1 Environmental resources: an overview

Over thousands of years, humans have developed ways of life that depend on almost all **environmental resources** found on Earth. Water from rainfall, minerals from rocks, and food from the forests and oceans have allowed us to build homes, farms, cities and highways all over the world. We have found and used resources in almost every corner of the Earth. Oil is drilled from beneath polar **ice caps** and water is drilled from far below barren **deserts**. Deep in the rainforests we have found plants that can cure illnesses and we have even worked out how to generate electricity from the waters flowing in our rivers.

Types of environmental resources

Geographers divide all of the environmental resources on Earth into three types.

Renewable resources

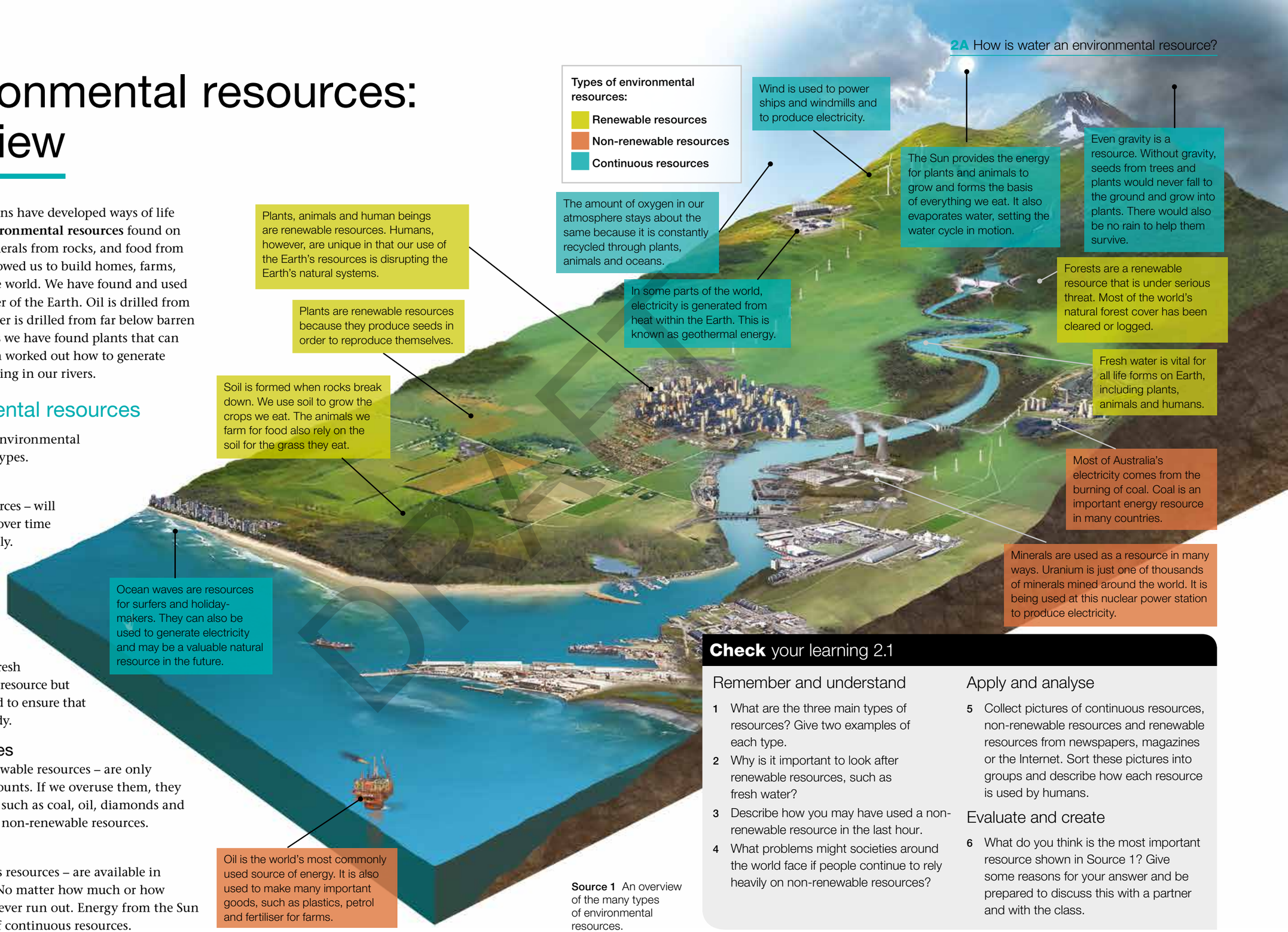
The first type – renewable resources – will replenish themselves naturally over time if we do not use them too quickly. The trees in a forest are a good example of a renewable resource. We can cut them down for wood, but they will grow back in time. We just need to manage them carefully. In countries such as Australia, fresh water is considered a renewable resource but it needs to be carefully managed to ensure that enough is available for everybody.

Non-renewable resources

The second type – non-renewable resources – are only available in limited (finite) amounts. If we overuse them, they will one day run out. Minerals such as coal, oil, diamonds and uranium are good examples of non-renewable resources.

Continuous resources

The third type – continuous resources – are available in unlimited (infinite) amounts. No matter how much or how often we use them, they will never run out. Energy from the Sun and wind are both examples of continuous resources.



Source 1 An overview of the many types of environmental resources.

Check your learning 2.1

Remember and understand

1 What are the three main types of resources? Give two examples of each type.
2 Why is it important to look after renewable resources, such as fresh water?
3 Describe how you may have used a non-renewable resource in the last hour.
4 What problems might societies around the world face if people continue to rely heavily on non-renewable resources?

Apply and analyse

5 Collect pictures of continuous resources, non-renewable resources and renewable resources from newspapers, magazines or the Internet. Sort these pictures into groups and describe how each resource is used by humans.

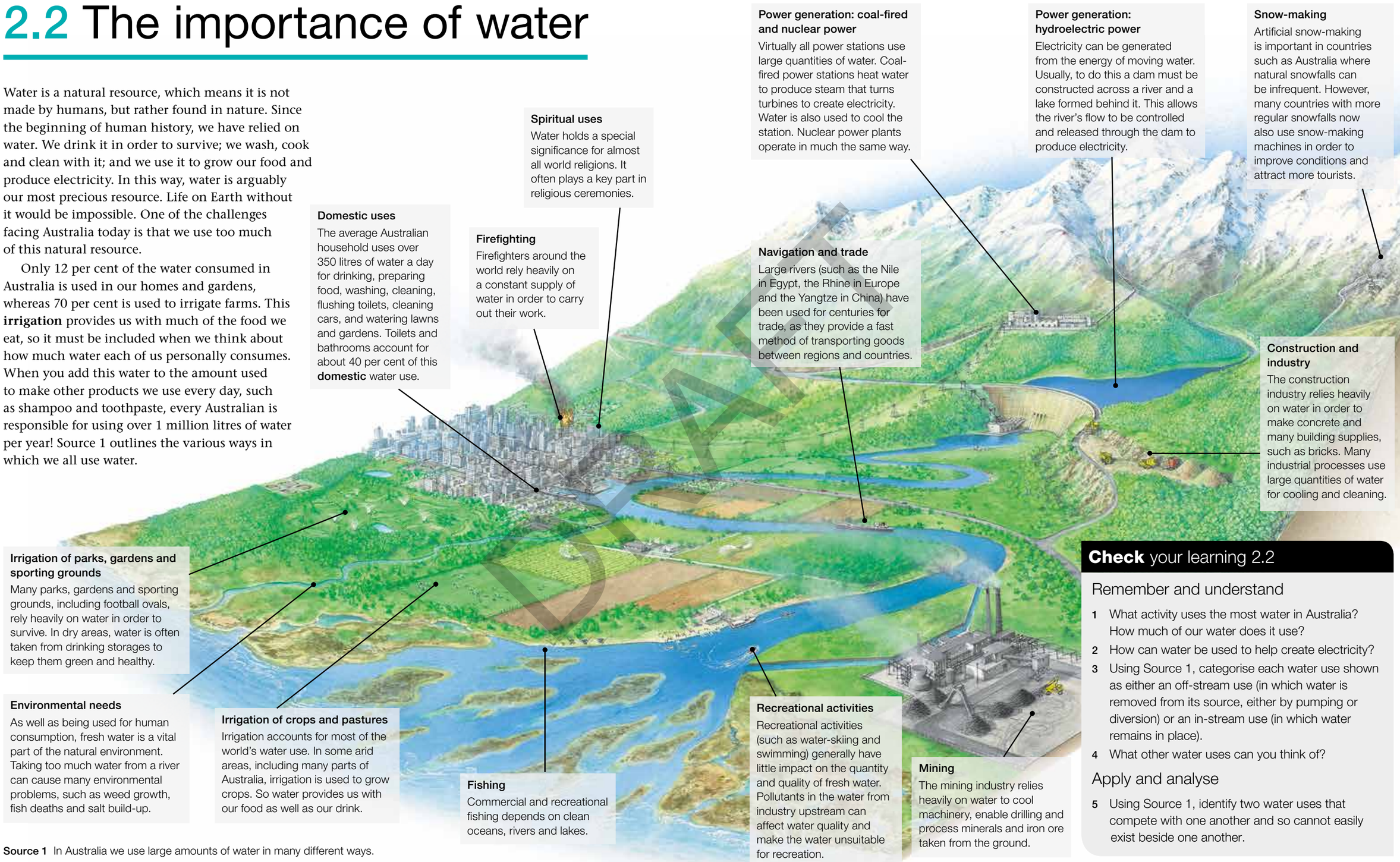
Evaluate and create

6 What do you think is the most important resource shown in Source 1? Give some reasons for your answer and be prepared to discuss this with a partner and with the class.

2.2 The importance of water

Water is a natural resource, which means it is not made by humans, but rather found in nature. Since the beginning of human history, we have relied on water. We drink it in order to survive; we wash, cook and clean with it; and we use it to grow our food and produce electricity. In this way, water is arguably our most precious resource. Life on Earth without it would be impossible. One of the challenges facing Australia today is that we use too much of this natural resource.

Only 12 per cent of the water consumed in Australia is used in our homes and gardens, whereas 70 per cent is used to irrigate farms. This **irrigation** provides us with much of the food we eat, so it must be included when we think about how much water each of us personally consumes. When you add this water to the amount used to make other products we use every day, such as shampoo and toothpaste, every Australian is responsible for using over 1 million litres of water per year! Source 1 outlines the various ways in which we all use water.



Domestic uses
The average Australian household uses over 350 litres of water a day for drinking, preparing food, washing, cleaning, flushing toilets, cleaning cars, and watering lawns and gardens. Toilets and bathrooms account for about 40 per cent of this **domestic** water use.

Spiritual uses
Water holds a special significance for almost all world religions. It often plays a key part in religious ceremonies.

Firefighting
Firefighters around the world rely heavily on a constant supply of water in order to carry out their work.

Power generation: coal-fired and nuclear power
Virtually all power stations use large quantities of water. Coal-fired power stations heat water to produce steam that turns turbines to create electricity. Water is also used to cool the station. Nuclear power plants operate in much the same way.

Power generation: hydroelectric power
Electricity can be generated from the energy of moving water. Usually, to do this a dam must be constructed across a river and a lake formed behind it. This allows the river's flow to be controlled and released through the dam to produce electricity.

Snow-making
Artificial snow-making is important in countries such as Australia where natural snowfalls can be infrequent. However, many countries with more regular snowfalls now also use snow-making machines in order to improve conditions and attract more tourists.

Navigation and trade
Large rivers (such as the Nile in Egypt, the Rhine in Europe and the Yangtze in China) have been used for centuries for trade, as they provide a fast method of transporting goods between regions and countries.

Construction and industry
The construction industry relies heavily on water in order to make concrete and many building supplies, such as bricks. Many industrial processes use large quantities of water for cooling and cleaning.

Irrigation of parks, gardens and sporting grounds
Many parks, gardens and sporting grounds, including football ovals, rely heavily on water in order to survive. In dry areas, water is often taken from drinking storages to keep them green and healthy.

Environmental needs
As well as being used for human consumption, fresh water is a vital part of the natural environment. Taking too much water from a river can cause many environmental problems, such as weed growth, fish deaths and salt build-up.

Irrigation of crops and pastures
Irrigation accounts for most of the world's water use. In some arid areas, including many parts of Australia, irrigation is used to grow crops. So water provides us with our food as well as our drink.

Fishing
Commercial and recreational fishing depends on clean oceans, rivers and lakes.

Recreational activities
Recreational activities (such as water-skiing and swimming) generally have little impact on the quantity and quality of fresh water. Pollutants in the water from industry upstream can affect water quality and make the water unsuitable for recreation.

Mining
The mining industry relies heavily on water to cool machinery, enable drilling and process minerals and iron ore taken from the ground.

Source 1 In Australia we use large amounts of water in many different ways.

Check your learning 2.2

Remember and understand

1 What activity uses the most water in Australia? How much of our water does it use?
2 How can water be used to help create electricity?
3 Using Source 1, categorise each water use shown as either an off-stream use (in which water is removed from its source, either by pumping or diversion) or an in-stream use (in which water remains in place).
4 What other water uses can you think of?

Apply and analyse

5 Using Source 1, identify two water uses that compete with one another and so cannot easily exist beside one another.

2.3 Where water comes from

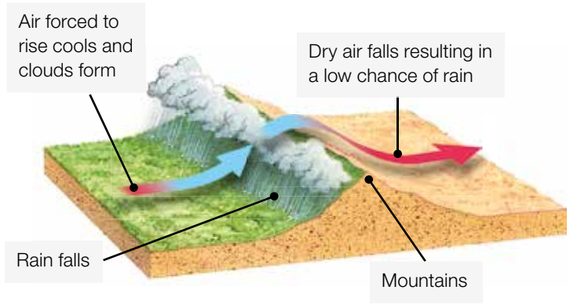
Water is one of our most precious environmental resources. Without it, nothing can survive. It is an essential, renewable resource that occurs naturally on Earth. It can exist as a solid (such as ice in a **glacier**), a liquid (such as water in a river) or a gas (such as steam). Fresh water is an available resource when in liquid form and a potential resource as a gas or a solid. Liquid water is constantly being recycled through the atmosphere, rivers and oceans in a natural system known as the **water cycle** (see Source 2).

In the water cycle, water from the oceans and lakes is heated and evaporated by the Sun. The evaporated water vapour, which is like steam, then rises until it reaches the cooler parts of the atmosphere. Cold air cannot hold as much moisture as warm air, so the water vapour turns back into liquid water in a process known as **condensation**. These drops of water then form into clouds, which may be carried on to land by winds and forced to rise. The colder air can no longer hold the condensed droplets and they fall as rain. The rainwater finds its way back to the world's lakes and oceans through rivers and streams and the process begins again.

As you can see in Source 2, rain falls when wet air masses are forced to rise. There are three reasons that air masses rise. Each of these will produce different types of rainfall at different places on the Earth's surface.

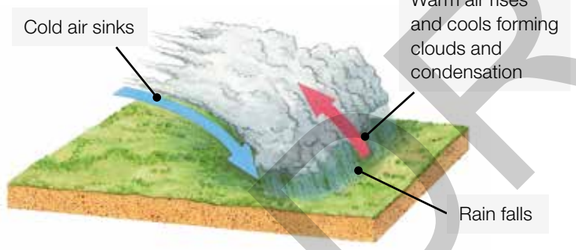
Orographic rainfall

Air is forced to rise due to the height of landmasses, such as mountains. As the air cools, condensation forms, producing rain. As the air begins to fall from the high land, it warms up, creating dry regions.



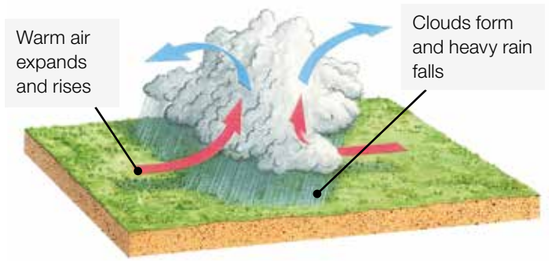
Frontal rainfall

Two air masses meet and the cooler air mass wedges itself under the warmer air mass. This forces the warm air to rise and cool, causing condensation and rain along a distinct line.



Convectional rainfall

Temperatures during the day warm the ground causing warm air to rise rapidly and condense at high altitude. This produces heavy rain and thunderstorms.



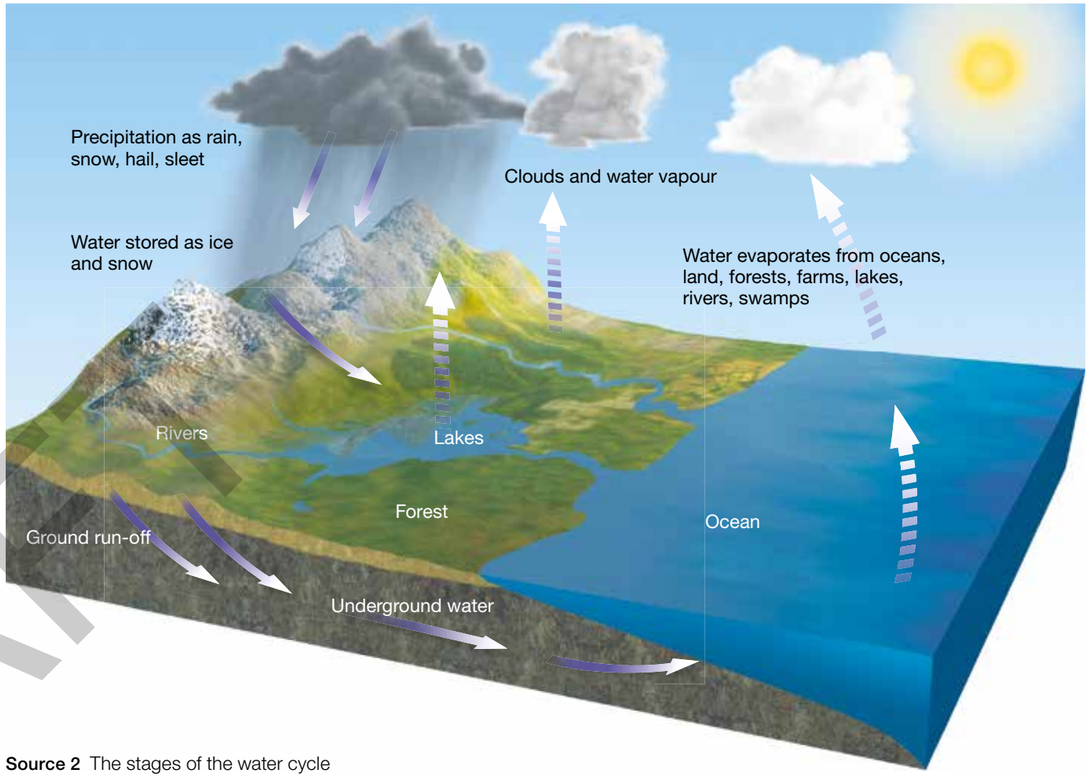
Source 1 Different types of rainfall

keyconcept: Interconnection

The water cycle

The water cycle links together large areas of the natural environment (see Source 2). The world's oceans, mountains, rivers and atmosphere are all important parts of this cycle. The water cycle links together the natural and human environments because water is so central to all human activities. The presence of water is key when settling new farms and cities. For more information on the key concept of interconnection, refer to page XX of 'The geography toolkit'.

The water cycle



Source 2 The stages of the water cycle

Check your learning 2.3

Remember and understand

1 What is the water cycle?
2 What causes water to fall as rain?
3 List these words in the correct order within the water cycle: precipitation, condensation and evaporation. Now write a definition for each in your own words.

Apply and analyse

4 What is the difference between frontal rainfall and orographic rainfall? How are they similar?
5 Why do you think the wettest place in Australia is near Tully on the eastern slopes of the Great Dividing Range in Queensland? You might like to find Tully in an atlas to help with your answer.
6 The water cycle helps us to understand how water moves in our world but it can also help us understand how rivers change the landscape. How do you think the rivers shown in Source 2 have changed this landscape?
7 What type of rainfall do you receive most often in the place where you live? Why will the answer differ for students who live in other parts of Australia?
8 Salt water in oceans cannot be used to drink or water crops. Is salt water an available or potential resource?

Evaluate and create

9 Imagine that you are a water droplet in a cloud. Describe your journey through the water cycle in language that a young child would find interesting. Here is a start: 'Floating along with billions of my closest friends, I thought nothing would ever change …'

2.4 Accessing water resources

Although the surface of the Earth is covered with water, only a tiny per centage of that water is fresh and available for consumption. Typically this is found in surface water, such as lakes and rivers. Source 1 shows the breakdown and availability of this water. As populations grow and more water is used, people are also using groundwater locked away in underground **aquifers**. This water supports every man, woman, child, animal and plant on Earth. This makes water our most precious resource.

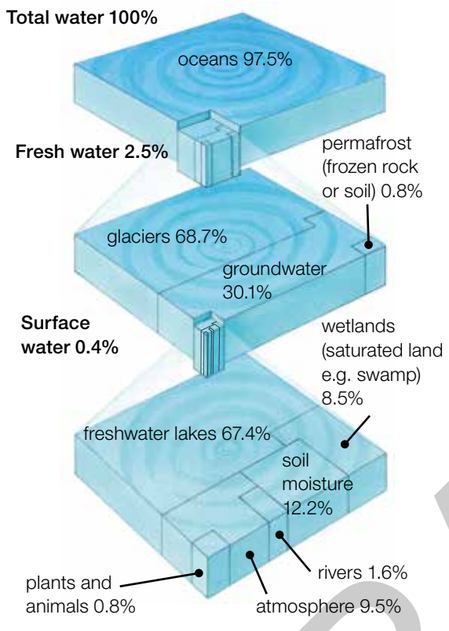
To further complicate matters, the available fresh water is not evenly distributed across the planet. Some areas of the world have much more than they need, while other areas do not have enough.

Countries with large rivers, such as the Amazon River in Brazil, and those with high rainfall, such as Indonesia and Papua New Guinea, can be thought of as being 'water rich'. Other countries, including Australia, can be considered to be 'water poor'.

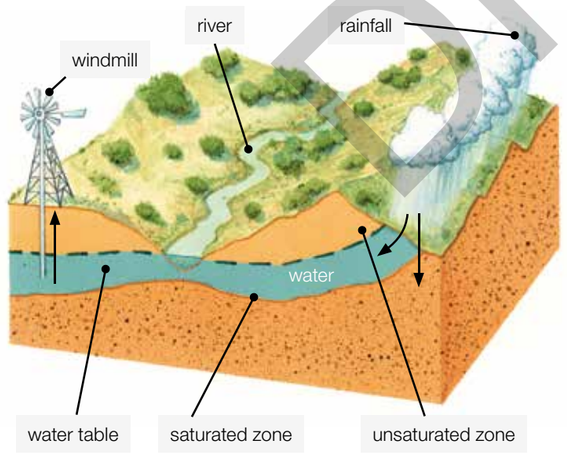
Groundwater

When it rains, water seeps into the soil to provide moisture for plants to survive. As water passes through the spaces between soil and rock it becomes groundwater. In the saturated zone, all the spaces between soil and rock particles are filled with water. The top of this zone is referred to as the water table (see Source 2).

Groundwater is fed by surface water from rainfall and rivers and naturally comes to the surface at springs or at oases in dry areas. Groundwater is also drawn to the surface by **bores** drilled into the ground. Most of Perth's water is drawn from an underground aquifer, a layer of permeable rock that stores water.



Source 1 Distribution of the world's water

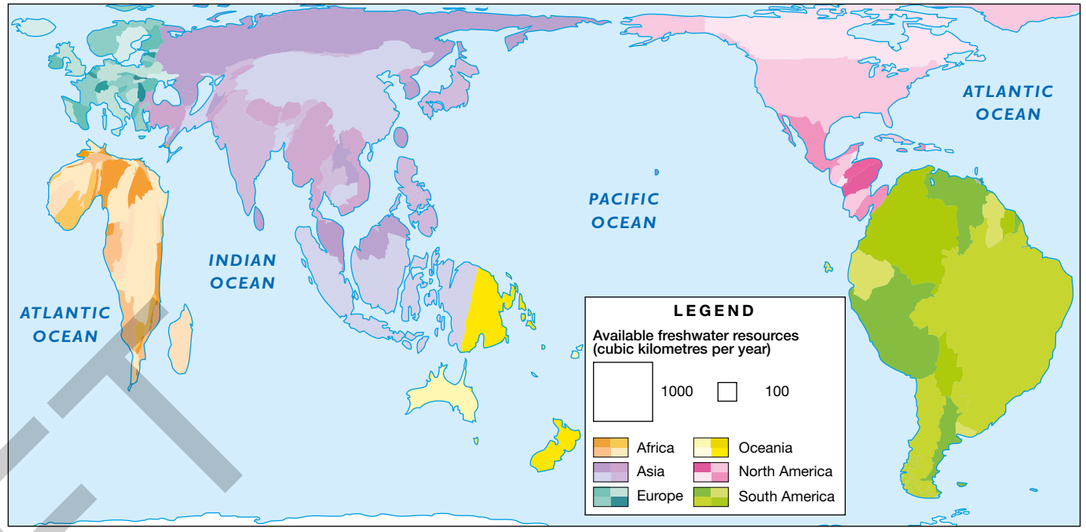


Source 2 Groundwater from aquifers is pumped to the surface via bores for use by humans. In this example, water is pumped through a bore using a windmill.

The world's freshwater resources

Source 3 is a map of the world as you have never seen it before. While each country is shown in its correct location, its size shows the proportion of the world's freshwater resources found there. Countries that appear fat are water rich; those that appear thin are water poor. Comparing the size and shape of countries in Source 3 with the same countries on a standard world map (like the one provided at the back of this book) will clearly show which are water rich (larger than normal) and which are water poor (smaller than normal).

WORLD: FRESHWATER RESOURCES



Source 3

Source: Oxford University Press

skilldrill

Using the PQE method to describe maps

The PQE method is used by geographers to identify trends and patterns in data and draw conclusions. For more information on the PQE method refer to section 1B of 'The geography toolkit'. There are three steps to follow when using the PQE (pattern, quantify, exceptions) method to describe maps:

Step 1 Pattern: Give a general overview of the pattern, referring to particular places. Which areas seem to have common features? (For example, 'The map of the world's freshwater resources shows that countries throughout South America have lots of fresh water').

Step 2 Quantify: Quantify your general overview using data for specific regions or countries. (For example, 'Brazil has more than 5000 km^3 of fresh water a year.')

Step 3 Exceptions: Point out any exceptions to the pattern you have described. (For example, 'Madagascar, the island off Africa, appears to have abundant water supplies, whereas the rest of the African continent does not.')

Apply the skill

1 Use the PQE method to describe the world's freshwater resources. Be sure to describe areas that are water rich and those that are water poor. The world map on the inside back cover will be useful.

Check your learning 2.4

Remember and understand

1 How much of the world's water is fresh water, available for our use?

2 Is Australia water rich or water poor? What does this mean?

3 Study Source 3.
- **a** Which countries would you consider to be the most water rich? Which are the most water poor?
- **b** Compare the freshwater resources of Australia, New Zealand and Papua New Guinea.

Apply and analyse

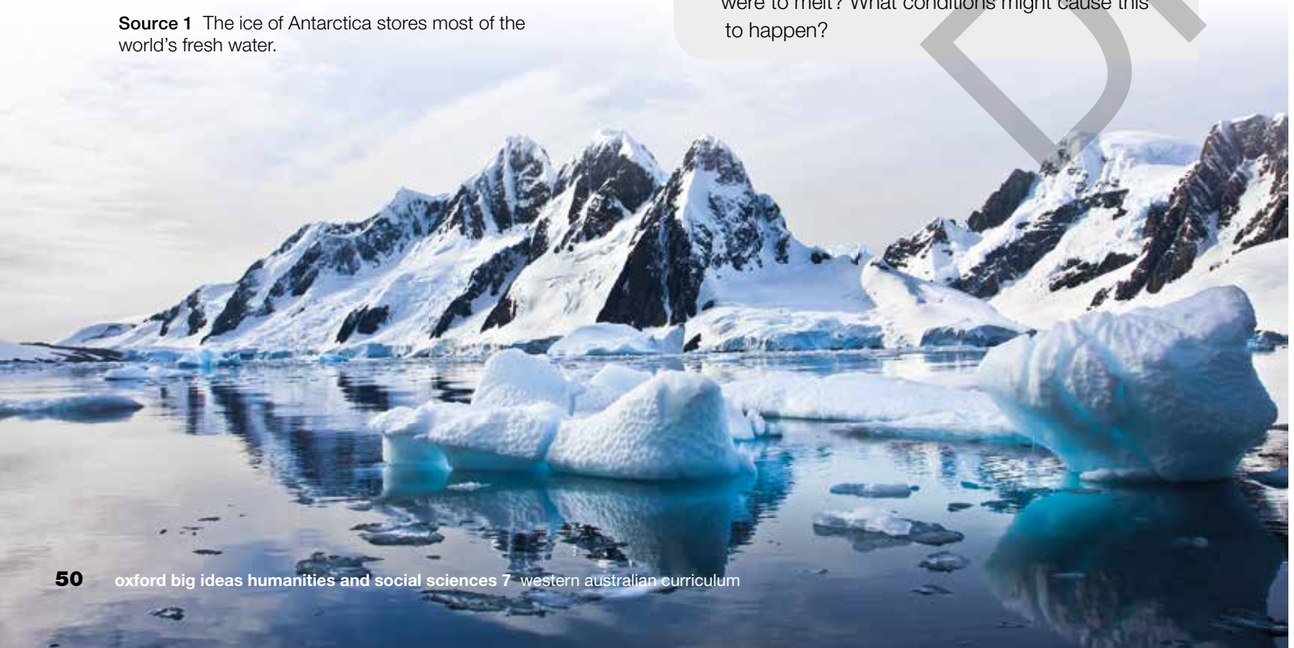
4 What can countries that are water poor do to access more fresh water? Brainstorm this as a class. Think first of those methods that you already know about, perhaps those used in your local area, and then expand these into other possibilities.

2.5 Stored water

The water cycle is the movement of water through the Earth, but most of the fresh water on Earth is in storage. Fresh water can be stored for days or weeks in a lake or for thousands of years underground or in an ice cap, such as the one that covers much of Greenland. About 97.5 per cent of the Earth's water is found in the oceans and is too salty to drink. Much of the remaining 2.5 per cent, which is safe for us to drink, is locked in the polar **ice caps** and in flowing rivers of ice, known as **glaciers**.

Antarctica contains nearly 70 per cent of the world's fresh water as ice in an ice sheet that covers large sections of bedrock (solid ground) in Antarctica. The ice sheet has an average thickness of 2500 metres and scientists have found places where the ice is thought to be twice this thickness. If this ice were to melt, sea levels around the world would rise by up to 60 metres. Because the temperature in the interior of Antarctica remains below freezing, any snow that has fallen there in the last few million years has never melted and has gradually formed into a great dome of ice. The ice is gradually moving towards the sea away from the centre of the continent. As it reaches the sea, the ice breaks off into gigantic **icebergs**.

Source 1 The ice of Antarctica stores most of the world's fresh water.



Check your learning 2.5

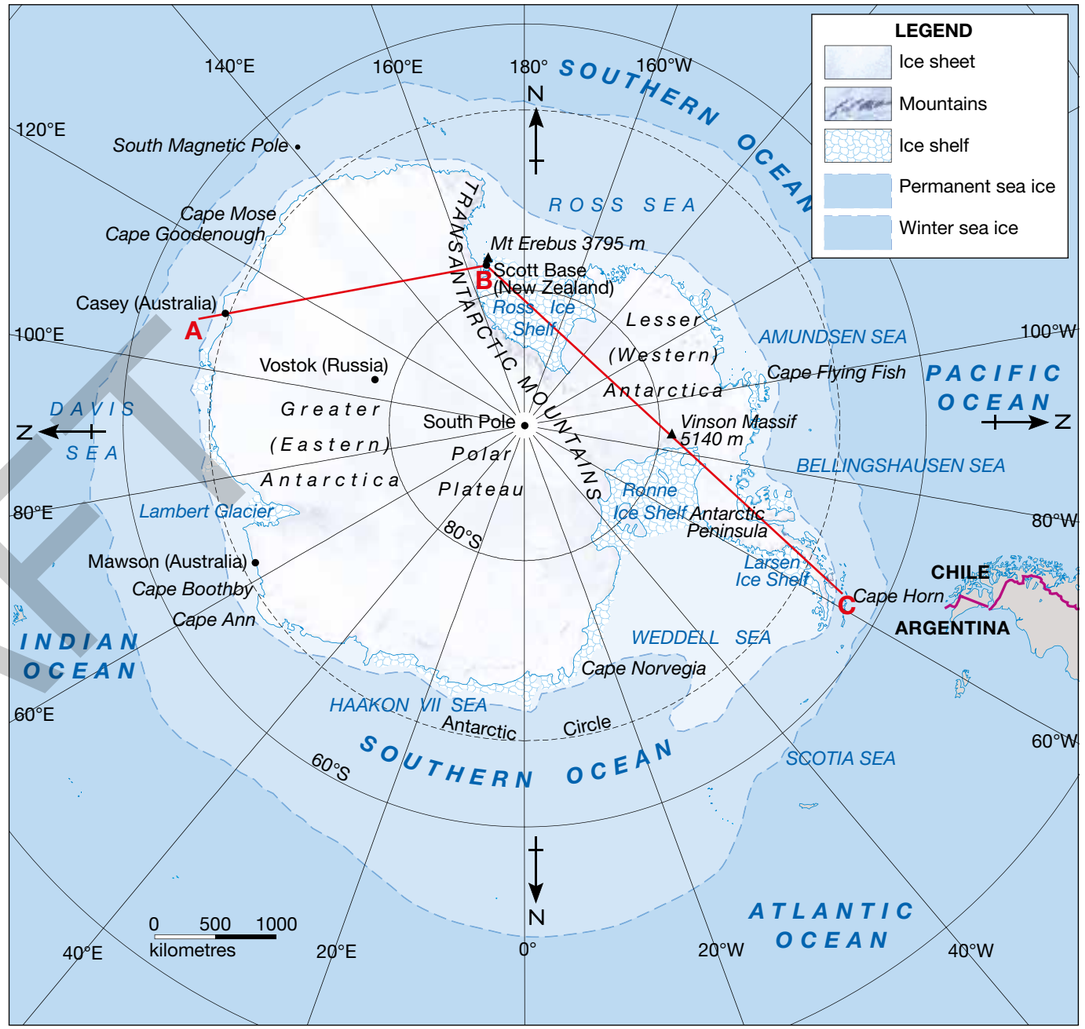
Remember and understand

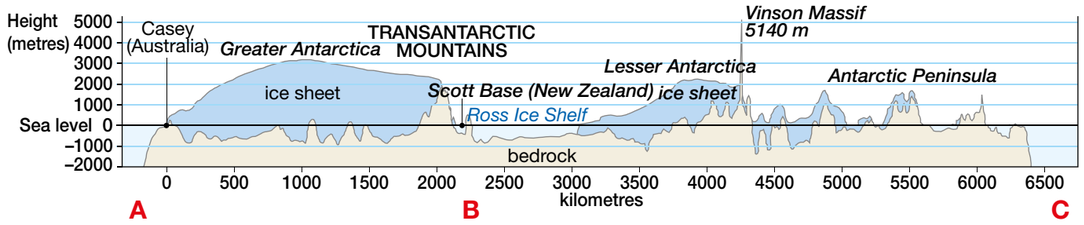
1 List three places where ice is stored.
2 Where is most of the world's fresh water stored?
3 Why doesn't the ice in Antarctica melt?

Apply and analyse

4 Look carefully at the map in Source 2.
  a What happens to the sea surrounding Antarctica in winter?
  b What is the difference between an ice sheet and an ice shelf?
5 Look carefully at the cross-section of Antarctica in Source 2. This shows a view of Antarctica from the side as if it had been cut along the A–B–C line on the map.
  a Over which part of Antarctica is the ice sheet the thickest?
  b Describe what Antarctica would look like without its ice sheet.
  c Why is this cross-section a better way of showing the thickness of ice in Antarctica than the map?
6 What would happen if all the ice in Antarctica were to melt? What conditions might cause this to happen?

ANTARCTICA: LANDFORMS





Source 2

Source: Oxford University Press

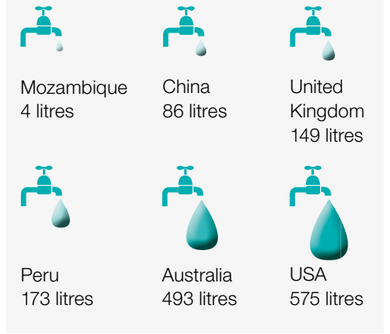
2.6 The world's drinking water

Drinking water, sometimes called potable water, is water that is safe to drink and use for cooking and washing. In Australia, most water undergoes some form of treatment to make it safe to drink. Water treatment removes sediments, pollutants and microorganisms that can make us sick. Australians are among the world's biggest water users, using almost 500 litres of water per person per day. This figure is for all water use, including water used in agriculture and industry. While this amount has declined in recent years, it still ranks among the highest in the world. Experts estimate that each Australian will need to use 12 per cent less water by 2030 in order to stay within the limits imposed by our rainfall. Some households have started to use a number of strategies to save water, while many others continue to waste large amounts.

Access to safe drinking water

In Australia, we take for granted that we have flush toilets, running water from taps and clean, safe drinking water. However, millions of people around the world get sick or die each year from drinking contaminated water. The United Nations estimates that half the world's population has problems caused by lack of access to clean water. More than 1 billion people do not have access to a reliable freshwater supply, and 2.6 billion do not have basic sanitation, such as running water to clean their hands or flush their toilets.

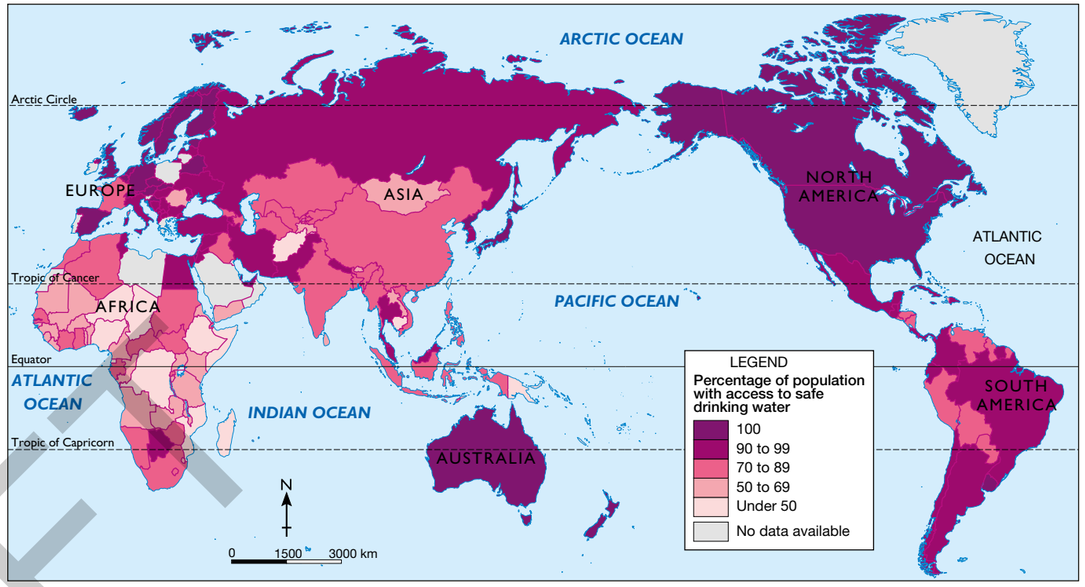
It is estimated that, at any one time, almost half the people in poorer countries are suffering from health problems due to a lack of safe water. Each year, millions of people die from diseases carried in their water. Millions of women and children around the world, particularly in Africa, spend several hours a day collecting and carrying enough water to keep their families alive for another day.



Source 1 Water use per person per day. Mozambique has the lowest daily water use per capita while the United States has the highest. Source: United Nations 2006

Source 2 In Chad, as in many African countries, each day begins with a walk to the village well.

WORLD: ACCESS TO SAFE DRINKING WATER



Source 3

Source: Oxford University Press

keyconcept: Environment

Serah's story

Serah and her six children live in Ethiopia in Africa. The scarcest resource in her region is water. Before dawn, she makes her first journey to the village pump. Once there were three wells, but the 8-metre well has dried up. The 9-metre well has a little salty water at the bottom.

The flow from the pump of the 25-metre well has slowed to a painful trickle. There is just barely enough for everyone to drink.

While it takes her 25 minutes to walk down the hill to the pump, it will take her 40 minutes to make the return journey with the 10-litre jar balanced on her head. She makes this trip at least twice a day. She tends not to drink as much as the others as she believes she should look after her children before herself. This means that she cannot produce enough milk for her baby, so he is often ill. The water contains parasites that make her other children sick, but Serah has little choice.

For more information on the key concept of environment, refer to page XX of 'The geography toolkit'.

Check your learning 2.6

Remember and understand

1 What is potable water?
2 How many people in the world do not have access to a reliable supply of fresh water?
3 Describe the differences in the drinking water available in most Australian homes and in Serah's village.

Apply and analyse

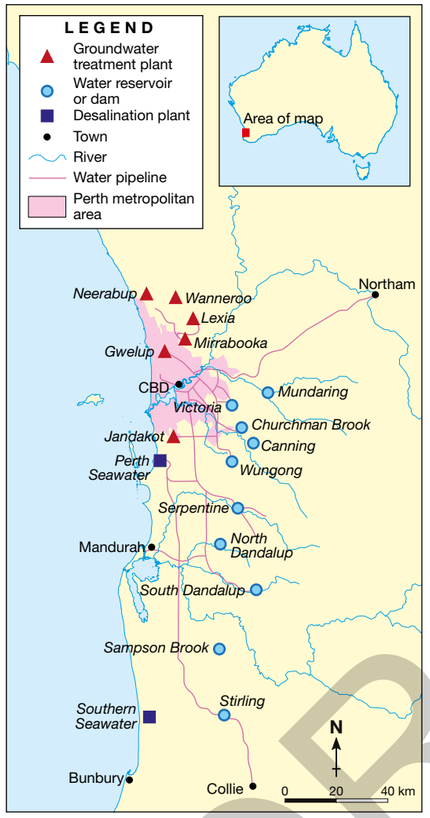
4 Using Source 3 and the world map on the inside front cover of this book, identify two countries with excellent access to safe water and two countries with poor access to safe water. Which continent has the worst access to safe water?
5 Read Serah's story.
   a How much water will Serah collect in two trips to the pump?
   b How many people depend on her trips to the pump?
   c How much will each person receive?
   d The average toilet in Australia uses 8 litres per flush. Write a statement about the way water is used in Australia compared to Ethiopia.

2A rich task

Perth's water supply

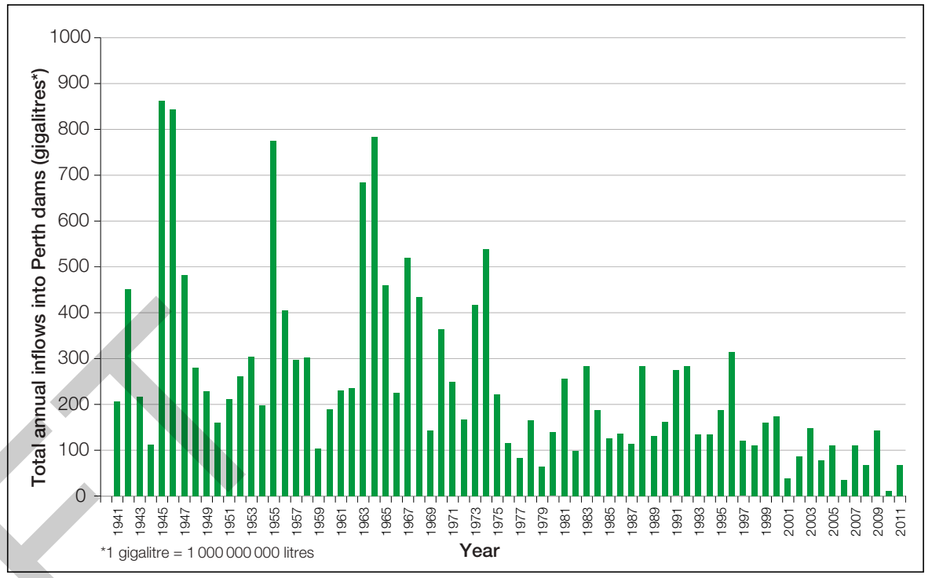
Like many Australian cities and towns, Perth faces many challenges in supplying its population with enough fresh water. A decline in its rainfall over the last 100 years has meant that the people of this rapidly growing city can no longer rely on rivers, lakes and dams to supply all their water needs. About half of Perth's water now comes out of the ground. North of the city are large aquifers which have collected rainwater for thousands of years and stored it within sand or limestone layers. Wells are dug to access the water which is treated, mixed with rainwater and used by Perth residents in their homes, farms and gardens. Up to 20 per cent of Perth's water comes from two large desalination plants. The city was one of the first in Australia to use desalination plants to provide fresh water. The Western Australian state government hopes that expansion of these plants will help to 'drought-proof' Perth.

PERTH: WATER RESOURCES



Source 2 Source: Oxford University Press

Source 1 One of Perth's desalination plants. The Perth Seawater Plant removes the salt from sea water to produce fresh water.



Source 3 Water flowing in to Perth's dams 1941–2011

skilldrill

Using a map legend

In order to show the features on maps clearly, various symbols and colours are used. To help us unlock the information on the map these symbols are explained in a legend (or key). There are three main types of map symbols:

- Point symbols – show features in one particular place (such as a railway station or desalination plant)
- Line symbols – show features that connect places on the map (such as roads and rivers)
- Area symbols – use colours or patterns to represent large areas (such as lakes and cities).

Apply the skill

1 Study Source 2.
   - **a** What symbol has been used for desalination plants on this map?
   - **b** Give an example of an area symbol used on this map.
   - **c** How many groundwater treatment plants supply water to Perth?
   - **d** What do you notice about the location of the dams on this map?

Extend your understanding

1 Look carefully at Source 3.
   - **a** Compare the annual flow of water into Perth's dams before and after 1975. What difference can you see?
   - **b** List the four years with the smallest annual inflows of water. What do you notice from this pattern?
   - **c** Why do you think the annual inflow of water changes so greatly between years?

2 What two other sources of water does Perth use to access water other than dams fed by rain?

3 Do you think it is possible to drought-proof a city? Give some reasons for your answer.

4 What do you think will happen to the water in an aquifer if water continues to be pumped out of it for use in a city such as Perth?

5 Why does Perth need more water now than it did 100 years ago?

6 What are some of the strategies being tried to address water problems in other parts of Australia?

2.7 Water connects people and places

People rely on water to survive. As a result, easy access to water influences where people choose to live. Cities, towns and villages are often located near fresh water sources such as rivers, lakes and underground water reserves. Water sources also directly influence the way people live; for example, the crops they grow or the transport they use. As human settlements tend to cluster around the same types of water sources, these water sources need to be shared by the communities. Because of this, many places around the world are connected with each other through these water sources. Generally, three main factors relating to water influence where people settle. These factors are discussed below and shown in Source 1.

Historical and environmental factors

Historically, towns and cities have developed along rivers and near lakes and other fresh water sources. People will settle anywhere there is water, adapting their way of life to the local environmental features. Communities in the Hindu Kush region of the Himalayas in Pakistan and Afghanistan depend on the seasonal melting of the snow and glaciers to provide them with fresh water. This melt also feeds the great rivers in the region, the Indus River and the Ganges River, that supply water to the many cities and communities that have been established along their banks – around 1.5 billion people.

Agriculture

Communities also rely on fresh water to grow crops and farm animals. The availability of fresh water will determine the sorts of crops grown. In places where water is limited, crops that need little **irrigation**, such as corn, will be grown. Crops that rely heavily on water, such as rice, are grown on **floodplains** where water is plentiful. These floodplains and **deltas**, located on flat land where rivers meet the sea, have particularly rich soil due to the deposits of silt that has travelled down the river from the mountains.

Trade and transport

Rivers move water across the Earth's surface, carrying water great distances to the sea. Rivers, lakes and oceans also act as transport networks, allowing products and people to move easily from one place to another, connecting the communities established on their banks.

Check your learning 2.7

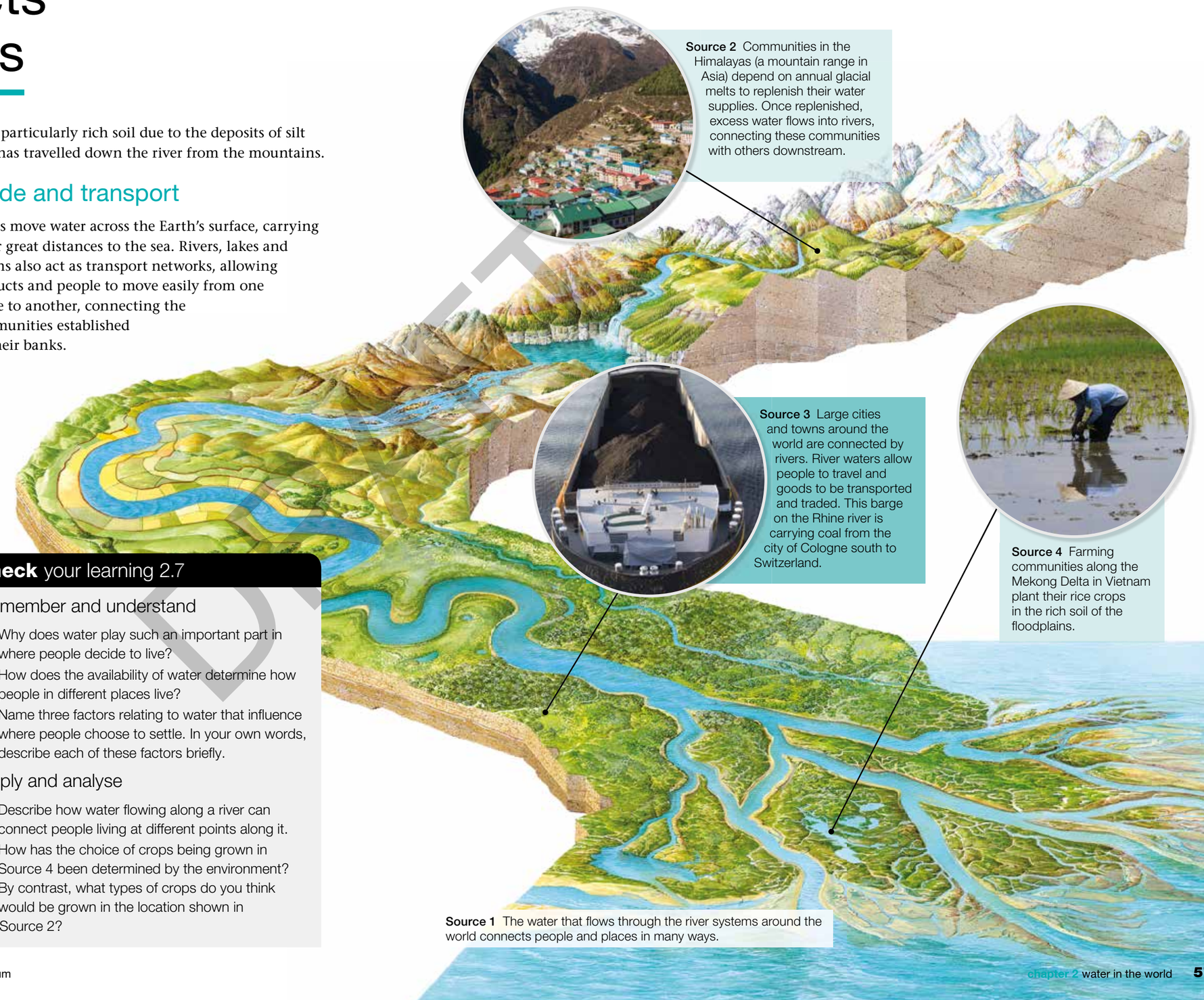
Remember and understand

1. Why does water play such an important part in where people decide to live?
2. How does the availability of water determine how people in different places live?
3. Name three factors relating to water that influence where people choose to settle. In your own words, describe each of these factors briefly.

Apply and analyse

4. Describe how water flowing along a river can connect people living at different points along it.
5. How has the choice of crops being grown in Source 4 been determined by the environment? By contrast, what types of crops do you think would be grown in the location shown in Source 2?

How rivers connect people and places



Source 2 Communities in the Himalayas (a mountain range in Asia) depend on annual glacial melts to replenish their water supplies. Once replenished, excess water flows into rivers, connecting these communities with others downstream.

Source 3 Large cities and towns around the world are connected by rivers. River waters allow people to travel and goods to be transported and traded. This barge on the Rhine river is carrying coal from the city of Cologne south to Switzerland.

Source 4 Farming communities along the Mekong Delta in Vietnam plant their rice crops in the rich soil of the floodplains.

Source 1 The water that flows through the river systems around the world connects people and places in many ways.

2.8 Water affects places

As well as connecting different people and places, water can also affect them – in both positive and negative ways. On the positive side, water from the rain and rivers is used to irrigate the crops and farm the livestock that we eat. This water has a positive effect on the places in which we live. Without it, no life could exist. On the negative side, water in all its states – whether as a liquid (water), a solid (snow and ice) or a gas (fog) – can cause serious problems and damage in different places. Snow storms can shut down cities for days, heavy fog can disrupt air travel and cripple airports, and heavy rainfalls can cause widespread flooding.

A good way of understanding how water affects places is to look at some case studies relating to rivers. Rivers are interesting to study because if there is a problem upstream (such as a flood or pollution) this problem will quickly travel downstream, affecting the people who live there. Flooded rivers can affect many settlements along their banks, collecting and carrying rubbish or even trees and cars, as they go. If pollution or toxic chemicals enter the water at one location on the river, they quickly affect other parts of the river downstream, as well as the people who use it.

Case study: Tisza River pollution, 2000

In 2000, a storage pond used by a gold mine in Romania burst its banks. Around 100 000 cubic metres of water containing poisonous cyanide spilt into a local river that flowed into the Tisza River in nearby Hungary.

The cyanide spill killed much of the fish and plant life for several 100 kilometres downstream. Drinking water was polluted in four different countries: Romania, Hungary, Serbia and Bulgaria.

Source 1 A Hungarian fisherman pulls out toxic fish from Lake Tisza on the Tisza River 12 days after a serious chemical spill upstream in Romania on 30 January 2000.

Case study: Thailand floods, 2011

In 2011, the people of Thailand experienced some of the worst flooding they had seen for decades. Areas of Thailand are prone to flooding as the annual monsoon brings heavy rain, particularly in the north of Thailand. In early 2011, a tropical cyclone combined with the monsoon to more than triple the amount of rain falling on northern Thailand. As heavy rains continued for several months, rivers burst their banks in the mountainous north, resulting in flash flooding and at least 13 deaths.

Flooding continued downstream in many large towns built beside rivers. Soon the country's capital, Bangkok, became the area of greatest concern. Located on a low floodplain at the mouth of the Chao Phraya and Tha Chin Rivers, Bangkok is very prone to flooding and, despite an intricate system of flood walls and canals, much of the city flooded. By the time the floodwaters receded, they left more than 500 people dead and a damage bill of more than US$45 billion.

Source 2 Floodwaters in the main street of Ayutthaya during the floods in Thailand in 2011 shut down the city and resulted in many deaths

Check your learning 2.8

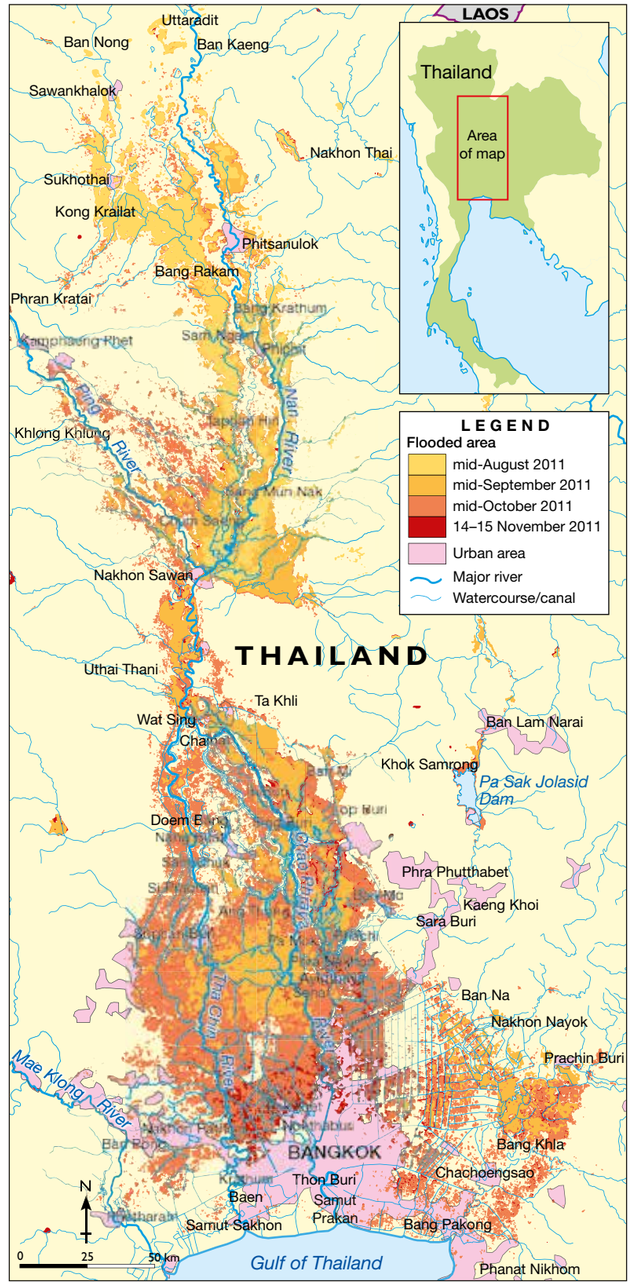
Remember and understand

1 Give examples to show how water affects places in its gas, liquid and solid states.
2 What problems did the gold mine in Romania cause downstream?

Apply and analyse

3 Look carefully at Source 3.
   a When did floodwaters reach Bangkok?
   b How far had some of the floodwater travelled? (Use the scale provided to calculate the distance.)
4 Decide whether each of the following facts makes flooding in Bangkok more likely or more dangerous. Justify your answer for each one.
   a Between June and October Thailand experiences its wet season with heavy monsoon rains.
   b Bangkok has been built on the Chao Phraya River delta.
   c Between 1985 and 2010 Thailand's population increased by more than 10 million people.
   d The land on which Bangkok is built is sinking by 30 millimetres a year.

THAILAND: TIME LAPSE MAP SHOWING THE SPREAD OF FLOODWATERS, MID-AUGUST 2011 TO 15 NOVEMBER 2011



Source 3 Source: Oxford University Press

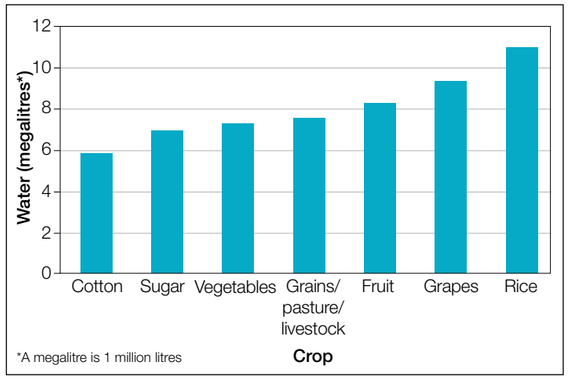
2.9 Water for food

Farmers are by far the biggest users of water in Australia. About 70 per cent of the fresh water used each year in Australia is used in agriculture. This water is used to produce an enormous range of products, many of which you consume every day (see Source 2).

You may not realise it, but a lot of water was needed to produce your breakfast. Many everyday products use even more water. For example, it takes up to 50000 litres of water to produce 1 kilogram of beef, and 685000 litres to produce enough wool to make one suit. The amount of water needed to produce an item of food, such as a steak, or a piece of clothing, such as a suit, is known as **virtual water**.

In Australia, many crops are grown in the Murray–Darling Basin in south-eastern Australia (see Source 4). While a lot of the water used in this region falls on the farms as rain, much of it is taken from the rivers. Movement and control of water has a large economic impact in this region.

In the past, the rivers in this region had a normal cycle of flood and drought. Farmers needed a more reliable flow of water and so a system of dams and weirs was built along the river. These collect water during wet times and release it gradually during dry times, thereby controlling the flow of the river.



Source 2 Water used per hectare (10000 square metres) to grow selected crops

Farmers are allowed to use a certain amount of water each year and are charged for the amount of water they use. Because they have to pay for their water, farmers in this region use it very carefully. Another reason for farmers to use water as efficiently as possible is the scarcity of water in many parts of Australia. In the early years of the twenty-first century, a widespread and severe drought turned the Darling River and many others into a series of pools separated by kilometres of dry river bed. Because of these factors, many farmers and farming industries have developed more water-efficient methods of farming.

Apricots
Apricots are mainly grown and processed in northern Victoria and southern New South Wales. Western Australia grows about 3 per cent of Australia's apricots.
Estimated water needed to produce 1 kilogram of apricots: 1391 litres

Bread
The main ingredient in bread is wheat. Western Australia produces 50 per cent of wheat in Australia, across 4000 farms.
Estimated water needed to produce 1 kilogram of wheat: 750 litres

Milk and butter
More than 60 per cent of Australia's milk and milk products comes from Victoria. Western Australia produces only 4 per cent of Australia's milk.
Estimated water needed to produce 1 glass of milk: 200 litres
Estimated water needed to produce 1 kilogram of butter: 18070 litres

Raspberry jam
The main ingredient in raspberry jam is sugar. Virtually all of Australia's sugar is grown in Queensland. Raspberries grown in the Goulburn Valley make up 40 per cent of the jam.
Estimated water needed to produce 1 kilogram of sugar: 173 litres Estimated amount of water needed to produce 1 kilogram of raspberries:
713 litres

Rice Bubbles
Rice Bubbles are made from 89 per cent whole white rice, which is grown in the Murrumbidgee Irrigation Area (part of the Murray–Darling Basin). Much of the rice industry is centred around Deniliquin in southern New South Wales.
Estimated water needed to produce 1 kilogram of rice: 1550 litres

Source 1 Water requirements to produce typical breakfast foods

Source 3 An irrigation channel in the Murray–Darling Basin

Murray River irrigation

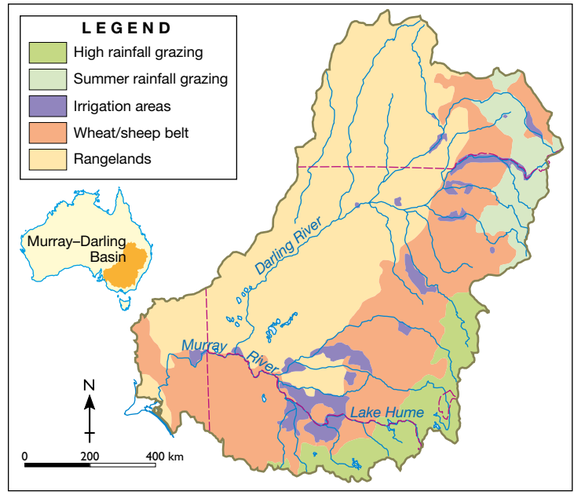
Lake Hume is an artificial lake formed by the Hume Weir near Albury–Wodonga on the Murray River. Completed in 1936, it is one of a series of dams and weirs built to control the flow of water in the Murray River. Its main purpose is to trap water during periods when there is a large amount of water in the Murray River and release it gradually to keep the flow of the river relatively constant.

A network of irrigation pipes and open channels carries the water from the Murray River hundreds of kilometres to individual farms. Open channels are generally less efficient than pipes as water is lost to evaporation and water seeping into the soil. However, they are much cheaper to build than pipes.

When the water reaches the farms it flows through gravity or is pumped onto the crops or pastures. A common method of irrigation is the use of a pivot spray. A giant arm with sprayers attached moves around a central pivot point, creating distinctive circles of green.

Source 5 Pivot spray irrigation

MURRAY–DARLING BASIN: LAND USE



Source 4 Source: Oxford University Press

Check your learning 2.9

Remember and understand

1. How much of Australia's fresh water is used on farms?
2. How does water for irrigation of crops and pastures reach the farms?
3. Rank the breakfast foods shown in Source 1 in order from greatest water need to least water need.

Apply and analyse

4. Can farmers use as much water as they want?
5. Look at Source 2.
   a. Which crop uses the most water?
   b. Which crop uses the least water?
6. Why do you think it takes so much water to produce 1 kilogram of rice?
7. In what ways is the Murray–Darling Basin one of Australia's most important resources?
8. Look closely at the map (Source 4).
   a. What relationship do you notice between irrigation areas and rivers?
   b. Explain the nature of this relationship.

Evaluate and create

9. Draw a labelled diagram to clearly show how pivot spray irrigation works. Use Source 5 to help you.

2.10 Water for energy

Moving water has been used as a source of energy since ancient Greek and Roman times, with the invention of the water-driven wheel. Watermills built by the Romans used the force of the flowing water to drive the blades of a large wooden wheel. This, in turn, rotated an axle to drive the machinery inside the mill to grind grains like wheat and corn.

Hydroelectricity

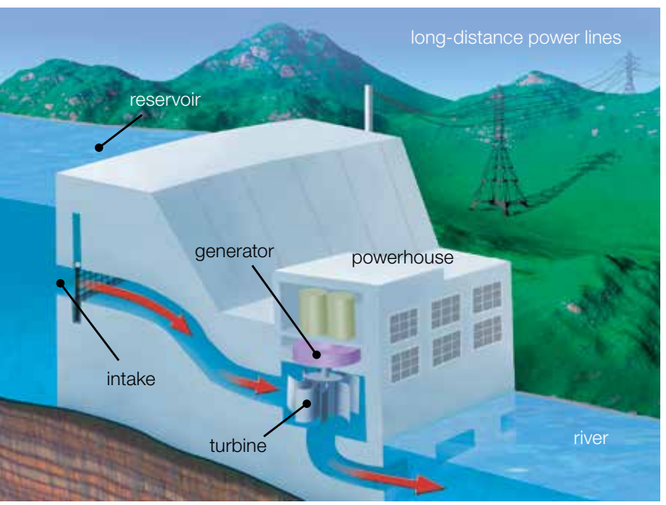
Today electricity is generated following the same basic concept used in Roman watermills. A dam is built across a river, creating a large reservoir of water. This water is then released through turbines, causing them to turn. The spinning turbines rotate giant magnets around a huge coil of copper wire to create electricity. The faster the water flows, the more electricity is created. This type of electricity is known as hydroelectricity.

Australia's largest plant is the Snowy Mountains Hydroelectric Scheme. More than 100 000 people from over thirty countries constructed the huge tunnels, dams and power stations. Electricity generated by the scheme is used in the Australian Capital Territory, New South Wales and Victoria.

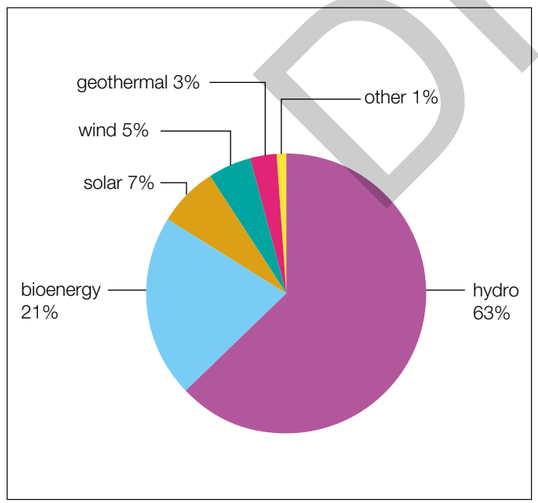
Hydroelectricity is the largest source of renewable, non-polluting energy in the world. The main negative impact of building a hydroelectric plant is that the natural flow of the river is stopped and the land behind the dam is flooded. The flooding of valleys behind the dam can destroy natural habitats and human features, such as houses, fences and roads.

Case study: Three Gorges Dam, China

China's Three Gorges Dam is not only the world's largest dam, it is also the largest power station ever built. More than 2 kilometres long and 180 metres high, the dam has turned the Yangtze River into a lake 660 kilometre long. As well as producing electricity, the dam has increased the Yangtze River's shipping capacity, and has reduced the flooding hazard downstream. The building of the Three Gorges Dam stirred protests around the world, as it involved displacing 1.25 million people and flooding more than 600 square kilometres of land; that is about 30 000 times the size of the Melbourne Cricket Ground.

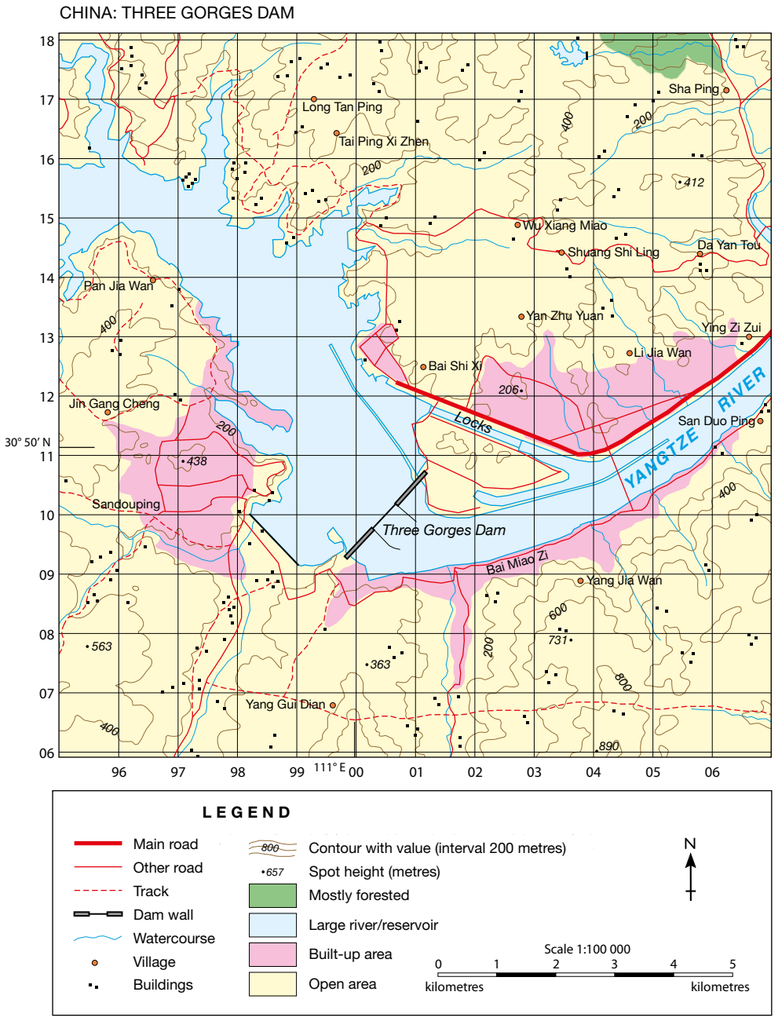


Source 1 How a hydroelectric power station works



Source 2 Energy from renewable and continuous sources. Hydroelectric power accounts for most of the total energy produced from these sources around the world.

Source 3 An oblique aerial view of the Three Gorges Dam on the Yangtze River in China. Water flows through the open sluice gates. The hydroelectric power station is to the left of the sluice gates.



Source 4 Source: Oxford University Press

Check your learning 2.10

Remember and understand

1 How is water used to create electricity?
2 What is the main source of renewable energy in the world?
3 What advantages and disadvantages does the building of dams bring?
4 How can you stop a river flowing to enable a dam wall to be built?

Apply and analyse

5 Look carefully at Source 3. Oblique aerial images are taken from an angle and show a foreground and a background. Is the dam wall in the foreground or the background?
6 Draw a sketch of the oblique aerial image (Source 3) and label the following:
- Three Gorges Dam
- Yangtze River
- hydroelectricity plant

2B rich task

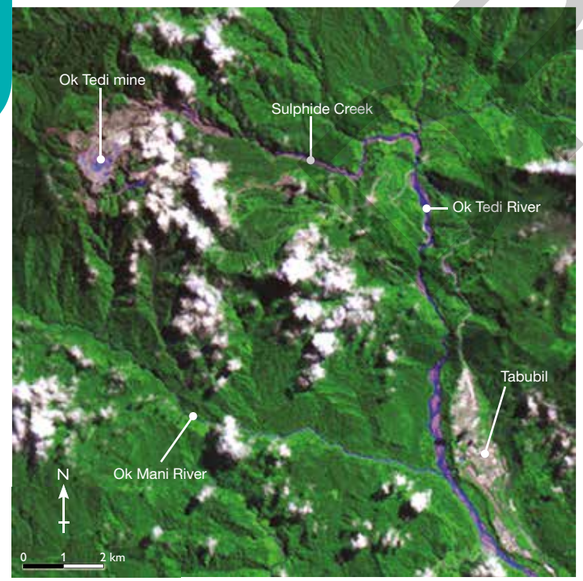
The Ok Tedi mine

The Ok Tedi copper and gold mine is located on the Ok Tedi River, in Papua New Guinea. During mining operations large amounts of chemicals are used to separate the precious gold and copper minerals from other rocks. These chemicals, along with ground up rocks and ore (known as **tailings**), need to be disposed of. In order to do this, the mine owners (BHP Billiton) built a dam known as the tailings dam. The tailings dam allowed heavy metals and solid waste from the mine to settle. Cleaner water would then be released into the river system.

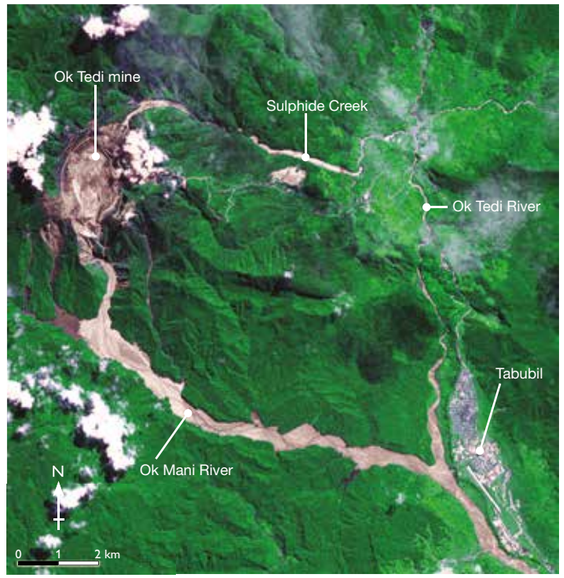
Unfortunately, an earthquake in 1984 collapsed the tailings dam. BHP Billiton argued it was too expensive to rebuild it.

Since 1984 the mine has discharged 70 million tonnes of tailings into the river system each year. Chemicals from these tailings destroyed wildlife in the river, particularly fish. The materials dumped into the river changed a deep and slow river into a shallow river with rapids. Transport up and down the river became more difficult. The change in the river bed led to frequent floods that spread contaminated mud onto 1300 square kilometres of farms along the Ok Tedi River. The discharge from the Ok Tedi mine caused great harm to the 50 000 Indigenous people who live in the 120 villages downstream of the mine. Millions of dollars in compensation was paid to those affected by the misuse of the river system.

Source 1 Ok Tedi mine in Papua New Guinea



Source 2 Satellite image of Ok Tedi mine, 5 June 1990



Source 3 Satellite image of Ok Tedi mine, 26 May 2004

skill**drill**

Identifying change over time

By carefully examining photographs, satellite images or maps from different times we can see the changes that occur at a location. When studying the same area at two different times:

Step 1 Find a key feature, such as a river or main road, as a reference point on both sources.

Step 2 Note the areas of the image where there has been little or no change.

Step 3 List the differences in the later image where there has been change.

Step 4 Look for other information on the image that shows what might have contributed to the change.

Step 5 Describe the type of change – permanent change or seasonal change (such as different stages of crop production or plant growth).

Apply the skill

1 Study Sources 2 and 3.

- **a** In what two years were the satellite images taken?
- **b** Were the images taken at different times of the year?
- **c** What changes to the rivers occurred between the two years when these images were taken?
- **d** Why did these changes occur?
- **e** Are these changes permanent or seasonal?
- **f** Draw a sketch map of the area in 2004, using a key and labels to outline the changes that have occurred since 1990.

Extend your understanding

1 What competing uses were there for the Ok Tedi and Ok Mani Rivers?

2 What problem did BHP Billiton have managing the polluted water in their tailings dam?

3 What environmental impact did the tailings have on the rest of the river?

4 What social impact did the actions of BHP Billiton at the Ok Tedi mine have on the Indigenous users of the river?

5 Give another example where change in water use in one part of a river has impacted on water users downstream.

2.11 Water in Australia

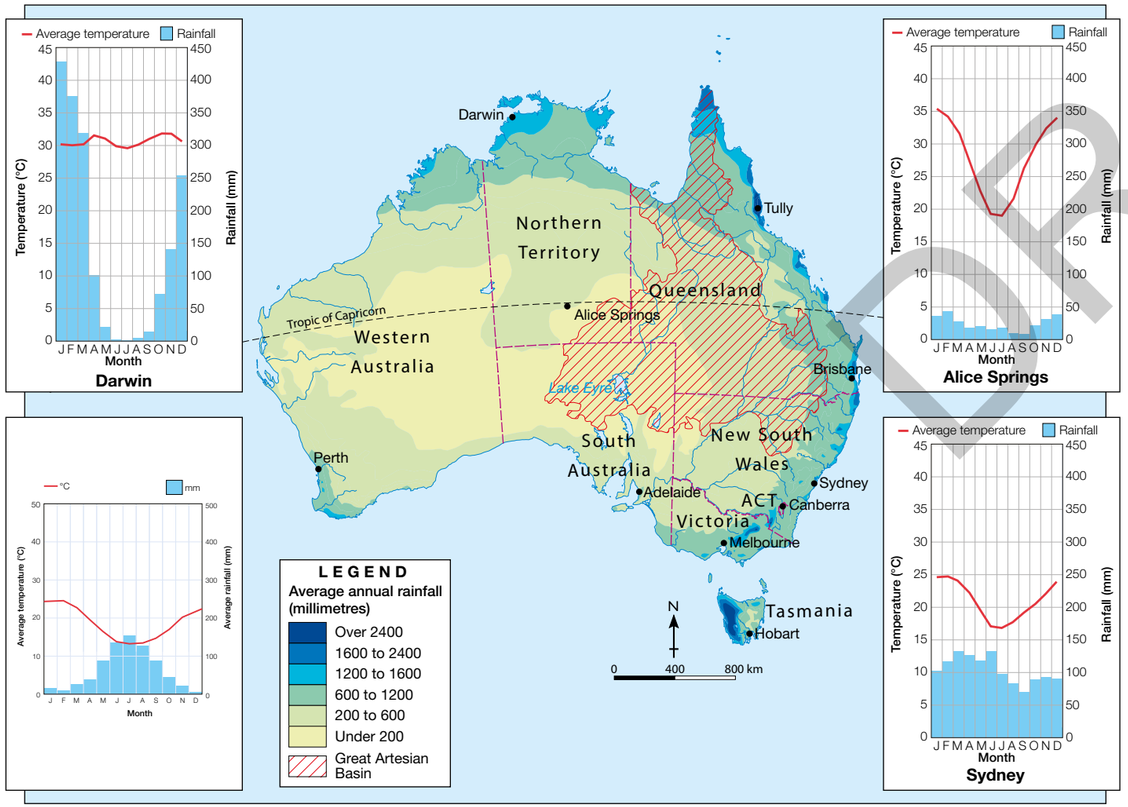
Australia has the lowest volume of water in rivers and the smallest number of permanent wetlands of any continent except Antarctica. Australia's water supplies are not evenly distributed. The northern third of the continent lies in the **tropics** and receives heavy rainfall with **monsoons** in the summer. It is a water-rich area. By comparison, vast areas of the interior receive very little rain.

Virtually all of Australia's large cities and towns are positioned on the coast, especially in the east and south-east. This is because reliable rainfall in these regions has made them more liveable than drier parts of the country. Yet pressure from a large number of water users has put great strain on water resources in these areas.

Rainfall distribution in Australia

Much of the Australian continent is dry. It is only the northern, eastern and south-western coastal regions that receive good annual rainfall. The climate of the eastern half of Australia is influenced by the Great Dividing Range. It extends 3500 kilometres from the northern tip of Cape York to southern Victoria. Moisture-rich winds from the south-east push warm, moist air over the land. Forced to rise and cool, the water droplets fall onto the east coast as rain, but as the air descends to the west, it becomes warmer and drier.

AUSTRALIA: AVERAGE ANNUAL RAINFALL (CLIMATE GRAPHS FOR SELECTED LOCATIONS)



Source 1

Source: Oxford University Press

Source 2 Australia's heaviest rainfall makes Tully the white-water rafting capital of Australia.

Being such a large country, Australia has a great deal of variation in rainfall. It is common for one part of the country to have floods while another has a long drought. The wettest place in Australia is Tully, near Innisfail in north Queensland, which averages 4204 millimetres of rainfall a year. Tully receives so much rain because of its location within the tropics on the north-eastern facing slopes of the Great Dividing Range.

The driest place in Australia is on the shores of Kati Thanda (Lake Eyre) in South Australia, which receives little more than 100 millimetres per year. Kati Thanda receives so little rain because it lies far from any supply of moisture. Air masses reaching the interior of the country have generally dropped their rain on to the south-eastern corner of Western Australia, and so they are dry by the time they arrive at Kati Thanda.

Many communities in the interior of Australia rely on underground water as well as the little rain that falls. Lying beneath much of eastern Australia is the world's largest underground water supply, the Great Artesian Basin (see Source 1). It is over 1.7 million square kilometres in size and covers approximately 22 per cent of Australia. The water is trapped underground in a sandstone layer covered by sedimentary rock, creating a aquifer. Farmers and communities access this water by drilling a well and pumping water to the surface with a windmill.

Australia's river resources

Rivers are a vital source of fresh water for many people. Australia, though, has the lowest volume of water in rivers of any inhabited continent on Earth. On average, just 12 per cent of Australia's rainfall is collected in rivers; this is referred to as the river discharge. The remaining 88 per cent of rainfall is used by plants, held in natural water storages (such as lakes, wetlands and aquifers) or returned to the atmosphere through evaporation. The Darling River, part of Australia's largest river basin (the Murray–Darling Basin), loses enough water every year through evaporation to fill Sydney Harbour four times.

Check your learning 2.11

Remember and understand

1 Why do many Australians live on the southern and eastern coast?
2 Where are the wettest regions of Australia? Where are the driest regions of Australia?
3 How do many farmers and communities in inland Australia access more water?
4 Use the map in Source 1 to estimate how much rainfall is received every year on average where you live.

Apply and analyse

5 Use the PQE method explained in the skilldrill on page XX to describe the distribution of Australia's rainfall.
6 Four climate graphs are shown in Source 1. Each of these gives us two important pieces of information about the climate at a particular place. Rainfall is shown as a series of blue bars while average temperatures are shown with a red line. The trickiest part of reading a climate graph is reading the correct scales. Temperature is shown on the left-hand side, rainfall is shown on the right-hand side, and months along the bottom. For more information on reading a climate graph refer to page XX of 'The geography toolkit'.
   a Which is the most water poor of the four places shown? Why is this?
   b Which has the most even or reliable rainfall throughout the year? Why is this?
   c Which has the most seasonal rainfall?

2.12 Water quality and quanitity in Australia

Water is particularly difficult to manage in Australia, the driest inhabited continent on Earth. Australia has the lowest amount of water in rivers and the smallest areas of permanent wetlands in the world. Australia's water supplies are not evenly distributed. The northern third of the continent is water rich, while vast areas of the interior receive very little rain. Variable rainfall patterns make it quite common for one part of the country to experience major flooding while others experience extended periods of drought.

The Darling River

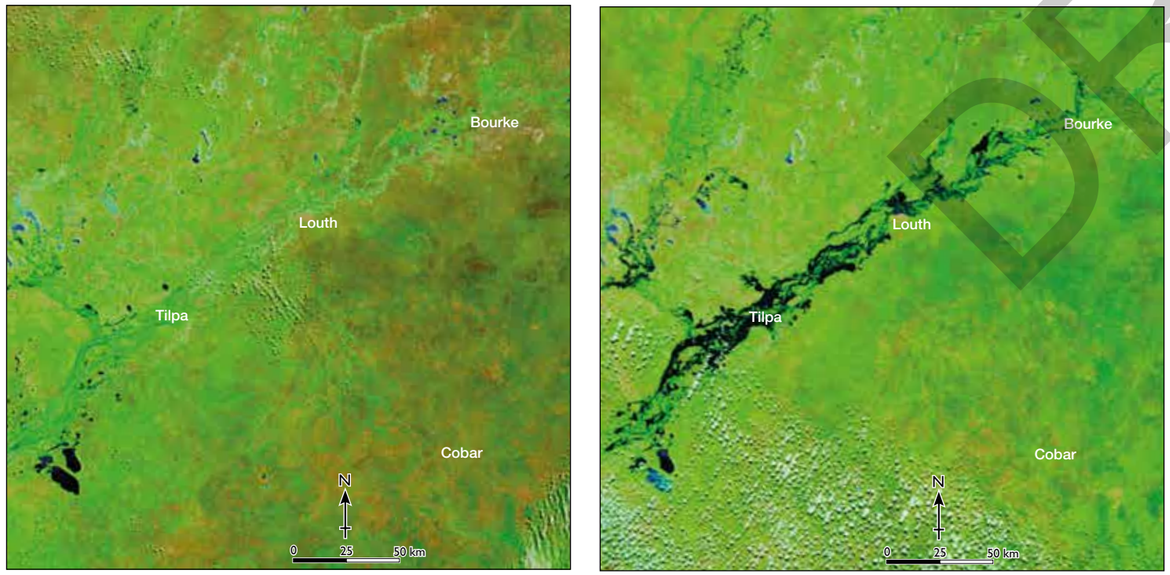
The Darling is Australia's third-longest river, flowing 1390 kilometres from Brewarrina until it joins the Murray River at the town of Wentworth. The Murray and Darling are the main rivers in the Murray–Darling River Basin, where 40 per cent of Australia's food is produced.

The flow of water in the Darling River varies greatly due to drought and water that is taken to supply farms for irrigation. The Darling can be a small trickle or a raging torrent – it can even dry up completely. The Darling River stopped flowing at the town of Menindee, near Broken Hill in New South Wales, 48 times between 1885 and 1960.

Climate change

Australians have come to see drought as part of the natural cycle of rainfall patterns, but a new threat now faces us – and it is one we do not fully understand. For years scientists have been warning us about the possibility that our climate is changing. While the vast majority of the world's scientific community now accepts that the planet is warming due to the effects of greenhouse gases, these experts are much less sure how this will affect specific places and specific climates.

It appears that climate change will mean less water for many Australians in the future, putting even greater pressure on our current supplies. Much of Australia's fresh water comes from water collected in rivers, lakes and dams. This water will evaporate more quickly in the future, meaning that there will be less available for use in cities and rural areas. Source 4 shows the trends in annual rainfall over the last four decades. The green areas have had an increase in rainfall while the yellow and brown areas have had a decrease.



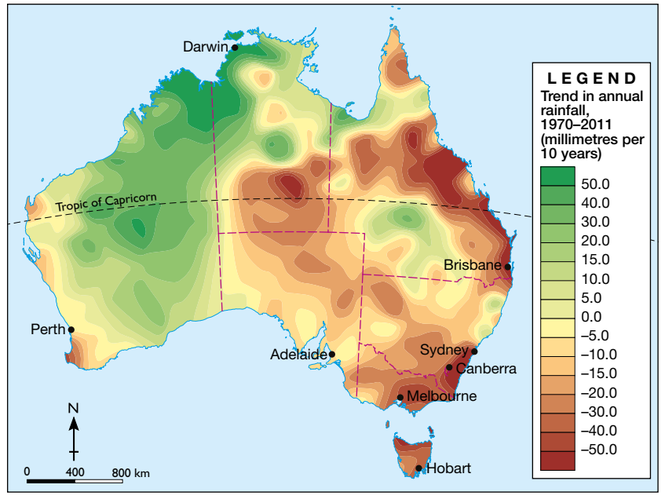
Source 1 These satellite images of the Darling River show the river affected by drought in 2011 (left), and flooded in March 2012 (right). These images use a photographic technique to help geographers distinguish between water and land. The colours used in the image are blue for water, bright green for vegetation, and an earth-tone for bare ground.

Source 2 Part of the poem 'My Country' by Dorothea Mackellar (1908)

I love a sunburnt country,
A land of sweeping plains,
Of ragged mountain ranges,
Of droughts and flooding rains,
I love her far horizons,
I love her jewel-sea,
Her beauty and her terror –
The wide brown land for me! …
Core of my heart, my country!
Her pitiless blue sky,
When sick at heart, around us,
We see the cattle die –
But then the grey clouds gather,
And we can bless again
The drumming of an army,
The steady, soaking rain…

Source 3 The Darling River

AUSTRALIA: RAINFALL TRENDS, 1970–2011



Source 4 Source: Oxford University Press

Check your learning 2.12

Remember and understand

1 Which part of Australia is the most water poor?
2 Read the poem 'My Country' in Source 2.
   a Decide if you think the poem accurately describes the part of Australia you live in.
   b Which line in the poem best sums up Australia's variable water supply?
3 Why might a warmer future lead to less water being available in Australia?
4 Look at Source 1. How and why did the flow of water along the Darling River change between 2011 and March 2012?

Apply and analyse

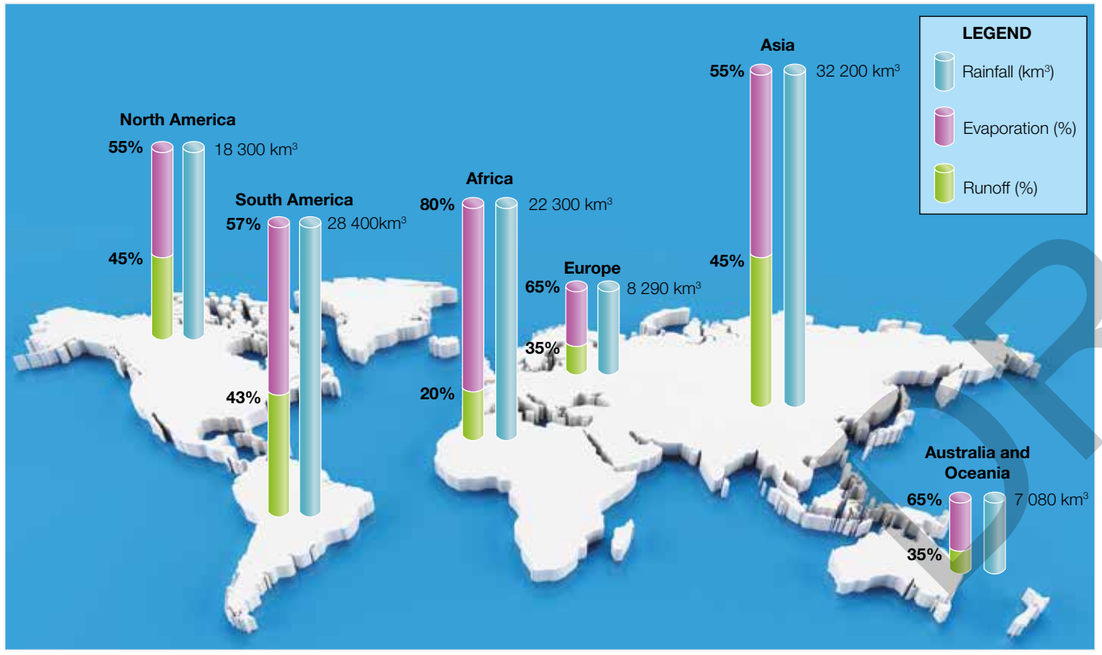
5 Look carefully at Source 4.
   a Between 1970 and 2011, which parts of Australia experienced significant decreases in annual rainfall?
   b Which capital cities have been most affected?
   c How has the Murray–Darling River Basin been affected?

2.13 Water in the world

In an average year, 577000 km³ of rain falls on Earth. Of this, 458000 km³ fall, on the oceans and 119000 km³ on land.

When water falls to earth as rain, most of it **evaporates** back into the atmosphere. Of the annual rainfall that falls on land 74000 km³ (or 62 per cent) evaporates. In Australia, around 65 per cent of our total rainfall each year evaporates. The remaining 35 per cent runs off the land, and of this, only about 12 per cent ends up in our rivers. Only Africa has a higher evaporation rate than Australia.

The amount of water in Australian rivers is the smallest of all inhabited continents, with South America experiencing the highest volumes of water in its rivers. For example, the Amazon River (the second-longest river in the world) carries more water than any other river on Earth with an average discharge (volume of water flowing through it) greater than the next seven largest rivers combined. Nearly 20 per cent of all the fresh water entering the oceans comes from the Amazon River.



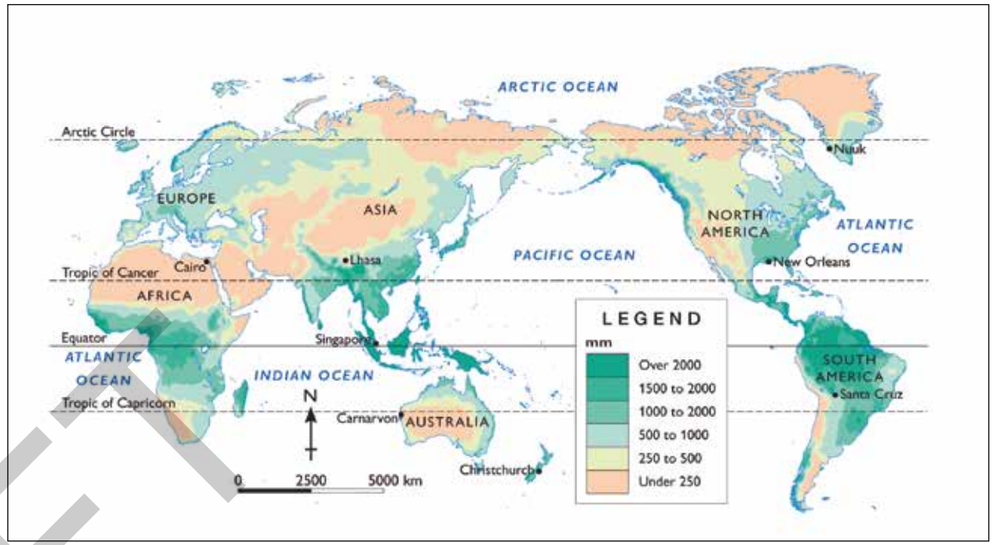
Source 1 Average volume of yearly rainfall (km³), evaporation and runoff by world region

Source: FAO Aquastat

Source 2 Some of Australia's driest regions are in the desert.

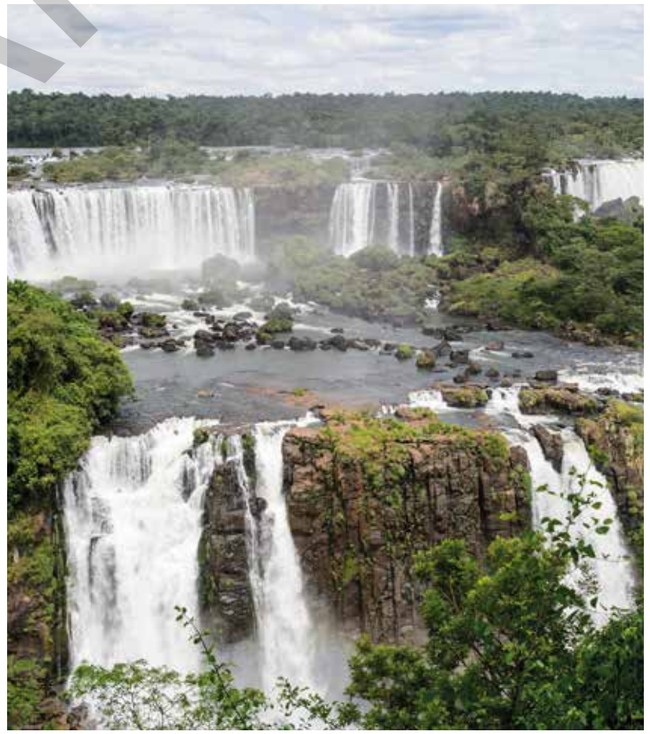
Source 3 Fresh water is found in ponds, lakes and rivers, such as this river in the Kimberley.

WORLD: ANNUAL RAINFALL



Source 4

Source: Oxford University Press



Source 5 South America's high rainfall has contributed to the creation of the Iguazu Falls, which is 80 metres high and 3 kilometres wide.

Check your learning 2.13

Remember and understand

1 Use Source 1 to rank the six inhabited continents from the continent with the most runoff to the continent with the least.

2 Which river carries the most water and how does it compare to other rivers?

Apply and analyse

3 Look carefully at Source 4.

- **a** Which region of the world is the wettest? Why do you think this is the case?
- **b** Which part of Africa experiences the lowest rainfall? What type of landscape would you expect to find here?
- **c** Which part of Asia is the wettest? What are some of the advantages and disadvantages of high rainfall?
- **d** Does the region north of the Arctic Circle have low or high rainfall? How might much of the water in this region be stored?

2.14 New ways of thinking about water

As global pressure on water resources increases, water experts are beginning to think of water in new ways. New terms for describing types of water and usage have been devised, including **virtual water**, and blue and green water. This new thinking is designed to promote a better understanding of the ways in which people use water and will help to make water usage more sustainable.

Virtual water

The amount of water used to produce a good or service is called virtual water. This includes the water used to grow crops or raise animals as well as the water needed in processing these crops and animals into products. Experts coined the term virtual water because we cannot actually see how much water went into producing the goods and services we consume every day. For example, 15 000 litres of water are needed to produce just 1 kilogram of beef. This 15 000 litres of water is known as virtual water.

It is often impossible to move real water between water-rich countries and water-poor countries. It is, however, relatively simple to transport virtual water in the form of goods, such as meat and wheat. This helps to support water-poor countries with their water needs.

Source 1 One kilogram of rice contains 1500 litres of virtual water, making it one of the world's thirstiest crops.

Blue water and green water

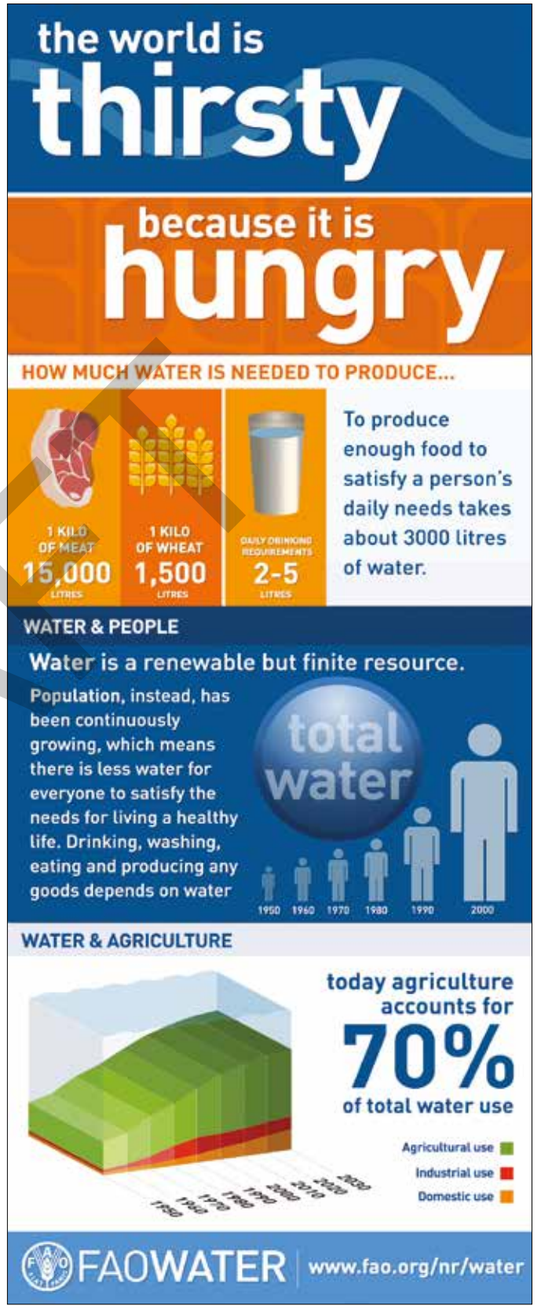
Historically, water suppliers have focused on the capture and supply of blue water (that is, water in storages, such as lakes, rivers and acquifers) over green water (that is, rainwater stored in the soil as soil moisture). Green water is the water that remains in the soil to be used by plants. Farmers in dry regions, such as the interior of Australia, need to understand how to manage both their blue water resources and their green water resources. Installing a rainwater tank to collect and store water for later use is an example of blue water management. Adding a layer of mulch to slow the evaporation of water from the soil is an example of green water management.

Water footprints

The total amount of water you consume each year is known as your **water footprint**. This includes the real water you consume (by drinking, bathing and cleaning) and the virtual water you use through your consumption of goods and services. The total volume of water used by everyone who lives in a country, including the water used to produce exported goods, is the national water footprint.

The size of a country's water footprint is largely determined by the country's:

- climate, especially the amount of rainfall and evaporation
- farming methods, especially how efficiently water is used
- production and consumption of crops
- general consumption and production patterns.



Source 2 A poster from the United Nations that uses the idea of virtual water to communicate a message

Countries where people eat lots of beef and rice and buy many manufactured goods use more water than countries where people eat mainly vegetables and have few personal goods.

Australians are one of the world's biggest water users. It is estimated that Australia's population will increase to about 35 million by 2056 and this will place a great strain on an already stressed water-supply network. Experts believe that Australia's capital cities, for example, will need 76 per cent more water by 2056 than is currently supplied.

The good news is that Australians have embraced new water-saving measures. Despite the population of Australia increasing by 7.7 per cent between 2003 and 2009, the amount of water used by households actually fell by 12 per cent. This is due largely to water restrictions in many capital cities and the use of new technologies, such as dual-flush toilets and water-saving showerheads.

Check your learning 2.14

Remember and understand

1 What is virtual water?
2 What is the difference between blue water and green water?
3 Why is it important to understand virtual water when working out your water footprint?
4 How can an understanding of virtual water help water-rich countries to decide what to produce and export?

Apply and analyse

5 Source 2 states that the world is thirsty because it is hungry.
   a What does this mean?
   b What evidence is presented to support this idea?
6 Look carefully at the image of the Chinese farmer working in his rice fields (Source 1).
   a How is he using water as a resource?
   b How is he able to control the flow on water in his fields?
   c Explain how this makes his use of water more sustainable.

2C rich task

Windhoek, Namibia

Namibia is the driest country in Africa south of the Sahara Desert. Its capital, Windhoek, receives about 360 millimetres of rainfall a year and its 250 000 people rely on three dams for most of their water. These dams, however, are built on rivers that do not always flow and are therefore unreliable for city water use.

In 1969 the government decided to mix water from traditional sources, such as dams and wells, with recycled water from the city's sewage-treatment plant in order to supplement Windhoek's fresh water. As the city's population continued to grow rapidly, in the 1990s it was decided to build another treatment plant to convert sewage into drinking water. This was completed in 2002. Now more than one-third of Windhoek's drinking water comes from this unlikely source, making the city the world leader in turning waste-water into drinking water.

Source 1 Water is a scarce and precious resource in Namibia. These women walk for hours a day to get water.

Source 2 Climate data: Windhoek, monthly averages

Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Rainfall (mm)	76	74	79	41	8	0	0	0	3	10	23	48
Temperature (°C)	29	28	27	25	22	20	20	23	25	29	29	30

skilldrill

Drawing climate graphs

Climate graphs combine column graphs and line graphs to help us interpret the climate in a specific location. In order to draw a climate graph, geographers gather climate data – the monthly average rainfall and temperature – for the location they are investigating.

Step 1 Look carefully at the climate data to find the lowest and highest temperature figures that you will need to show on your graph. In this example, Windhoek's temperature varies from 20 to 30 degrees Celsius. Decide on a scale that shows this range of data, then place it on the left-hand axis of your climate graph.

Step 2 Using graph paper, plot the temperature data on your graph by placing a small, neat dot in the centre of each month at the correct height. Join the dots with a smooth red line and continue the line to the edges of the graph.

Step 3 Look carefully at the climate data to find the lowest and highest rainfall figures that you will need to show on your graph. In this example, Windhoek's rainfall varies from 0 to 79 millimetres a month. Decide on a scale that shows this range of data, then place it on the right-hand axis of your climate graph.

Step 4 Plot the rainfall on your graph by drawing a blue column to the correct height for each month. You may like to very lightly shade the bars with a blue pencil.

Step 5 Complete your graph with a suitable title and a label for each of the three axes.

Apply the skill

1 Using the steps shown above and the data in Source 2 and referring to the Alice Springs climate graph (Source 1 on page XX), construct a climate graph for Windhoek.

Extend your understanding

1 Describe the annual pattern of rainfall in Windhoek.

2 Explain how this annual pattern makes dams and reservoirs an unreliable water resource.

3 Describe the annual pattern of temperature and explain the impact of these temperatures on the evaporation of water held in dams.

4 Compare the climates of Windhoek and Alice Springs (Source 1 on page XX).

5 Examine the map of Namibia. Identify three water resources on this map.

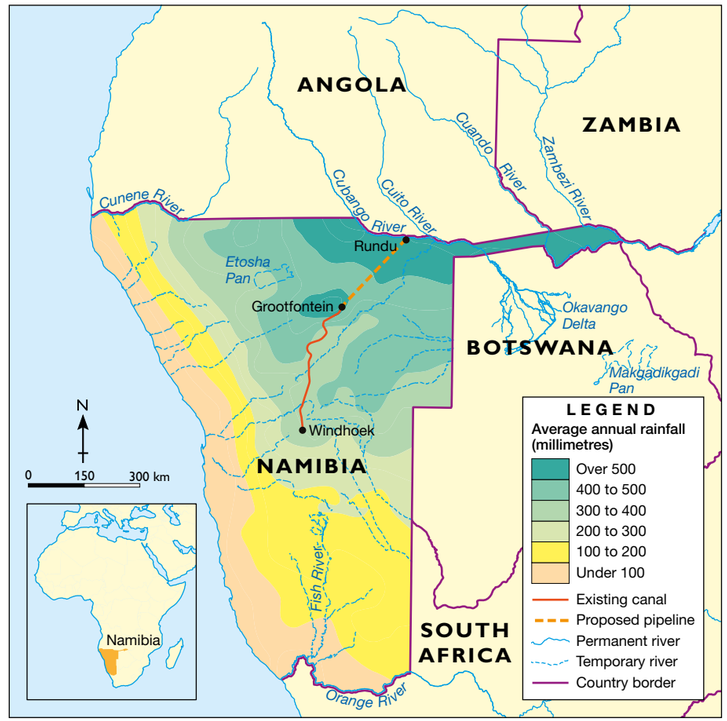
6 a What have the people of Windhoek done to make their water supply more sustainable and safe?

b What problems does lack of access to safe water cause?

7 Use the information on the map (Source 3) to explain why a pipeline is proposed to be built from the Cubango River to Grootfontein.

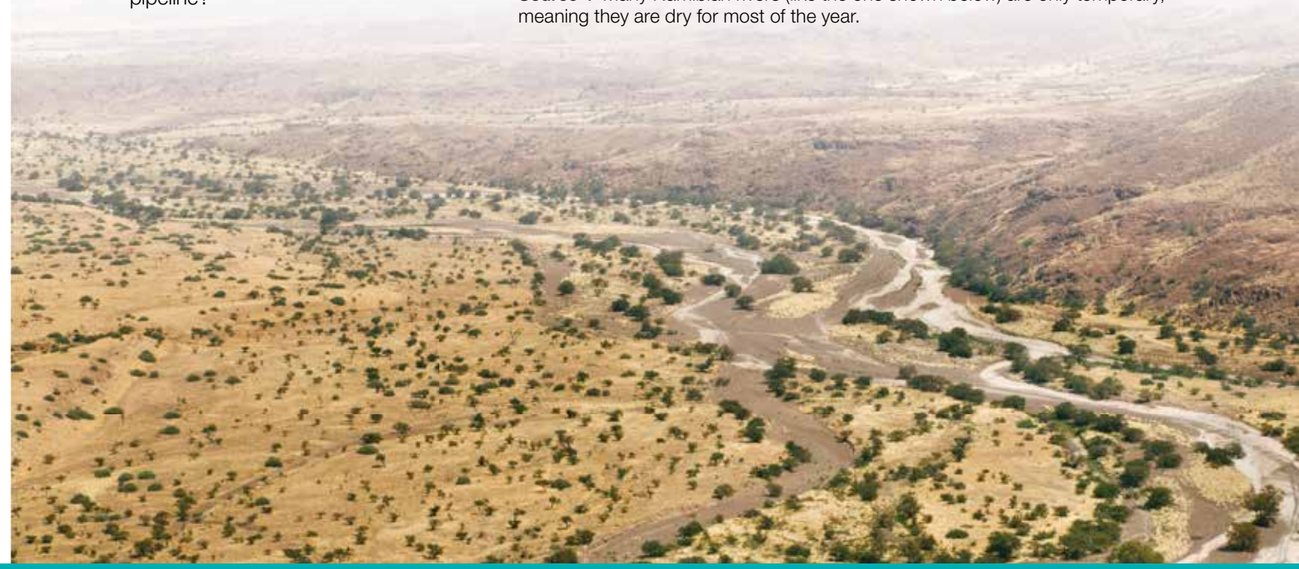
8 Why would the people of Botswana be concerned about this proposed pipeline?

NAMIBIA: AVERAGE ANNUAL RAINFALL



Source 3 Source: Oxford University Press

Source 4 Many Namibian rivers (like the one shown below) are only temporary, meaning they are dry for most of the year.



2.15 The challenges of managing water

Water is an essential environmental resource that is important for the health of humans and the health of the environment. Different values are often placed on water; for example, water used for economic purposes can also have great spiritual and cultural importance for a community. Competition for water use needs careful management. It is often not easy to come up with solutions. Water management is difficult because:

- it is an essential resource needed by every person on the planet
- it moves through the environment quickly so it is difficult to capture and store
- its availability is not constant – it changes over time and in different locations
- it is a shared resource with many competing uses.

Over the past 50 years the world's population has doubled, and the output from farms and industries has surged to meet increasing demands. The growth in demand and competition for water has put a much greater strain on global water supplies. We need to make good decisions to fairly share the use of water and minimise the impact our water use has on the natural environment.

Source 1 Sewage spills into the Ganges River in the city of Varanasi

Case study: Ganges River, India

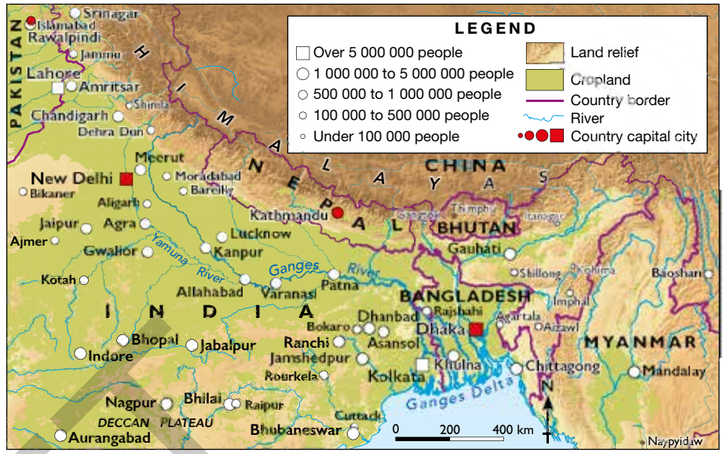
The Ganges River begins high in the Himalayan mountains, and travels across India before flowing east into Bangladesh and into the Bay of Bengal. In total, the river is 2525 kilometres long. The Ganges is worshipped by Hindus, who believe bathing and praying in the river purifies them. This sacred river is also used by millions of Indians who live along its banks and depend on it for their daily needs.

In the last 30 years, India's population has grown to nearly 1.2 billion people; one-third of these people live along the banks of the Ganges. Huge increases in the size of cities, factories and agriculture have put enormous pressure on the river. Irrigation canals siphon off large amounts of water to grow food for the country's increasing population. Untreated **waste-water** is dumped into the river from cities and towns that lack proper sewage-treatment facilities. Around 25 per cent of India's population work in manufacturing and industry. The waste-water and **effluent** from these industries often contain hazardous chemicals. The Ganges is now one of the most polluted rivers in the world.

Overuse and lack of management have meant that India's most sacred river is gradually dying. In Varanasi, a city on the banks of the Ganges in north-eastern India, the bacterial count in the water is 3000 times higher than the safe levels established by the World Health Organization. Polluted water is the main cause of skin problems, disabilities and infant deaths, but many Hindus refuse to accept that the Ganges (or Mother Ganga as they call her) is the source of these problems. 'People have so much faith in this water that when they bathe in it or sip it, they believe it is the nectar of God [and] they will go to heaven,' says a scientist at the Central Pollution Control Board in India.

In 2011, Indian officials signed an agreement with the World Bank for a $1 billion loan to finance a government project that aims to stop the flow of untreated waste-water into the Ganges by 2020.

COURSE OF GANGES RIVER



Source 2 Source: Oxford University Press

Source 3 Tens of thousands of Hindu devotees gather on the banks of the holy Ganges River to bathe and offer prayers during Karthik Purnima festival in Patna, India.

Check your learning 2.15

Remember and understand

1. Why is water difficult to manage?
2. List three reasons why water resources are under threat.
3. Look carefully at Source 3.
   a. Why have all of these people gathered at the Ganges River?
   b. What dangers do they face?
4. List as many competing uses of the Ganges as you can.
5. Why is the Ganges River so difficult to manage?

Apply and analyse

6. Look at Source 2. Why is the pollution of the Ganges a much greater problem in Kolkata than in Kanpur in northern India?
7. How do you think the pollution of the Ganges affects the natural environment around the river?

2.16 Water and Indigenous Australians

Water is a vital resource valued by both Indigenous and non-Indigenous Australians. Non-Indigenous Australians generally consider water as a natural resource with great economic and aesthetic value. Indigenous Australians on the other hand generally value water for cultural and spiritual reasons. They regard the rivers and waterholes as an inseparable part of their land. Land and water management is a key part of the culture of Aboriginal and Torres Strait Islander peoples.

A spiritual connection with water

Prior to European settlement, most Aboriginal peoples lived in the well-watered coastal areas and along the rivers of the Murray–Darling Basin. Aboriginal people in the arid areas of Australia studied the habits of wildlife to detect water supplies. They mapped the location of water in their artwork. In these maps, spirals identified the location of pools and wells while wavy lines showed the location of running water (see Source 2).

Source 2 In the past, Indigenous Australians communicated the location of water resources through symbols on maps (like this one) and through spoken instructions and stories.

Aboriginal people also passed on their knowledge of water resources through stories. The Worrorra people live in the Prince Regent River region of the Kimberley. Their Dreaming (or Lalai) stories tell of the formation of the Prince Regent River.

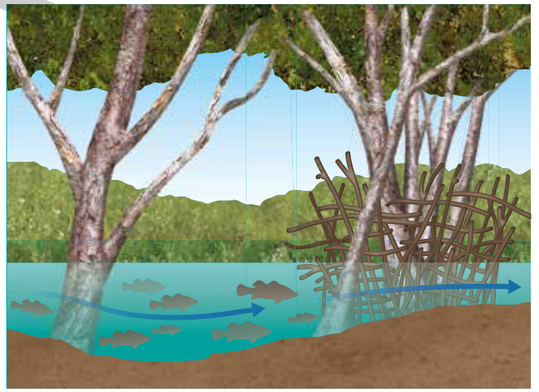
The stories tell of how the Wunggurr snake (a creator) dug a path where the Prince Regent River now flows by travelling from far inland to the sea. Other creator beings called Wandjina then took the animal forms of Rock Cod and Melo (a large sea snail), and created Malandum (the Prince Regent River) by swimming upstream along this path. At what is now called King Cascade Falls, Rock Cod was forced to stop abruptly by the Lalai Bowerbird and thrust herself against the soft mud, where she created a step-like cliff. Today, a waterfall flows over these rocks from the stream above where the Bowerbird lives (see Source 4).

Source 1 Aboriginal links to water in the Kimberley region of Western Australia go back thousands of years. These scenes were created by the Worrorra people on a cave ceiling about 8000 years ago. The scene is said to depict a 'great fish chase', showing figures representing both Rock Cod and Dugong and their Wandjina captors.

Indigenous water management

Traditionally, Aboriginal peoples in drier areas of Australia depended on their knowledge of water sources to survive. They accessed water trapped in waterholes, rocks and tree hollows. They watched the flight paths of birds, such as the zebra finch, to help uncover wells and springs. The long roots of eucalypt trees were followed to find underground water, and water was collected from the morning dew on plants. Indigenous Australians would also enlarge rock holes and chip channels through rocks to divert water into specific holes to increase their access to water. To catch fish, dams were built across narrow creeks using rocks or woven branches (see Source 3).

In modern Australian society, Indigenous Australians have been largely left out of the decision-making process when it comes to managing their traditional water sources. In some remote areas of Australia, many traditional water sources have become unreliable or unusable because station owners have given their cattle access to these important areas without consulting the Aboriginal peoples.



Source 3 An Aboriginal dam made of woven branches designed to catch fish.

Urlampe in the Northern Territory, 1330 kilometres south-southeast of Darwin, is home to one of Australia's most remote Aboriginal communities. Allan Rankine of the Urlampe Aboriginal Corporation is responsible for managing the water supply for the community. Allan decides what water the community pumps from the bore and how it will be distributed. Traditionally, Aboriginal land and water management plans are clearly defined and everyone understands and respects them.

Source 4 King Cascade on the Prince Regent River is now a popular tourist destination.

However, Allan and the traditional owners of the area do not have control over all important water resources in the region. The permanent spring that Allan visited as a child has been polluted by cattle. This once valuable water resource is now undrinkable.

Check your learning 2.16

Remember and understand

1. Where did most Aboriginal peoples live in Australia before Europeans arrived in 1788?
2. Give examples of traditional and modern Aboriginal water management.
3. How are Indigenous and non-Indigenous views of water resources different?
4. Both Aboriginal peoples and Europeans built dams along the Murray River. What impact did each have?

Apply and analyse

5. Look carefully at Source 4.
   - a. What is the spiritual value of this place to the local Indigenous people?
   - b. What value might this site have to a tourist?
6. Look carefully at Source 2.
   - a. Sketch the symbols you think represent water holes and running water.
   - b. Why were maps such as these important to Aboriginal communities?
   - c. Why do you think maps like these are still being produced by Indigenous Australians?

2.17 Competition for water supplies

Fresh water from rivers is used by people in cities, farms and factories. Competition for this precious economic resource has seen the introduction of dams all over the world to store the water flowing down rivers and ensure a constant supply of water to the people nearby. Because people living along the entire length of rivers depend on them for water, competition also exists between upstream and downstream users. The flow and quality of water available to downstream users depends on how the river is used upstream.

Case study: the Murray River

The Murray River provides an excellent example of what happens when demand for river water threatens to outpace supply. Water from the Murray River has many competing uses, including irrigation, domestic urban water supply, industrial water supply, maintaining the natural environment, recreation, navigation, hydroelectricity and water storage. There are three major water storage dams on the Murray River. There are also 10 weirs (another type of dam) built across the river to slow the river flow and allow towns to access the water. Locks have been built where the water level can be raised and lowered to allow boats to travel from one side of the weir to the other.

A series of pumps and pipes carries some of the water from the Murray River to water users in towns, cities and farms many kilometres from the river (see Source 1). One of these pipes carries water from the town of Mannum to Adelaide, 60 kilometres away. The amount of water pumped from the river to Adelaide varies from year to year but can be as high as 90 per cent of Adelaide's water needs in some years.

The agriculture sector is by far the largest user of water from the Murray River. On average, 3780 gigalitres (3780 billion litres) is diverted each year to irrigate farmland to grow crops and raise livestock. Clearing of native vegetation in the river valley has enabled irrigated crops and pastures to be grown, but also forced salty groundwater to the surface and into the river. Along with pesticides and fertilisers, the salty water causes problems for users downstream. Near the South Australian town of Waikerie a system of pumps intercepts some of the salty water before it reaches the Murray River. It is carried in pipes to a 400-hectare lake. It is estimated that this scheme prevents more than 100 tonnes of salt a day reaching the river. Most of the water not used for irrigation is diverted to homes and industries throughout South Australia through six major pipelines (see Source 1). The average amount of water that flows from the Murray River into the ocean near Adelaide is now just 25 per cent of the total natural flow. This is because around 75 per cent of this water is taken out of the river upstream.

MURRAY RIVER AND SOUTH AUSTRALIAN WATER PIPELINES

Source 1 Source: Oxford University Press

Source 2 Oblique aerial photograph of the Murray River at Mannum, South Australia

Source 3 This image was taken in 1981 when the mouth of the Murray River completely closed, creating changed conditions for wildlife and plants in the region.

key concept: Scale

The changing scales of water management

The water in the Murray River is one of Australia's most precious resources but is very difficult to manage. This is mainly because there is so much competition for the water. The water is used by thousands of farmers to produce food and other products for millions of people. Many towns and cities in three different states use the river to supply residents with water for their homes and businesses.

In the past, many upstream water users have only considered their own water needs when taking water from the river. They have not considered how this would impact on people and places downstream. We now know that this local-scale approach to water use damages the health of the river. Water must be managed at the regional scale, considering the needs of all water users and the environment in the entire river basin. For more information on the key concept of scale, refer to page XX of 'The geography toolkit'.

Check your learning 2.17

Remember and understand

1 What competition is there for Murray River water?
2 What are the two major uses of Murray River water?
3 How have the competing water uses of boating and water storage in weirs been catered for along the Murray?
4 What problems have been caused downstream by upstream usage of the Murray River water?

Apply and analyse

5 Why is it difficult to manage the water resources of the Murray River?
6 In the foreground on the left of the Mannum oblique aerial photograph (Source 2) you can see a small marina and a residential development. Are these developments at a local or regional scale?
7 Examine Source 1.
   a How many pipelines are shown that access water from the river?
   b Use the scale to estimate the distance water travels from Swan Reach to Edithburgh.

Evaluate and create

8 Draw a map of Source 2. Use a legend to show the following features: the Murray River, irrigated farmland, irrigated golf course and sporting ground, a marina for houseboats and the town of Mannum.

2.18 Managing water scarcity

Water is most difficult to manage when there is not enough to go around. Water becomes scarce when the demand for clean water exceeds the available supply. It is one of the biggest issues facing Africa, the second driest inhabited continent in the world after Australia. Whereas all Australians have access to clean water, millions of Africans face water shortages. Of the 800 million people who live in Africa, more than 300 million live in water-scarce areas.

The cause

The main reasons for water scarcity in Africa are:

- a large and fast-growing population
- large areas with low and variable rainfall
- poor water quality
- lack of water infrastructure, such as pipelines.

The problem

Water scarcity contributes to the deaths of many African children. Local water sources may contain harmful bacteria that cause diseases, such as typhoid and dysentery. These diseases are spread by drinking and washing in contaminated water.

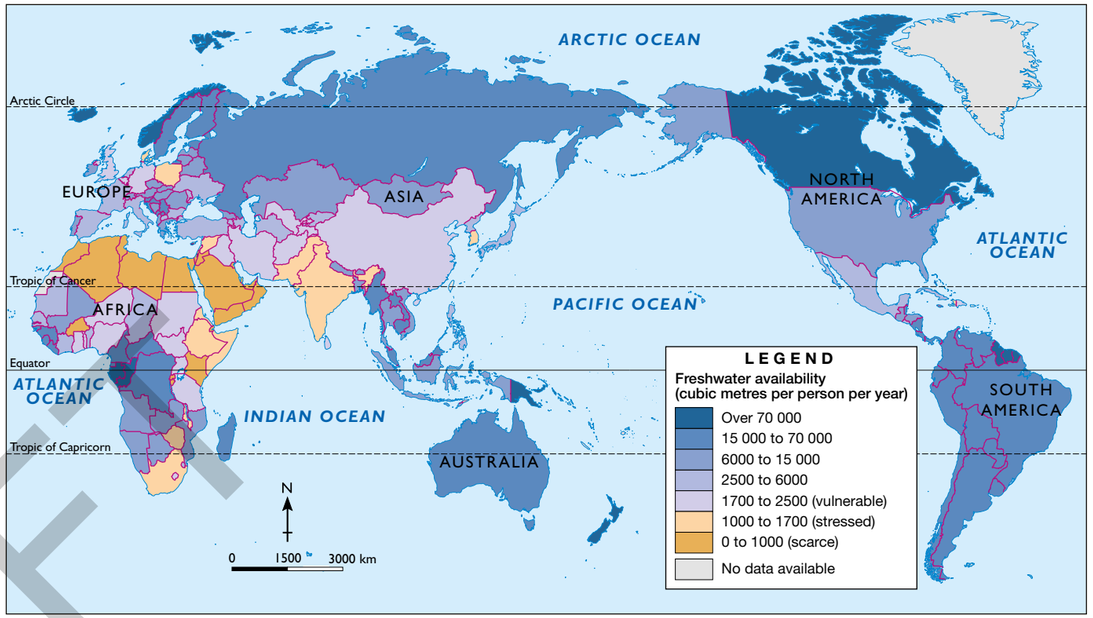
The solution

The most common solution to water scarcity in African villages is digging a well. A water well is created by digging or boring into the ground in order to reach groundwater in underground aquifers. Clean water from a well stops people catching any water-borne diseases. Providing clean and drinkable water for communities across Africa is a high priority for many of its **developing countries** and international relief agencies, such as World Vision and AusAID.

Source 2 This woman in Zambia is collecting water from a dried-up river bed half a kilometre from her house. She uses a saucepan to fill the large container, which she will carry on her head or shoulder back to her home.

Source 1 A young girl in Guinea-Bissau enjoys clean water from a new well that has been sponsored by the World Vision aid agency.

WORLD: FRESHWATER AVAILABILITY PER PERSON PER YEAR, 2007



Source 3

Source: Oxford University Press

Source 4 A woman fills a water container from a well in the desert in Niger. In most African societies, women are the collectors and managers of the family water supply. African women can spend up to 60 per cent of their day collecting water, especially where water sources are far from the village.

Check your learning 2.18

Remember and understand

1 What is water scarcity?
2 Why is water scarcity such a problem in Africa?
3 What problems does water scarcity cause, especially for women and young children?

Apply and analyse

4 Look carefully at Source 3.
   a Describe the area of Africa that suffers most from water scarcity.
   b Australia is the driest inhabited continent on Earth. Does it have a water scarcity problem? Why or why not?
   c Compare freshwater availability in Australia and New Zealand. Which country has access to more fresh water? Why do you think this might be the case?

Evaluate and create

5 Create a poster or PowerPoint presentation highlighting the problems of water scarcity in Africa and how it affects people's lives.

2.19 Managing water in Australia's biggest cities

In order to ensure that reliable supplies of safe water are available for use now and into the future, we all need to use water more **sustainably**. Careful management of our existing supplies and reductions in our consumption will help to achieve this. We also need to remember that people are not the only living creatures on the planet. The interests of all living organisms need to be considered if the natural environment is to be protected for the future.

Source 1 The Warragamba Dam near Sydney is one of the largest domestic water supply dams in the world. It supplies 80 per cent of Sydney's water.

Ensuring reliable water supplies in Australian cities

Over 60 per cent of Australia's population lives in one of our five largest cities – Adelaide, Brisbane, Melbourne, Perth and Sydney – all of which are home to more than a million people. The sites of these cities were chosen in large part because of their reliable rainfall and access to fresh water from neighbouring rivers. However, all of these cities have now outgrown their original water supplies. Large dams have been built to provide a permanent water supply for large towns and cities, but population growth and drought have put enormous pressure on these reserves. As a result, many Australian cities are now looking at a number of strategies to reduce their water usage and ensure they have access to reliable supplies into the future. Some of these options are discussed here.

Option 1: Build more dams

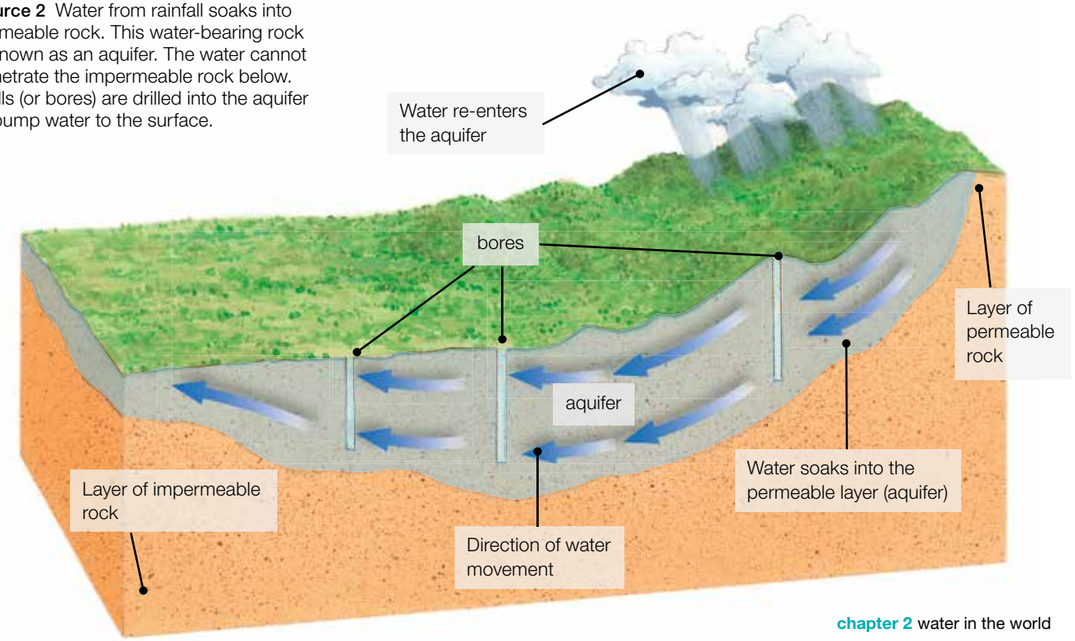
Across Australia, governments are thinking about building more dams to create a reliable water supply for our growing population. Dams can also be used to create hydroelectric power when water let through the dam wall turns a turbine to create electricity.

Option 2: Use underground water reserves

Drilling water **bores** is a common method used on Australian farms for supplying water for irrigation and animals. Many Australian cities have started to use this method to add to their freshwater supplies. Deep holes, called bores, are drilled down into a layer of rock under the ground that holds water. This layer of rock is called an **aquifer**. The water is then pumped to the surface (see Source 2). It is also possible to replace the water in the aquifers during wet periods by pumping the water back underground. In this way, aquifers operate as underground dams. In Western Australia scientists are trialling a method of treating storm water (rainwater that falls on the hard surfaces of a city, such as roofs and roads) and using it to recharge the aquifers that supply much of Perth's water.

There are large aquifers in many areas of Australia, including beneath Melbourne. Often this water has a high mineral content and must be treated before it can be used for drinking and other household uses. This water could be used for industrial purposes, such as to clean machinery and irrigate crops. This would allow drinking water, currently used for these other purposes, to be added to the city's water supplies. This idea of using lower-quality water for non-domestic purposes has been considered in many Australian cities.

Source 2 Water from rainfall soaks into permeable rock. This water-bearing rock is known as an aquifer. The water cannot penetrate the impermeable rock below. Wells (or bores) are drilled into the aquifer to pump water to the surface.



Option 3: Build desalination plants

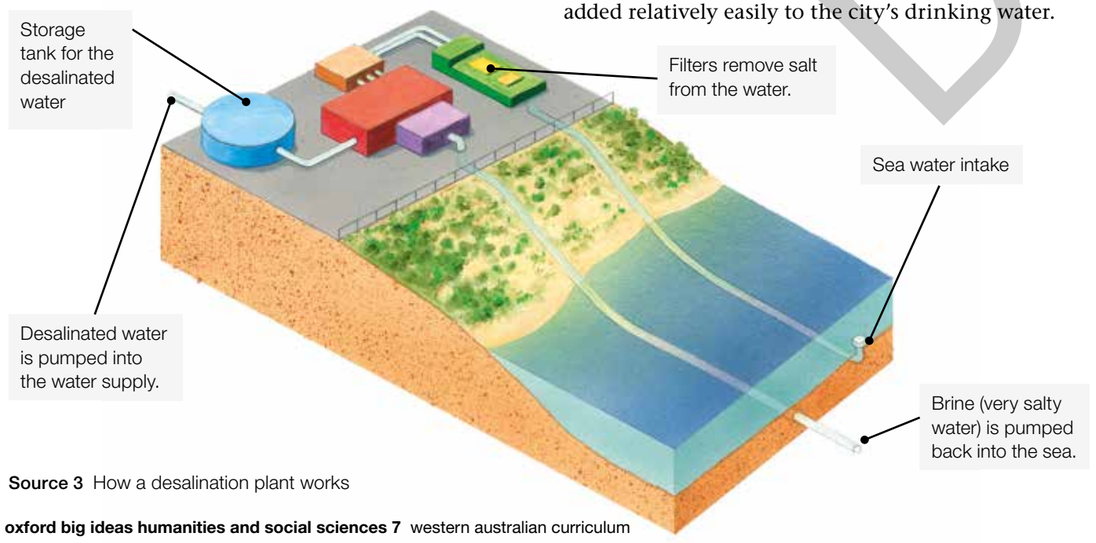
Desalination plants treat sea water to remove from it the salt and other impurities (see Source 3). This process, known as reverse osmosis, turns sea water into fresh water for drinking. As Australia has easy access to a vast supply of sea water, desalination plants are an attractive option for many cities.

There are three main reasons why there are not more of them already:

- Desalination plants cost a lot of money, making the water they produce expensive. The Perth desalination plant, opened in 2006, cost $387 million to build and adds about $44 a year to every consumer's water bills.
- Desalination plants use a lot of electricity and can damage the environment. It has been estimated that the Sydney desalination plant uses as much electricity as 120 000 households. A new power plant had to be built to run it, adding to the cost.
- Desalination plants can damage the environment. They release highly concentrated salt water (brine) back into the ocean, which can harm marine animals.

Option 4: Build water pipelines

Perhaps the simplest method of ensuring a reliable water supply is to move water from areas that have a surplus. This already happens in most Australian cities. Rainwater is collected in catchments in the hills and forests close to cities and piped to treatment plants and then to water users.



Source 3 How a desalination plant works

Source 4 Huge pipes carry water beneath our city streets. Here, pipes are being laid in Brisbane.

One proposal currently involves piping water not just hundreds of kilometres but thousands. For many years, there has been an idea to pipe water from the Fitzroy River in the Kimberley region in north-western Western Australia to the city of Perth. This pipeline would need to be 3700 kilometres long. The cost of transporting water this far through steel pipes is much greater than other options, such as desalination plants, and so this method is unlikely to be used in the near future. It will also cause environmental problems at the source of the water and would require large amounts of energy to build and operate.

Option 5: Capture and store storm water

Storm water is collected in pipes and gutters and discharged in the sea or rivers. Rainwater tanks capture this fresh water but cities have not been designed to collect this water on a large scale.

In Adelaide, there is a plan to capture this water through existing pipes and treat it in the current water-treatment facilities. In this way, it could be added relatively easily to the city's drinking water.

Option 6: Recycle and treat wastewater and sewage

Water that leaves our homes is generally unsuitable to be used again. In using the water to clean clothes, dishes and ourselves and to flush toilets we have polluted the water. This water (known as wastewater or sewage) is usually piped to a treatment plant where it is cleaned and purified and then released back into rivers and bays. In some places, notably Singapore and Windhoek (see 2C Rich task) in Namibia, this water is added to rainwater and piped back into homes and to other water users.

Source 5 At this plant in Singapore, waste water (sewerage) is processed and then used in industry or blended with rainwater for use in homes.

key**concept**: Sustainability

In trying to use our resources sustainably, we sometimes have to change our attitudes and behaviours. While many Australians believe that we should use less water or use water from different sources, it can be difficult to convince people to change.

In 2012 the Western Australian government successfully completed a trial of the Groundwater Replenishment Scheme and set a goal to deliver the project officially by the end of 2016. This scheme involves treating wastewater using a number of methods so that it meets drinking water standards. It is then injected as groundwater where it continues to be cleansed naturally. The water is removed later and treated again before it is used as drinking water. The project has the capacity to recharge 14 billion litres of water into groundwater supplies

One of the great benefits of storing drinking water as groundwater, is that groundwater supplies are not affected by changes in climate the same way dams or rivers might be. As Australia continues to experience a dryer climate, increased groundwater supplies could help Western Australians by reducing the need for rainfall for drinking water, and by sustainably recycling water rather than wasting it.

While some people might not like the idea of drinking wastewater, recycled water is an important addition to our water supply and is actually very clean once it has been treated. For more information on the key concept of sustainability, refer to section 1A of 'The geography toolkit".

Check your learning 2.19

Remember and understand

1 In your own words, describe what a sustainable resource is.
2 List five different ways that governments might investigate to find extra water resources for growing cities.
3 When a new dam is built across a river, what problems are caused for people and wildlife upstream from the dam?
4 How can aquifers be used to provide and to store water?
5 What are the advantages and disadvantages of desalination?
6 Where does the water that you use at home come from? Where does it go when you are finished using it?

Apply and analyse

7 What plan for recycling did Toowoomba residents oppose? Do you think the recycling plan was a good idea?
8 Why doesn't Perth pipe water from wet places in Western Australia?

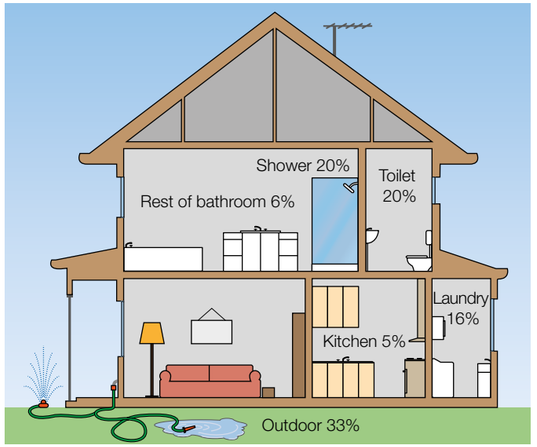
Evaluate and create

9 For the capital city in your state, complete the following activities:
   a Research the city's current water supply. Which of the water supply methods described here does it currently use?
   b Which of these methods do you believe should be used to add to this water supply?
   c What impacts would these new methods of water supply have on the natural environment and the cost of water?

2.20 Managing water at home

The easiest way for us to become involved in water management is to understand how we can be more water wise at home. A resource management plan takes into account the range of uses of the resource, the amount of the resource required and the impact of resource use on the environment. Decisions are then made about what is the best and most **sustainable** way to use the resource. Sustainability is an important concept in geography. In order for a resource to be used sustainably there must not be so much used that it affects the ability of the resource to replace itself naturally. Domestic users of water are under more pressure than ever before to manage their water use properly as our water resources become more stressed.

As you have learned, Australians are among the highest users of water in the world. Nearly half of the domestic water usage occurs in the bathroom. To improve water management in the home we need to select water-saving appliances, capture and recycle water and attempt to use less water. To ensure we have a sustainable supply of water into the future, think about some of the water-saving ideas shown in Source 1.



Source 2 Water use in the home

Bathroom
Take shorter showers and install new water-efficient showerheads that use no more than 9 litres of water per minute (compared with old-style showerheads that use 20 litres per minute). This can save up to 20 000 litres of water per person per year.

Laundry
Only use the washing machine when you have a full load. Redirect the waste water from the washing machine into a collection bin and use it on the garden, but make sure you use detergents that will not kill your plants.

Outside
Don't use the hose to clean hard surfaces outside; use a broom. Install a plastic pool cover to reduce water lost to evaporation. Install a rainwater tank to use the water that falls on your roof. It can be used to flush toilets, wash clothes and water the garden. Top up the pool with water from the tank.

Kitchen
Don't rinse dishes under a running tap. Ensure the dishwasher is full before turning it on.

Garden
Plant native gardens using local plants that are accustomed to the climate and soil conditions in your area. Use drippers to deliver water directly to the base of the plants where they need it. Avoid sprinklers, which allow water to be blown away and evaporated.

Source 1 A range of simple water-saving ideas

key**concept**: Sustainability

The air shower

Despite living in one of the world's driest places, Australians are among the world's biggest water users. Many scientists believe that our use of water is not sustainable and have looked for ways to increase our water supply or decrease the amount of water we use.

AIR SHOWER SET TO CUT WATER USE BY 30 PER CENT

As Australians become increasingly alert to the importance of using water wisely in the home, CSIRO researchers have found a way to use a third less water when you shower – by adding air.

The scientists have developed a simple 'air shower' device which, when fitted into existing showerheads, fills the water droplets with a tiny bubble of air. The result is the shower feels just as wet and just as strong as before, but now uses much less water.

The researchers, from CSIRO Manufacturing Materials Technology in Melbourne, say the device increases the volume of the shower stream while reducing the amount of water used by about 30 per cent.

Given the average Australian household uses about 200 000 litres of water a year, and showers account for nearly a third of this, the 'air shower' could help the average household save about 15 000–20 000 litres a year. If you extend this across the population, that is an annual saving of more than 45 000 Olympic-sized swimming pools …

CSIRO website

For more information on the key concept of sustainability, refer to page XX of 'The geography toolkit'.

Source 3 This cartoon was first published in 2007 during a period of severe drought.

Check your learning 2.20

Remember and understand

1 What does a management plan need to take into account?
2 Which room in the house uses the most water?
3 What is the easiest way of reducing the amount of water and energy used in the shower?
4 Suggest three ways that water can be gathered and reused around the home.
5 Give two examples of how technology can be used to help save water.

Apply and analyse

6 Look carefully at the news article.
  a What have researchers at CSIRO developed to help save water in the home?
  b What water savings do they hope to make?
  c Apply your understanding of the air shower to develop a new water-saving product idea to clean dishes.
7 Look carefully at Source 3.
  a What is the cartoonist suggesting about our management of water in the future?
  b When was the cartoon drawn and what influence might this have had on the cartoonist?

Evaluate and create

8 Create your own water-saving reminder for display in one of the rooms of your house.

2D rich task

The Wodaabe nomads

Communities in extreme environments develop ways of life that allow them to survive and thrive. In the south-eastern part of Niger, in Africa, live the Wodaabe people. They live in a desert region where water is often scarce and feed for their cattle is in short supply. In response to these conditions they have become **nomads** and rarely stay in one place for more than 10 days. They follow the seasonal rains across the desert as rain brings grass for the cattle; this takes them on a route they have followed for hundreds of years.

The seasonal migrations of the Wodaabe take them from the clay plains near Lake Chad to the sandy soils away from the lake. Over the last few decades the lake has become smaller as other communities in the area have used its water for irrigation. This has meant that the Wodaabe's have had to change annual migration routes. The reduction in the size of the lake has meant that more grass is able to grow on land that was once covered in water, but it has also meant that freshwater supplies have become less reliable.

Source 1 Packing up the homestead to follow the rains

Source 2 Climate data: Nguigmi, Niger

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	0	0	0	1	5	11	55	100	15	1	0	0
Temperature (°C)	21	24	28	31	33	33	31	30	30	29	25	22

skilldrill

Understanding flow maps

Flow maps show the movement of things from one place to another (for example, people or goods). Flow maps can be simple or complex. They can show the movement of one group of people around a small area or compare the movement of many different goods around the world. Depending on what they are showing, flow maps use arrows of different colours and sizes. These arrows help the person making the map show different things moving around and the numbers of these things. Here are some steps that will help you understand flow maps:

Step 1 Read the title of the map carefully, as this will tell you exactly what is being shown.

Step 2 Look at the legend on the map. This will tell you what the different coloured arrows on the map are showing and provide you extra information that you may need (like the time of year this movement happens).

Step 3 Look for patterns in the movements shown on the map. Are the movements related to changes in the weather, to the time of year, to political or economic factors or all of these things?

Step 4 Once you have identified the pattern being shown, try to explain the reasons for it.

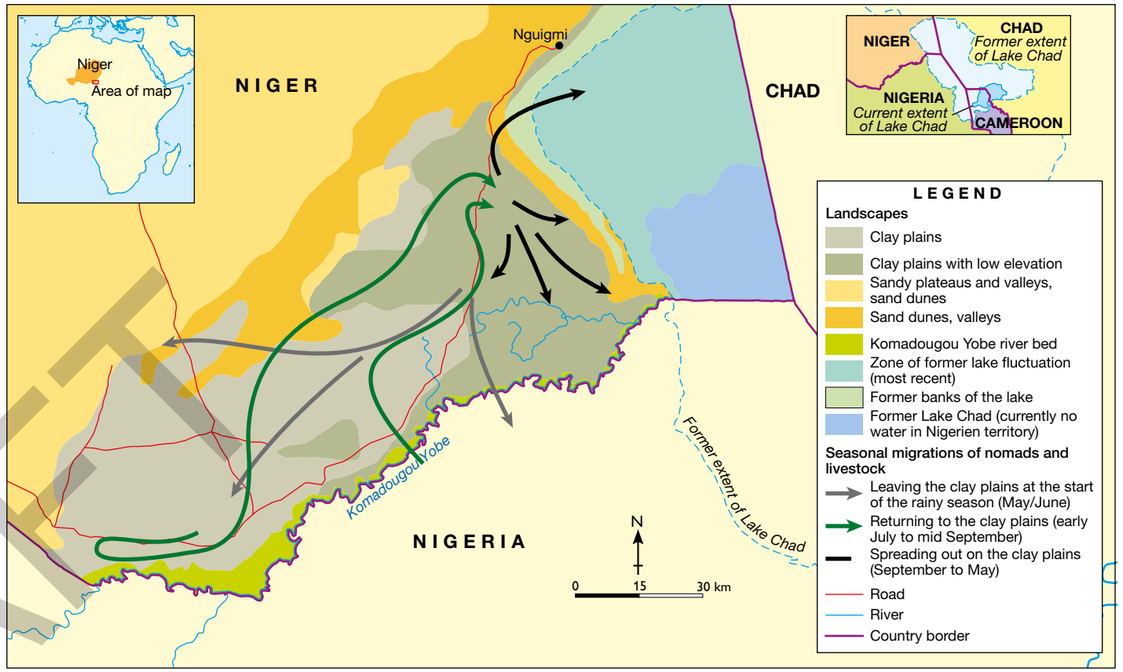
Apply the skill

1 Describe the movement of the Wodaabe during the months of May and June.

2 Where do the Wodaabe travel to from the beginning of July to mid September?

3 In your own words, explain the pattern being shown in Source 3.

SOUTH-EASTERN NIGER: NATURAL ENVIRONMENTS AND SEASONAL MIGRATION ROUTES OF THE WODAABE



Source 3 Source: Oxford University Press

Source 4 Young men of the Wodaabe tribe

Extend your understanding

1 Clay plains with low elevation are the best areas for the Wodaabe to graze their cattle in the dry season. Why? Describe the location of the clay plains with low elevation.

2 Construct a climate graph for Nguigmi in Niger using climate data provided in Source 2.
   - **a** When is the rainy season?
   - **b** When is the dry season?

3 Would you describe the Wodaabe as voluntary migrants?

4 Source 1 shows a Wodaabe family packing their belongings, to follow the rains. Describe their possessions. How many donkeys would your family need to move?