

Mathematics Level 7

Chapter 1 — Water in the world

This work is licensed under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License. To view a copy of this license, visit <http://creativecommons.org/licenses/by-nc-nd/4.0/> or send a letter to Creative Commons, PO Box 1866, Mountain View, CA 94042, USA.

Attribution: Classbasics Pty Ltd, vwx.au

Curriculum codes refer to the *Victorian Curriculum F–10 Version 2.0*, published by the Victorian Curriculum and Assessment Authority (VCAA). Classbasics is not affiliated with the VCAA; the VCAA does not endorse this resource and makes no warranties regarding it.

Distribution note: this document may be distributed, and whole pages may be removed from it, provided only WHOLE pages are removed (never part of a page). This allows teachers to remove tests, exams and subtopics they do not want to issue.

Aboriginal and Torres Strait Islander content has been excluded as accuracy cannot be guaranteed, and it is better to be respectful than cover the entire curriculum inaccurately.

Significant effort has been made to ensure this content is legal. Please send any areas of concern to admin@vwx.au with appropriate document/legal references so errors can be verified and changes be made.

Contents

Section	Page
Renewable water: the water cycle, and the flows that connect and change places	2
The many ways water is used and valued	17
Australia's water resources: distribution, variability and the forecast impacts of climate change	29
Water scarcity: its nature, causes and the strategies for overcoming it, in Australia and West Asia or North Africa	43
Atmospheric and hydrometeorological hazards: causes, impacts and responses	55

Renewable water: the water cycle, and the flows that connect and change places

Next time you turn on a tap, think about where the water was last week. It may have been rain on a mountain forest, water sitting in a dam, or water soaking in the soil of a farm paddock. It may even have been part of the ocean a few months before that. Every drop of water on Earth is second-hand water: the same water, moved and cleaned and moved again by one endless loop. In this section we meet water as a **resource** — something people need and use — and we learn the words that geographers use to sort it, store it, and follow it from place to place. Start with the word cards below; each word is defined again where it first appears.

The words that will do the work

water cycle the endless loop that moves water between the sea, air, land and living things	evaporation heat turning liquid water into water vapour that rises into the air	condensation water vapour cooling into tiny droplets that make clouds	precipitation water falling from clouds as rain, hail, sleet or snow
infiltration rain soaking into the soil and rock	runoff water flowing over the land into creeks and rivers	groundwater water held underground in the gaps of soil and rock	green water soil moisture that plants and crops use
blue water water in rivers, lakes, dams and underground	renewable resource a resource that natural processes replace again and again	river basin all the land that drains into one river and its tributaries	upstream / downstream upstream is closer to a river's source; downstream is closer to its mouth

Each word is defined again where it first appears in this section.

Twelve word cards for the section: water cycle, evaporation, condensation, precipitation, infiltration, runoff, groundwater, green water, blue water, renewable resource, river basin, upstream and downstream

Teacher note. This section carries **VC2HG8K01** for the whole chapter, so the classification it teaches (renewable / non-renewable / continuous, and green / blue water) is the backbone later sections build on. The water cycle is taught here as the connector that makes water renewable and that links places together; the fieldwork hook for the chapter also opens here — seed the idea that students can map where their own town's water comes from and where it goes after use (the Melbourne figure models it). Per TOC §2A, elaboration .E04 is trimmed: the Mutitjulu Waterhole example is cut (First Nations content is excluded from this book), while the Snowy Mountains diversion and the Ord River irrigation scheme are retained as the environmental/economic impact examples. Assess with the evidence-based response at the end: look for correct use of the classification, a named place, and a number used as evidence.

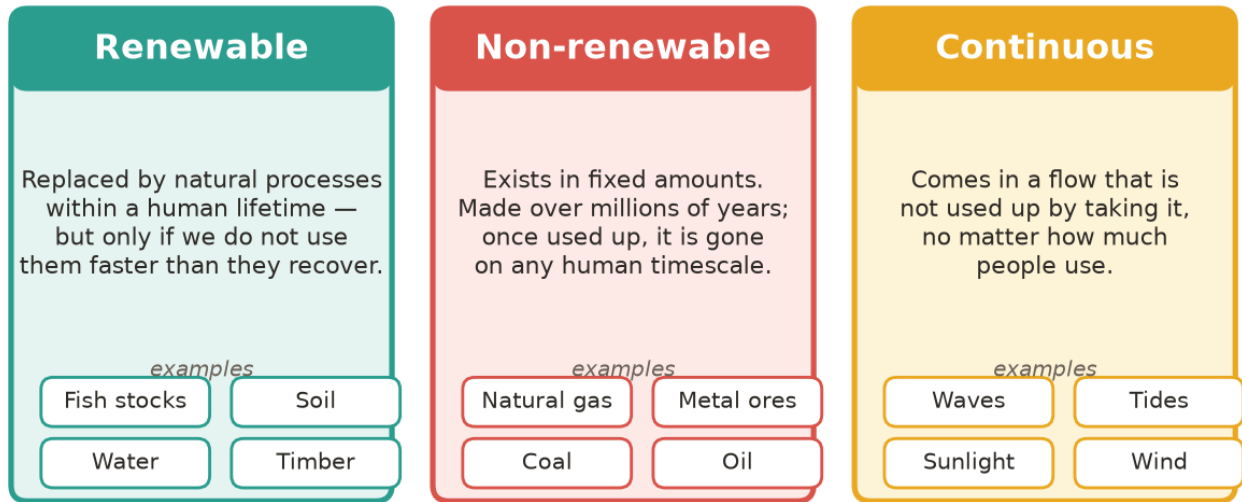
Theory

Water is a resource we can sort

A **resource** is anything in the environment that people need and use. Geographers sort resources by how they are replaced. A **renewable resource** is replaced by natural processes within a human lifetime — but only if we do not use it faster than it recovers. A **non-renewable resource** exists in a fixed amount; once it is used up, it is gone on any human timescale. A **continuous resource** comes in a flow that is not used up by taking it, no matter how much people use.

Three ways to classify a resource

Resources are grouped by how they are replaced.



Water is renewable because the water cycle keeps replacing it.

Even so, a river or an aquifer can be emptied or made dirty faster than the cycle repairs it.

This is the debate: what actually makes water renewable — and when can it run out anyway?

Three columns sorting resources into renewable, non-renewable and continuous types, with examples and a band explaining that water is renewable because the water cycle keeps replacing it

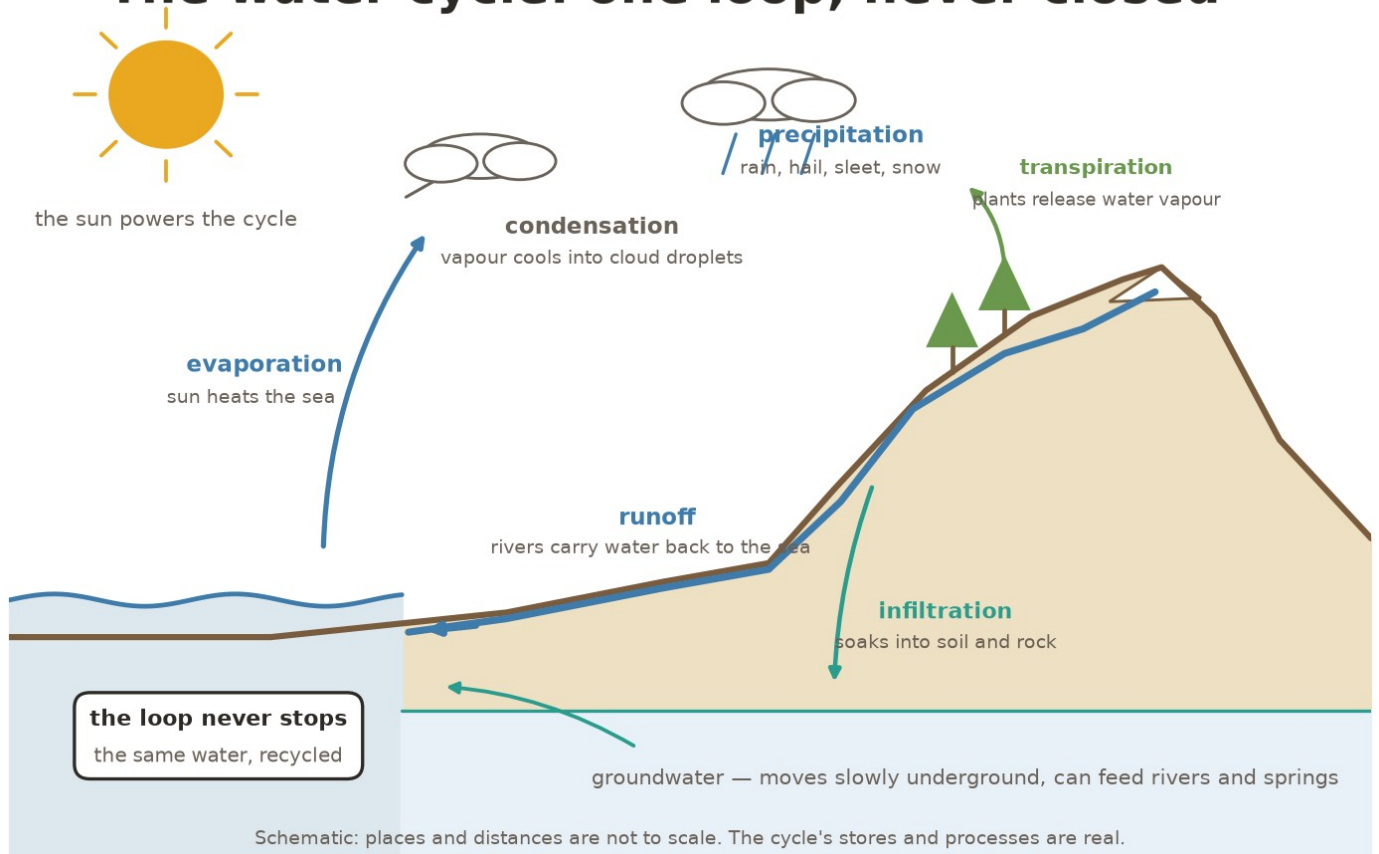
Water sits in the renewable column *because of the water cycle*: the cycle keeps replacing it. Yet a river or an **aquifer** — a body of groundwater held in the gaps of soil and rock — can still be emptied or made dirty faster than the cycle repairs it. That is the debate in this section: what actually makes water renewable, and when can it run out anyway?

Source: resource classification as taught in VC2 Geography Levels 7–8, elaboration .E02. Checked 25 August 2026.

The water cycle: one loop, never closed

The **water cycle** is the endless loop that moves water between the sea, the air, the land and living things. The sun powers it. **Evaporation** is heat turning liquid water into water vapour that rises into the air. **Transpiration** is the water vapour that plants release from their leaves. **Condensation** is vapour cooling into the tiny droplets that make clouds. **Precipitation** is water falling from clouds as rain, hail, sleet or snow. On land, **runoff** is water flowing over the ground into creeks and rivers, and **infiltration** is rain soaking into the soil and rock to become **groundwater**.

The water cycle: one loop, never closed

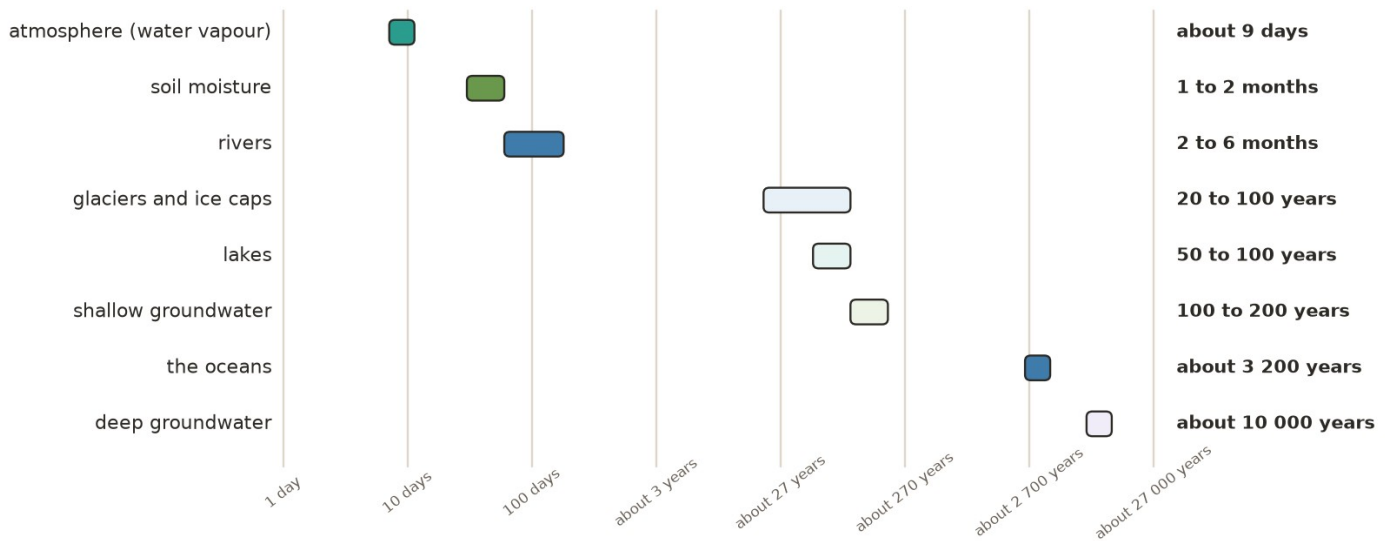


Schematic landscape showing the water cycle as one closed loop: evaporation from the sea, condensation into clouds, precipitation over mountains, transpiration from plants, runoff in a river, and infiltration into groundwater that feeds back towards the sea

Water does not stay in one store for ever. The **residence time** is the average stay of a drop in each store. A drop sits in the air for only about nine days but can be locked in deep groundwater for about ten thousand years. Even so, every store is linked: a drop parked in ice for a hundred years still returns to the same cycle.

How long does water stay in each store?

Residence time — the average stay of a drop in each store.



The scale is spaced by multiplication, not addition — each step is ten times longer.

Every store is linked: a drop parked in ice for 100 years still returns to the same cycle.

Data: residence-time estimates compiled in the USGS Water Science School, checked 25 August 2026.

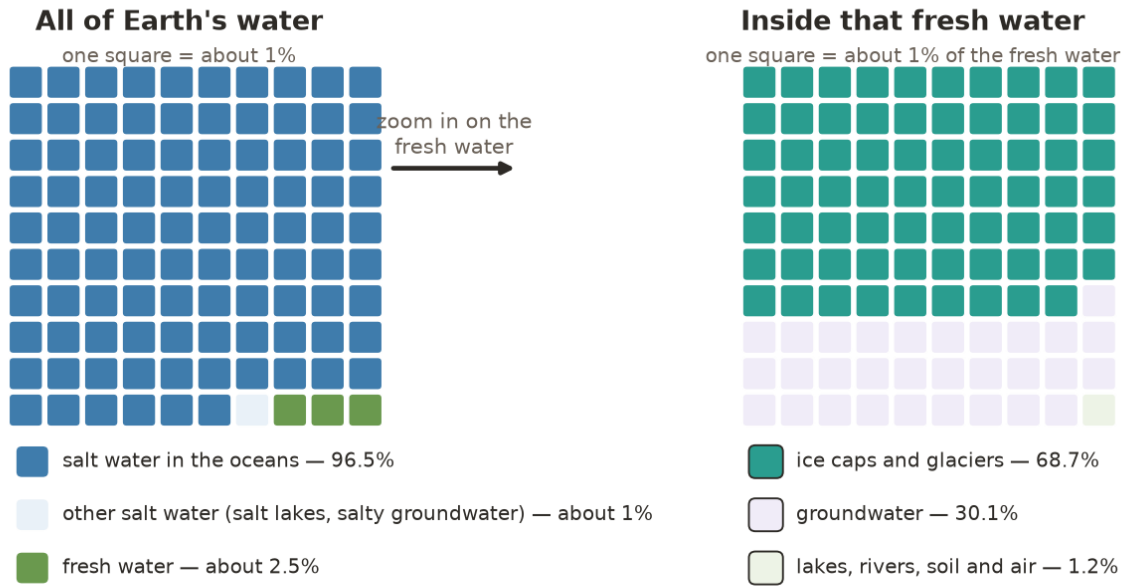
Chart of residence times on a multiplicative scale, from about nine days in the atmosphere to about ten thousand years in deep groundwater

Source: residence-time estimates compiled in the USGS Water Science School. Checked 25 August 2026.

Where is all the water? Available now, or only potential

Most of Earth's water is not the water in your bottle. About 96.5% of it is salt water in the oceans. Of the small fresh share, most is locked in ice caps and glaciers, and most of the rest is groundwater. The water most people can reach easily — in lakes and rivers — is a tiny slice of one percent.

Where is all the Earth's water?



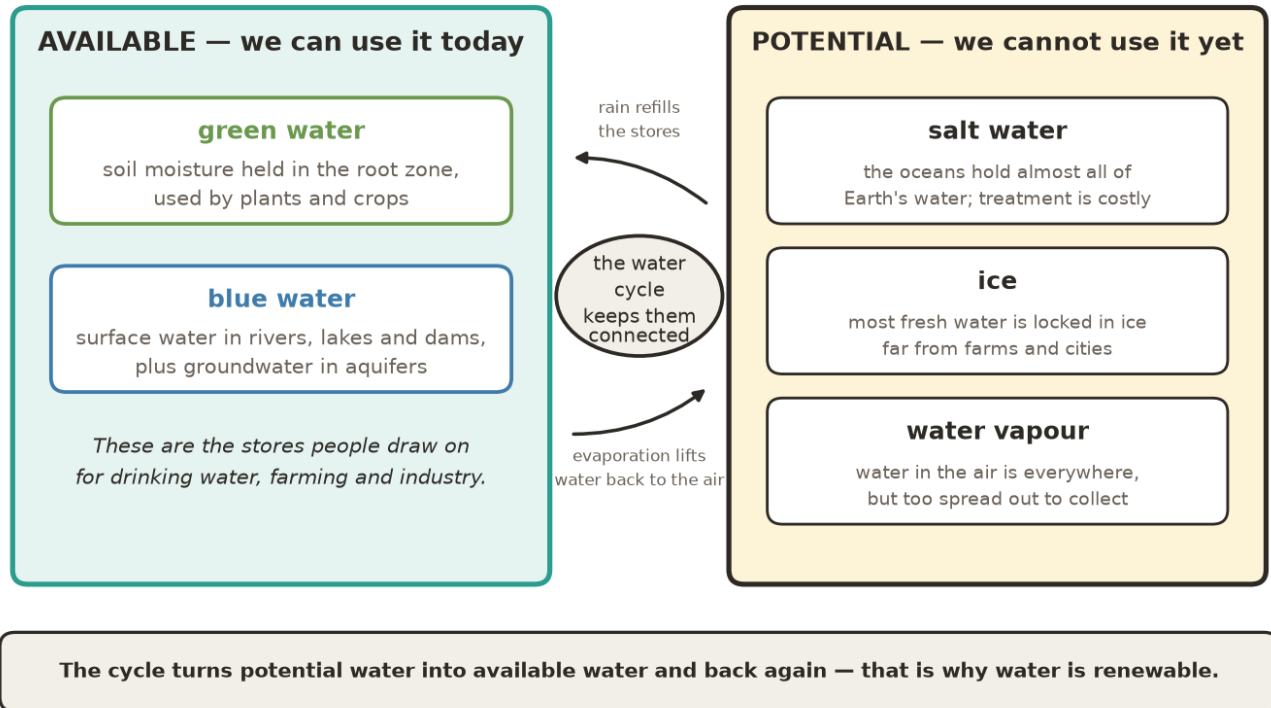
The water most people can reach easily — in lakes and rivers — is a tiny slice of one percent.

Data: United States Geological Survey (USGS), Water Science School, checked 25 August 2026. Squares are rounded to whole percents.

Two hundred-square grids: one showing that about 96.5% of Earth's water is salt water, and a zoomed grid of the fresh water showing ice caps and glaciers about 68.7%, groundwater about 30.1%, and lakes, rivers, soil and air about 1.2%

Geographers therefore split water stores into two groups. **Available** water is the green and blue water people can draw on today. **Potential** water exists but cannot be used yet — salt water that would need costly treatment, ice locked far from farms and cities, and water vapour too spread out to collect. The water cycle is what turns potential water into available water and back again, and that is why water counts as renewable.

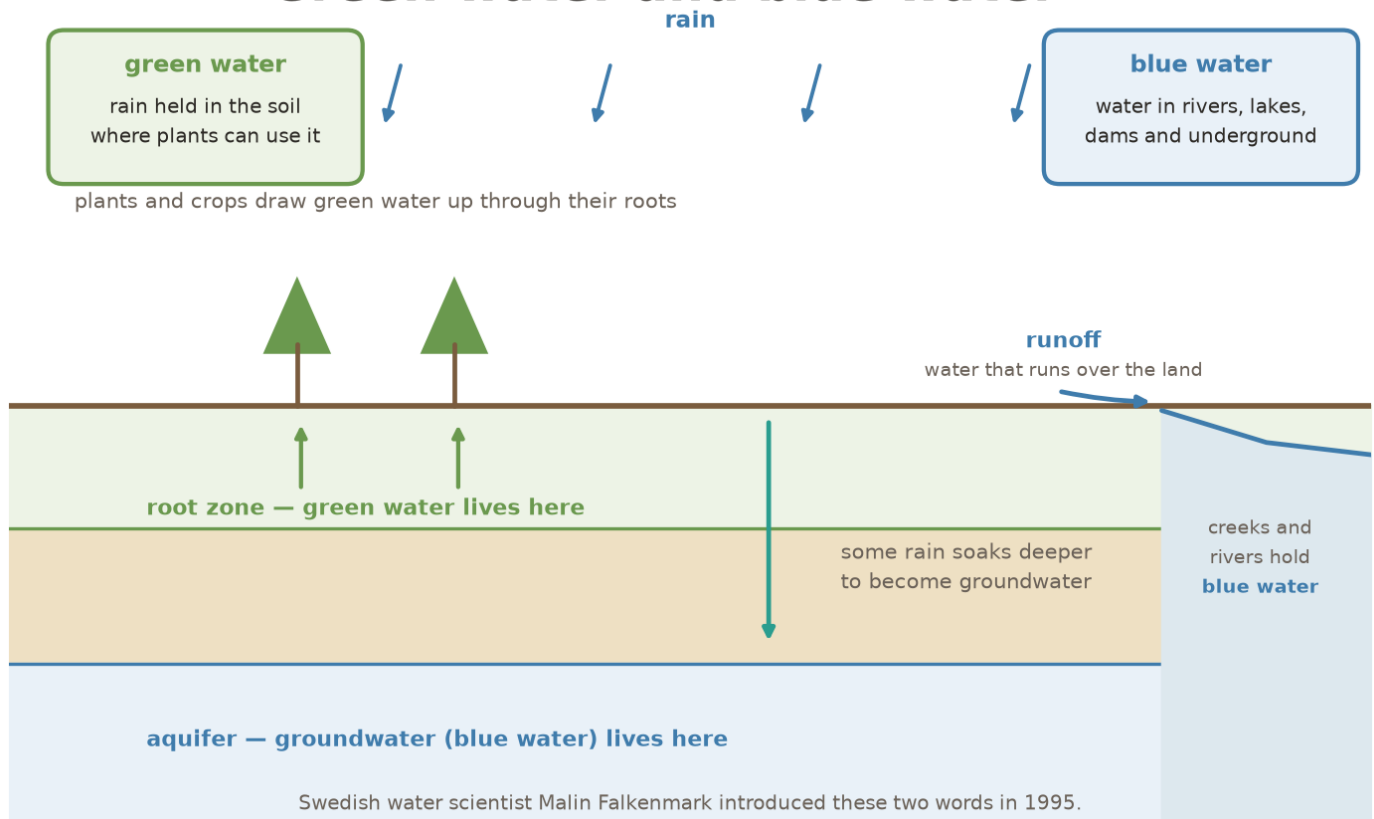
Water as a resource: available now, or potential?



Two panels: available water (green water and blue water) on the left and potential water (salt water, ice, water vapour) on the right, joined by arrows through the water cycle

Within the available water, Swedish water scientist Malin Falkenmark gave us two more words in 1995. **Green water** is rain held in the soil where plants can use it — the water of farms and forests. **Blue water** is the water in rivers, lakes, dams and underground — the water of taps, towns and irrigation channels.

Green water and blue water



Soil cross-section showing green water in the root zone used by plants, and blue water in creeks, rivers and the aquifer, with rain splitting into infiltration and runoff

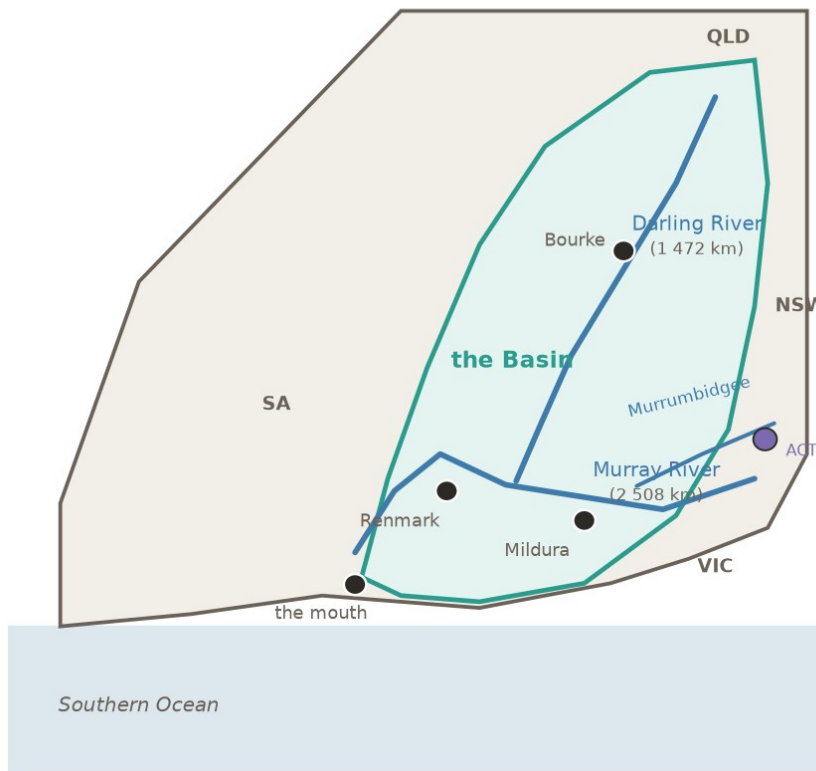
Sources: United States Geological Survey (USGS) Water Science School; Malin Falkenmark's green and blue water concept, 1995. Checked 25 August 2026.

Flows of water connect places: the river basin

A **river basin** is all the land that drains into one river and its tributaries. Because every part of a basin drains to the same river, water connects the places inside it: what happens **upstream** — closer to a river's source — is felt **downstream**, closer to its mouth.

Australia's biggest basin is the Murray–Darling Basin. It covers about one-seventh of the country, its rivers grow about one-third of Australia's food, and five states and territories share it. Australia is the driest continent where people live. The Basin's average flow is about 24 000 GL a year (one gigalitre, GL, is one thousand million litres), and that flow swings a lot between drought and flood, so upstream choices matter enormously.

The Murray-Darling Basin



The Basin in numbers

1 061 469 km²

of land — about one-seventh of Australia

about 24 000 GL

average flow in a year (highly variable)

one-third

of Australia's food supply is grown here

5

states and territories share it:
Qld, NSW, ACT, Vic, SA

2 508 km

of the Murray River — Australia's longest
A gigalitre (GL) is one thousand million litres.

Schematic map: shapes simplified,
not to scale.

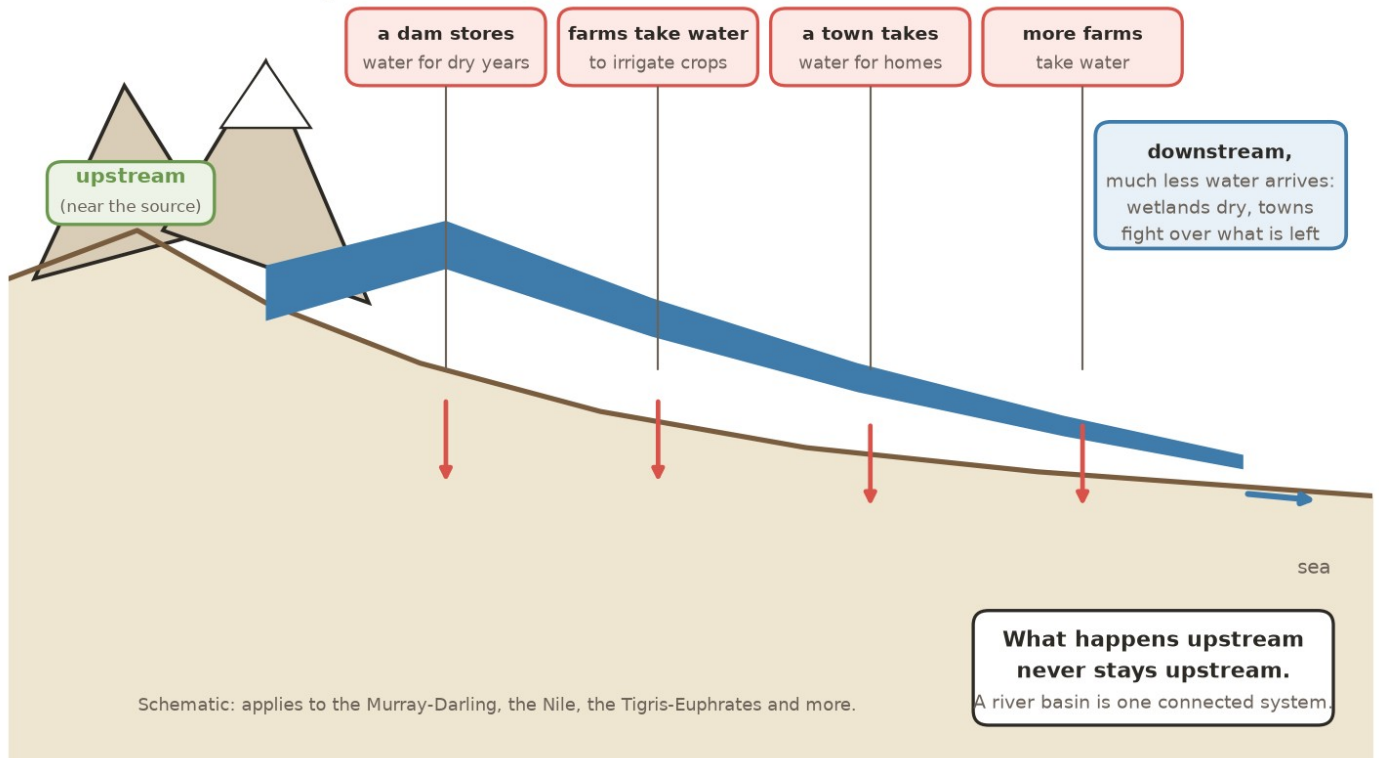
Data: MDBA basin facts,
checked 25 August 2026.

Schematic map of the Murray-Darling Basin with the Murray, Darling and Murrumbidgee rivers, key towns and a facts panel: about 1 061 469 square kilometres, about 24 000 GL average flow, one-third of Australia's food, five states and territories

The same logic works at any scale, from a single creek to a whole continent. Each take of water upstream — a dam, a farm, a town — means less arrives at the end.

Upstream choices, downstream effects

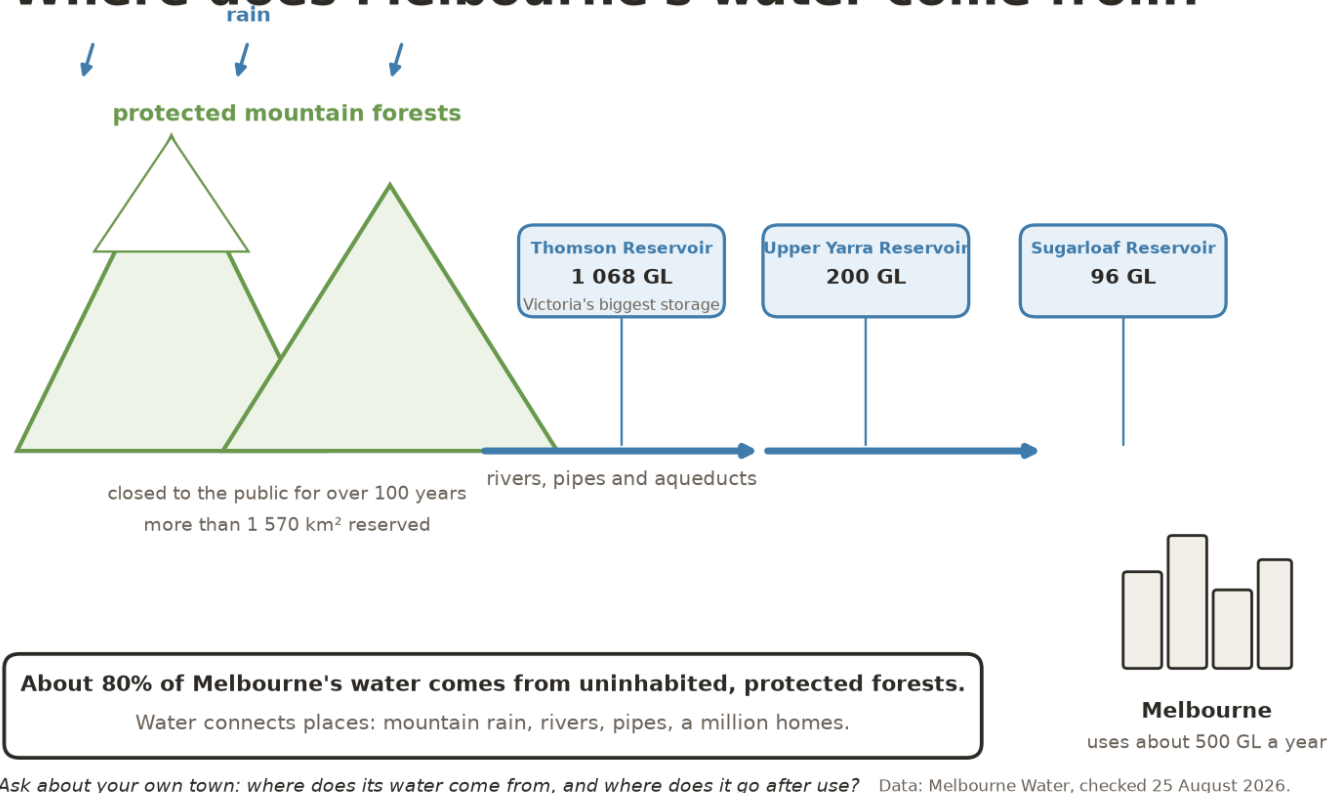
source: snow and rain in the ranges



Schematic of a river thinning towards the sea as a dam, farms and a town take water upstream, with a downstream box noting wetlands dry and towns fight over what is left

You are part of a flow like this too. Melbourne gets about 80% of its water from protected mountain forests that have been closed to the public for over 100 years. Rain on the forests runs into rivers, is stored in reservoirs such as the Thomson (1 068 GL), and travels by pipes to about a million homes — around 500 GL a year. Mountain rain and city taps are one connected system.

Where does Melbourne's water come from?



Flow diagram from protected mountain forests through Thomson, Upper Yarra and Sugarloaf reservoirs to Melbourne, noting about 80% of the city's water comes from protected forests

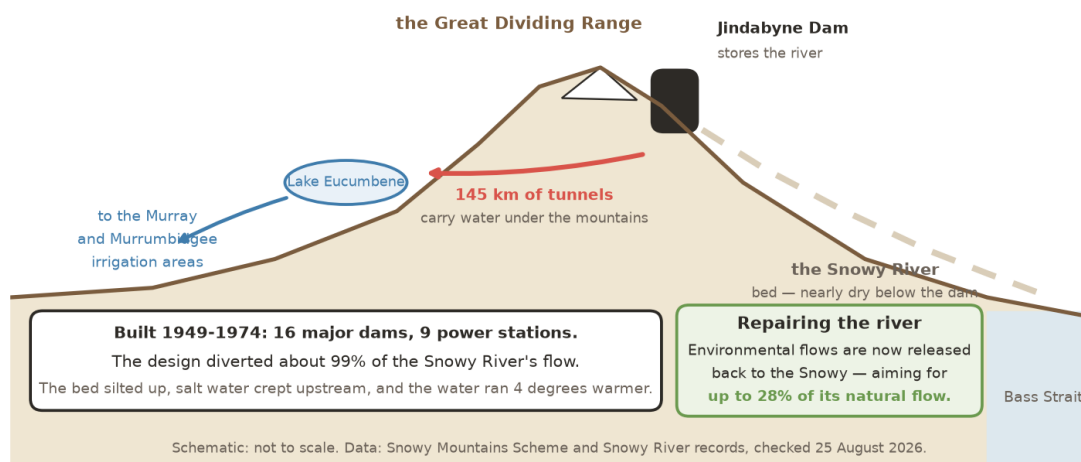
Sources: Murray–Darling Basin Authority basin facts; Melbourne Water. Checked 25 August 2026.

Flows of water change places

Moving water changes the land itself. Over long time, running water cuts valleys into rock and carries the pieces downstream, so a river builds and re-shapes the places it flows through. The valleys of the Murray, the Darling and the Snowy were all carved this way, and the same flows lay down the flat, fertile soil that farms now use.

People also move water, and that changes places fast. The **Snowy Mountains Scheme**, built 1949–1974, used 16 major dams and 145 km of tunnels to send about 99% of the Snowy River's flow west under the Great Dividing Range to the Murray and Murrumbidgee irrigation areas. Downstream on the Snowy, the river bed silted up, salt water crept upstream from the sea, and the water ran about four degrees warmer — clear environmental costs of an economic win for the western farms. Today, environmental flows are released back to the Snowy, aiming for up to 28% of its natural flow.

Moving water across the divide: the Snowy Mountains Scheme

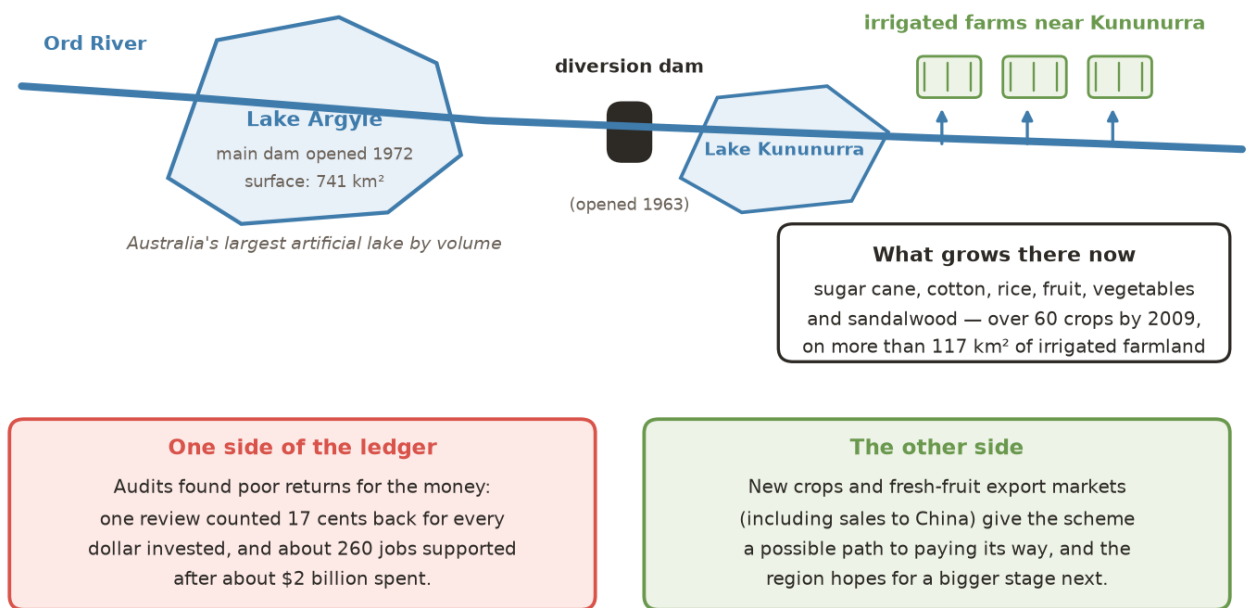


Cross-section of the Snowy Mountains Scheme: Jindabyne Dam stores the river, 145 km of tunnels carry water west to Lake Eucumbene and the Murray and Murrumbidgee, the Snowy River bed is nearly dry below the dam, and a box notes environmental flows now aim for up to 28% of natural flow

In northern Western Australia, the **Ord River Irrigation Scheme** dammed a dry-country river near Kununurra. The diversion dam opened in 1963 and Lake Argyle — Australia's largest artificial lake by volume — followed in 1972. Water turned more than 117 km² of land into irrigated farms growing sugar cane, cotton, rice, fruit and sandalwood. The economics are debated: one review counted only 17 cents back for every dollar invested and about 260 jobs supported after about \$2 billion spent, while new export crops give the scheme a possible path to paying its way.

Damming a dry-country river: the Ord River scheme

Ord River, northern Western Australia, near Kununurra

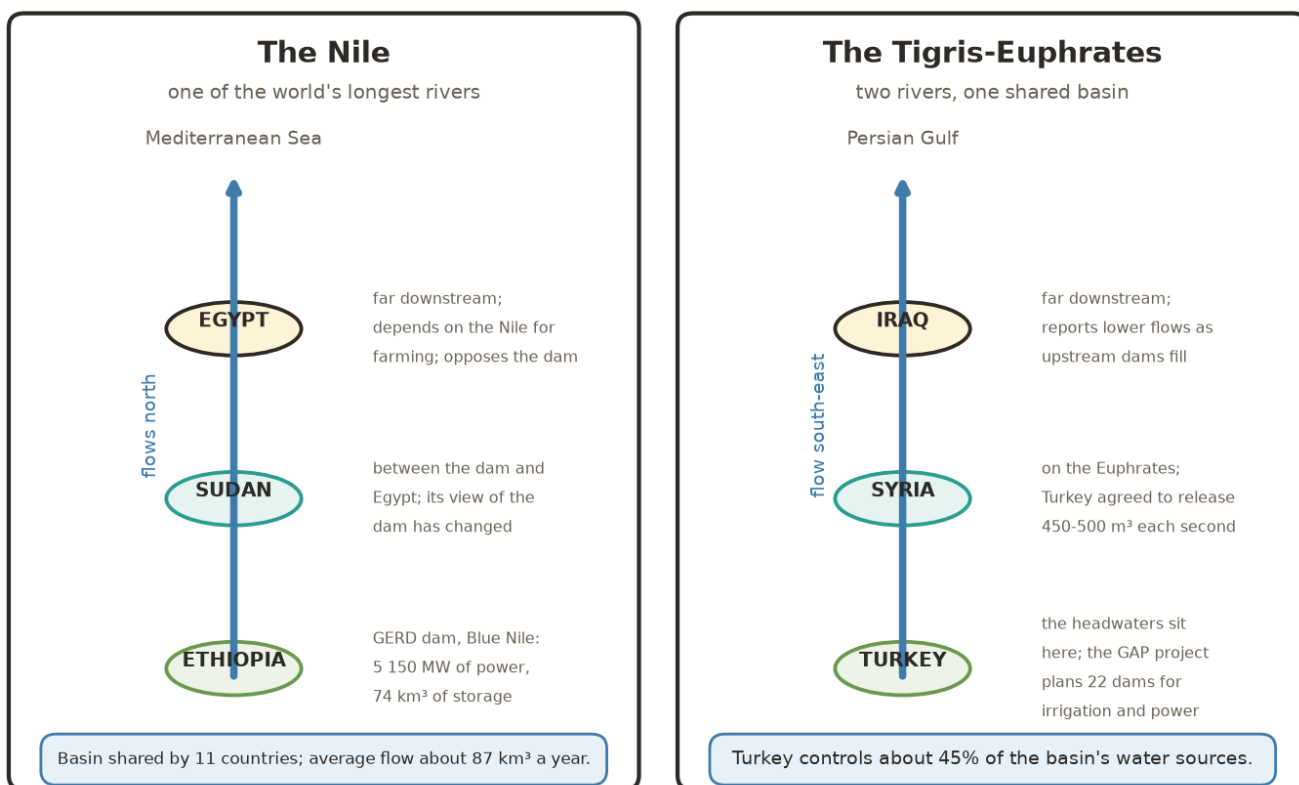


Data: Ord River Irrigation Scheme records, checked 25 August 2026.

Plan of the Ord River scheme: Lake Argyle, the diversion dam, Lake Kununurra and irrigated farms, with two boxes giving both sides of the economic debate

When a basin crosses borders, upstream and downstream become different countries. The Nile basin is shared by 11 countries; far downstream, Egypt depends on the river for farming and opposes Ethiopia's Grand Ethiopian Renaissance Dam (GERD) on the Blue Nile — a dam with 5 150 MW of power and 74 km³ of storage. In the Tigris–Euphrates basin, Turkey controls about 45% of the water sources and plans 22 dams; downstream, Syria and Iraq report lower flows. Both basins ask the same question: when water flows across borders, who decides how much each country keeps?

Sharing one river between countries



Both basins ask the same question: when water flows across borders, who decides how much each country keeps?

Two panels comparing the Nile (Ethiopia, Sudan, Egypt) and the Tigris-Euphrates (Turkey, Syria, Iraq) as chains of countries sharing one flow from source to sea

Sources: Snowy Mountains Scheme and Snowy River records; Ord River Irrigation Scheme records; Wikipedia articles on the Nile, the Grand Ethiopian Renaissance Dam and the Tigris–Euphrates river system. Checked 25 August 2026.

Worked examples

Example 1 — Classifying a real water store

The Thomson Reservoir in Victoria holds 1 068 GL of surface water. Classify it using the words of this section.

Step 1 — Green or blue? The Thomson is surface water stored in a dam, so it is **blue water**. (Green water would be rain held in the soil of a paddock.)

Step 2 — Available or potential? People draw on it today for Melbourne's taps, so it is **available** water.

Step 3 — Renewable, non-renewable or continuous? It is **renewable**: rain and melting snow in the protected forests refill it through the water cycle. It is not non-renewable (it is not a fixed amount like coal), and not continuous (a long drought can shrink it, unlike sunlight).

Step 4 — Can it still run short? Yes. In a long dry spell, less rain arrives while the city keeps drawing about 500 GL a year, so the store can fall. Renewable does not mean unlimited: it only refills as fast as the cycle runs.

Example 2 — Tracing an upstream choice downstream

In 1949, work began to divert the Snowy River. Trace the change using upstream/downstream thinking.

Step 1 — The upstream choice. Dams (such as Jindabyne Dam) and 145 km of tunnels took about 99% of the Snowy's flow west across the divide, to feed Murray and Murrumbidgee irrigation areas.

Step 2 — The downstream change. Below the dams the river bed silted up, salt water crept upstream from Bass Strait, and the water ran about four degrees warmer.

Step 3 — Who and what felt it. Plants and animals adapted to a cold, fast river lost their home; the river's natural job of carving and cleaning its valley nearly stopped.

Step 4 — The response. Environmental flows are now released back to the Snowy, aiming for up to 28% of its natural flow — a repair that shows the basin is one connected system: the upstream choice never stayed upstream.

Practice questions

Scaffolded

1. Use the three columns in the second figure. Sort these resources: coal, sunlight, fish stocks, wind, oil, tides, water, metal ores.
2. Name the water-cycle process that: (a) turns sea water into vapour; (b) cools vapour into cloud droplets; (c) drops water as rain, hail, sleet or snow; (d) soaks rain into the soil and rock.
3. From the hundred-square grids: (a) about what share of all Earth's water is salt water? (b) inside the fresh water, which is the biggest store?
4. Say whether each store is available or potential water: (a) a river; (b) the oceans; (c) an aquifer under a farm; (d) an ice sheet far from any town.
5. Say whether each is green water or blue water: (a) wet soil in a paddock; (b) a dam; (c) groundwater in an aquifer; (d) moisture drawn up by a tree's roots.
6. Use the residence-time chart. Order these stores from the shortest stay to the longest: rivers, deep groundwater, the atmosphere, lakes.
7. From the Murray–Darling map: (a) about what share of Australia's land does the Basin cover? (b) name two rivers in the Basin; (c) about how long is the Murray River?
8. From the Melbourne figure: (a) about what share of the city's water comes from protected forests? (b) name the biggest storage and say how much it holds.

Un scaffolded

9. Water is classified as a renewable resource, yet a town can still run short of water. Explain both facts so that they agree.
10. A new dam is built upstream of a farming town on the same river. Give one benefit and one risk for the town below the dam.
11. Egypt watches a dam in Ethiopia, and Iraq watches dams in Turkey. Use the words upstream and downstream to explain why.
12. "What happens upstream never stays upstream." Explain this sentence in your own words, using one example from this section.

Evidence-based extended response

13. "Flows of water connect places and change them." Write one well-structured paragraph (or plan a poster or slide) using **at least two** real cases from this section — for example the Snowy Mountains Scheme, the Ord River scheme, the Murray–Darling Basin, the Nile, the Tigris–Euphrates or Melbourne's water supply. For each case you must: (a) name the places the water connects; (b) describe one way the flow changed a place; (c) use one number from this section as evidence.

Answers

1. Renewable: fish stocks, water. Non-renewable: coal, oil, metal ores. Continuous: sunlight, wind, tides.
2.
 - (a) evaporation; (b) condensation; (c) precipitation; (d) infiltration.
3.
 - (a) about 96.5%; (b) ice caps and glaciers (about 68.7% of the fresh water).
4.
 - (a) available; (b) potential; (c) available; (d) potential.
5.
 - (a) green; (b) blue; (c) blue; (d) green.
6. The atmosphere (about 9 days), rivers (2–6 months), lakes (50–100 years), deep groundwater (about 10 000 years).
7.
 - (a) about one-seventh; (b) any two of the Murray, the Darling, the Murrumbidgee; (c) 2 508 km.
8.
 - (a) about 80%; (b) the Thomson Reservoir, 1 068 GL. 9–12. See worked answers below.

Worked answers

9. Renewable means the water cycle keeps replacing water, so the total store is refilled by rain. But a local store — a dam, a river, an aquifer — can be drawn down faster than the cycle refills it, or polluted so it cannot be used. So water as a whole is renewable, while a town's supply can still run short.

10. Benefit: the dam stores water for dry years and can release it to the town's farms, and it may slow floods. Risk: less water (or changed timing of flows) reaches the town below the dam, so in dry years its farms and wetlands may miss out — the upstream choice is felt downstream.

11. Rivers flow one way, so Ethiopia and Turkey sit upstream and Egypt and Iraq sit downstream. An upstream dam holds back or slows the flow while it fills and generates power, so less water arrives downstream. Egypt's farms and Iraq's flows therefore depend on choices made in another country.

12. A river basin is one connected system, so a change at one point travels with the flow. Example: diverting about 99% of the Snowy River's flow upstream left the downstream river bed dry and silted, let salt water creep upstream and warmed the water about four degrees — the upstream scheme changed places far below the dams.

13. A strong response names real places, links them with the flow, and uses numbers as evidence. Sample paragraph:

Water flows tie distant places into one system, and when the flow changes, the places change. The Snowy Mountains Scheme connected the Snowy River with the Murray and Murrumbidgee: 145 km of tunnels moved about 99% of the Snowy's flow west to irrigation areas, enriching farms in one place while the Snowy's own valley silted up and warmed downstream of Jindabyne Dam. In the Murray–Darling Basin, the same logic runs through five states and territories: upstream takes of the Basin's average 24 000 GL a year decide how much water reaches downstream towns like Mildura and Renmark, and how much reaches the mouth in South Australia. In both cases, a number tells the story — about 99% diverted, about 24 000 GL a year — and both show that what happens upstream never stays upstream.

VC2HG8K01 Taught with the full elaboration set .E01–.E06 except the TOC §2A trim: on .E04 the Mutitjulu Waterhole example is cut (First Nations content excluded from this book); the Snowy Mountains diversion and Ord River irrigation examples are retained. Elaboration ids are for linkage only; the VCAA content description behind the code is the expectation. Draws on: .E01 (forms of water: green/blue, available/potential, connected through the water cycle) · .E02 (renewable/non-renewable/continuous; the debate about what makes water renewable) · .E03 (movement of water connects places) · .E04* (environmental, economic and social impacts of moving water: Snowy, Ord) · .E05 (moving water changes places: erosion and valleys) · .E06 (river-basin flows; upstream affects downstream; Nile, Tigris–Euphrates, Murray–Darling).

The many ways water is used and valued

For the teacher

Owens: VC2HG8K02 (Geographical Knowledge and Understanding, Water in the world).

Draws on: .E01 environmental flows (sustainability link); .E02 water's economic uses and recreation value; .E04 protected water places in Australia and Asia; .E05 water's spiritual meaning in one Asian culture (Asia link).

§2A note: the CD's "including..." clause is taught **without its First Nations half** — per CONTENT_POLICY Rule 1 and TOC §2A, no Aboriginal or Torres Strait Islander content is used in this book; the Asia half of the clause is delivered in full (.E05 and the Asian places in .E04). .E03 is excluded and not taught.

Achievement standard sentence served here: the band standard's sentence on the sustainable management of water (TOC §1). Section 1A owns "renewable"; this section builds "valuable" — the five kinds of value that make water worth managing; 1C–1E build the management half.

Teaching sequence: 1. Introduce the five lenses as the curriculum's own sorting of water's value (Figure 1B.1). 2. Environmental value: the Snowy River story defines environmental flows (Figure 1B.2), then who depends on them (Figure 1B.3). 3. Economic value: Melbourne's storages (Figure 1B.4) and the five uses table (Figure 1B.5). 4. Cultural and aesthetic value: protected water places in Australia and Asia (Figure 1B.6). 5. Spiritual value: the Ganges in Hindu belief (Figures 1B.7–1B.8). 6. Pull the lenses together on one river (Figure 1B.9), then Worked Examples 1–2 as a model reading and a model paragraph. 7. Practice tasks, then the evidence-based writing task (which feeds the Chapter 1 inquiry and the 6C exit standard).

Vocabulary notes: *environmental flow, reservoir, megalitre, catchment, World Heritage, sacred, pilgrimage, hydroelectricity, turbine* are defined at first use; the five lens words are the curriculum's own. All remaining student-facing vocabulary is at or below Year 7. No First Nations content is used (see the series front matter and §2A).

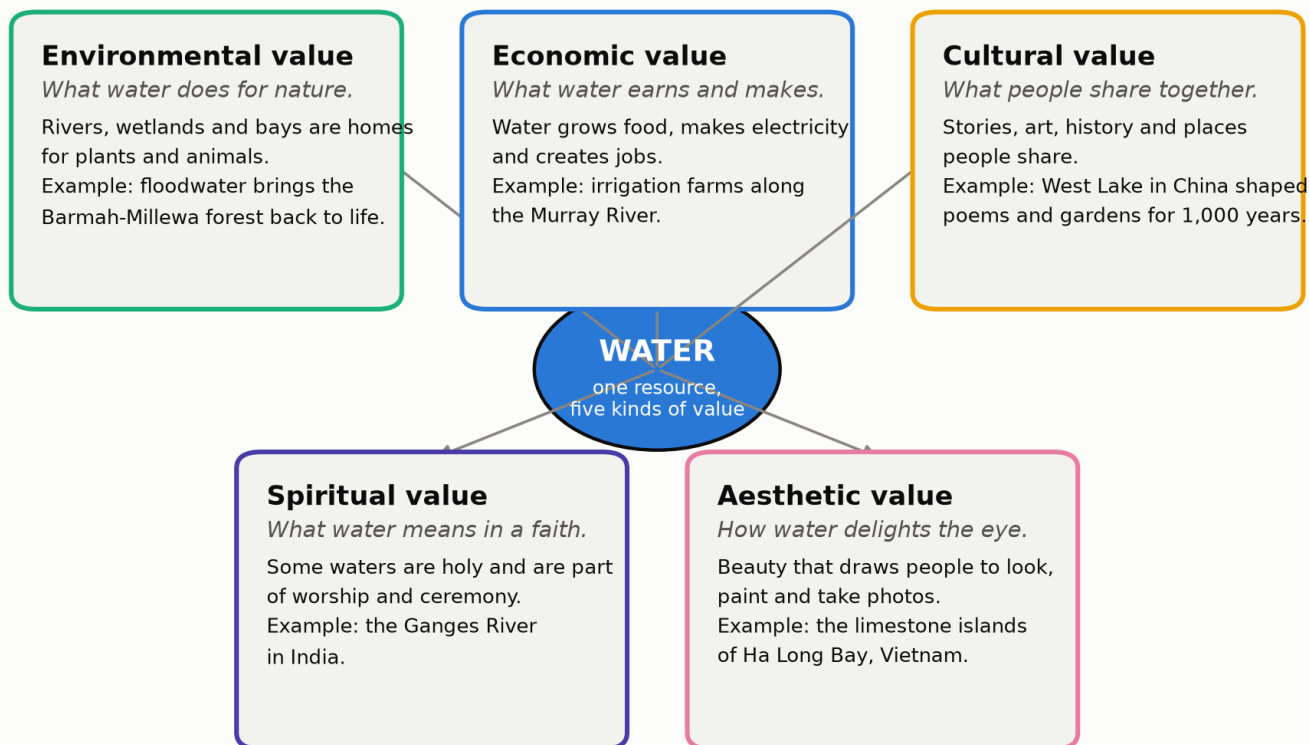
Theory

One resource, five kinds of value

Water is one resource, but it does many kinds of work. It keeps nature alive. It grows food and makes power. It is part of festivals, art and shared history. In some faiths it is holy. And it is beautiful — people travel far just to look at it. The Victorian Curriculum sorts these into five kinds of value: environmental, economic, cultural, spiritual and aesthetic (VC2HG8K02). Figure 1B.1 shows them as five lenses on the same resource. We use this sorting because the curriculum names it — it is the frame this section works with, and it is a useful frame, because it stops us forgetting the kinds of value that are not about money.

Five lenses on the value of water

The Victorian Curriculum sorts water's value into five kinds (VC2HG8K02).



Original figure for this book. The five kinds of value are those named in the Victorian Curriculum (VC2HG8K02).

Concept diagram: a circle labelled WATER in the centre, “one resource, five kinds of value”, with five cards around it — Environmental value (what water does for nature; example: floodwater brings the Barmah-Millewa forest back to life), Economic value (what water earns and makes; example: irrigation farms along the Murray River), Cultural value (what people share together; example: West Lake in China shaped poems and gardens for 1,000 years), Spiritual value (what water means in a faith; example: the Ganges River in India), Aesthetic value (how water delights the eye; example: the limestone islands of Ha Long Bay, Vietnam).

Figure 1B.1 — Five lenses on the value of water. The five kinds are the ones named in VC2HG8K02.

The five words, in plain language:

- **Environmental value** — what water does for nature: rivers, wetlands and bays as homes for plants and animals.
- **Economic value** — what water earns and makes: food, power, jobs and money.
- **Cultural value** — what people share together: stories, art, history and shared places.
- **Spiritual value** — what water means in a faith: waters that are holy and part of worship.
- **Aesthetic value** — how water delights the eye: beauty that draws people to look, paint and photograph.

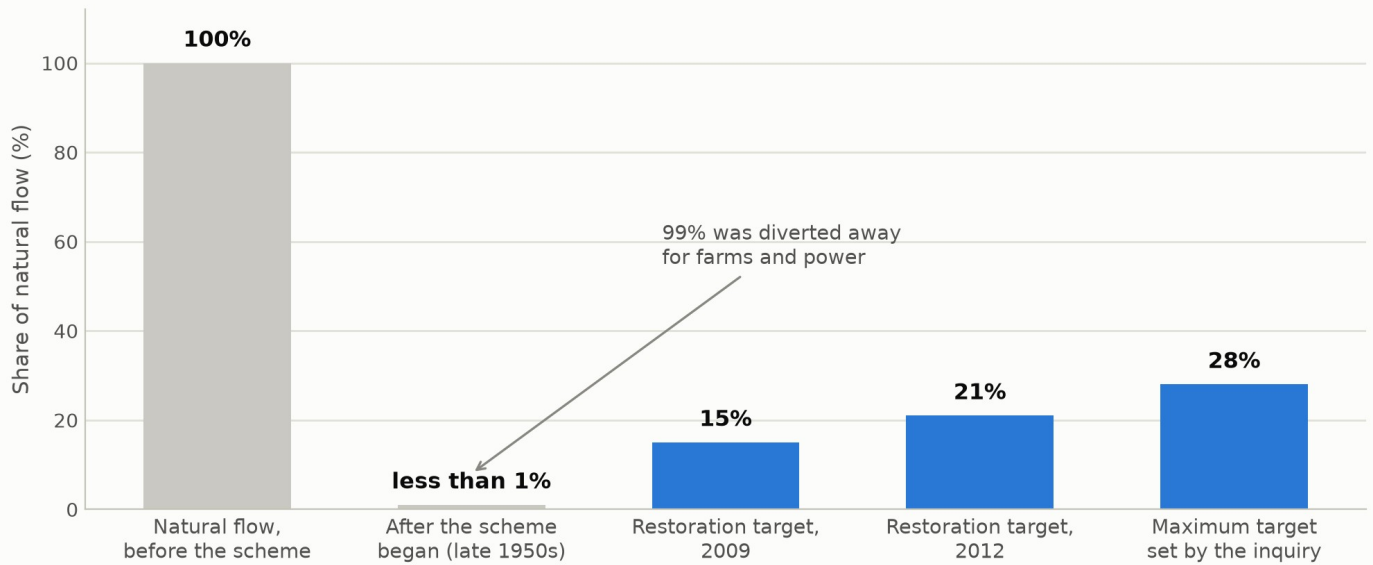
Environmental value: a river needs its own water

A river is not a pipe. If all of its water is taken for other uses, the river itself dies — and then it can no longer supply anyone. An **environmental flow** is water left in a river, or released back into it, to keep the river healthy.

The Snowy River in New South Wales and Victoria shows what happens when a river loses its flow. Before the Snowy Mountains Scheme, the river ran at about 100% of its natural flow at Jindabyne. The Scheme now turns about 99% of that water aside through tunnels to make **hydroelectricity** (electricity made from moving water) and to feed irrigation farms inland. Below the dam, the Snowy fell to less than 1% of its flow (Figure 1B.2).

The Snowy River almost ran dry

Flow of the Snowy River below Jindabyne, as a share of its natural flow. Water was diverted for irrigation farming and electricity; later targets returned some of it.



Source: Snowy Water Inquiry (Victorian Government) outcomes, as reported in the Wikipedia entry "Snowy River", retrieved 25 August 2026.

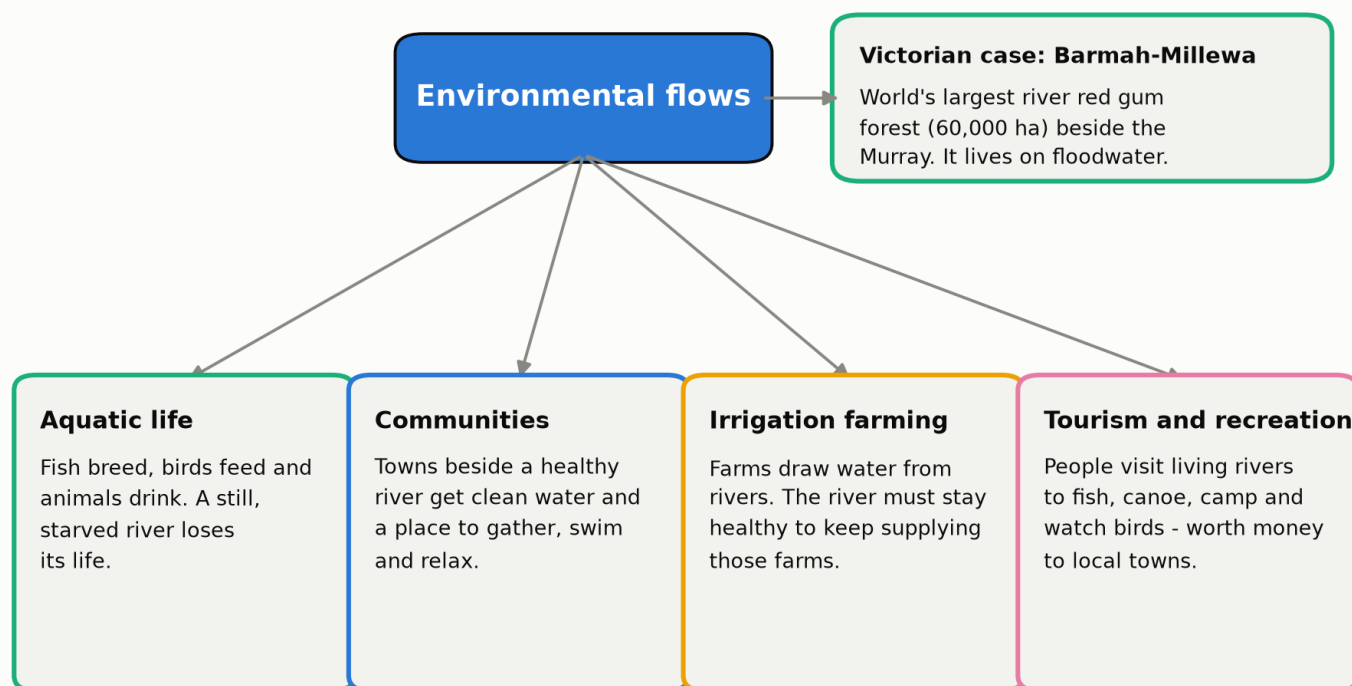
Bar chart of the share of the Snowy River's flow passing Jindabyne: about 100% before the Snowy Mountains Scheme, less than 1% after the Scheme, then environmental flow targets of 15% set in 2009, 21% set in 2012, and a maximum of 28%.

Figure 1B.2 — The Snowy River at Jindabyne: flow before the Scheme, after it, and the environmental flow targets (source: Wikipedia entry "Snowy River", retrieved 25 August 2026).

A river at 1% cannot do its work. So managers now give water back: targets of 15% (2009), 21% (2012) and up to 28% of the flow (Figure 1B.2). That given-back water is the environmental flow. The curriculum calls environmental flows an essential use of water (VC2HG8K02.E01) — not what is left over after the other uses, but a use in its own right. Figure 1B.3 shows who depends on them.

What do environmental flows support?

An environmental flow is water left in a river, or released back into it, to keep the river healthy. Here is who benefits (examples named in VC2HG8K02.E01).



Original model figure for this book. Barmah-Millewa facts: Wikipedia entry "Barmah Forest", retrieved 25 August 2026.

Concept diagram: a box labelled "Environmental flows" with arrows to four cards — Aquatic life (fish breed, birds feed and animals drink), Communities (towns beside a healthy river get clean water and a place to gather, swim and relax), Irrigation farming (farms draw water from rivers, so the river must stay healthy), Tourism and recreation (people visit living rivers to fish, canoe, camp and watch birds) — plus a Victorian case card: Barmah-Millewa, the world's largest river red gum forest (60,000 ha) beside the Murray, which lives on floodwater.

Figure 1B.3 — What environmental flows support, with a Victorian case (case facts: Wikipedia entry "Barmah Forest", retrieved 25 August 2026).

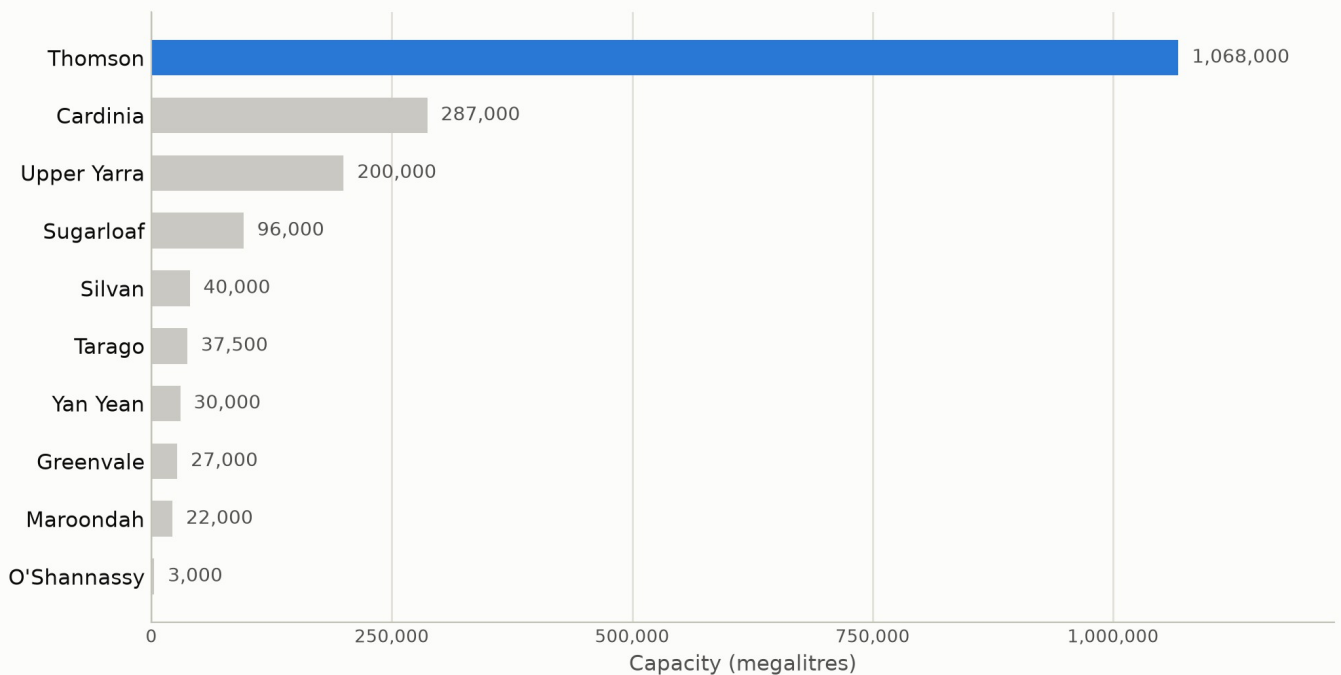
The Barmah–Millewa forest in Figure 1B.3 is the world's largest river red gum forest — 60,000 hectares beside the Murray River. Red gums need floodwater: when the river is allowed to rise and spread, the forest breeds, feeds and renews itself. Environmental flows are how a river stays able to support everyone who draws on it — that is the sustainability idea in this.

Economic value: what water earns and makes

Water is also an economic good. Figure 1B.4 shows Melbourne's ten **reservoirs** — lakes made by damming creeks to store water. Together they hold 1,810,500 **megalitres**. A megalitre is one million litres of water, a little under half an Olympic swimming pool. The **catchments** — the land that drains into the storages — are nearly all protected forest, and that keeps the water clean before it is treated and piped to taps.

Where Melbourne's water is stored

Capacity of Melbourne's ten major reservoirs. One megalitre is one million litres. All together they hold 1,810,500 megalitres.



Source: Melbourne Water, as reported in the Wikipedia entry "Melbourne Water", retrieved 25 August 2026. About 80% of Melbourne's water comes from uninhabited, protected forest catchments.

Horizontal bar chart of Melbourne's ten water storages and their capacities in megalitres, from Thomson (1,068,000) down to O'Shannassy (3,000); all ten together hold 1,810,500 megalitres.

Figure 1B.4 — Melbourne's water storages and their capacities (source: Wikipedia entry "Melbourne Water", retrieved 25 August 2026).

Water's economic work goes well beyond drinking water. Figure 1B.5 gives five uses, each with a real Australian example. In the electricity row, the spinning machines are **turbines** — moving or falling water spins them, and they make the power.

The economic uses of water

Five ways water does economic work in Australia, each with a real, sourced example.

Use	What it looks like	Real Australian example
Irrigation farming	Water is delivered to crops and pastures so food can grow.	Rivers of the Murray-Darling Basin supply 55% of Australia's total water use (National Water Account 2020).
Drinking water	Water is cleaned and piped to homes, schools and shops.	Melbourne's ten reservoirs hold 1,810,500 megalitres (Melbourne Water).
Electricity	Moving or falling water spins turbines to make power.	The Snowy Mountains Scheme diverts river water through power stations.
Fishing and seafood	Fish and shellfish are caught in bays, rivers and the sea.	The Gippsland Lakes - about 354 square kilometres of coastal lakes - support fishing (Ramsar-listed wetland, 1982).
Tourism and recreation	People spend money to swim, sail, dive and visit water places.	Tourism at the Great Barrier Reef earns more than AUD \$3 billion a year.

Sources: National Water Account 2020 (as reported in Wikipedia "Water resources of Australia"); Melbourne Water (Wikipedia "Melbourne Water"); Wikipedia "Snowy River", "Gippsland Lakes", "Great Barrier Reef" - all retrieved 25 August 2026.

Table of five economic uses of water with a real Australian example each: Irrigation farming (rivers of the Murray-Darling Basin supply 55% of Australia's total water use, National Water Account 2020); Drinking water (Melbourne's ten reservoirs hold 1,810,500 megalitres); Electricity (the Snowy Mountains Scheme diverts river water through power stations); Fishing and seafood (the Gippsland Lakes, about 354 square kilometres of coastal lakes, support fishing; Ramsar-listed wetland, 1982); Tourism and recreation (tourism at the Great Barrier Reef earns more than AUD \$3 billion a year).

Figure 1B.5 — Five economic uses of water (sources as noted on the figure, retrieved 25 August 2026).

The fishing row names the Gippsland Lakes. They are **Ramsar-listed**: on a world list of important wetlands, named after the town of Ramsar where the agreement was signed.

Two numbers to notice. The rivers of the Murray–Darling Basin supply 55% of all the water used in Australia — most of it for irrigation farming. And tourism at the Great Barrier Reef earns more than \$3 billion a year. That second number is also recreational value (VC2HG8K02.E02): water landscapes are places people swim, sail, dive, fish and camp — and a landscape people pay to visit is an economic fact for the towns beside it.

Cultural and aesthetic value: water places the world protects

Some water places are so beautiful, or so full of shared meaning, that countries and the world agree to protect them. A **World Heritage** listing is the world's strongest label: a place so special that it belongs to everyone on Earth and must be looked after for good. National parks are a country's own protection. Figure 1B.6 lists water places in Australia and Asia that carry these labels, as VC2HG8K02.E04 asks us to know.

Water places protected for their beauty and culture

Sites in Australia and Asia on the World Heritage List or protected as national parks (VC2HG8K02.E04). World Heritage places are judged by UNESCO, the United Nations cultural body, to have outstanding value for all people.

Place	Country	The water place	Protection	Valued for
Great Barrier Reef	Australia	World's biggest coral reef, stretching over 2,300 km	World Heritage, 1981	Nature, beauty, tourism
Ha Long Bay	Vietnam	Bay of 1,969 limestone islands	World Heritage, 1994	Beauty, culture (dragon legend)
Jiuzhaigou Valley	China	Coloured lakes and tiered waterfalls	World Heritage, 1992	Beauty
West Lake, Hangzhou	China	Lake shaped by poets, causeways and temples	World Heritage, 2011	Culture, beauty
Angkor	Cambodia	City built around giant reservoirs, moats and canals	World Heritage, 1992	Culture
Mount Fuji and the Fuji Five Lakes	Japan	Sacred mountain with five lakes at its base	World Heritage, 2013	Spiritual, cultural, beauty
Wilsons Promontory National Park	Australia (Victoria)	Bays, beaches and granite headlands	National park, since 1898	Beauty, recreation
Port Campbell National Park (Twelve Apostles)	Australia (Victoria)	Limestone stacks rising from the sea	National park	Beauty, recreation

Sources: World Heritage dates and descriptions from the Wikipedia entries for each site; Wilsons Promontory and the Twelve Apostles from their Wikipedia entries - all retrieved 25 August 2026.

Table of eight water places in Australia and Asia protected for their beauty or cultural value, with the protection each carries: Great Barrier Reef (World Heritage, 1981); Gippsland Lakes (Ramsar-listed wetland, 1982); Wilsons Promontory (national park, 1898); Twelve Apostles (Port Campbell National Park); Ha Long Bay, Vietnam (World Heritage, 1994); Jiuzhaigou, China (World Heritage, 1992); West Lake, China (World Heritage, 2011); Angkor, Cambodia (World Heritage, 1992); Mount Fuji, Japan (World Heritage, 2013).

Figure 1B.6 — Water places in Australia and Asia protected for their beauty and cultural value (sources as noted on the figure, retrieved 25 August 2026).

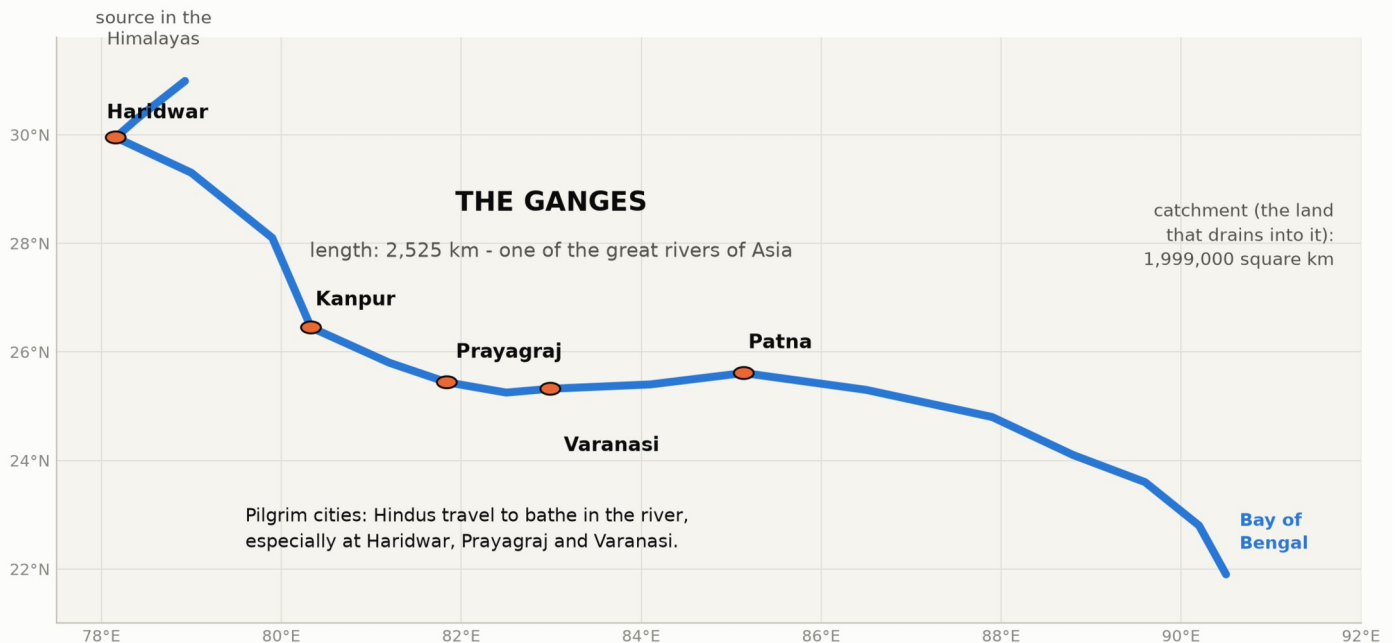
Look at the reasons in the table: Jiuzhaigou for its coloured lakes and waterfalls; West Lake because its gardens and poems have shaped Chinese art for about 1,000 years; Mount Fuji as “a sacred place and a source of artistic inspiration” — that one line carries spiritual, cultural and aesthetic value together. Protecting places like these is a way of saying their value is not only what they earn.

Spiritual value: the Ganges in Hindu belief

The curriculum also names spiritual value, and asks us to see it in an Asian culture (VC2HG8K02.E05). For Hindus, the Ganges River in India is **sacred** — holy; more than a resource, a living part of their faith. Hindus believe that bathing in the Ganges washes away sins. A **pilgrimage** is a journey made for religious reasons, and millions of Hindus make pilgrimages to the river each year. Figure 1B.7 maps the river and its pilgrim cities.

The Ganges: a sacred river and its pilgrim cities

A simple map drawn for this book. City positions are real; the river line is simplified. The Ganges rises in the Himalayas and flows to the Bay of Bengal.

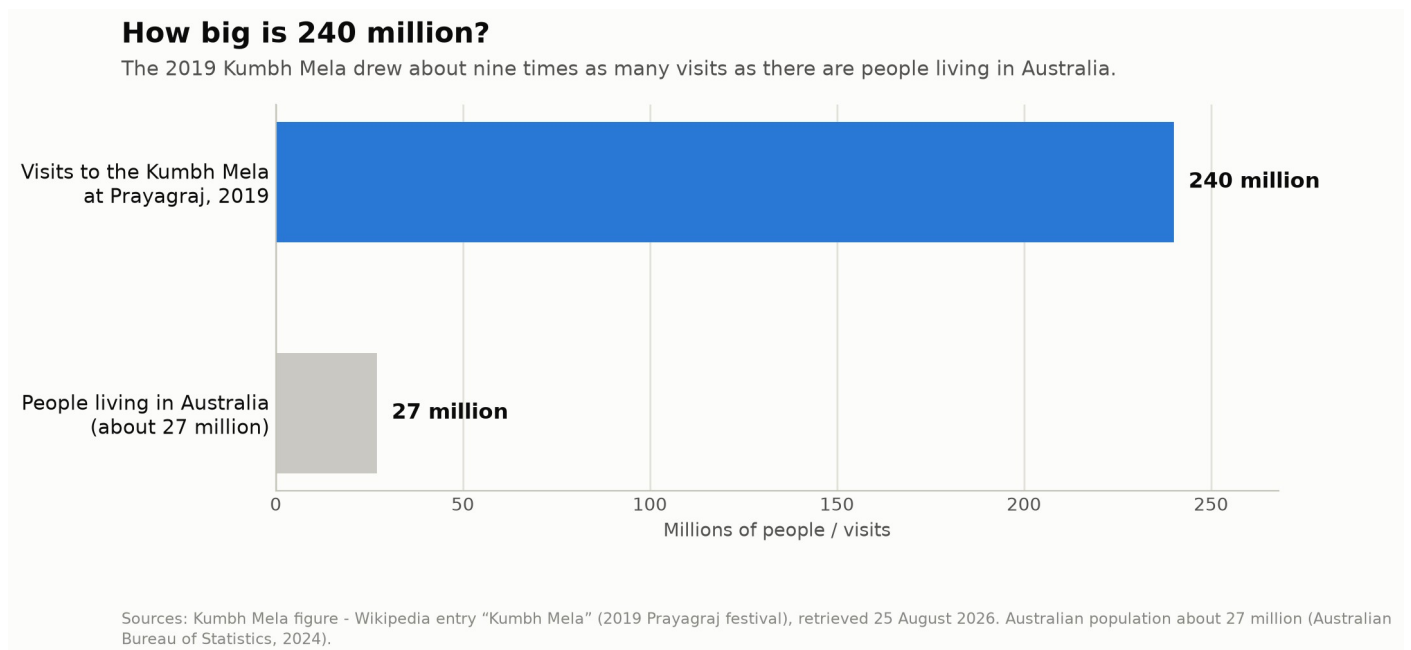


Source: Wikipedia entry "Ganges" (length, catchment, cities and practices), retrieved 25 August 2026.

Simple map of northern India showing the Ganges River from its source in the Himalayas to the Bay of Bengal, with five pilgrim cities marked: Haridwar, Kanpur, Prayagraj, Varanasi and Patna; river length 2,525 km, catchment 1,999,000 square km.

Figure 1B.7 — The Ganges: a sacred river and its pilgrim cities (source: Wikipedia entry "Ganges", retrieved 25 August 2026).

The biggest gathering on the river is the Kumbh Mela. In 2019, at Prayagraj, it drew about 240 million visits. Figure 1B.8 sizes that number up against Australia's population.



Bar chart comparing visits to the 2019 Kumbh Mela at Prayagraj (240 million) with the number of people living in Australia (about 27 million) — the Kumbh bar is about nine times as long.

Figure 1B.8 — How big is 240 million? (sources: Wikipedia entry "Kumbh Mela"; Australian Bureau of Statistics, 2024; retrieved 25 August 2026).

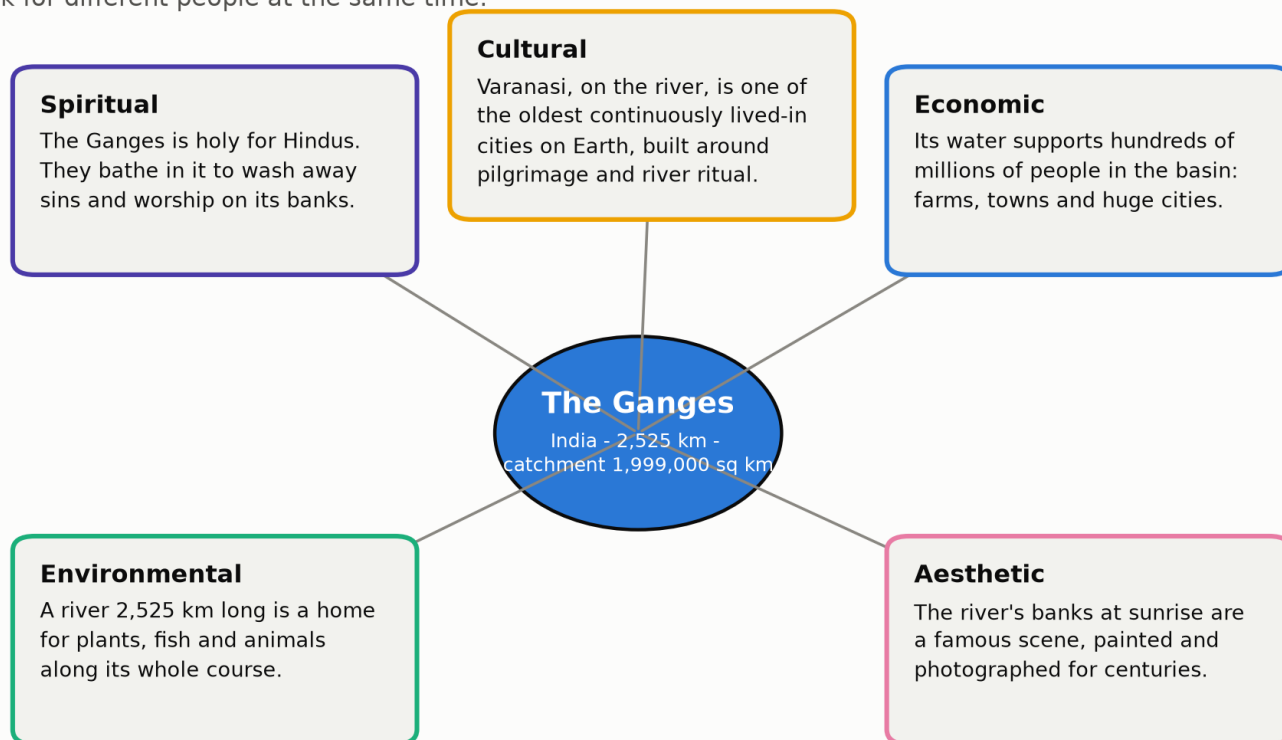
Spiritual value changes what water *is*, not just what it does. To a pilgrim at Haridwar or Varanasi, the water is not scenery and not supply — it is part of worship. That is why the five-lens sorting matters: the economic lens alone cannot see what the Ganges is to a Hindu.

One place, many values

Real water places rarely carry just one value. Figure 1B.9 reads the Ganges through all five lenses at once.

One water place, many values

The Ganges, India, read through the five lenses. The same river does different kinds of value-work for different people at the same time.



Original model figure for this book. Facts: Wikipedia entries "Ganges", "Varanasi" and "Kumbh Mela", retrieved 25 August 2026.

Concept diagram: a circle labelled The Ganges (India, 2,525 km, catchment 1,999,000 sq km) with five cards — Spiritual (holy for Hindus, who bathe in it to wash away sins), Cultural (Varanasi, one of the oldest continuously lived-in cities on Earth), Economic (its water supports hundreds of millions of people), Environmental (a home for plants, fish and animals along its whole course), Aesthetic (its banks at sunrise painted and photographed for centuries).

Figure 1B.9 — One water place, many values (sources: Wikipedia entries "Ganges", "Varanasi" and "Kumbh Mela", retrieved 25 August 2026).

And values can pull against each other. The Ganges is sacred, yet in places it is badly polluted, because the same banks that carry temples also carry cities and factories. The Great Barrier Reef earns tourist dollars, yet the very visits that earn the money add to the warming and waste that stress the reef. Managing water means weighing several values at once — which is exactly what the five lenses are for.

Worked examples

Example 1 — scaffolded: Port Phillip Bay through the five lenses

Task: read one real Australian water place through the five lenses, using evidence. Port Phillip Bay is 1,930 square kilometres, only about 8 metres deep on average, and about 5.5 million people live around it.

Lens	Evidence at the bay
Environmental	Seagrass, dolphins, seals at the Heads and thousands of seabirds live in the shallow bay.
Economic	The Port of Melbourne ships goods through it; fishers and boat tours earn from it.
Cultural	Sailing, beach days and bay-side festivals are shared habits of Melbourne life.
Spiritual	For some visitors the bay at sunrise is a place of quiet and wonder — a personal spiritual value.
Aesthetic	The bay's light and water are painted and photographed all year round.

Closing move: one place, five true readings at once. Note the spiritual row: spiritual value can be personal, and honestly present even where no faith names the place holy — but write “for some people” and the claim stays true.

Example 2 — scaffolded: a model paragraph on why an environmental flow is an essential use

Task: write a paragraph answering “why is leaving water in a river an essential use, not a leftover?” Model response:

Before the Snowy Mountains Scheme, the Snowy River ran at about 100% of its flow at Jindabyne; after it, less than 1% (Figure 1B.2). At 1%, a river cannot breed fish, feed the farms downstream, or carry a town's swimming and fishing — which is why managers now give back 15–28% of the flow. The Barmah–Millewa forest shows the same rule on the Murray: without floodwater, the world's largest river red gum forest dries and dies. So an environmental flow is not water wasted on the river; it is the water that keeps the river able to do every other job — that is what “essential” means here.

The sentence pattern is: **numbers that show the loss → who is hurt → the word “essential” earned by the argument.** Use the same pattern in Q12 and in the writing task.

Practice tasks

Scaffolded

Q1. Look at Figure 1B.1. (a) Name the five lenses. (b) Which lens is “what water earns and makes”? Which is “what water means in a faith”?

Q2. Look at Figure 1B.2. (a) What share of the Snowy's flow was left at Jindabyne after the Scheme? (b) What target was set for 2012? (c) In your own words, say what an environmental flow is.

Q3. Look at Figure 1B.3. Name the four groups that environmental flows support.

Q4. Look at Figure 1B.4. (a) Which storage holds the most water, and how much? (b) The ten storages hold 1,810,500 ML in all. Does Thomson alone hold more than half of that? Show your working.

Q5. Look at Figure 1B.5. Match each clue to a use: (a) earns more than \$3 billion a year; (b) 55% of Australia's water use; (c) spinning water makes power; (d) about 354 square kilometres of coastal lakes.

Q6. Look at Figure 1B.6. (a) Name two Australian and two Asian water places from the table. (b) Which protection label do Ha Long Bay and the Great Barrier Reef share? (c) Which place is protected for its coloured lakes and waterfalls?

Q7. Look at Figures 1B.7 and 1B.8. (a) Name three pilgrim cities on the map. (b) About how many times Australia's population is 240 million? Show your working.

Q8. Look at Figure 1B.9. Pick two lenses and copy the card's evidence for each. Then say in one sentence which lens you think is strongest for the Ganges, and why.

Un scaffolded

Q9. Choose one water place you have visited or know well — a beach, a creek, a lake, a dam. Read it through three lenses of your choice, with one piece of evidence per lens. Three to four sentences.

Q10. Steelman practice. Claim: “The Great Barrier Reef’s most important value is economic — more than \$3 billion a year.” Write two careful sentences *for* the claim and two careful sentences *against* it, using at least two other lenses. A good answer argues each side honestly.

Q11. VC2HG8K02.E04 names bays, rivers, waterfalls and lakes protected for aesthetic and cultural value. Choose Jiuzhaigou or West Lake and explain, in three to four sentences, why a place like that can be worth protecting even if it earned no money at all.

Q12. A dam manager says “water for power and farms comes first”. A river manager says “the river’s own water comes first”. Using the Snowy numbers (Figure 1B.2), say which manager you back, or how the two could share — three to four sentences. There is no single right side; marks go to the reasoning and to the numbers you use.

Evidence-based writing task

A water place and its values. Write one paragraph (5–7 sentences) about one named water place — one from this section, or one you have visited. Include: (1) at least three of the five lenses; (2) at least one piece of evidence — a number from a figure in this section, or something you have seen yourself; (3) a closing sentence that weighs two of the lenses against each other. Underline your evidence. You are marked on the reasoning, not on which lens you rank first.

Answers and suggested responses

Q1. (a) Environmental, economic, cultural, spiritual, aesthetic. (b) Economic; spiritual.

Q2. (a) Less than 1%. (b) 21%. (c) Any wording that says: water left in a river, or given back to it, to keep the river healthy.

Q3. Aquatic life; communities; irrigation farming; tourism and recreation.

Q4. (a) Thomson, 1,068,000 ML. (b) Half of 1,810,500 is 905,250; 1,068,000 is more than 905,250, so yes — Thomson alone holds more than half of Melbourne's stored water.

Q5. (a) Tourism and recreation (Great Barrier Reef). (b) Irrigation farming (Murray–Darling Basin). (c) Electricity (Snowy Mountains Scheme). (d) Fishing and seafood (Gippsland Lakes).

Q6. (a) Any two each from: Great Barrier Reef, Gippsland Lakes, Wilsons Promontory, Twelve Apostles / Ha Long Bay, Jiuzhaigou, West Lake, Angkor, Mount Fuji. (b) World Heritage. (c) Jiuzhaigou.

Q7. (a) Any three of Haridwar, Kanpur, Prayagraj, Varanasi, Patna. (b) $240 \div 27 \approx 8.9$, so about nine times.

Q8. Answers vary. Check: two lenses, each with the card's evidence, plus one reasoned sentence.

Q9. Answers vary. One mark per lens that carries real evidence.

Q10. For (example): the \$3 billion pays for boats, towns and jobs; without the money, protection loses its friends. Against (example): the reef was valuable for millions of years before tourists came (environmental); it is part of the world's heritage whether or not anyone pays (cultural, aesthetic). Mark on the honesty of each side.

Q11. Answers vary. Check: the answer names beauty (aesthetic) or shared meaning (cultural) as a value that does not need money to be real.

Q12. Answers vary. Check: the answer uses at least one Snowy number (100% / <1% / 15–28%) and gives a reason; either side, or a share model, can score full marks.

Writing task. Check for three lenses, one underlined piece of evidence, and a closing weighing sentence. Mark on the reasoning, not on the conclusion reached.

Sources (teacher-facing)

- Victorian Curriculum v2.0 (VCAA export 2026-07-29, via TOC §3): VC2HG8K02 and elaborations .E01, .E02, .E04, .E05; band achievement standard.
- Wikipedia entries, retrieved 25 August 2026: “Snowy River” (pre-Scheme flow about 100%, post-Scheme less than 1%, targets 15% / 21% / max 28%); “Barmah Forest” (60,000 ha, world's largest river red gum forest); “Melbourne Water” (ten storages, 1,810,500 ML total, protected-forest catchments); “Water resources of Australia” (National Water Account 2020: Murray–Darling Basin 55% of national water use); “Gippsland Lakes” (about 354 km², Ramsar 1982); “Great Barrier Reef” (World Heritage 1981; tourism more than AUD \$3 billion a year); “Port Phillip” (1,930 km², mean depth 8 m, about 5.5 million people); “Wilsons Promontory” (protected 1898); “Twelve Apostles” (Port Campbell National Park); “Ganges” (2,525 km; catchment 1,999,000 km²; pilgrim cities and beliefs); “Varanasi”; “Kumbh Mela” (2019 Prayagraj, about 240 million visits); “Ha Long Bay” (World Heritage 1994); “Jiuzhaigou” (World Heritage 1992); “West Lake” (World Heritage 2011); “Angkor” (World Heritage 1992); “Mount Fuji” (World Heritage 2013, “sacred place and source of artistic inspiration”).
- Australian Bureau of Statistics (2024): Australian population about 27 million.

Australia's water resources: distribution, variability and the forecast impacts of climate change

Geography 7 · Chapter 1 — Water in the world · Section 1C Owns **VC2HG8K03** (Students learn about). Draws on elaborations .E01 .E02 .E03 .E04 .E05.

Theory

Teaching sequence (teacher note — not assessed student text)

1. Open with the balance question *where does the rain go?* (Figure 1) and teach the terms of the water balance before any mapping.
2. Map the distribution (Figures 2–4): let students state the wet-edge, dry-middle pattern from the figures before reading the prose.
3. Variability (Figures 5, 6, 10): same dams, different decades; then the sponge effect to explain why droughts linger.
4. Observed change (Figures 7, 8) before forecasts (Figure 8 band, Figure 9) — keep *observed* and *forecast* language distinct in class discussion.
5. Close with the evidence-based response task (Q13) as the CD's assessment; it is source-led and needs no material beyond this section.
6. All tasks are source- and figure-led. Fieldwork is not required here (fieldwork method is owned by 5B).

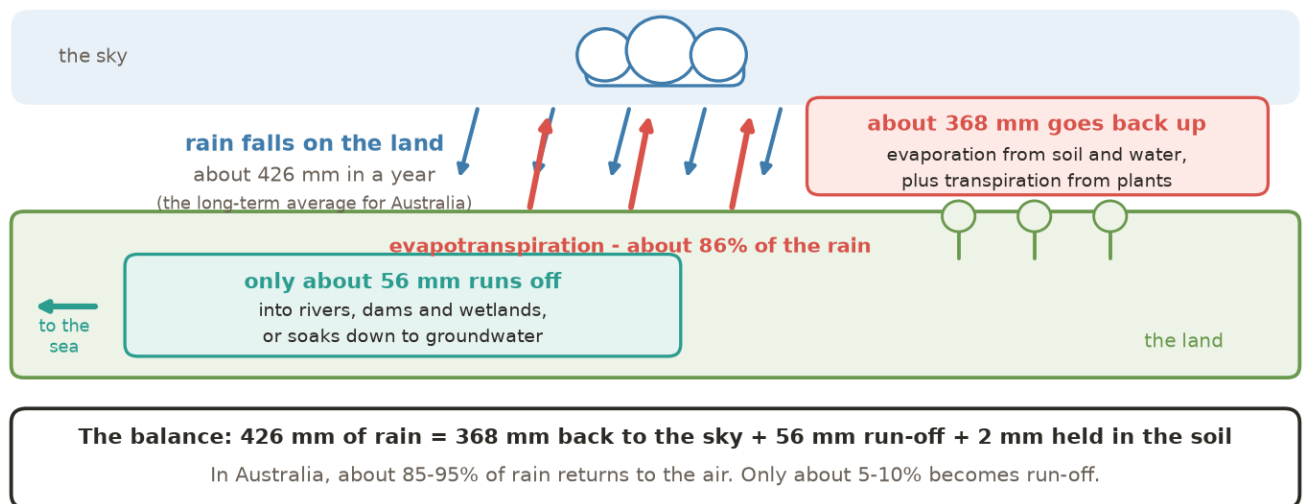
1. The water balance: where the rain goes

The water cycle (Section 1A) keeps refilling Australia's water. But rainfall alone does not tell us how much water people can use. For that we need the **water balance** — the account of the water that comes in and the water that goes out.

When rain falls on the land, three things happen to it. Some **evaporates**: the sun turns liquid water into vapour and it returns to the sky. Some is taken up by plants and released from their leaves — **transpiration**. Together these two losses are called **evapotranspiration**. The rest **runs off**: it flows into rivers, dams and wetlands, or soaks down to become **groundwater**, the water held in the spaces in soil and rock underground.

Where does Australia's rain go?

The water balance of an average year, from the long-term record (1911-2012)



Compare: in a very wet year (2011-12) Australia had 567 mm of rain - 33% above average.

That is why rainfall alone does not tell us how much water people can use.

Data: Bureau of Meteorology, Australian Water Resources Assessment 2012, checked 25 August 2026.

Long-term modelled averages for the whole continent. Figures are rounded.

A water balance diagram for Australia: about 426 millimetres of rain falls in an average year, about 368 millimetres returns to the sky as evapotranspiration, and only about 56 millimetres runs off into rivers, dams and groundwater.

Source: Bureau of Meteorology, Australian Water Resources Assessment 2012 (long-term record 1911–2012), checked 25 August 2026.

So in an average year about 426 mm of rain falls on Australia, about 368 mm goes back to the sky, and only about 56 mm runs off — roughly 13% of the rain. Across the continent, about 85–95% of the rain returns to the air and only about 5–10% becomes run-off.

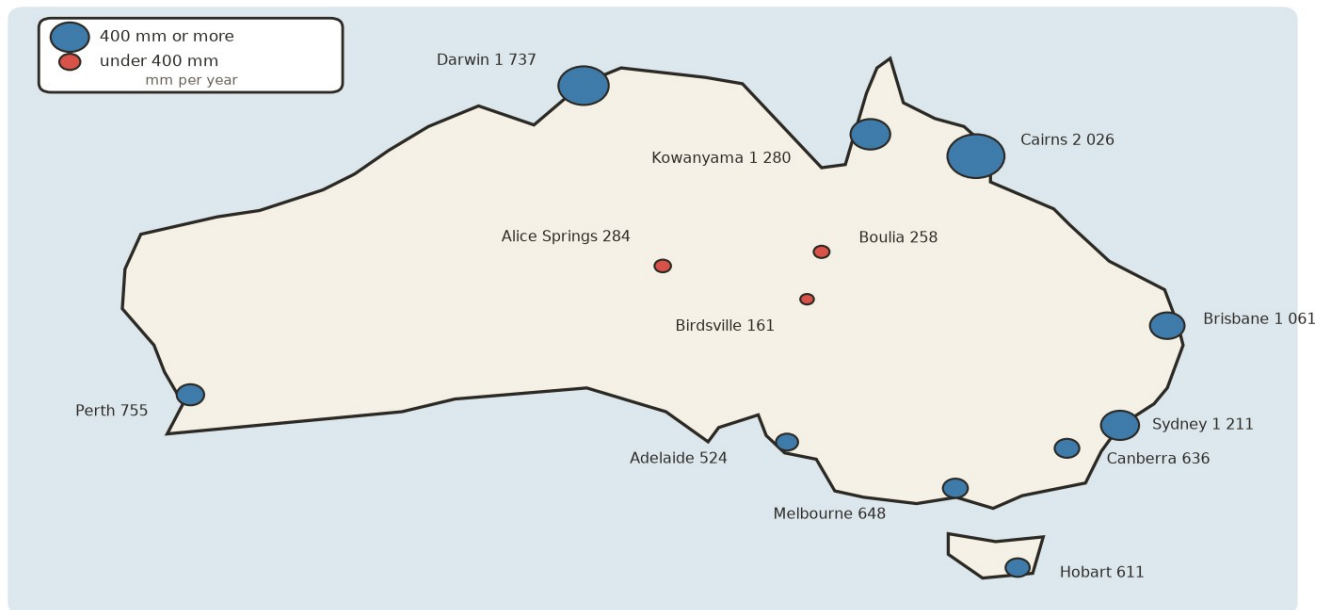
Now compare Australia with other continents (.E01). Australia is the driest continent that people live on: its rainfall averages only 457 mm a year (1900–2020). And its rivers are the third most variable in the world — their flows change about twice as much as the rivers of most other countries, in a study of 1,221 rivers across 36 countries. So even where another continent gets the same rain as Australia, more of that rain stays in its rivers and less evaporates. The water balance explains why Australia has less water to use than wetter continents.

(A data note: the two long-term averages above — 426 mm and 457 mm — come from two different government records using different methods and year ranges. They differ a little and tell the same story.)

2. Where Australia's water is

Wet edges, dry middle: rain per year across Australia

Each dot is a Bureau of Meteorology measuring station. Bigger dot = more rain.



Cairns gets about 2 026 mm of rain a year. Birdsville gets about 161 mm - roughly 13 times less.

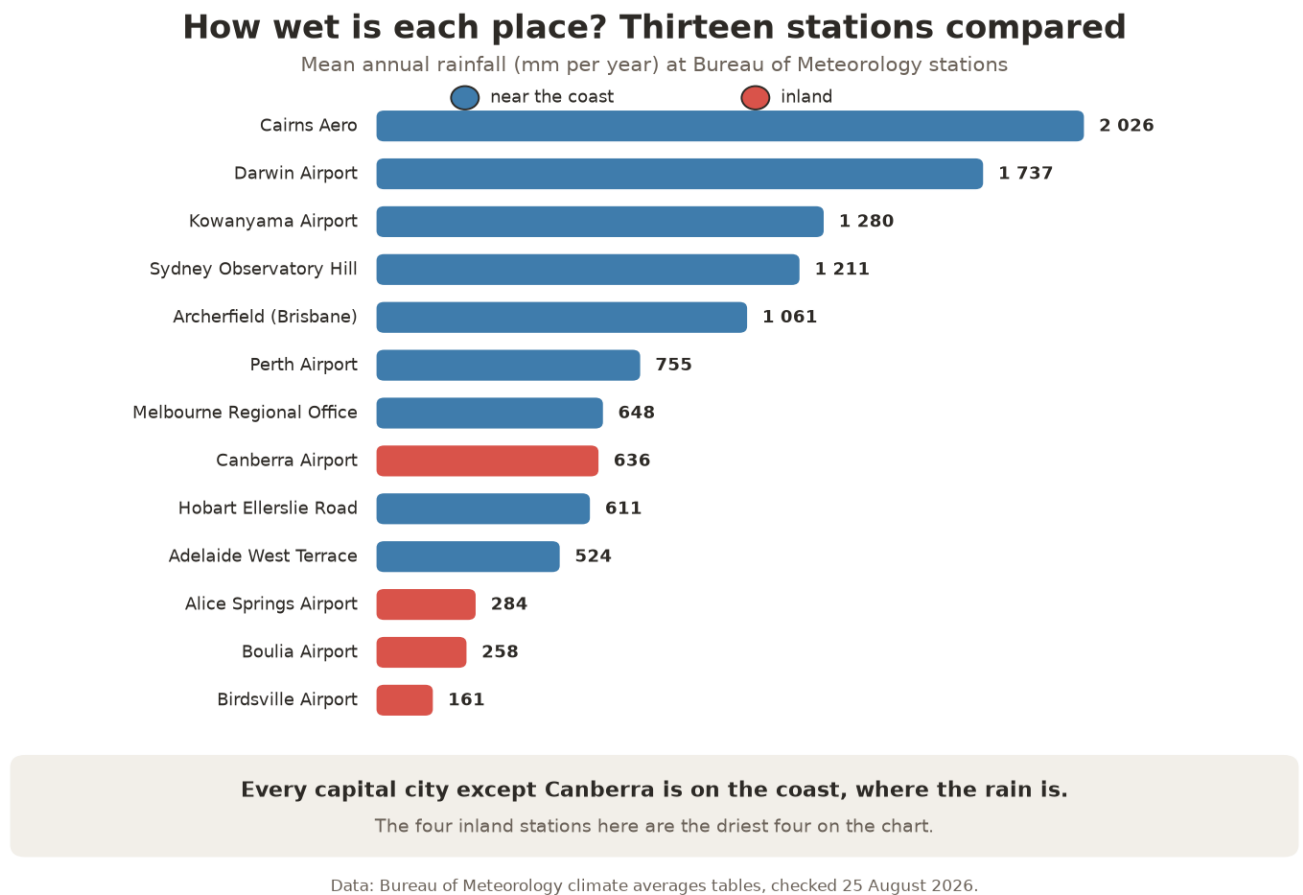
The wettest places are near the coast in the north and east. The centre is dry almost everywhere.

Data: Bureau of Meteorology climate averages (13 stations), checked 25 August 2026.

The coastline is simplified, and dots are placed at the approximate position of each station.

A simplified map of Australia showing 13 Bureau of Meteorology rainfall stations as dots. Large blue dots near the north, east and south-west coasts show wet places such as Cairns with 2 026 millimetres a year; small red dots in the centre show dry places such as Birdsville with 161 millimetres.

Source: Bureau of Meteorology climate averages, 13 stations, checked 25 August 2026.



A bar chart of mean annual rainfall at 13 stations, from Cairns Aero at 2 026 millimetres down to Birdsville Airport at 161 millimetres, with coastal stations in blue and inland stations in red.

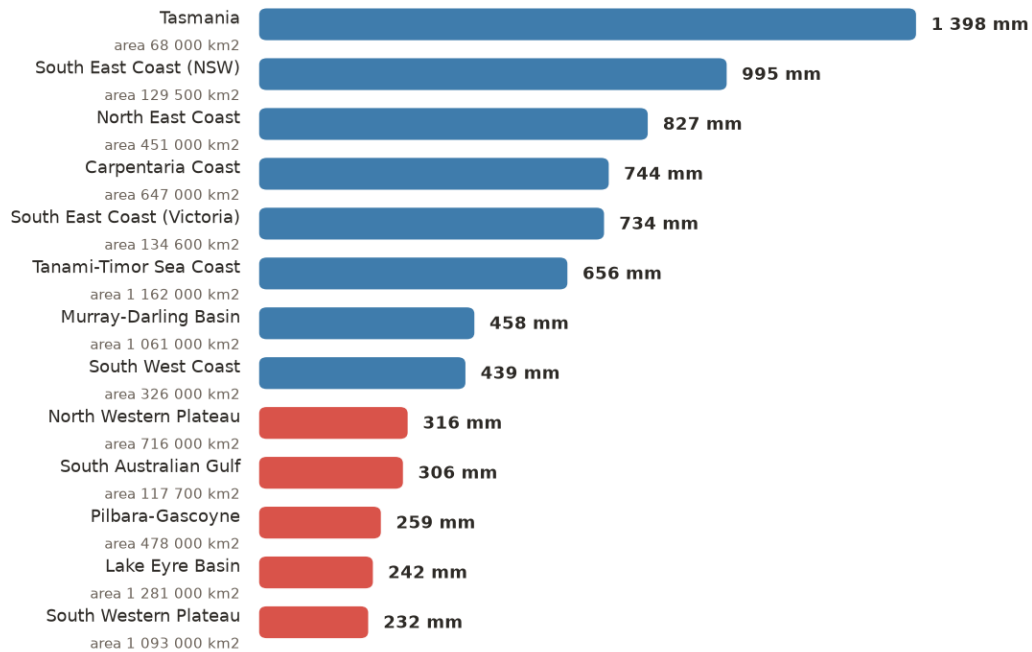
Source: Bureau of Meteorology climate averages tables, checked 25 August 2026.

The pattern is clear: the wet places ring the coast — especially the north and east — while the middle is dry. Cairns gets about 2 026 mm of rain in a year; Birdsville gets about 161 mm, roughly 13 times less.

Geographers also split the continent into 13 **drainage divisions** — big areas whose rain collects into the same river systems.

Thirteen great water areas: Australia's drainage divisions

Rainfall per year in each division, with the division's area



The four driest divisions get under 310 mm of rain a year, yet together they cover about two-fifths of the continent.

Data: Australia State of the Environment 2021 (drainage divisions table), checked 25 August 2026.

A bar chart of the 13 drainage divisions, from Tasmania at 1 398 millimetres of rain a year down to the South Western Plateau at 232 millimetres, with each division's area listed.

Source: Australia State of the Environment 2021, inland water (drainage divisions table), checked 25 August 2026.

What does this mean for people? (.E02) Most Australians live where the water is: every capital city except Canberra is on the coast. People in the dry middle get far less rain than people on the wet coasts — 161 mm at Birdsville against 2 026 mm at Cairns — so inland towns must save what rain they can. Because Australian rivers are so variable, more than 500 large surface-water storages (dams) have been built to keep wet-year water for dry years — each holding at least 1 GL. (A **gigalitre**, GL, is one billion litres — about 400 Olympic swimming pools.)

3. Why Australia's water varies

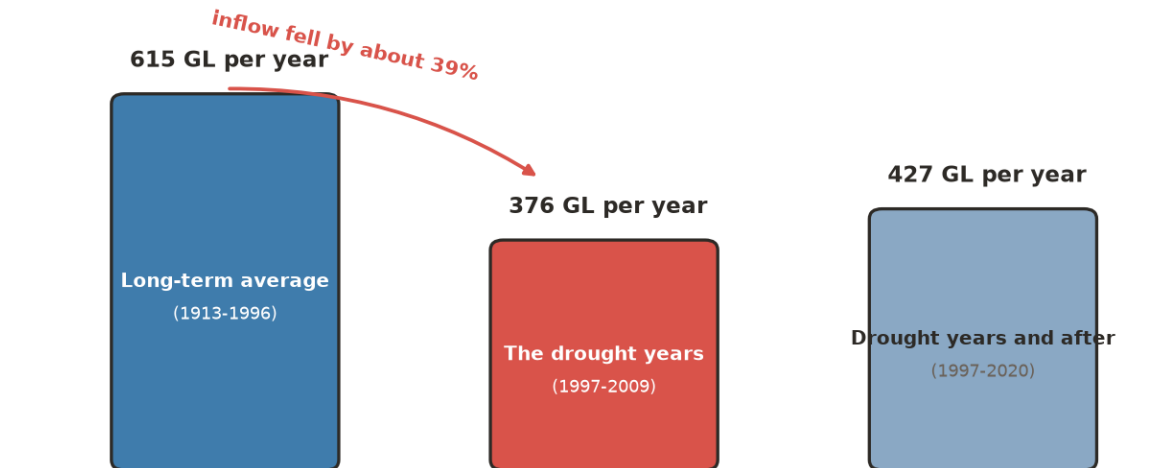
Rain here differs from place to place *and* from year to year. Five factors drive that variability (.E03):

- **Location.** Coastal and northern places get far more rain than inland and far-central places (Figures 2–4).
- **Climate and its drivers.** Australia has wet years and dry years. In some years the Pacific Ocean is in a **La Niña** phase, which usually brings extra rain to much of Australia; in other years it is in an **El Niño** phase, which usually brings less.
- **Topography** — the shape of the land. When moist sea air meets a range such as the Great Dividing Range, it rises, cools and drops its rain on the coastal side, leaving the inland side drier.
- **Seasonality** — *when* the rain arrives. Northern Australia gets most of its rain from the summer **monsoon**, the wet-season storms of the tropics, while southern Australia leans on winter rain.
- **Evaporation.** Hotter places and hotter years lose more water back to the sky, so less runs off.

Because of these factors, Australia's rivers rise and fall more than almost any others on Earth (Section 1). The numbers make it real:

Same dams, different years: water flowing into Melbourne's storages

Average inflow per year (gigalitres, GL) for three different periods



Rain is variable: the same city can get far less water from one decade to the next.

Dry soil also soaks up rain like a sponge, so even less reaches the dams.

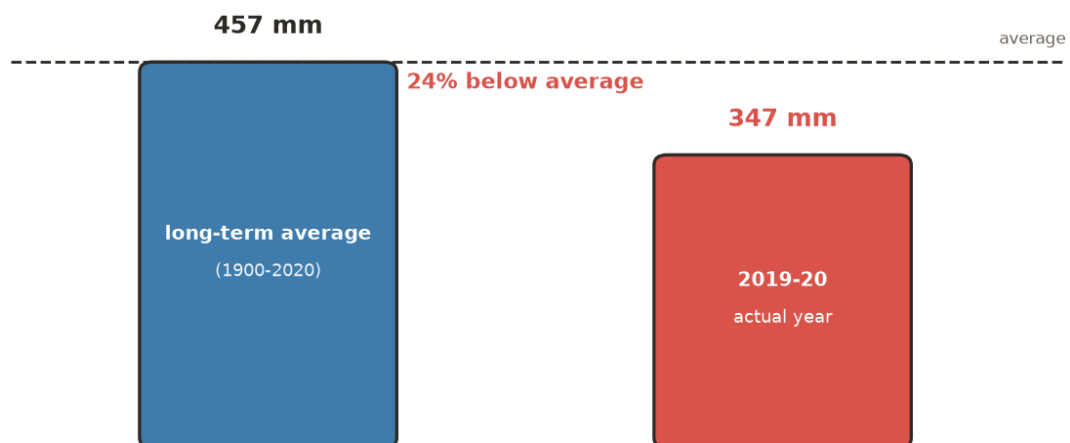
Data: Melbourne Water, checked 25 August 2026. 1 GL = 1 billion litres.

A bar chart of water flowing into Melbourne's storages: a long-term average of 615 gigalitres a year (1913–1996), falling to 376 gigalitres in the drought years 1997–2009, and 427 gigalitres across 1997–2020.

Source: Melbourne Water, checked 25 August 2026.

One very dry year: Australia's rainfall in 2019-20

Area-averaged rainfall for the whole continent, in millimetres



2018-19 was the driest two-year stretch on record across Australia.

In dry years like these, dams fall and water restrictions can start.

Data: Australia State of the Environment 2021, checked 25 August 2026.

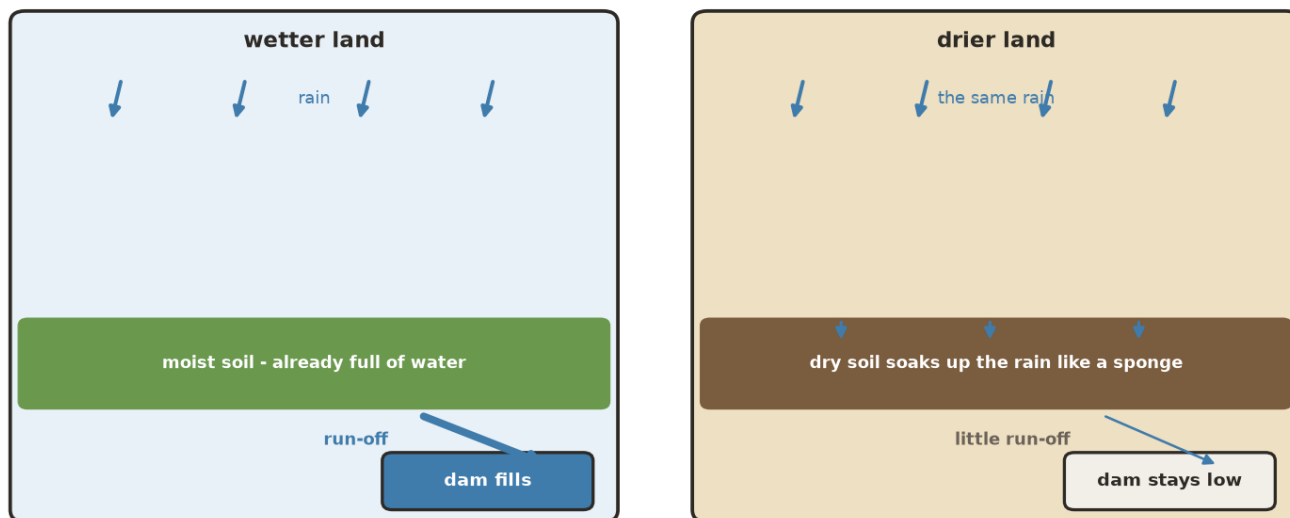
A bar chart comparing Australia's long-term average rainfall of 457 millimetres with the 347 millimetres that fell in 2019–20, a year 24% below average.

Source: Australia State of the Environment 2021, inland water, checked 25 August 2026.

And a dry year does not end just because rain returns. Dry catchments (the land that drains into a river or dam) behave like a dry sponge:

The sponge effect: dry land drinks the rain

The same storm, falling on two different catchments



After dry years, the first rains go to refilling the soil - dams recover slowly.

This is one reason droughts keep affecting water supplies even after rain returns.

Idea: Melbourne Water (the sponge effect), checked 25 August 2026.

A two-panel schematic: the same rain falls on wetter land and on drier land. On the wetter land, moist soil lets water run off and the dam fills; on the drier land, dry soil soaks the rain up like a sponge and the dam stays low.

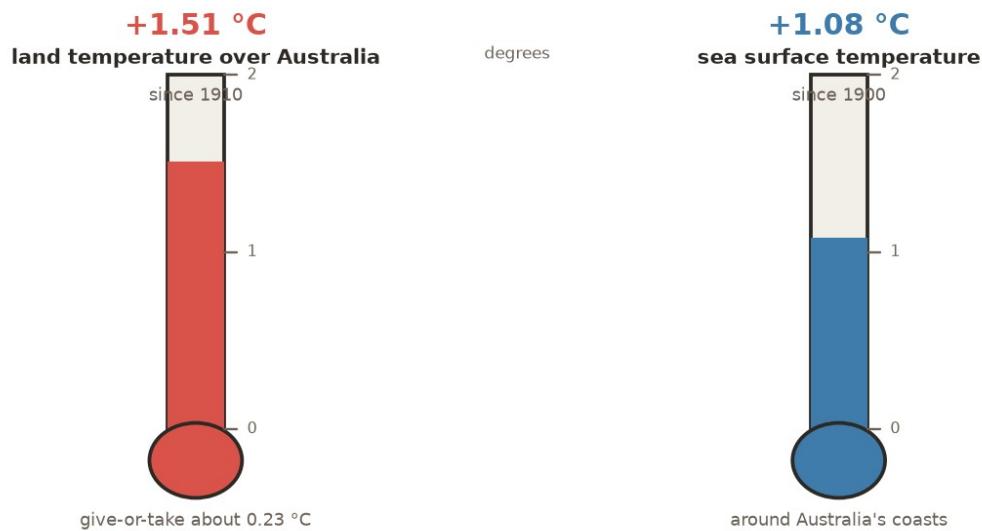
Source: the sponge effect as described by Melbourne Water, checked 25 August 2026.

4. Climate change: what is already observed

The climate is changing, and the water balance is changing with it (.E04).

Australia is getting hotter

How much temperatures have risen since records began



A hotter climate changes the water balance: more evaporation, drier soil.

Warming is one reason water resources are forecast to change.

Data: Bureau of Meteorology, State of the Climate 2024, checked 25 August 2026.

Two thermometer diagrams: land temperature over Australia has risen 1.51 degrees Celsius (give-or-take about 0.23 degrees) since 1910, and sea surface temperature around Australia has risen 1.08 degrees since 1900.

Source: Bureau of Meteorology, State of the Climate 2024, checked 25 August 2026.

Rain is changing: the south is getting drier

Change in April-October rainfall recorded by the Bureau of Meteorology

The rain that farms and dams rely on in winter has fallen away.



Forecasts for the future (State of the Climate 2024):

- cool-season rain to keep falling across southern and eastern Australia
- heavy rain to fall in shorter, harder bursts, even where averages fall

Data: Bureau of Meteorology, State of the Climate 2024, checked 25 August 2026.

A bar chart of recorded falls in cool-season rainfall: south-west Australia down 16% for April–October since 1970 and down 20% for May–July since 1970; south-east Australia down 9% for April–October since 1994.

Source: Bureau of Meteorology, State of the Climate 2024, checked 25 August 2026.

The Bureau also reports that since 1970 the flow in rivers has fallen at most measuring stations in the south — while rain and river flows have *risen* in parts of northern Australia since the 1970s. The drying is not everywhere; it is a pattern, and the pattern is strongest in the south.

5. What is forecast

A **forecast** is what scientists expect from here on, and they state how sure they are (.E04, .E05). For the Murray–Darling Basin — the continent’s biggest river system, home to about 2.4 million people and the source of much of Australia’s food — the picture is this:

What scientists forecast for the Murray-Darling Basin

From the Sustainable Yields 2025 report for the Murray-Darling Basin

Hotter temperatures right across the Basin	almost certain
Less run-off and less water available, especially in the south	very likely
Winter rainfall to fall in the southern Basin	very likely
Winter rainfall to fall in the northern Basin	likely
Droughts more often, more severe, and longer	report finding
Groundwater to refill more slowly, especially in the south	report finding

"Almost certain" and "very likely" are the scientists' own words for how sure they are.
"Likely" means it may well happen. "Report finding" is reported without a chance rating.

The Murray-Darling Basin covers about 1 million square kilometres.

About 2.4 million Australians live there, and it grows much of Australia's food.
So a drier Basin matters to the whole country.

Data: Murray-Darling Basin Authority, Sustainable Yields 2025, checked 25 August 2026.

A list of forecasts for the Murray-Darling Basin with confidence chips: hotter across the Basin (almost certain); less run-off and water available, especially in the south (very likely); winter rain to fall in the southern Basin (very likely) and northern Basin (likely); droughts more often, more severe and longer; groundwater to refill more slowly in the south.

Source: Murray–Darling Basin Authority, Sustainable Yields 2025, checked 25 August 2026.

For southern and eastern Australia as a whole, the forecast adds: cool-season rain keeps falling; south-west Western Australia keeps drying; droughts grow longer and more severe; and heavy rain arrives in shorter, harder bursts.

So the distribution, the variability and the forecasts all point the same way: water in southern Australia will be harder to lean on, and managing it well — the story of Section 1D — matters more, not less.

Worked examples

Demonstration 1 — scaffolded (.E01)

Use the water balance to compare Australia with a made-up wetter continent, “Continent B”. All figures are mm per year.

Working	Comment
Australia: rain 426; to the sky 368; held in soil 2. Run-off = $426 - 368 - 2 = 56$ mm.	Run-off is the share left for rivers, dams and groundwater.
Australia's share: $56 \div 426 \approx 0.13$, about 13%.	Of every 100 L of rain, only about 13 L reach the rivers.
Continent B (made up): rain 800; to the sky 420; soil 0. Run-off = $800 - 420 = 380$ mm.	Same bookkeeping, different continent.
Continent B's share: $380 \div 800 \approx 0.48$, about 48%.	Nearly half the rain becomes river water.
Compare 48% with 13% — and Australia also gets less	Less rain, <i>and</i> a smaller share of it becomes water to

Working	Comment
rain to start with.	use. ✓

Demonstration 2 — scaffolded (.E03)

How much water did Melbourne’s storages miss in the drought years?

Working	Comment
Long-term inflow 615 GL a year (1913–1996); drought inflow 376 GL a year (1997–2009).	Read the two periods from Figure 5.
Gap: $615 - 376 = 239$ GL each year.	The same catchments delivered this much less water, every year.
Share: $239 \div 615 \approx 0.39$, a fall of about 39%.	Close to two-fifths less.
In pools: 1 GL $\approx$ 400 Olympic pools, so 239 GL $\approx$ 95 600 pools — every single year.	Changing the unit makes a big number real. ✓

Practice questions

Scaffolded

Q1 (.E01). Figure 1. (a) How many mm of rain fall on Australia in an average year? (b) How many mm go back to the sky? (c) Show that the run-off share is about 13%.

Q2 (.E01). A made-up catchment gets 500 mm of rain in a year. Evapotranspiration takes 400 mm and the soil holds none. (a) How many mm run off? (b) What share of the rain is that, as a percentage?

Q3 (.E02). Figure 3. Put these places in order from driest to wettest: Cairns, Birdsville, Canberra, Darwin. Which two are inland?

Q4 (.E02). Using one number from Figure 3, give one reason most Australians live near the coast.

Q5 (.E03). Match each factor (1–5) to the sentence (a–e) it explains. 1 location · 2 climate driver · 3 topography · 4 seasonality · 5 evaporation (a) The Great Dividing Range squeezes rain onto the coastal side. (b) Nearly all of Darwin’s rain arrives in the summer wet season. (c) Alice Springs sits far from the sea, in the dry middle. (d) A hot year returns more water to the sky, so rivers get less. (e) A La Niña year usually brings extra rain to much of Australia.

Q6 (.E03). Figure 5. (a) Which period had the lowest inflow? (b) How many GL a year below the long-term average was it? (c) About what percentage fall is that?

Q7 (.E04). Figures 7 and 8. (a) By how much has the land temperature over Australia risen since 1910? (b) Which region lost the most cool-season rain, and by how much?

Q8 (.E05). Figure 9. Name the finding rated “almost certain”, and two findings rated “very likely”.

Un scaffolded

Q9 (.E02). Describe the pattern in Figure 4, then explain two reasons the pattern looks like that. (3–4 sentences.)

Q10 (.E03). “A year of average rain does not mean average water.” Explain this sentence using the sponge effect and one number from Figure 5 or Figure 6.

Q11 (.E04). Using Figures 7 and 8, list two changes already observed in Australia’s climate and name the part of the country that is drying most.

Q12 (.E05). Build a cause-and-effect chain, in your own words, from a hotter climate to less water in a southern town’s dam. Use at least four steps.

Evidence-based response task

Q13 (.E01–.E05). Claim: *Australia’s water resources are spread unevenly, vary a lot, and are likely to become harder to lean on as the climate changes.*

Write a response of 150–200 words (paragraph or poster) that:

- uses at least **three** figures from this section as evidence, naming the number **and** its source;
 - explains — not just lists — how each piece of evidence supports the claim;
 - closes with one sentence on what this means for people in southern Australia.
-

Answers

Q1. (a) about 426 mm. (b) about 368 mm. (c) $56 \div 426 \approx 0.13 \approx 13\%$.

Q2. (a) $500 - 400 = 100$ mm. (b) $100 \div 500 = 20\%$.

Q3. Birdsville (161), Canberra (636), Darwin (1 737), Cairns (2 026). Inland: Birdsville and Canberra.

Q4. Any one with a figure, e.g. coastal Cairns gets 2 026 mm a year while inland Birdsville gets 161 mm, so more water for farms and towns is found near the coast.

Q5. 1–c, 2–e, 3–a, 4–b, 5–d.

Q6. (a) The drought years, 1997–2009. (b) $615 - 376 = 239$ GL a year. (c) about 39%.

Q7. (a) $+1.51$ °C (give-or-take about 0.23 °C). (b) South-west Australia: -20% for May–July since 1970 (and -16% for April–October).

Q8. Almost certain: hotter across the Basin. Very likely (any two): less run-off and water available (especially the south); winter rain to fall in the southern Basin.

Q9. Pattern: rainfall is high in the coastal divisions (Tasmania 1 398 mm, South East Coast NSW 995 mm) and low in the inland divisions (Lake Eyre Basin 242 mm, South Western Plateau 232 mm). Reasons (any two): distance from the sea; the Great Dividing Range keeping rain on the coastal side; the north's monsoon rain; high evaporation in the hot centre.

Q10. After dry years the soil soaks up the first rains like a sponge, so dams recover slowly — e.g. Melbourne's inflow averaged only 427 GL a year across 1997–2020, well below the 615 GL long-term average, even after rain returned.

Q11. Observed: land temperature up 1.51 °C since 1910; cool-season rain down (e.g. -16% in the south-west since 1970); river flows down at most southern stations. Drying most: the south (south-west and south-east).

Q12. Any four-step chain, e.g. hotter air → more evaporation from soil and storages → drier soil soaks up more of the rain → less run-off reaches rivers → dams fill less → the town's water supply shrinks.

Q13. See the sample response in the worked solutions.

Fully-worked solutions

Q1. (a) 426 mm. (b) 368 mm. (c) Run-off = $426 - 368 - 2 = 56$ mm; $56 \div 426 \approx 0.13$, so about 13% of the rain runs off.

Q2. (a) $500 - 400 = 100$ mm runs off. (b) $100 \div 500 = 0.20 = 20\%$ — a wetter share than Australia's real 13%.

Q3. Driest to wettest: Birdsville 161 mm → Canberra 636 mm → Darwin 1 737 mm → Cairns 2 026 mm. The two inland places are Birdsville and Canberra.

Q4. Sample: *Coastal places get far more rain — Cairns 2 026 mm a year against 161 mm at Birdsville — so rivers, dams and groundwater near the coast can supply more people.*

Q5. 1–c (location), 2–e (climate driver), 3–a (topography), 4–b (seasonality), 5–d (evaporation).

Q6. (a) 1997–2009. (b) $615 - 376 = 239$ GL a year less. (c) $239 \div 615 \approx 0.39 \approx 39\%$ below the long-term average.

Q7. (a) 1.51 °C warmer since 1910 (give-or-take about 0.23 °C). (b) South-west Australia, down 20% for May–July since 1970 (April–October down 16%).

Q8. “Almost certain”: the Basin gets hotter. “Very likely”: less run-off and less water available (especially in the south), and winter rainfall falling in the southern Basin.

Q9. Sample: *Figure 4 shows the wet divisions on the coasts — Tasmania at 1 398 mm and the South East Coast (NSW) at 995 mm — and the dry divisions inland, with the South Western Plateau at 232 mm. Two reasons: moist sea*

air drops its rain near the coast, and ranges such as the Great Dividing Range leave the inland side drier; the hot centre also loses more water to evaporation.

Q10. Sample: *Rain has to reach the dam to count. After long dry spells the soil soaks up the first rains like a sponge, so inflows stay low: Melbourne's storages averaged 427 GL a year across 1997–2020 against a long-term average of 615 GL. So even a "normal" rain year can still leave water short.*

Q11. Sample: *Already observed: the land is 1.51 °C warmer than in 1910, and cool-season rain has fallen (–16% in the south-west since 1970, –9% in the south-east since 1994). The south of the continent is drying most.*

Q12. Sample chain: (1) a hotter climate speeds up evaporation; (2) more water leaves soils, rivers and storages; (3) drier soil soaks up more of each rain; (4) less run-off reaches the rivers; (5) the town's dam fills less often; (6) water restrictions become more likely.

Q13. Sample response (about 180 words):

Australia's water is spread unevenly. Figure 3 shows Cairns near the wet coast getting 2 026 mm of rain a year while Birdsville in the dry middle gets 161 mm (Bureau of Meteorology), and Figure 4 shows the four driest divisions — about two-fifths of the continent — under 310 mm (State of the Environment 2021). This supports "spread unevenly".

It also varies a lot: Melbourne's storages received 615 GL a year over 1913–1996 but only 376 GL in the drought years 1997–2009 (Melbourne Water) — a fall of about 39% from the same catchments, which supports "varies a lot".

Finally, the climate is changing the balance: Australia has warmed 1.51 °C since 1910 and cool-season rain in the south-west has fallen 16% since 1970 (State of the Climate 2024), and the Sustainable Yields 2025 report rates less run-off in the Murray–Darling Basin "very likely". This supports "harder to lean on".

For people in southern Australia, that means planning for less water: bigger storages, smarter use, and new sources.

Sources (all checked 25 August 2026)

- Bureau of Meteorology, *Australian Water Resources Assessment 2012* — National Overview (long-term water balance 1911–2012; read via an archived copy of the BOM page).
- Bureau of Meteorology, *State of the Climate 2024* (warming, observed rainfall changes, river-flow trends, forecasts).
- Bureau of Meteorology, climate averages station tables (13 stations' mean annual rainfall).
- Australian Government, *Australia State of the Environment 2021* — Inland water: water sources (457 mm mean; driest inhabited continent; streamflow variability; 2019–20 rainfall; 500+ storages; drainage divisions table).
- Melbourne Water, *Our water supply challenges* (storage inflows; the sponge effect).
- Murray–Darling Basin Authority, *Sustainable Yields 2025* — insights and findings (Basin forecasts; Basin facts).

Water scarcity: its nature, causes and the strategies for overcoming it, in Australia and West Asia or North Africa

Curriculum focus — Victorian Curriculum 2.0, Geography, Levels 7 and 8, strand *Geographical Knowledge and Understanding*, sub-strand *Water in the world*. Content description VC2HG8K04.

Elaborations drawn on: VC2HG8K04 .E01 (causes of water scarcity), VC2HG8K04 .E02 (why water is hard to manage), VC2HG8K04 .E03 (evaluating strategies to overcome water scarcity). Case regions:

Australia and **West Asia** (with a look at North Africa).

In this section

Water is a **renewable resource**: the **water cycle** keeps refilling rivers, lakes and underground water. But water is not shared out evenly. Some places have far more than they need, and some places have far less. When a place cannot get enough fresh water to meet the needs of its people, its farms and its environment, we say it has **water scarcity**.

In this section you will learn:

- what water scarcity is, and the two ways a place can run short (**physical** and **economic** scarcity);
- what causes water scarcity;
- why water is such a hard resource to manage;
- the strategies places use to overcome water scarcity, and how we judge them;
- real examples from **Australia** and from **West Asia** (and a look at **North Africa**).

Key words to learn: water scarcity, physical scarcity, economic scarcity, renewable, groundwater, reservoir, desalination, stormwater, recycling, virtual water, irrigation, water stress.

1. What is water scarcity?

Water scarcity means a shortage of usable fresh water. It happens when the demand for water (how much people, farms and industry want to use) is more than the supply (how much fresh water is available).

There are two kinds of scarcity.

Physical scarcity is when there is simply not enough water in a place to meet all the demands. This includes the water that rivers and wetlands need to stay healthy. Dry regions with little rain, few rivers and high evaporation often have physical scarcity.

Economic scarcity is when water *is* there, but people cannot get it because there is not enough money, infrastructure or skill to capture, treat and deliver it. A place can have good rain yet still go thirsty if it lacks dams, pipes and treatment plants.

One common way to measure scarcity is to work out how much **renewable fresh water** a country has **per person** each year (in cubic metres, m³). The less water per person, the greater the scarcity. Researchers use these rough guide lines:

Water per person each year	What it means
more than 1,700 m ³	little or no water stress
1,000 to 1,700 m ³	water stress; shortages from time to time or in some places
less than 1,000 m ³	water scarcity
less than 500 m ³	absolute water scarcity

Two ways a place can run short of water

Physical scarcity

There is not enough water to meet all the demands, including the water that rivers and wetlands need to stay healthy.

Example: much of West Asia has very little renewable fresh water at all.

Economic scarcity

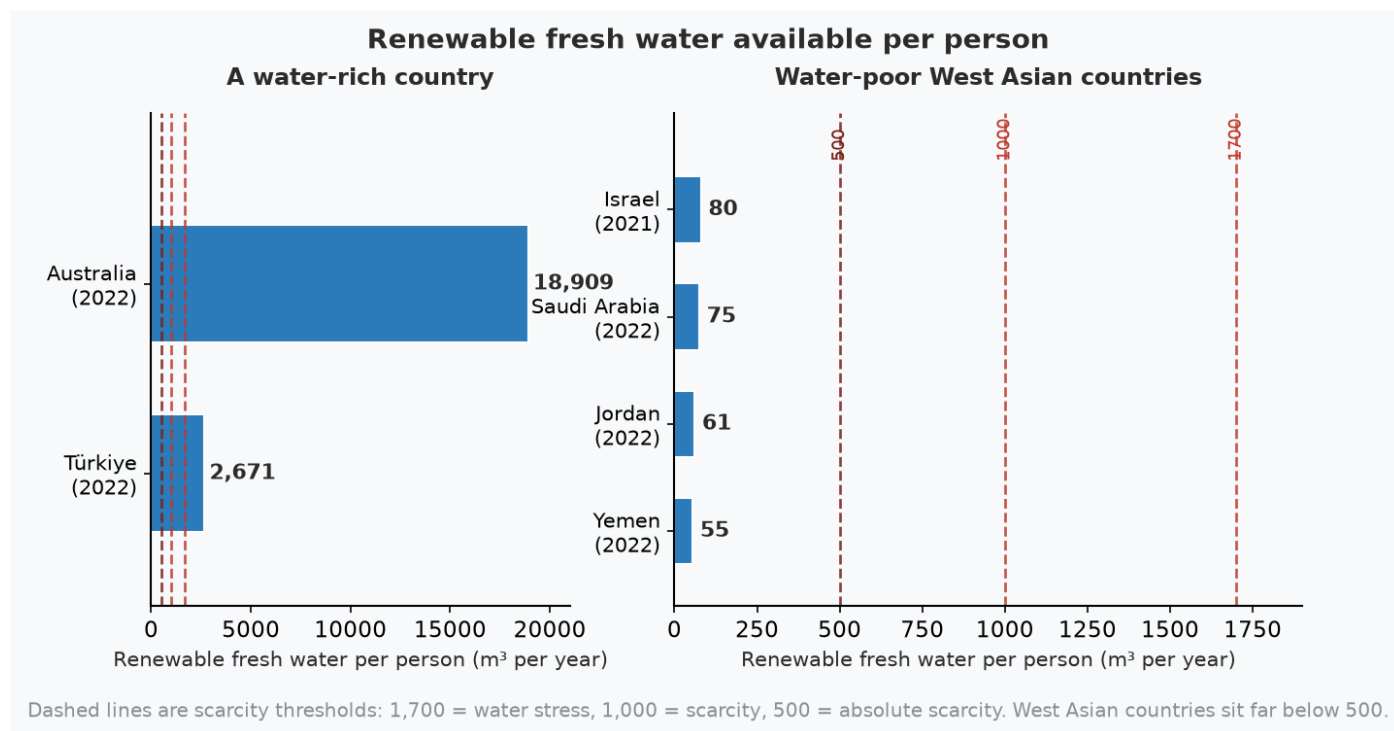
Water exists, but there is not enough money, infrastructure or capacity to capture, treat and deliver it to the people who need it.

Example: some places with good rainfall still lack dams, pipes or treatment.

Two labelled boxes explaining physical scarcity, where there is not enough water at all, and economic scarcity, where water exists but cannot be captured or delivered

2. Who is short of water? Reading the data

Let us look at real data for Australia and for West Asia (with North Africa's Egypt added for comparison).



Bar chart of renewable fresh water per person. Left panel: Australia about 18,909 and Turkey about 2,671 cubic metres, both above the scarcity lines. Right panel: Israel 80, Saudi Arabia 75, Jordan 61 and Yemen 55, all far below the 500 absolute scarcity line

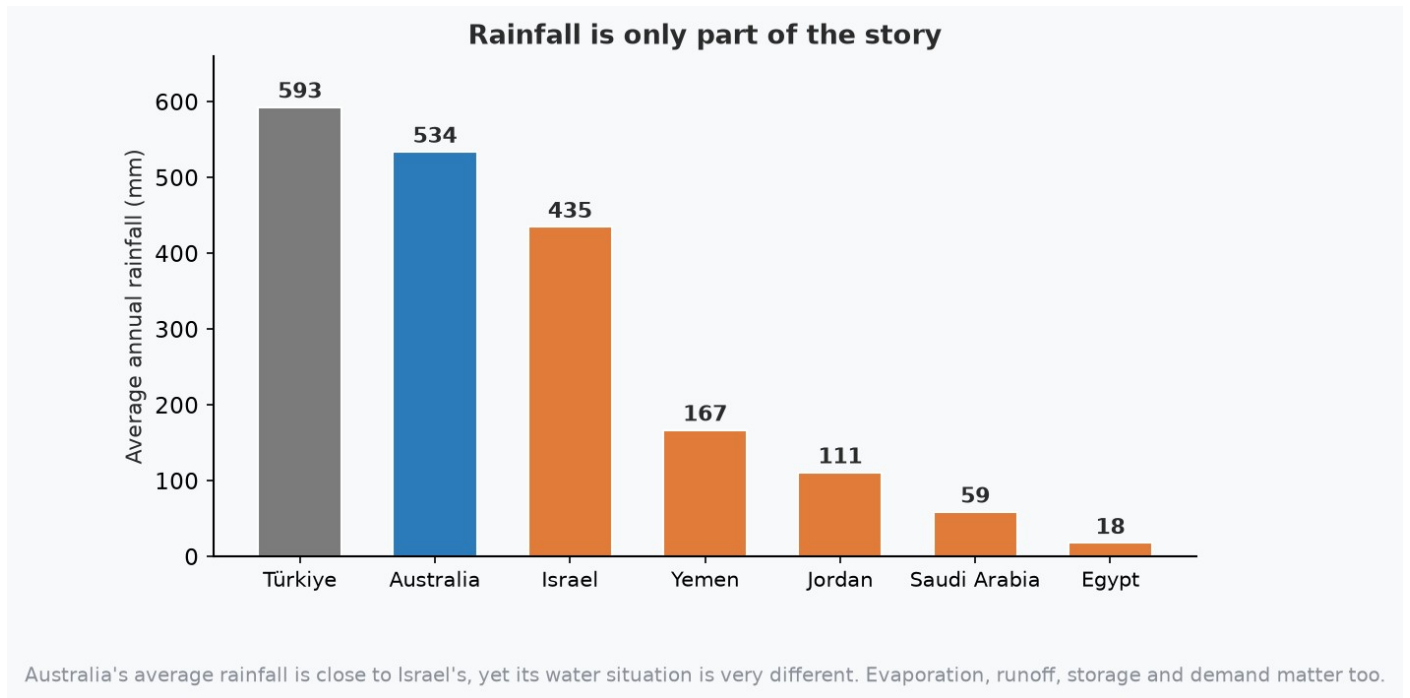
Source: World Bank indicator ER.H2O.INTR.PC — renewable internal freshwater resources per person (FAO AQUASTAT), latest year for each country, retrieved 25 August 2026.

Australia is **water-rich** as a whole: on average each person has about 18,900 m³ of renewable fresh water a year, far above every scarcity line. But look at West Asia. Israel, Saudi Arabia, Jordan and Yemen all sit far **below 500 m³ per**

person — that is **absolute water scarcity**. Egypt (North Africa) is even lower, at about 9 m³ per person, because almost all of its water arrives from the Nile, which starts in other countries.

So the pattern is clear: **Australia as a whole does not have a physical shortage of water, while much of West Asia and North Africa does.**

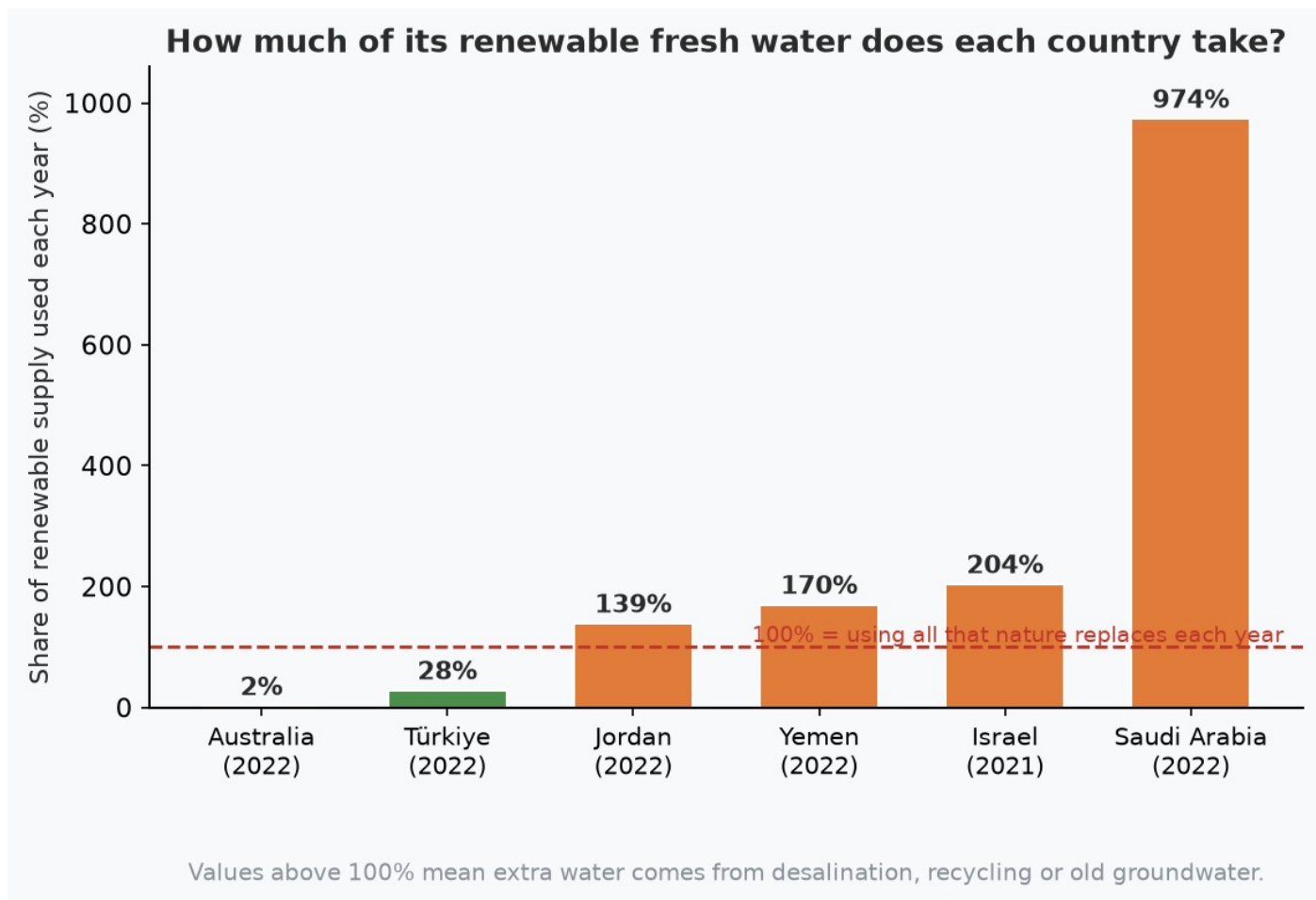
But a national average hides a lot. The next two charts explain why Australia still has to be careful with water.



Bar chart of average annual rainfall in millimetres: Turkey 593, Australia 534, Israel 435, Yemen 167, Jordan 111, Saudi Arabia 59, Egypt 18

Source: World Bank, indicator “Average precipitation in depth (mm per year)” (FAO), 2020, retrieved 25 August 2026.

Australia’s average rainfall (534 mm) is actually close to Israel’s (435 mm) and much higher than Saudi Arabia’s (59 mm). Yet Australia’s water situation is very different. Why? Because Australia is the driest inhabited continent: much of its rain is lost to **evaporation**, only a small share runs off into rivers, and the rain is spread very unevenly and changes a lot from year to year. **Rainfall alone does not tell you how much water a place can use.**



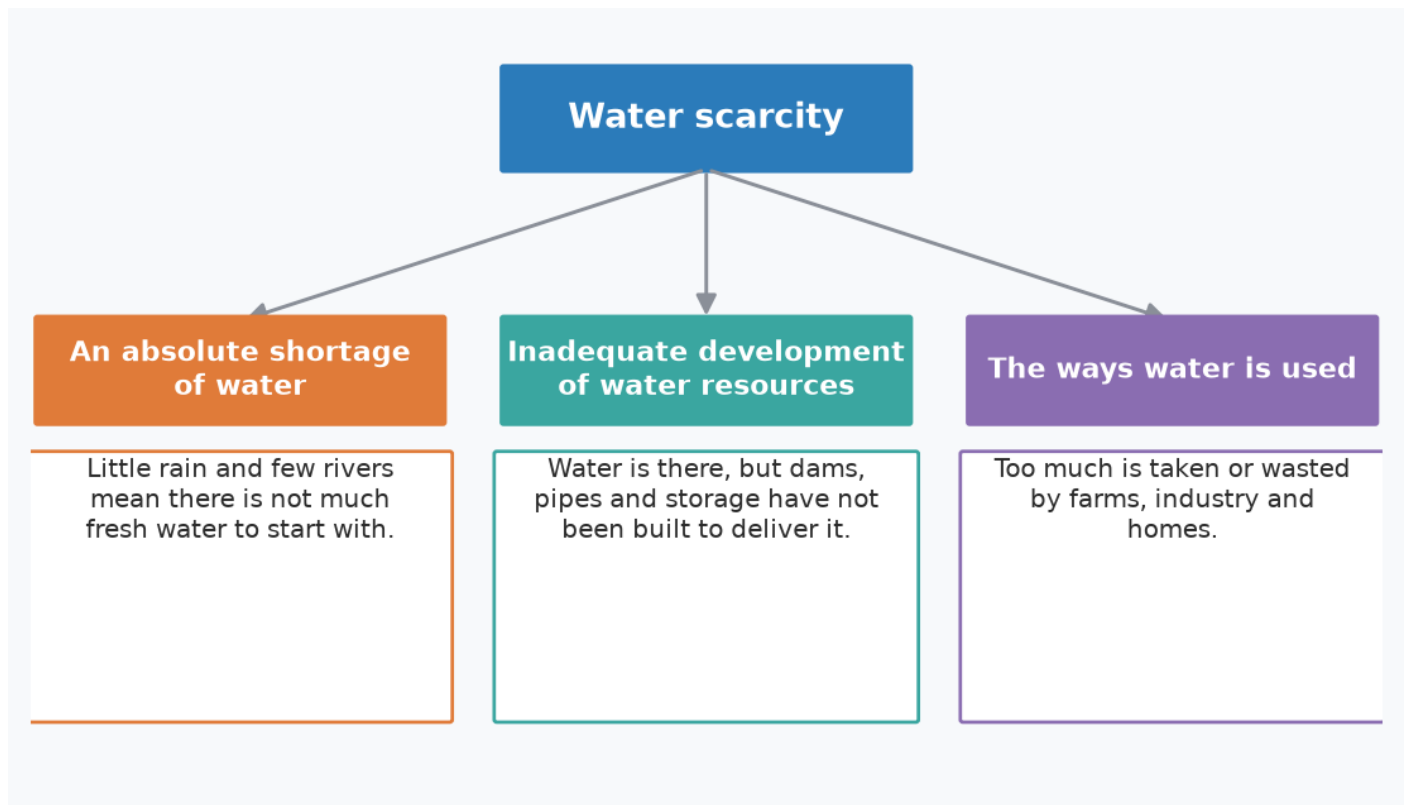
Bar chart of how much of its renewable fresh water each country uses each year: Australia 2 percent, Turkey 28 percent, Jordan 139 percent, Yemen 170 percent, Israel 204 percent, Saudi Arabia 974 percent, with a dashed line at 100 percent

Source: World Bank, indicator “Annual freshwater withdrawals, total (% of internal resources)” (FAO AQUASTAT), latest year for each country, retrieved 25 August 2026.

Australia uses only about **2%** of its renewable water each year. But Jordan, Yemen, Israel and Saudi Arabia use **more than 100%** — they take out more water than nature replaces each year. They can only do this by making new water (desalination and recycling) or by pumping old **groundwater** that took thousands of years to build up. Using water faster than it is replaced is not something a place can keep doing for ever.

3. What causes water scarcity?

Water scarcity has three broad causes.

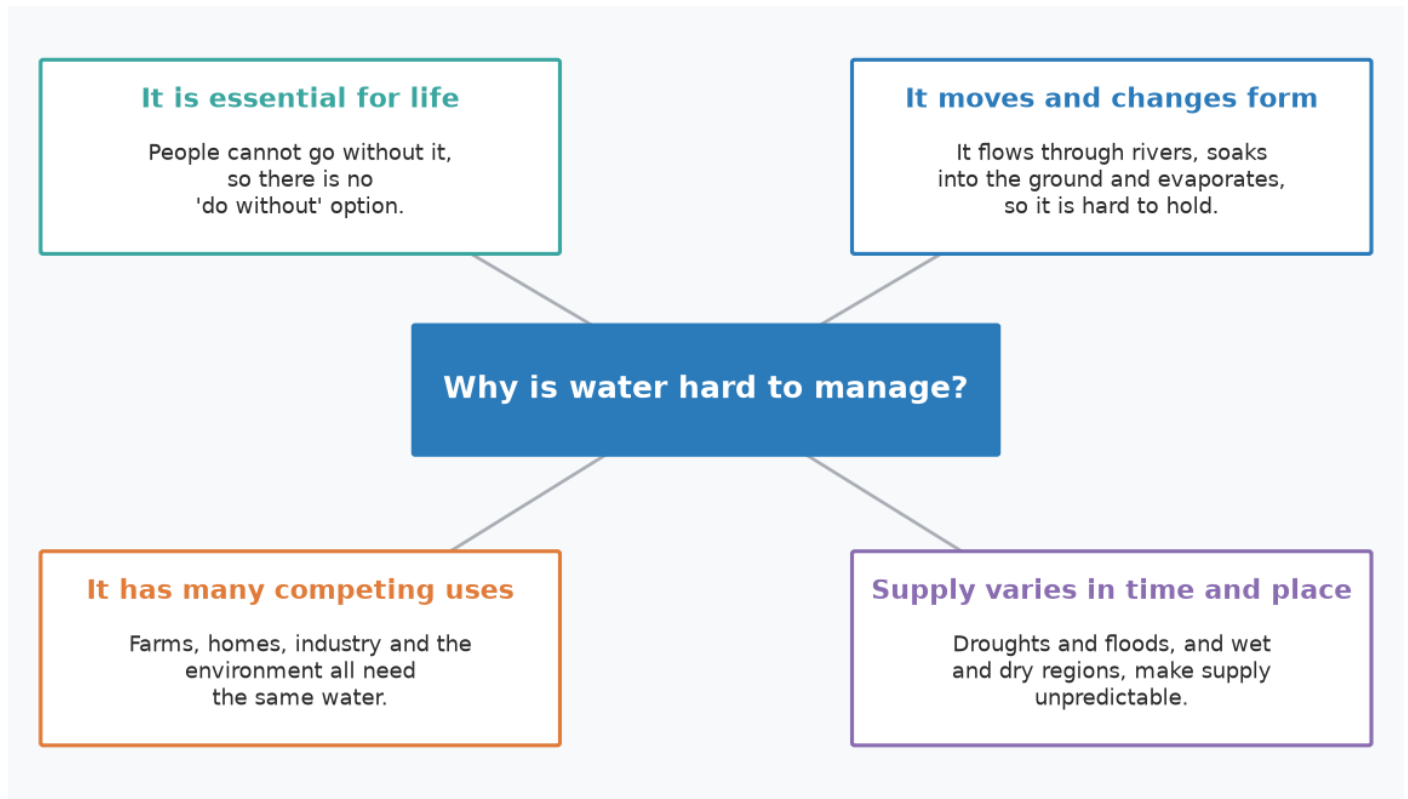


Concept map with water scarcity at the top branching to three causes: an absolute shortage of water, under-developed water resources, and the ways water is used, each with a short example

- 1. An absolute shortage of water.** A dry climate with little rain, few rivers and high evaporation means there is not much fresh water to start with. Most of West Asia and North Africa, and inland Australia, have this problem.
- 2. Inadequate development of water resources.** Water may be there, but if dams, pipes, treatment plants and storage have not been built, people cannot get it. This is the main cause of *economic* scarcity.
- 3. The ways water is used.** If farms, industry and homes take too much water, or waste it, the supply runs short even where the climate is not extreme. Growing water-hungry crops in dry places, leaking pipes, and over-pumping groundwater all add to water scarcity.

4. Why is water hard to manage?

Water is one of the hardest resources to manage, for four connected reasons.



Concept map with the question why is water hard to manage in the centre and four boxes: it is essential for life; it moves and changes form; it has many competing uses; and its supply varies in time and place

It is essential for life. People, animals and plants cannot survive without water, so there is no “do without” option. Demand never goes away.

It moves and changes form. Water flows through rivers, soaks into the ground and evaporates into the air. It does not stay where you want it, so it is hard to hold on to and to share in a fair way between places.

It has competing uses. The same water is wanted for drinking, farming, industry, power and for keeping rivers and wetlands healthy. Giving water to one use takes it from another.

Its supply varies over time and space. Rain comes in bursts. A place can flood one year and face drought the next. Some regions are wet while nearby regions are dry. This makes planning very hard.

Worked demonstration 1 — Is Australia running out of water?

Let us use the data to reason like geographers.

Step 1 — Look at the per-person chart. Australia averages about 18,900 m³ per person, far above the 1,700 m³ stress line. *Conclusion:* as a whole country, Australia does **not** have a physical shortage of water.

Step 2 — Look at the rainfall chart. Australia’s average rainfall (534 mm) looks moderate, but much is lost to evaporation and the rain is spread unevenly and changes from year to year. *Conclusion:* water is not where and when people need it.

Step 3 — Look at the withdrawals chart. Australia uses only about 2% of its renewable water on average. *Conclusion:* nationally, demand is small compared with supply.

Step 4 — Put it together. Australia as a whole is water-rich, **but** the water is in the wrong places at the wrong times. Most Australians live in cities far from the big rivers, and long droughts (such as the Millennium Drought of the late

1990s and 2000s) can cut supply sharply. So parts of Australia — and some years — can still face real scarcity even though the national average looks comfortable.

Geographer's conclusion: Australia does not have a national shortage; it has a **matching problem** between where water is and where people are, and drought makes the problem bigger. That is why Australia still plans carefully for water.

5. Strategies to overcome water scarcity

Places use many strategies. We can group them as ways to **make more water** (increase supply), ways to **use less water** (reduce demand), or ways to **move or share** water.

Six strategies to overcome water scarcity

Strategy	Type	What it does
Reduce water consumption	Use less (demand)	Water-saving fittings, fixing leaks, sensible garden and farm use.
Recycling and re-use	Use less / make more	Treat used water and use it again, often on farms and parks.
Stormwater harvest	Make more (supply)	Collect rain that runs off streets and roofs and store it for later.
Desalination	Make more (supply)	Remove salt from sea water to make fresh water; works in any season.
Transfer between regions	Move it (supply)	Pipes and channels move water from where there is plenty to where it is short.
Trade in virtual water	Share it (trade)	Import water-hungry goods instead of growing them locally.

Each strategy is judged on two things: how effective it is, and how sustainable it is for the environment, the economy and the community.

Table listing six strategies with their type and what they do: reduce water consumption, recycling and re-use, stormwater harvesting, desalination, transfer between regions, and trade in virtual water

Reduce water consumption means using less water: water-saving shower heads and taps, fixing leaks, watering gardens at cool times, and efficient farm irrigation. It is usually the cheapest and most sustainable strategy.

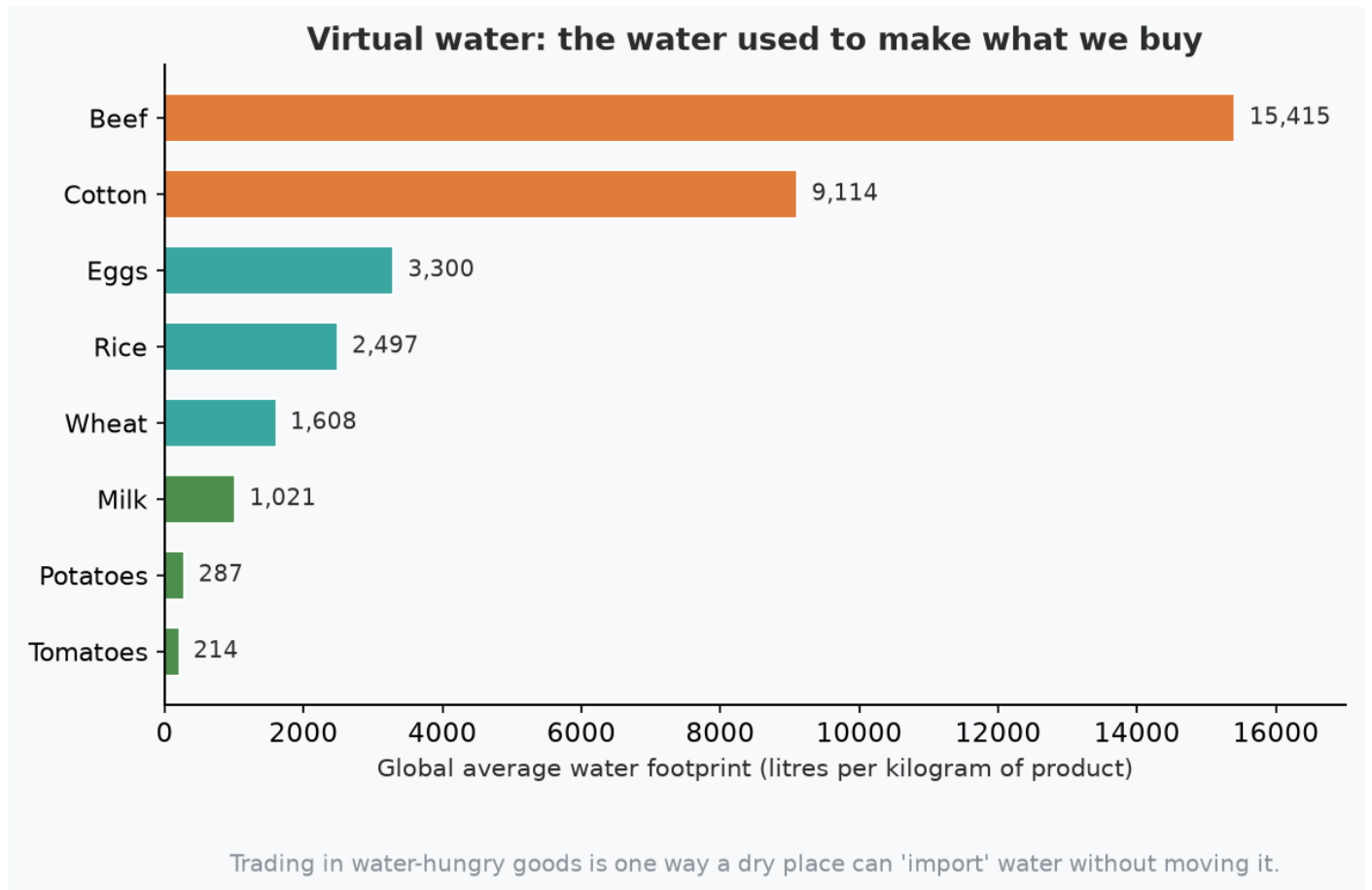
Recycling and re-use means treating used water and using it again, often to water farms, parks and industry. It stretches the same water further.

Stormwater harvesting means collecting the rain that runs off roofs, streets and drains and storing it to use later, instead of letting it run to the sea.

Desalination means removing salt from sea water to make fresh water. It works in any season and does not depend on rain, but it costs a lot of money and energy, and it must dispose of the leftover salty brine carefully.

Interregional transfer means moving water from a wet region to a dry one using pipes and channels. It can secure water for a city or farm region, but it is expensive to build and can harm the river the water is taken from.

Trade in virtual water. **Virtual water** is the water used to grow or make a product. When a dry country imports water-hungry food and goods instead of growing them at home, it is “importing” the water inside them. This lets a dry place save its own water.



Bar chart of the global average water footprint of products in litres per kilogram: beef 15,415, cotton 9,114, eggs 3,300, rice 2,497, wheat 1,608, milk 1,021, potatoes 287, tomatoes 214

Source: Water Footprint Network global average water footprints, retrieved 25 August 2026.

Notice that beef and cotton carry a very large water footprint. A dry country that imports beef or cotton instead of producing them at home is saving a great deal of water. That is virtual water trade in action.

Worked demonstration 2 — Evaluating a strategy mix: Israel

Israel is one of the most water-scarce countries in the world, yet it has built a reliable water supply. Let us **evaluate** its strategy mix for **effectiveness** (does it get enough water?) and **sustainability** (can it keep going without harming people or the environment?).

How Israel stretches a very small water supply

~86%

of Israel's drinking water came from desalination in 2022

~90%

of wastewater is treated and used again, mostly on farms

Israel also uses drip irrigation, which delivers water straight to plant roots and wastes far less than flooding a field.

Israel has very little renewable fresh water per person, so it makes, saves and re-uses almost every drop.

Two large statistics for Israel: about 86 percent of drinking water came from desalination in 2022, and about 90 percent of wastewater is treated and used again, mainly on farms, with a note that Israel uses drip irrigation

Source: Israel national water figures, retrieved 25 August 2026.

Desalination (about 86% of drinking water). *Effective:* yes — it gives a large, reliable supply that does not depend on rain. *Sustainability:* it uses a lot of energy and produces salty brine, so it is best powered by clean energy and managed carefully.

Recycling (about 90% of wastewater re-used). *Effective:* yes — it stretches the same water a second time, mainly for farms. *Sustainability:* very good, because it cuts the need to take fresh water from rivers and groundwater.

Drip irrigation. *Effective:* yes — it delivers water straight to plant roots, so far less is wasted than flooding a field. *Sustainability:* good, because it gets more food from each drop.

Geographer's conclusion: Israel's mix works because it does all three at once: it *makes* new water, it *re-uses* water, and it *uses water carefully*. No single strategy would be enough on its own. This is the key idea for evaluating strategies — judge each one, then look at how they combine.

6. A case study close to home: Melbourne, Victoria

Australia may be water-rich overall, but its cities still plan for drought. Melbourne is a good example.

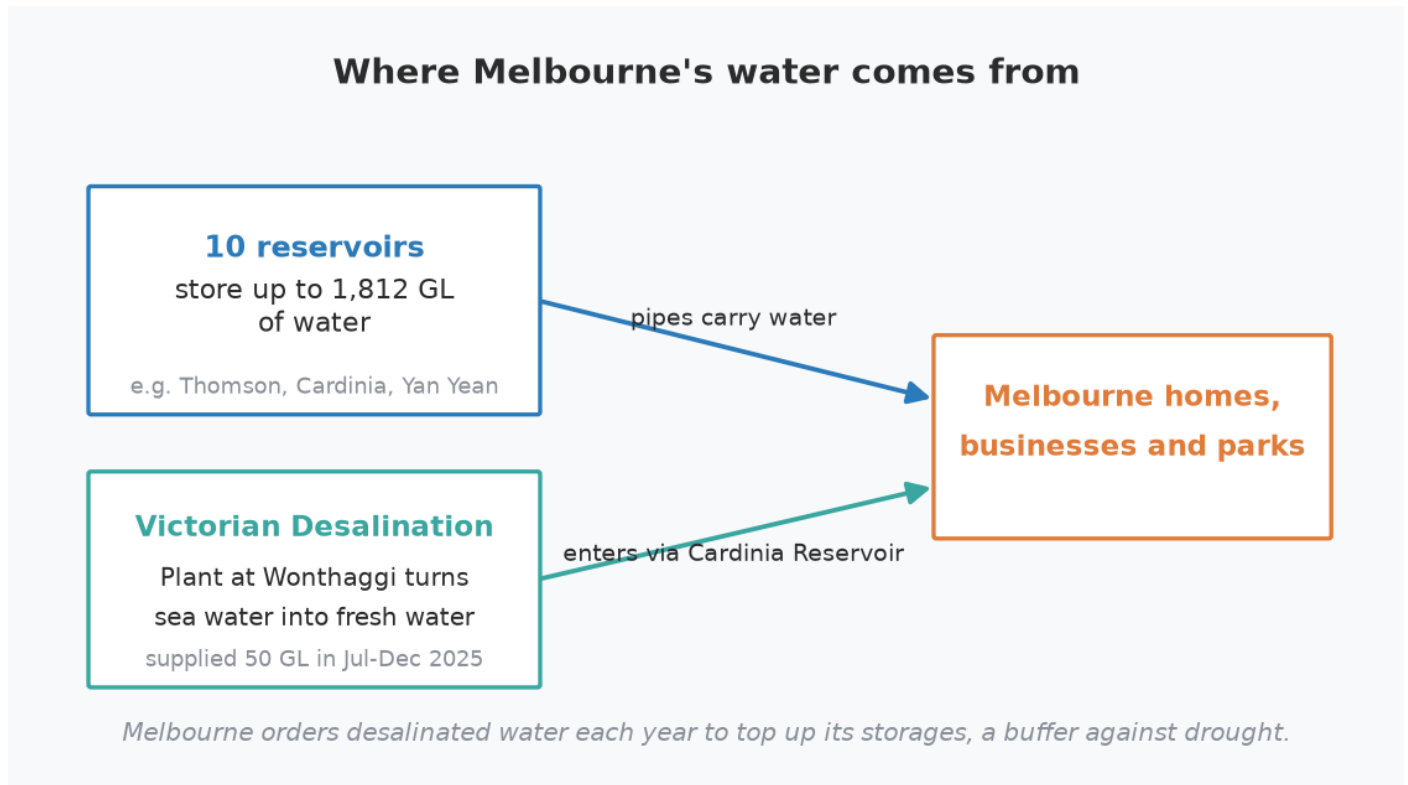


Diagram of Melbourne's water supply: ten reservoirs store up to 1,812 giganalitres and the Victorian Desalination Plant at Wonthaggi supplied 50 giganalitres from July to December 2025, entering via Cardinia Reservoir, together supplying Melbourne homes, businesses and parks

Source: Melbourne Water, water storage levels and desalination orders, retrieved 25 August 2026.

Melbourne stores water in **ten reservoirs** with a combined capacity of 1,812 **giganalitres** (GL) — that is 1,812 billion litres. In dry periods the storages can fall fast, as they did during the Millennium Drought. To guard against this, Melbourne can order water made by desalination from the **Victorian Desalination Plant** at Wonthaggi; in 2025 it supplied 50 GL, entering the system at **Cardinia Reservoir**. Melbourne also uses water restrictions, recycling and stormwater harvesting. Together these strategies spread the risk so the city does not rely on rain alone.

The Murray–Darling Basin: competing uses in Australia

The **Murray–Darling Basin** in south-eastern Australia is about one million square kilometres and is often called Australia's "food bowl". It is home to about 2.4 million people and to internationally important wetlands.

Source: Murray–Darling Basin Authority, retrieved 25 August 2026.

The Basin shows why water is hard to manage: the same river water is wanted for farming, for towns and industry, and for the rivers and wetlands themselves. In drought there is not enough for everyone, so choices must be made about who gets water. This is a real example of **competing uses** and of water scarcity caused by the *ways water is used* as well as by dry years.

Practice — scaffolded

Q1. Define **water scarcity** in your own words.

Q2. Name the two types of water scarcity shown in the first figure, and give one cause for each.

Q3. Use the per-person chart. (a) Which West Asian country has the *most* water per person? (b) Which has the *least*? (c) Do these countries sit above or below the 500 m³ absolute scarcity line?

Q4. The withdrawals chart shows several countries above 100%. Explain in one sentence what it means to use more than 100% of your renewable water.

Q5. Match each cause of scarcity (absolute shortage; inadequate development; the ways water is used) to one example: (i) a city with leaking pipes and no treatment plant; (ii) a desert with almost no rain; (iii) a farm over-pumping groundwater.

Q6. Give two reasons from the “hard to manage” figure why water cannot simply be left to look after itself.

Q7. Look at the virtual water chart. (a) Which product has the largest water footprint? (b) Which has the smallest? (c) Why might a dry country choose to import the high-footprint product?

Q8. For Melbourne, name one “make more” strategy and one “store” strategy mentioned in the case study.

Practice — unscaffolded

Q9. Jordan has about 61 m³ of water per person each year. Using the scarcity guide lines, classify Jordan’s situation and justify your answer.

Q10. “Rainfall alone does not decide how much water a place can use.” Use Australia and Israel as examples to explain this claim.

Q11. Choose **two** strategies from the strategies table. For each, give one strength and one drawback, then decide which is more sustainable for a dry city and say why.

Q12. Explain how the Murray–Darling Basin shows that water scarcity can be caused by the *ways water is used*, not just by a lack of rain.

Extended response

Q13. “Australia is a water-rich country, so it does not need to worry about water scarcity.” Do you agree? Write a short evidence-based response (about 150–200 words) using at least **two** figures from this section and **one** named Australian example (such as Melbourne or the Murray–Darling Basin). Refer to your sources.

Tip: a good response states a clear position, uses data as evidence, and explains the difference between a national average and local or drought-time scarcity.

Teaching notes (for the teacher)

This section delivers VC2HG8K04 with Australian and West Asian examples (the D12 default), adding Egypt as a North African comparison, which the content description’s case-region choice permits. Sequence the lesson as: nature (two types + thresholds) → causes → why water is hard to manage → strategies and evaluation → worked data demonstrations → Australian case studies. The two worked demonstrations model the data-reasoning and strategy-evaluation the achievement standard expects. Keep the focus on reasoning from the figures; every figure carries a source line (World Bank/FAO, Water Footprint Network, Melbourne Water, MDBA) and all were retrieved 25 August 2026. No Aboriginal and Torres Strait Islander content is included here, in line with the series content policy.

Glossary

Water scarcity — a shortage of usable fresh water; demand is more than supply. **Physical scarcity** — not enough water exists to meet all demands. **Economic scarcity** — water exists but cannot be captured, treated or delivered.

Renewable resource — a resource that nature refills, such as water in the water cycle. **Groundwater** — water stored

underground in soil and rock. **Reservoir** — a lake, natural or built, used to store water. **Gigalitre (GL)** — one billion litres. **Desalination** — removing salt from sea water to make fresh water. **Stormwater** — rain that runs off roofs, streets and drains. **Recycling (water)** — treating used water so it can be used again. **Virtual water** — the water used to grow or make a product. **Irrigation** — supplying water to crops. **Water stress** — the pressure that begins when water per person falls below about 1,700 m³ a year.

Atmospheric and hydrometeorological hazards: causes, impacts and responses

Curriculum — Victorian Curriculum 2.0, Geography, Levels 7 and 8 band. This section is the one home of content description **VC2HG8K05**. The elaborations below are illustrations of the description, not extra syllabus:

- **VC2HG8K05.E01** — the hazard’s physical causes and its patterns in time and place, studied through storms, droughts, tropical cyclones or floods
- **VC2HG8K05.E02** — economic, environmental and social impacts on people and places, community responses, and the practices that made a response work well
- **VC2HG8K05.E03** — prevention, preparedness, response and recovery: how communities and governments can lessen a hazard’s harm

Teacher note — teaching sequence. This is the first hazard study in the book; 3E repeats the same shape later with earthquakes, volcanoes and landslides, so teach the shape well here: causes and where-and-when patterns first, then impacts sorted into economic, environmental and social, then prevention, preparedness, response and recovery. Worked examples 1 and 2 model the two core skills (tracing a cause chain; sorting impacts) before the practice set. Levels 5–6 learning of bushfires and climate hazards (VC2HG6K05) is assumed: the idea of a hazard itself is recalled in Figure 1, not re-taught. The fieldwork hook at the end of the theory is a short discussion only; the full water-use observation is realised in 5B/6C.

Theory

Two names, one family. A **hazard** is a natural event that can cause harm to people, places and the environment. The hazards in this section are driven by the air, the weather and the water cycle. That is why they are called **atmospheric hazards** (to do with the air and weather) and **hydrometeorological hazards** (to do with water and weather — the longer name geographers use for the same family). Droughts, storms, tropical cyclones and floods all belong to it.

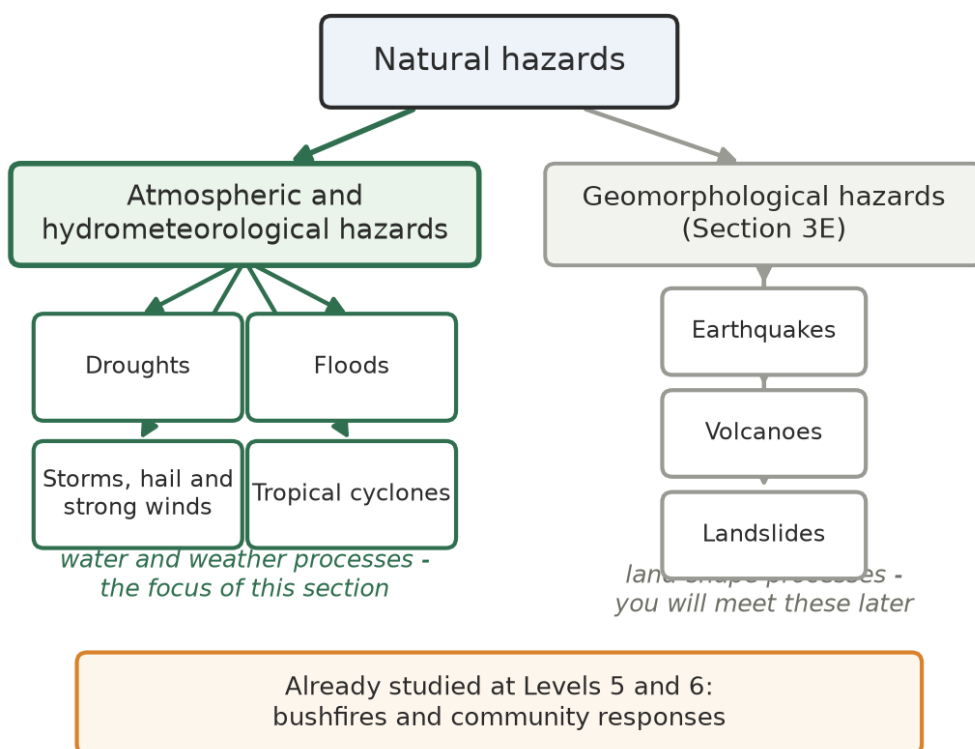
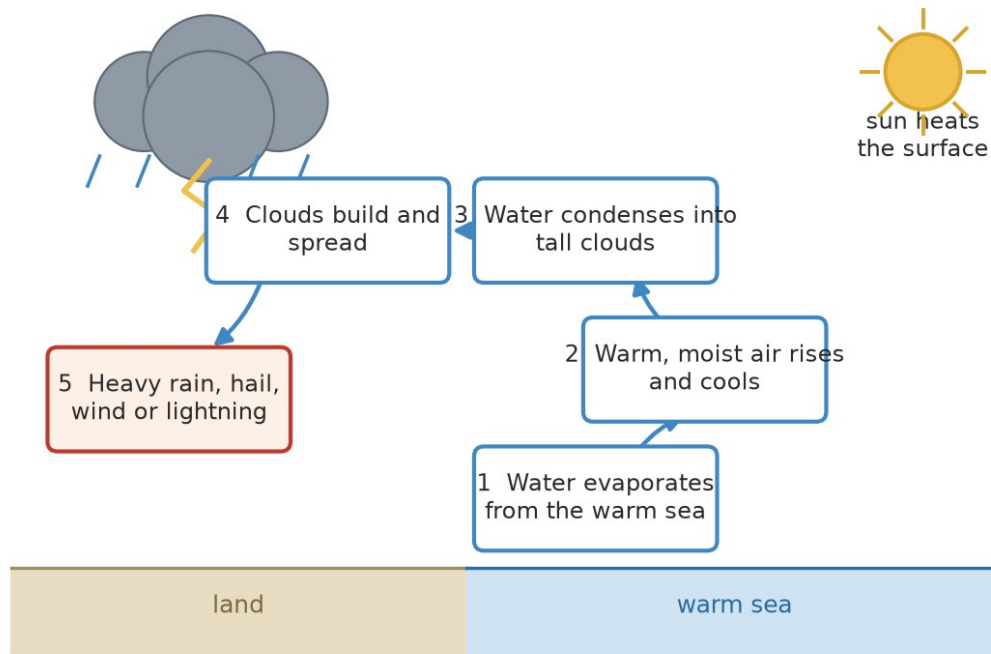


Figure 1. The two families of natural hazards. This section covers the green family.

Contested term — hazard or disaster? Emergency agencies draw a line between these words. A **hazard** is the event itself: a cyclone, a flood, a drought. The event becomes a **disaster** when the harm is so great that the affected community cannot cope without outside help. The same cyclone can be a hazard to one town and a disaster to the next town, depending on how prepared each town is. This book follows that

usage; in everyday news the two words are often used as if they meant the same thing, and that is a loose use, not a careful one.

Storms — the engine. A **storm** is a disturbance in the atmosphere that brings strong winds and heavy rain, often with lightning, thunder or hail. The engine is warm, moist air that rises: the sun heats the ground and the sea, water **evaporates** (turns from liquid to gas), the warm moist air rises, and higher up it cools, so the water vapour **condenses** back into cloud droplets. Condensing gives heat back to the air, which pulls more moist air up — and the cycle spins faster into a storm cloud.



How a storm gets its energy: warmth and moisture from the surface.

Figure 2. The storm

engine: a rising cycle of warm, moist air.

Tropical cyclones — structure. A **tropical cyclone** is a huge spinning storm system, hundreds of kilometres wide, that forms over warm ocean water. In the Australian region cyclones are graded **Category 1 to 5** on the Australian scale, with Category 5 the most severe. A cyclone has a calm **eye** at its centre, a ring of the strongest winds and rain called the **eyewall**, and long curved **rain bands** spinning around it. When a cyclone crosses the coast we say it makes **landfall**. As well as wind, a cyclone pushes a dome of sea water onto the coast called a **storm surge** — for many coastal towns the surge, not the wind, is the most dangerous part.

South of the equator, cyclones spin clockwise. This drawing is a cross-section: a slice straight through the storm.

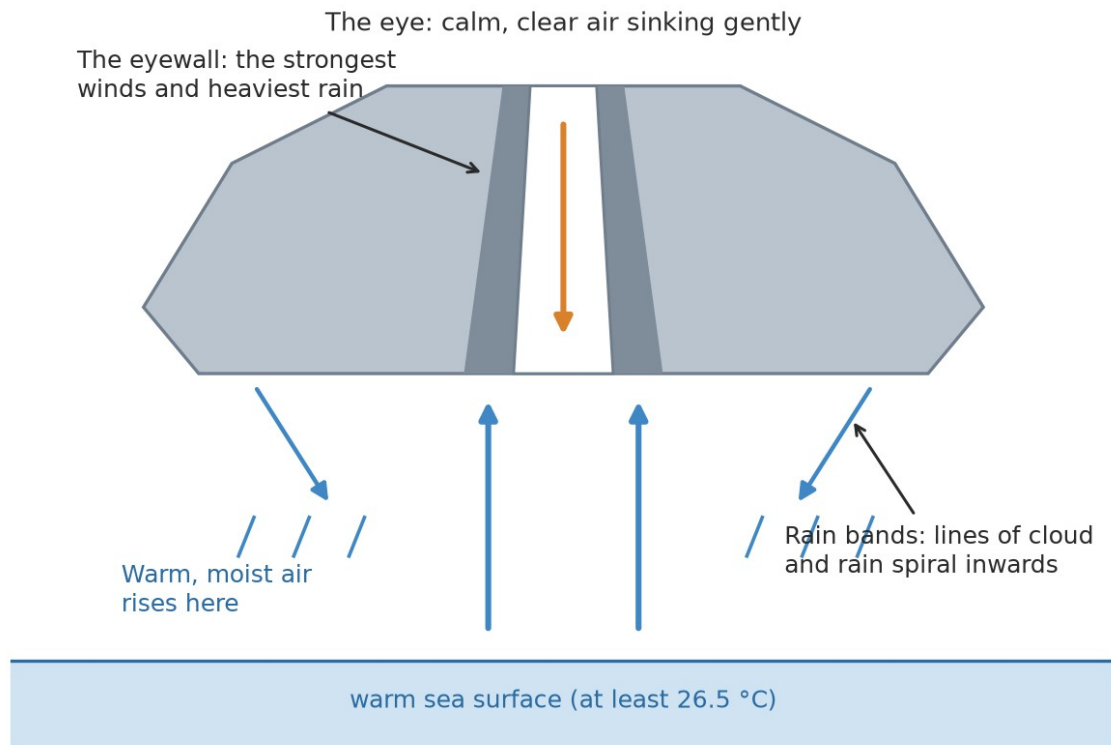
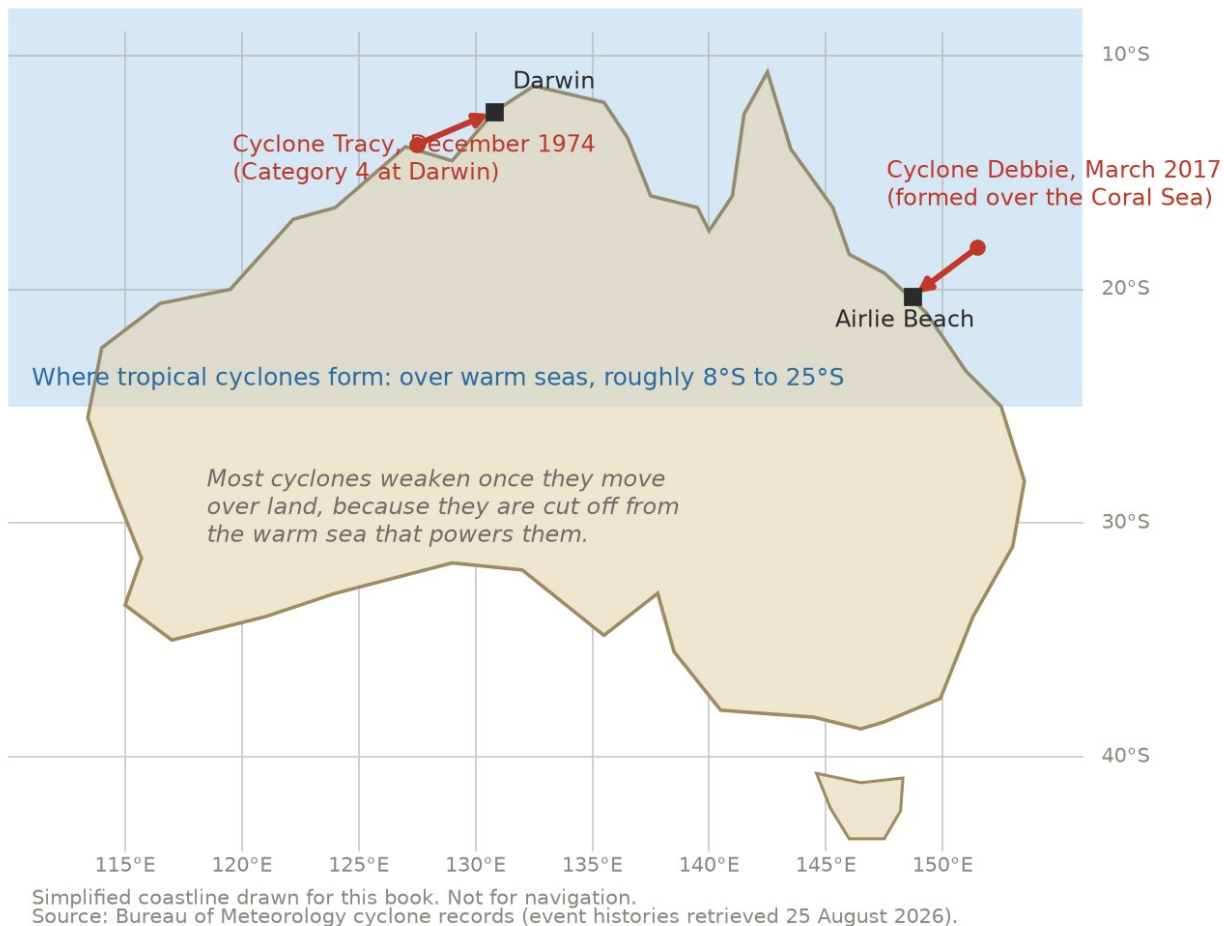


Figure 3. The structure of a tropical cyclone, seen from above.

Tropical cyclones — where and when. Australian cyclones form over the warm seas to the north of the country, so the risk is greatest along the coasts of Western Australia, the Northern Territory and Queensland. The official **cyclone season** runs from 1 November to 30 April, and the long-term average is about 11 tropical cyclones in or near the Australian region each season.



Figure

4. Where Australian tropical cyclones form and track. Simplified coastline drawn for this book. Not for navigation.

The official Australian cyclone season runs from 1 November to 30 April.

Long-term average: about 11 tropical cyclones in or near the Australian region each season (Bureau of Meteorology).

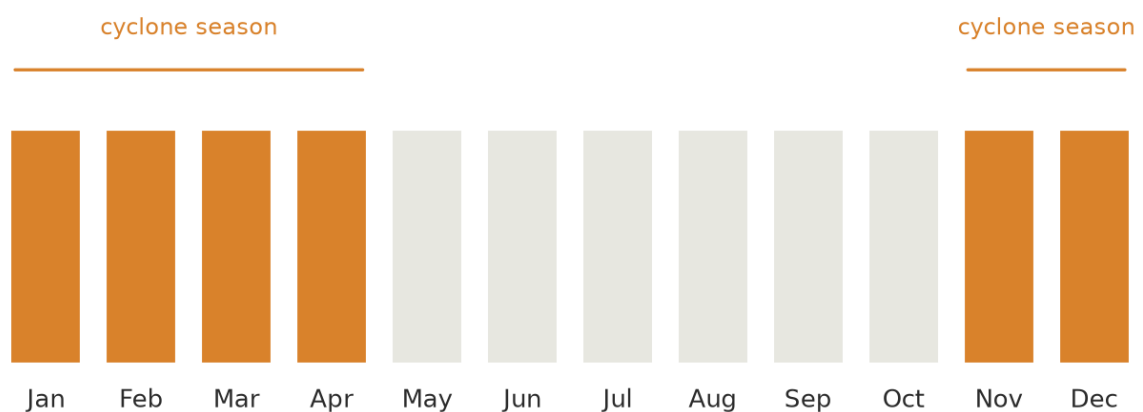


Figure 5. When: the official Australian cyclone season.

Two Australian cyclones anchor this section:

- Cyclone Tracy (Darwin, 25 December 1974).** A Category 4 cyclone. A gust of 217 km/h was recorded before the wind meter failed; the Bureau of Meteorology estimates gusts reached about 240 km/h. Sixty-six people died. More than 70% of Darwin's buildings were destroyed and 94% of its homes could not be lived in; about 35,000 people had to leave the city.

- **Cyclone Debbie (Queensland, 2017).** Debbie crossed the coast near Airlie Beach as a Category 3 cyclone on 28 March 2017 with winds of 150 km/h; a gust of 263 km/h was recorded on Hamilton Island. After landfall the system slowed and dumped rain: more than 1,000 mm fell in 48 hours over the Pioneer River catchment. Fourteen people died across Queensland and New South Wales, and the damage bill reached about A\$3.5 billion.

Source: Bureau of Meteorology cyclone event histories (retrieved 25 August 2026).

Drought — the slow hazard. A **drought** is a long stretch of time — months to many years — when rain is well below the usual average for a place, so water storages (reservoirs), rivers, farms and towns run short. Australia is one of the driest continents where people live, and drought is part of its normal climate. The **Millennium Drought** (1996–2010, with the driest years from 2001 to 2009) hit the south-east hard: over those years the south-east missed the equal of a full year of rain. Unlike a cyclone, which gives hours of warning, a drought is noticed only slowly, while it is already doing harm.

Over those years the south-east missed the equal of a full year of rain (Bureau of Meteorology).

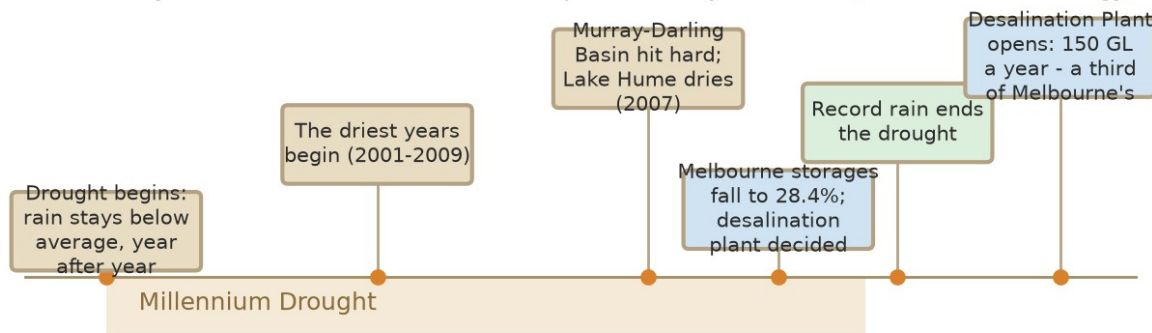
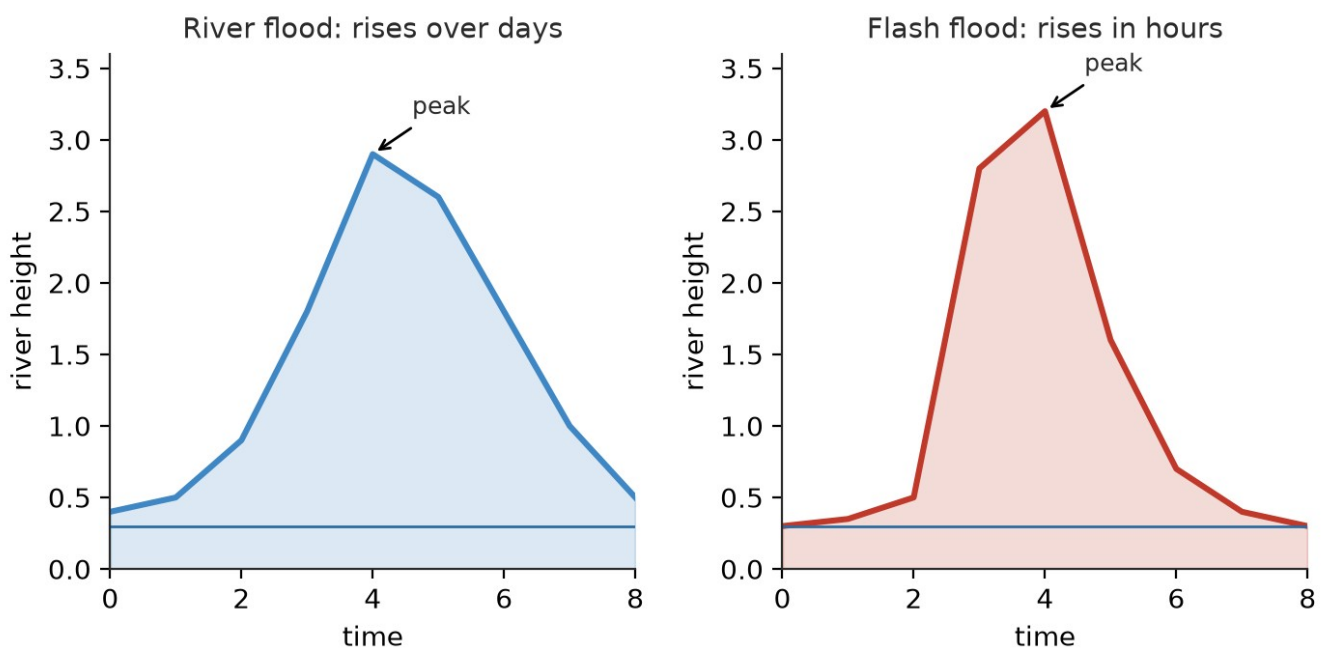


Figure 6. The Millennium Drought, 1996–2010, and how Victoria responded.

Source: Bureau of Meteorology drought record; Victorian government water records (retrieved 25 August 2026).

Floods — two speeds. A **flood** is water covering land that is usually dry. Floods come in two speeds. A **river flood** builds over days or weeks, as rain across a wide **catchment** (the area of land that drains into a river) flows into the river until it spills over the banks. A **flash flood** arrives in hours, when very heavy rain falls on a small area — most dangerous on steep ground, where water rushes downhill with little warning.



Brisbane River peaked at 4.46 m on 13 January 2011; about 20,000 Brisbane homes were flooded

Toowoomba and the Lockyer Valley, 10 January 2011: rain on steep ground sent a wall of water down the valley.

Figure 7. River flood versus flash flood: the same rain, two different speeds.

The **2010–11 Queensland floods** show both speeds at once. Weeks of rain caused river flooding across the state; the Brisbane River peaked at 4.46 m on 13 January 2011 and about 20,000 Brisbane homes flooded. On 10 January 2011, intense rain on steep ground sent a flash flood through Toowoomba and the Lockyer Valley. Thirty-three people died in the flood disaster across Queensland. The total cost to Australia was about A\$14 billion; insurance companies paid about A\$2.38 billion of it.

Source: Queensland government and Bureau of Meteorology flood records (retrieved 25 August 2026).

East coast lows — Victoria’s storm hazard. Not every big storm here is a tropical cyclone. An **east coast low** is a slow-moving storm system that forms off the south-eastern coast and can dump heavy rain and send destructive winds across eastern Victoria. In June 2021 one sat off the coast for five days: two people died, Gippsland towns were cut off by flash flooding, about 160,000 properties lost power, and about 200 homes were evacuated around Traralgon.

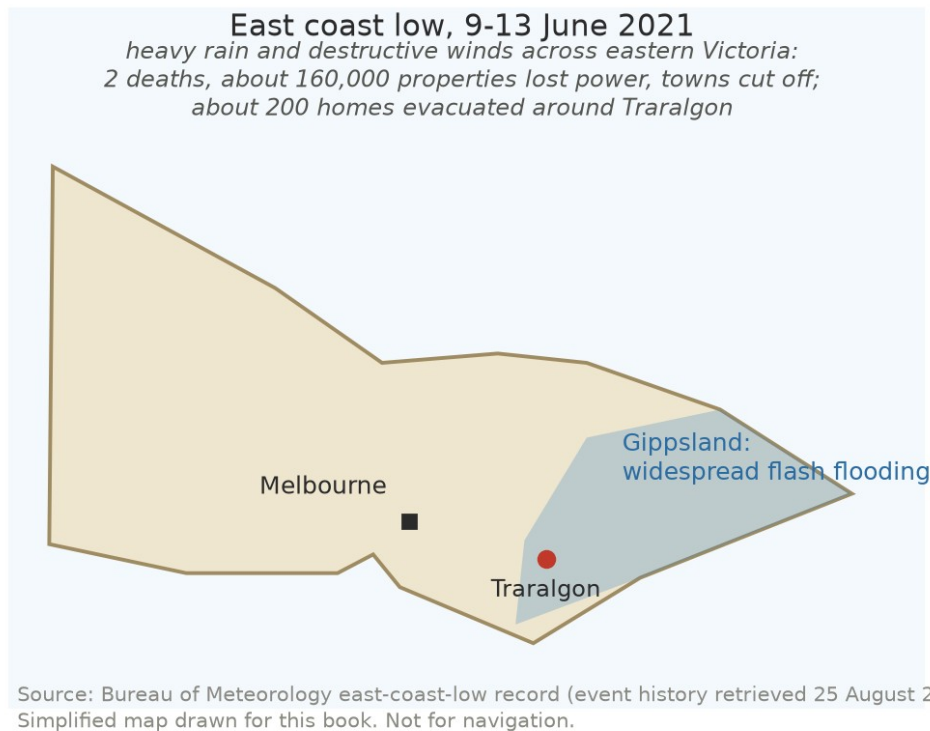


Figure 8. The east coast low of 9–13 June 2021, a Victorian case study. Simplified map drawn for this book. Not for navigation.

Source: Bureau of Meteorology east-coast-low record (event history retrieved 25 August 2026).

Contested term — the “1-in-100-year flood”. News reports use this phrase as if such a flood happens once every 100 years. That is not what it means. A 1-in-100-year flood is a flood size with a **1% chance of being equalled or passed in any single year** — like one ticket in a 100-ticket raffle, drawn every year. A town can have two such floods in two years, and the chance the next year is still 1 in 100. Geographers and flood planners prefer saying “the 1% chance flood” for exactly this reason, and many argue the old phrase makes people less prepared than they should be.

Impacts — three lenses. The harm a hazard causes is sorted into three lenses, and one event always shows all three:

- **Economic impacts** — the money side: damage to homes, businesses, farms and roads; insurance bills; lost jobs and closed shops.
- **Environmental impacts** — the natural-world side: erosion, polluted waterways, loss of plants and animals, changed landscapes.
- **Social impacts** — the people side: deaths and injury, lost homes and schools, stress and grief, but also communities pulling together and volunteers helping.

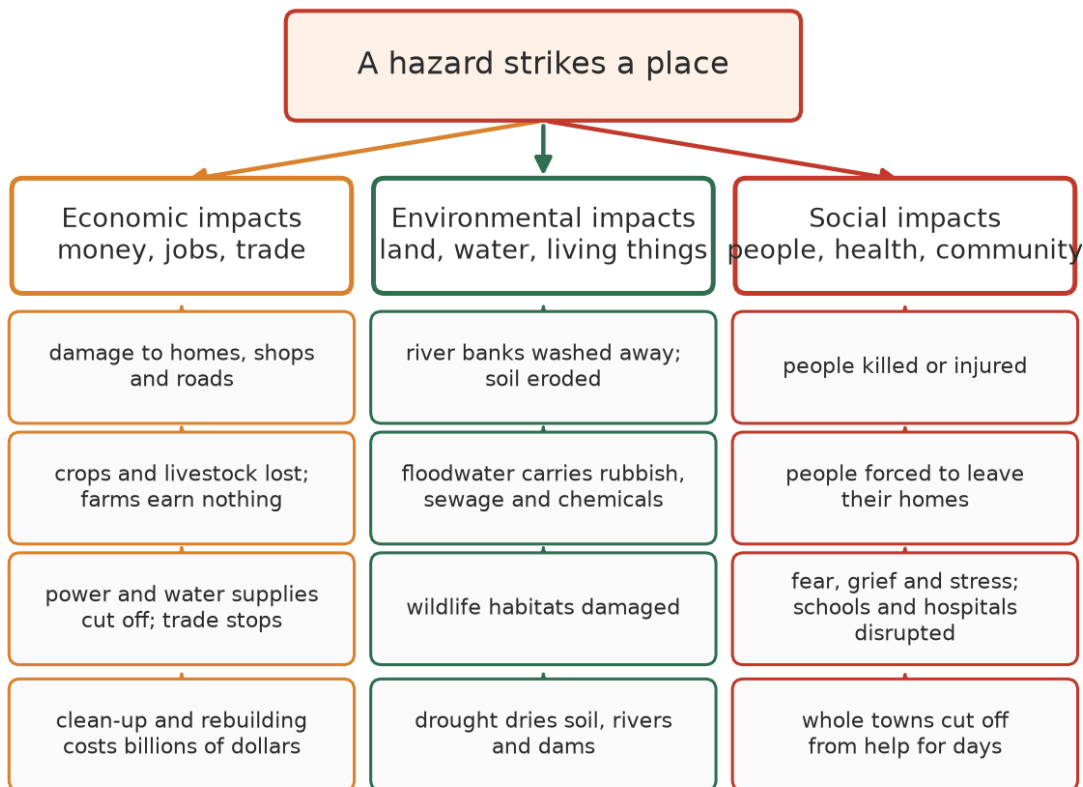
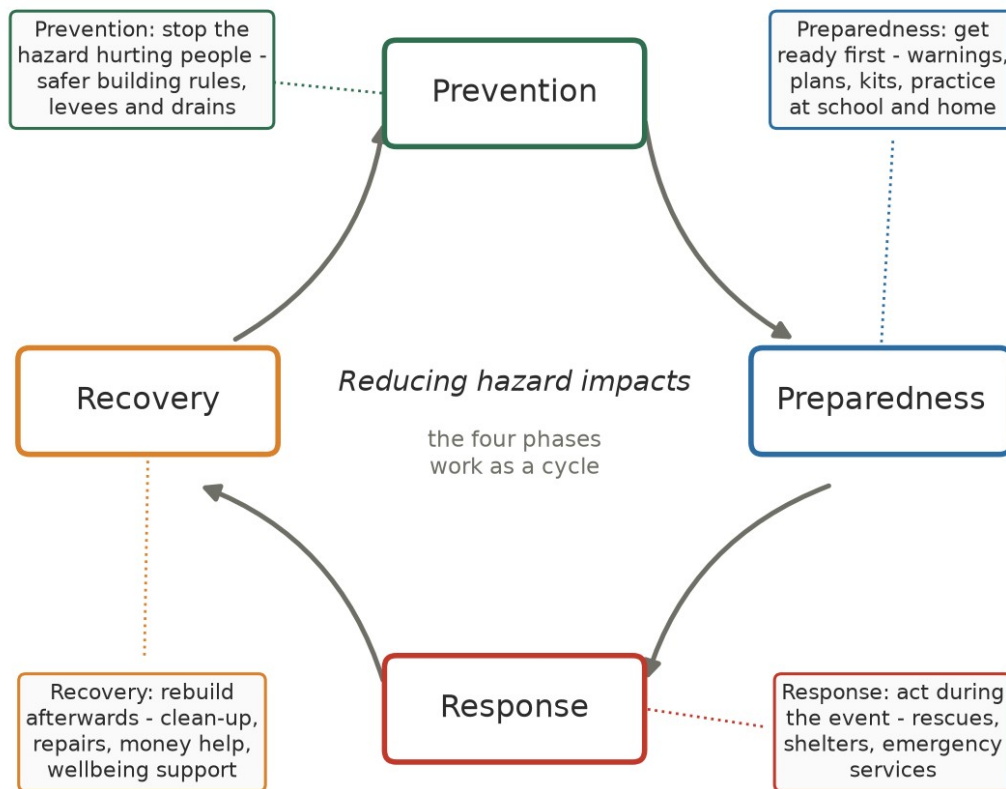


Figure 9. The

impacts web: one event, three lenses.

Responses — four steps. Australian governments and communities plan for hazards in four steps, remembered as **PPRR**:

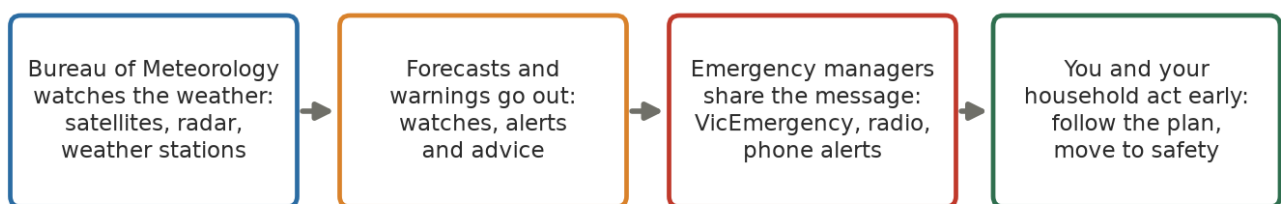
- **Prevention** — acting long before, to stop harm happening: building codes that make cyclone-country houses hold together, levees and dams, planning rules that keep new houses off the lowest flood ground.
- **Preparedness** — getting ready before the event: forecasts and warnings, household plans, emergency kits, sandbagging, community drills.
- **Response** — acting during and straight after the event: evacuations, rescues, emergency services and volunteers at work.
- **Recovery** — getting back on your feet afterwards: cleaning up, repairs and rebuilding, insurance payments, government support, and care for people's feelings and health.



Figure

10. The PPRR cycle.

Warnings only work if they travel. Australia's warning chain runs from the Bureau of Meteorology, which watches the weather with satellites, radar and weather stations, through public warnings, to emergency managers, and finally to households that act early. In Victoria, warnings are shared through **VicEmergency** (the state's emergency warning system), the Bureau of Meteorology, ABC radio and local emergency services.



In Victoria, warnings are shared through VicEmergency (the state's emergency warning system), the Bureau of Meteorology, ABC radio and local emergency services.

A warning only works if people hear it, understand it and act on it - that is why households make plans before the season starts.

Figure 11. The warning chain, from watching the sky to acting at home.

Fieldwork hook — your own town or suburb. Drought preparedness starts with knowing where your water comes from. This week, keep a simple log at home: where does your household's water come from (a river? a reservoir? groundwater?), and name two things your household does in a hot week that use extra

water. Bring your two observations to class. This small log opens the water-use fieldwork you will design and run in full in Sections 5B and 6C — here it is just a conversation starter.

Worked examples

Example 1 — scaffolded

Trace the cause chain and the where-and-when pattern of Cyclone Debbie, March 2017.

Step	What happened	What it shows
1	Debbie formed over warm ocean water north of Queensland.	Cyclones need warm sea to feed on (Figure 4).
2	It crossed the coast near Airlie Beach as a Category 3, on 28 March 2017, with winds of 150 km/h.	Landfall on the Queensland coast fits the pattern in Figure 4; 28 March sits inside the 1 November–30 April season (Figure 5).
3	A gust of 263 km/h was recorded on Hamilton Island.	Island and coastal sites take the strongest wind — the eyewall (Figure 3).
4	After landfall the system slowed and dumped more than 1,000 mm of rain in 48 hours over the Pioneer River catchment.	A weakening cyclone can still cause its greatest harm through rain and flooding, far from the coast.
5	Fourteen people died and the damage bill reached about A\$3.5 billion.	Impacts spread across two states — one hazard, many places.

Source: Bureau of Meteorology cyclone event histories (retrieved 25 August 2026).

Example 2 — scaffolded

Sort the impacts of the 2010–11 Queensland floods into the three lenses of Figure 9.

Evidence	Lens	Why it fits
33 people died across Queensland.	Social	Loss of life is a people impact.
About 20,000 Brisbane homes flooded.	Social	Homes, daily life and school are the people side (there is also an economic cost — one event can wear several lenses; pick the lens the evidence most directly shows).
The total cost was about A\$14 billion; insurance companies paid about A\$2.38 billion.	Economic	Money, bills and insurance are the money side.
Floodwater polluted waterways and eroded riverbanks.	Environmental	The natural world — water and land — is the environment lens.
Businesses and farms closed for weeks; jobs were lost.	Economic	Work and income are the money side.
Communities pulled together; volunteers helped clean up.	Social	How people feel and act towards each other is the people side.

Example 3 — unscaffolded

Model response. “The Millennium Drought was slow to arrive, but Victoria’s response was not slow forever. Explain one government response and how it reduced the impact of drought.”

Melbourne's water storages fell to 28.4% during the driest years, so the Victorian Government decided to build the Victorian Desalination Plant, which opened in December 2012 near Dalyston on the Bass Coast. It can supply 150 GL of water a year — about a third of Melbourne's needs — made from seawater instead of rain. That reduces the impact of the *next* drought: even if the catchments stay dry, Melbourne has a source of water that does not depend on rain, so homes and hospitals keep their supply. This is **prevention** in the PPRR cycle — acting in a quiet period so the next hazard does less harm.

Source: Victorian government water records (retrieved 25 August 2026).

Example 4 — unscaffolded

Model response. “Compare the causes of the two floods inside the 2010–11 Queensland flood disaster.”

The two floods had different causes working at different speeds. The **Brisbane river flood** was caused by weeks of rain across a wide catchment: water from a huge area flowed into the river until it overflowed, peaking at 4.46 m on 13 January 2011 — a slow rise over days (left graph, Figure 7). The **Toowoomba and Lockyer Valley flash flood** of 10 January 2011 was caused by intense rain falling in a short time on steep ground: the water could not soak in, so it rushed down the valley as a wall of water within hours (right graph, Figure 7). Same state, same summer, same rain bands — but wide catchment plus time gives a river flood, and small area plus steep ground plus intensity gives a flash flood.

Practice questions

Scaffolded

- Q1.** Use Figure 1. Name the two families of natural hazards and say which family this section studies.
- Q2.** In your own words, define (a) **landfall** and (b) **storm surge**. (*Hint: one word is about the coast, the other about the sea.*)
- Q3.** Use Figure 5. (a) Which months sit inside the official cyclone season? (b) Cyclone Debbie made landfall on 28 March 2017. Was that in season?
- Q4.** Use Figure 6. Put these events in order: the Victorian Desalination Plant opens; the driest years begin; the drought begins; record rain ends the drought; Melbourne storages fall to 28.4%.
- Q5.** Flash flood or river flood? (a) Water rises within hours after a storm drops heavy rain on steep ground. (b) A river keeps rising for a week as rain from a wide catchment flows into it.
- Q6.** Using Example 2 as a model, give one economic, one environmental and one social impact of the 2010–11 Queensland floods.
- Q7.** Match each action to its PPRR step (prevention, preparedness, response, recovery): (a) sandbagging doorways before a flood arrives; (b) rebuilding a bridge a year after a flood; (c) moving a suburb to safety as a cyclone nears; (d) a building code that requires cyclone-rated roofs in northern towns.
- Q8.** Use Figure 11. Name two ways a warning can reach a Victorian household.

Unscaffolded

- Q9.** Explain why tropical cyclones form over the ocean and not over land.
- Q10.** Drought is sometimes called the quiet hazard. Use two dated events from Figure 6 to explain why that name fits.
- Q11.** A resident says, “We had a 1-in-100-year flood last year, so we are safe for 99 years.” Explain the mistake in this thinking.
- Q12.** Choose one PPRR step and explain how it reduced the impact of the June 2021 east coast low on Gippsland communities.

Q13 — extended response. Australia spends money and time on all four PPRR steps. Using one hazard studied in this section, explain which **two** steps you judge save the most lives and money. Use at least two pieces of evidence from this section. *You are marked on the quality of your reasoning, not on which two steps you choose.*

Answers

Q1. The atmospheric and hydrometeorological family (water and weather processes) and the geomorphological family (land-shape processes); this section studies the first. **Q2.** (a) Landfall is the moment a cyclone crosses the coast. (b) A storm surge is the dome of sea water a cyclone pushes onto the coast. **Q3.** (a) November, December, January, February, March, April. (b) Yes — 28 March is inside the season. **Q4.** Drought begins (1996) → driest years begin (2001) → storages fall to 28.4% → record rain ends the drought (2010) → plant opens (2012). **Q5.** (a) Flash flood. (b) River flood. **Q6.** Any correct triple, e.g. economic: about A\$14 billion total cost; environmental: polluted waterways; social: 33 deaths / homes lost. **Q7.** (a) Preparedness. (b) Recovery. (c) Response. (d) Prevention. **Q8.** Any two of: VicEmergency warnings, ABC radio, phone alerts, Bureau of Meteorology warnings, local emergency services. **Q9–Q13.** See fully-worked solutions.

Fully-worked solutions

Q9. A tropical cyclone is powered by warm, moist air rising off the sea surface (the same engine as Figure 2, but far bigger). Over the ocean, evaporation keeps supplying moist air and heat; over land that supply stops, so a cyclone cannot form there and weakens quickly after landfall. That is also why cyclones form in the warm seas north of Australia (Figure 4) and not over the dry centre.

Q10. A cyclone or flood announces itself in hours or days; a drought arrives so quietly that harm is already done before it is named. Figure 6 shows the drought beginning in 1996 with rain below average year after year, and the driest years only beginning in 2001 — it took years just to see the pattern. At the same time, farms, storages and rivers were already running down. A hazard that builds quietly, for over a decade, across a whole region, earns the name “quiet hazard”.

Q11. A 1-in-100-year flood means a 1% chance in each single year, like a raffle drawn every year — not a flood on a 100-year timer. Last year’s flood does not use the ticket up: the chance this year is still 1 in 100, and two such floods can fall in two years. Believing the 99-year story makes people less prepared, which is why planners prefer “the 1% chance flood”.

Q12. Example (response): when the east coast low flooded Gippsland in June 2021, emergency services evacuated about 200 homes around Traralgon before the water rose, and 160,000 properties were reconnected to power afterwards — acting early and acting fast kept the death toll at two in a storm that cut off whole towns. Other steps can be argued with correct evidence; what earns marks is tying the step to dated evidence from Figure 8.

Q13. *Marking guide — reason, then conclude.* Award for: (1) naming one hazard and two PPRR steps clearly; (2) attaching at least two pieces of section evidence (dates, places, figures) to the argument; (3) explaining the *mechanism* — how the step stops harm, e.g. “warnings gave Gippsland households hours to move, so two deaths instead of more” or “cyclone building codes meant later storms destroyed fewer roofs than Tracy destroyed in 1974”; (4) weighing the other side honestly (a step not chosen still matters — recovery rebuilt Darwin; response saved lives in 2011). The conclusion itself is not marked: preparedness-plus-prevention, response-plus-recovery, or any pair can be argued to a high standard. A one-line answer with no evidence caps at half marks however confident it sounds.