Australian Government

Murray–Darling Basin Authority

Basin Plan Review

The future of climate and water availability in the Murray–Darling Basin

Sustainable yields report

November 2025

BPR Roadmap — Early Insights Paper — 2024 — Basin Plan Evaluation — Basin Outlook — 2025 — Sustainable yields report — Discussion Paper — 2026 — Basin Plan Review

Published by the Murray–Darling Basin Authority
MDBA publication no: 23/25
ISBN (online): 978-1-923558-10-6

Cataloguing data

Title: The future of climate and water availability in the Murray–Darling Basin, Murray–Darling Basin Authority Canberra, 2025. CC BY 4.0

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Acknowledgements

Writing, editing and design: Biotext Pty Ltd

Acknowledgement of First Nations and their people

We offer respect to the Traditional Custodians of Country in the Murray–Darling Basin and to their Nations. We pay our respects to Elders past and present.

We acknowledge their enduring deep Cultural, social, environmental, spiritual and economic connection to their lands and waters. First Nations people have been looking after Country in sophisticated ways for more than 65,000 years and continue to do so on behalf of their Nations and people.

We have heard many First Nations people express that when the lands and waters of Nations are not healthy, the people are unwell, and the ability to practice Culture and look after Country is impacted. This includes being able to swim in the local waterways and harvest traditional foods and resources.

First Nations people see waterways as living entities and live by the principle that everything is connected. Since colonisation, land, water and people have been separated. This goes against the way First Nations people see Country.

First Nations people in the Basin have been excluded from decision-making processes about water. Water management laws have contributed to disparity and dispossession, as they were developed without recognising First Nations' sovereignty. We acknowledge that this causes distress.

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At a glance

Understanding how climate change affects Basin water resources is critical to effective water management for the Basin.

The project

The 2025 Sustainable Yields project (SY 2025) provides critical information for the Basin Plan Review and future planning.

To provide a comprehensive picture of the Basin's future hydroclimate, SY 2025 has developed 3 climate scenarios for the Basin:

- warmer and slightly wetter around 2030, becoming hotter and slightly wetter around 2050
- warmer and drier around 2030, becoming hotter and drier around 2050
- warmer and much drier around 2030, becoming hotter and much drier around 2050.

Climate projections were developed at 2 time horizons:

- around 2030, to support the Basin Plan Review and policy
- around 2050, for long-term water planning.

The 3 scenarios at 2 time horizons form a 'plausible range' of climate futures, which excludes scenarios that are improbable.

Considering a range of plausible climate futures enables adaptive, resilient planning.

If only one scenario is used, key impacts that need to be managed could be missed. Using a plausible range that considers uncertainty enables flexibility in management and adaptation.

SY 2025 provides both climate scenarios and climate storylines to support understanding of what climate change means for the Basin.

Storylines show possible climate sequences for the northern and southern Basin, including increased heavy rainfall events, extended droughts and more frequent heatwaves.

Ongoing work in SY 2025 and across the MDBA will continue to improve understanding of climate change and its impacts.

Key messages

The Murray–Darling Basin's **climate is changing**.

With climate change:

- the Basin is virtually certain to be hotter
- annual rainfall is likely to become more variable
- heavy rainfall events are very likely to become more intense
- cool-season rainfall is likely to continue to decline in the northern Basin and very likely to decline in the southern Basin.

The changes in the Basin climate are having significant impacts on **water resources**.

SY 2025 shows that:

- runoff and water availability are very likely to continue to decline, particularly in the south
- droughts are very likely to become more frequent and severe, and may be of longer duration
- the frequency of moderate flood inundation is likely to decline, but the height and duration of large floods may increase
- long-term average annual flows are projected to decline – under current water management arrangements, this would have the greatest effect on downstream users and non-entitlement water
- groundwater recharge is projected to decrease, especially in the southern Basin.

Climate **variability** will continue to have a large effect on water resources.

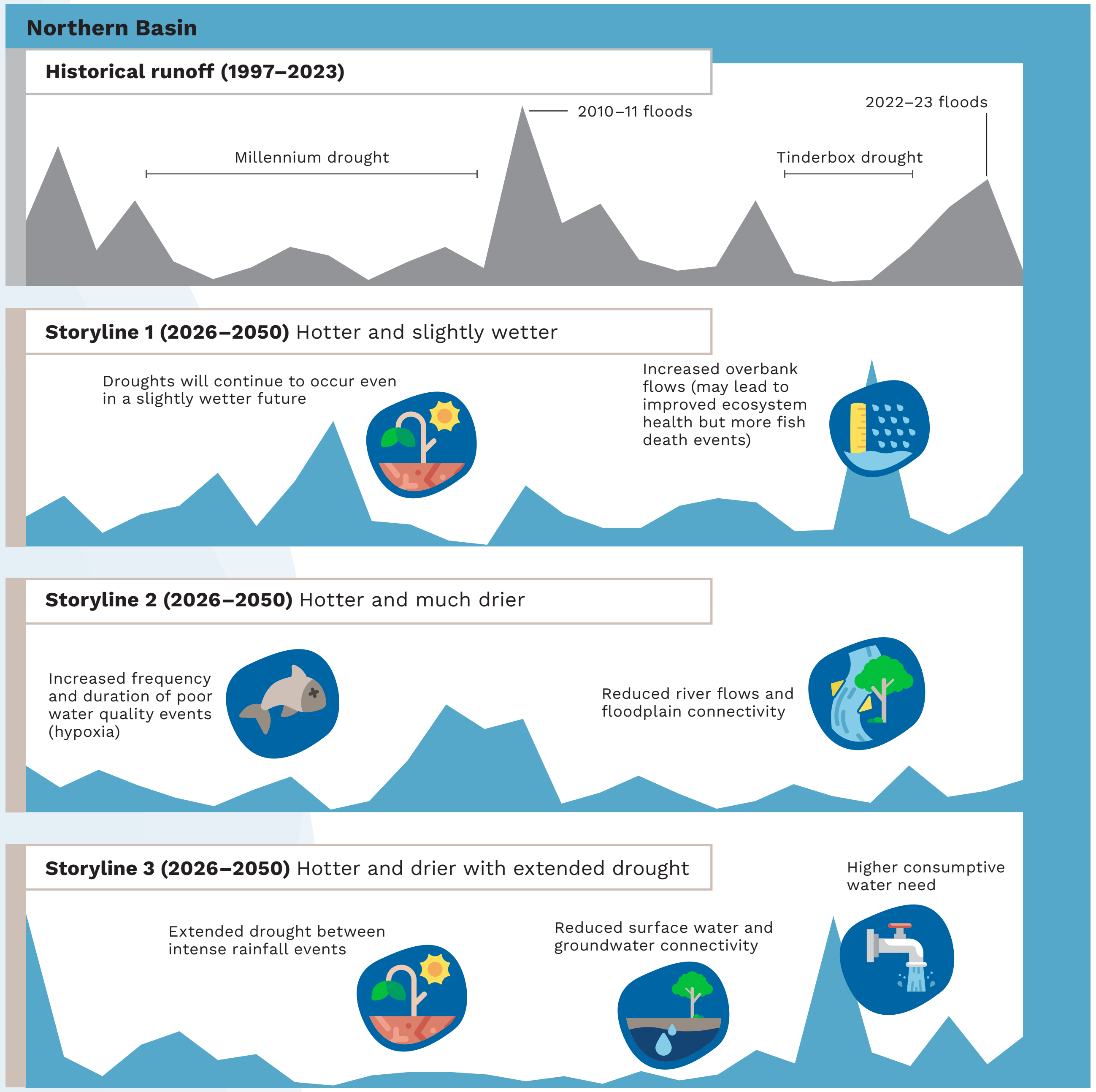
Basin climate is highly variable, with temperatures and rainfall varying widely from region to region, year to year or decade to decade. This variability will remain high and may increase with climate change.

The Basin hydroclimate will continue to be dominated by variability in the near term.

Climate storylines

The SY storylines are not predictions or forecasts, but rather possible climate sequences. While scenarios focus on changes to long-term climate averages, storylines focus on sequences of events. These examples help everyone understand what climate change could mean for the Basin.

The 3 storylines below show what runoff could look like over the next 25 years, compared with the last 25 years. SY storylines are compatible with the SY climate scenarios.



Historical runoff (1997–2023)

Comparing storylines to historical data and events helps understand how each storyline would look and feel compared to recent lived experience.

Storyline 1 (2026–2050) Hotter and slightly wetter

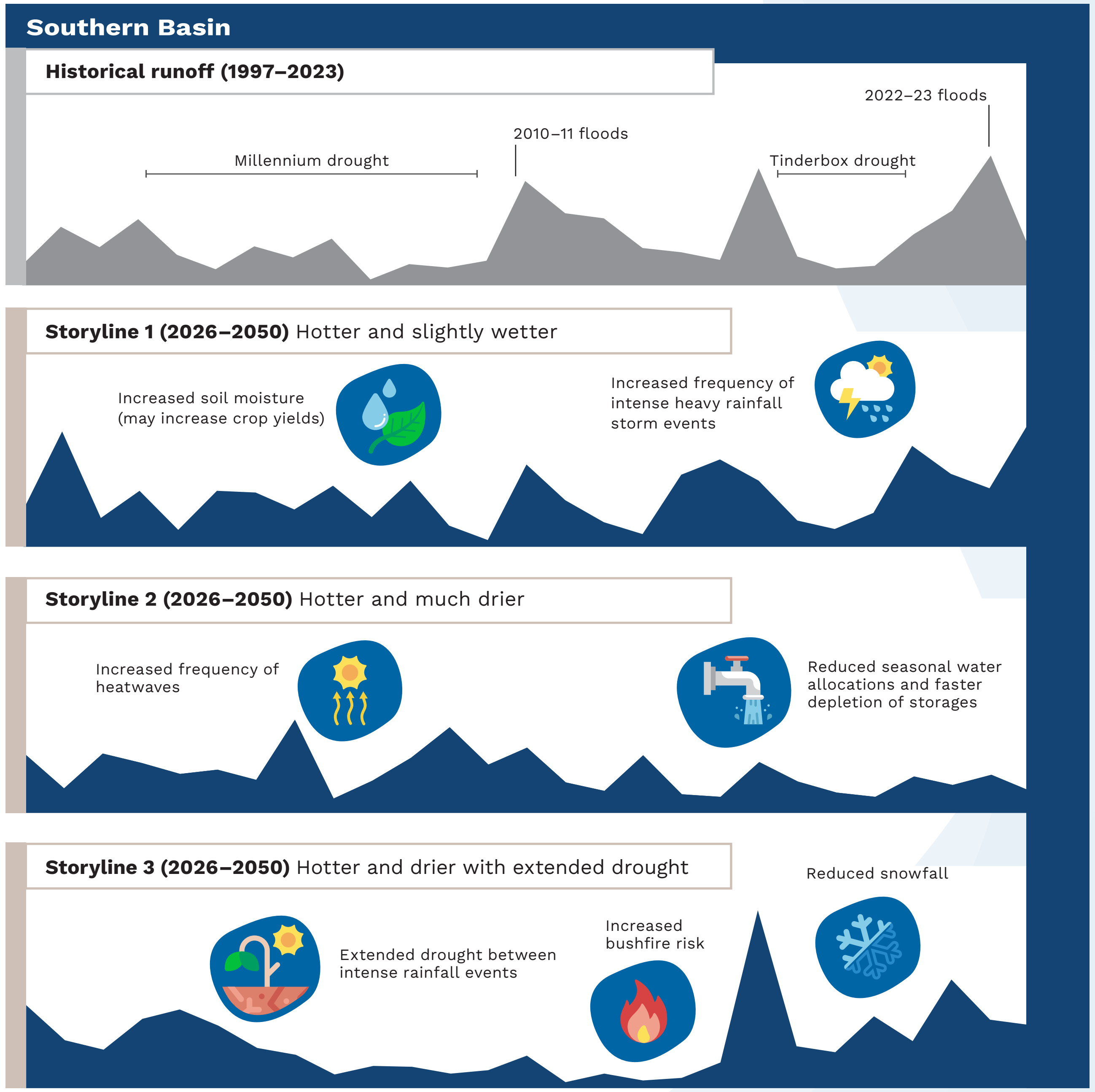
In this storyline, the Basin would experience higher temperatures but also more rainfall than now.

Storyline 2 (2026–2050) Hotter and much drier

In this storyline, the Basin would be hotter and would experience much less rain and runoff overall, with significant impacts on water availability and quality.

Storyline 3 (2026–2050) Hotter and drier with extended droughts

In this storyline, the Basin would be hotter and would experience less rain, and would also experience long periods of drought with significant impacts on the environment and water use.



Sustainable yields project

> The Murray–Darling Basin Sustainable Yields (SY) project, conducted by the Murray–Darling Basin Authority (MDBA), is a whole-of-Basin assessment focused on understanding the Basin's water resources and the potential impacts of climate change on these resources.

The Basin Plan aims to strike a balance between access to water for Basin communities and industries, while also providing water for the environment. The SY project provides fundamental information about climate change impact in the Basin, which is crucial to ensure water management strategies are robust and adaptive. Results from SY 2025 provide critical information for the 2026 Basin Plan Review, and SY 2025 will continue to be developed and refined to provide up-to-date data to support MDBA planning and water management into the future.

SY 2009

The first Murray–Darling Basin Sustainable Yields project delivered the most comprehensive and complex whole-of-Basin water assessment ever undertaken at that time.

SY 2009 investigated Basin water resources and the impacts of:

- catchment development
- changing groundwater extraction
- climate variability
- climate change.

The project was conducted by CSIRO together with the state jurisdictions, Commonwealth agencies and the then Murray–Darling Basin Commission. The findings were delivered from 2007 to 2009, with more than 1.4 billion simulations of water balances translated into 19 regional reports and more than 40 technical reports. SY 2009 modelling was used to inform the 2012 Basin Plan.

SY 2025

In 2022, the Australian Government recognised the need to update understanding of Basin water resources in the face of climate change. SY 2025 aims to provide a whole-of-Basin assessment of the potential impacts of climate change on water resources.

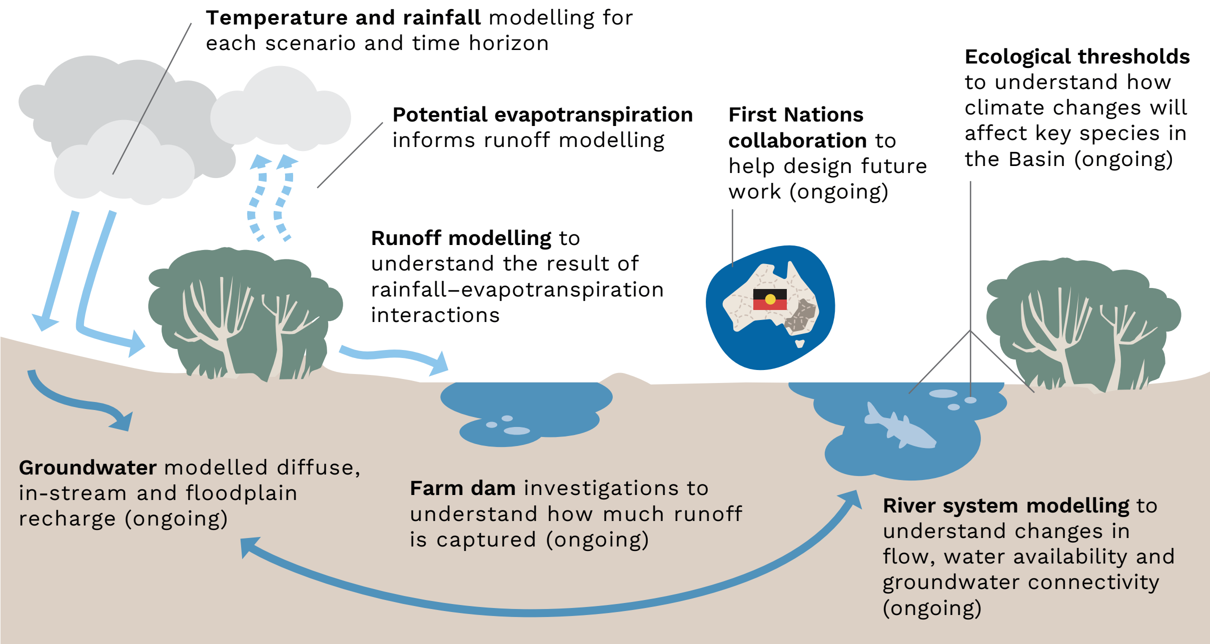
This assessment is essential for the MDBA to develop policy responses to climate change during the 2026 Basin Plan Review and ensure the review is informed by the latest hydrological and climate science. SY 2025 is one of several key reports providing input leading to the Review: the Sustainable Rivers Audit and Basin Plan Evaluation look at current conditions, and SY 2025 and the Basin Outlook consider the future.

SY 2025 has 5 modules, designed to provide a comprehensive picture of climate change and its effects on the Basin. The modules are delivering:

- Basin-wide hydroclimate projections that describe what can be expected from the changing climate
- updated river system models that incorporate future hydroclimate projections to better understand how much water would be available in Basin rivers in a changing climate
- improved understanding of groundwater recharge and surface water interception by farm dams, to ensure the MDBA has a full understanding of all relevant water systems
- improved understanding of ecological thresholds of change across the Basin, to enable better management to protect Basin ecosystems
- collaboration with First Nations peoples, to increase knowledge sharing and First Nations involvement in water management.

Each module has developed methodology to meet the aims of SY 2025, including the development of detailed computer models through iterative modelling and evaluation, desktop research, expert elicitation, pilot testing, and analysis of quantitative and qualitative data. The module delivering future hydroclimate projections feeds into the other modules to support the development of a comprehensive picture of the future of Basin water resources.

SY 2025 modules and model components



SY 2009 and SY 2025

SY 2025 builds on the processes and lessons learned from SY 2009 and other initiatives. SY 2025 is one of several important modelling initiatives undertaken by Basin states and research organisations.

Following the delivery of the 2009 project, CSIRO identified that key uncertainties remained in modelling of climate, catchment water yields and groundwater. SY 2025 has benefited from the significant advancements that have been made in climate science and modelling capabilities since then and has delivered results based on robust, up-to-date science and methodology. (See Sources for further details of relevant publications and contributors.)

Key changes and improvements include:

- additional data – the 17 years of new data between SY 2009 and SY 2025 include the breaking of the Millenium drought, several flood years and the short but severe Tinderbox drought, providing a better characterisation of the historical baseline hydroclimate.
- improved climate modelling – SY 2009 used the CMIP3 global climate model (GCM) ensemble from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4), which has been updated in SY 2025 to the latest CMIP6 ensemble from AR6. This updated ensemble supports a greater range of climate scenarios and has a finer resolution, greater model complexity and improved simulation of global climate processes. Climate change projections for the SY 2025 project come from a much larger ensemble of GCMs than in SY 2009.
- more accessible climate change projections – SY 2025 analysis expresses projections as a change in the climate variable per degree global warming, which is easier to interpret and communicate and can be applied to any future time period or emission scenario.
- improved hydrological impact modelling – SY 2025 uses a more consistent modelling approach across the entire Basin and uses stochastic data to place climate variability and climate change into historical context.
- improved river system modelling – water use and attenuation through the Basin is more accurately captured in SY 2025 with the addition of flood plain harvesting, land use and crop retention to the model, as well as improvements to the distribution of environmental watering sites and water recovery estimates.
- broader considerations – SY 2025 considers rainfall, in-stream and overbank groundwater recharge, whereas SY 2009 only looked at rainfall recharge. SY 2025 will also provide a more complete picture of the future by considering how farm dams may affect surface water and what future climate may mean for Basin ecology, and by seeking to establish First Nations partnerships.

Our changing climate

> The Murray–Darling Basin's climate is changing. This will have significant impacts on water availability and use for communities, industries and the environment.

Temperatures across Australia are now 1.5 °C hotter (on average) relative to 1910. Rainfall patterns are shifting, while average inflows in the Basin have decreased in the past 50 years, and droughts are occurring more often. Extreme events such as storms, droughts and floods are becoming more frequent and intense.

Understanding climate and hydrological modelling

> Understanding changes in climate and the resulting effects on Basin water resources is essential for effective water management. Computer modelling of climate and hydrological systems is critical to this understanding.

Historically, water management settings were largely developed using methods that assumed the future climate would look like the past. The risks associated with these methods have been realised over the past 25 years as the Basin experienced climate conditions that had not been measured before, particularly during the Millennium drought in the southern Basin and the Tinderbox drought in the northern Basin.

Climate change is accelerating, bringing the risk of large, rapid change in the climate of the Basin. Characterising the anticipated future condition of the Basin requires modelling climate change and the impact on water resources at the Basin scale.

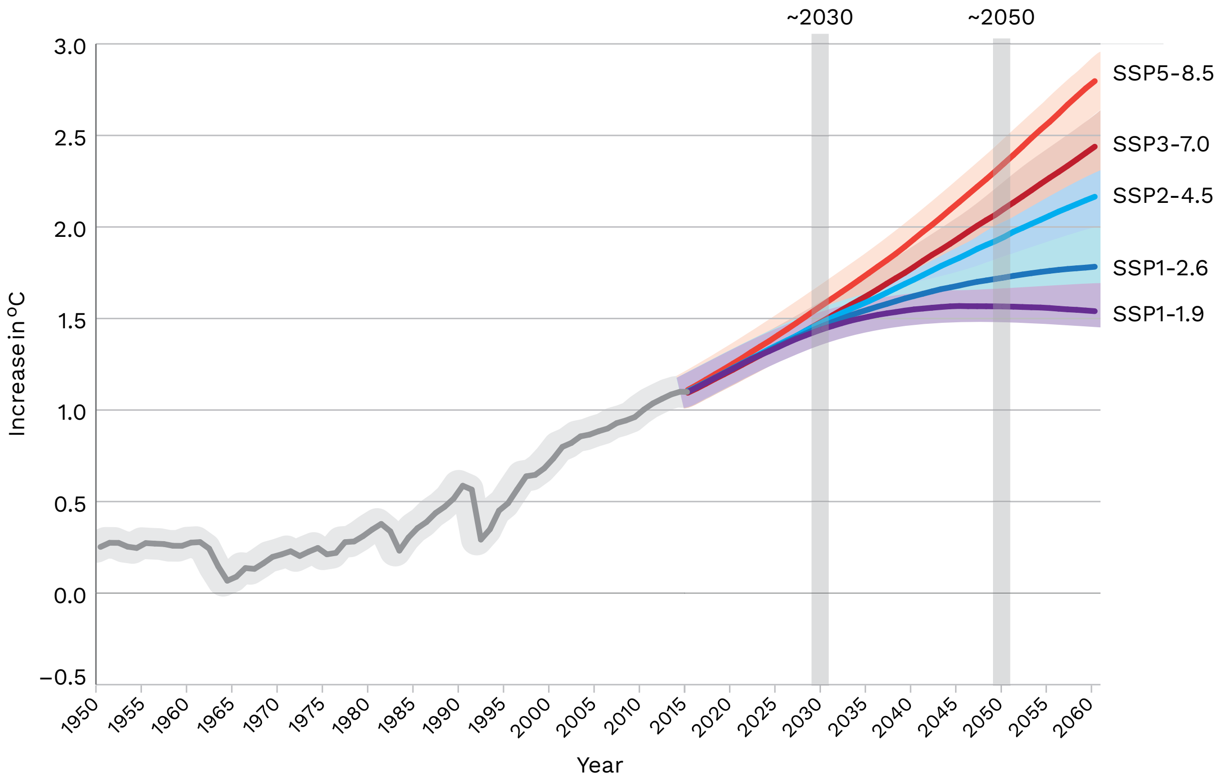
Modelling methodology

Hydroclimate refers to the interaction between climate and the movement and distribution of water in the landscape through precipitation (rain and snow), drainage (rivers and groundwater) and return to the atmosphere (evaporation and transpiration).

Hydrological models combine historical climate and water data from forward-looking climate models to simulate how water systems respond to future climate conditions and affect water availability and distribution.

Climate models are computer simulations of the world that aim to capture the interaction of the atmosphere, ocean and land. Climate models are used to understand how increased concentrations of greenhouse gases affect global temperatures and atmospheric circulation.

The models use scenarios that reflect different shared socioeconomic pathways (SSPs), which describe the trajectory of greenhouse gas emissions under future social and economic conditions. The IPCC has identified 5 potential SSPs with different mixes of technology, population growth, economic development and land use. The SSPs include the greenhouse gas emissions likely to occur with such socioeconomic change, and the resulting global warming levels. Under medium and high emission scenarios, global average temperature is projected to increase by about 2.0 °C by around 2050 relative to pre-industrial levels.



Defining the baseline climate

Climate models generally use the pre-industrial period (1850–1900) as the baseline climate against which to compare changes. This is because the period is a time before significant human influence on the global climate, particularly through the burning of fossil fuels and subsequent increase in greenhouse gas concentrations.

SY uses data from 1895 to the present. Changes to climate are presented as a difference to a 1990 baseline. This is because:

- better climate data are available for the Basin from 1990 than from the pre-industrial period
- it is closer to and more representative of the current climate; the historical climate for the Basin is considered stable from the first data acquisitions in 1895 to 1990, but by 1990 it had already become 0.5 °C warmer
- it maintains consistency with SY 2009 and with other major governmental and intergovernmental reporting (for example, IPCC, state of the climate reporting, Engineers Australia)

SY 2025 looks at a projected increase of global temperatures of 1.0 °C by around 2030 and 1.5 °C by around 2050 relative to 1990 – this is equivalent to 1.5 °C and 2.0 °C relative to the pre-industrial climate.

Climate variability and climate change

Climate variability is the changes in weather patterns that represent natural deviations in climate away from long-term averages. Climate change describes the change to those long-term averages. Current climate change is caused by human activities.

The Basin has a highly variable climate, influenced by changes in weather systems, large-scale circulation and climate drivers. The Basin experiences seasons, years and decades that are hotter and drier, or colder and wetter, than the long-term average.

Climate in the southeast of Australia is influenced by several large-scale drivers, including:

- El Niño Southern Oscillation (ENSO), which refers to the position of warm and cool water, the strength of winds, and atmospheric pressure in the equatorial Pacific Ocean. ENSO has 2 alternating phases: El Niño tends to result in dryer and warmer conditions and La Niña tends to result in milder and wetter conditions. Since the 1950s, there have been sharper swings between the El Niño and La Niña phases, with more frequent dry periods punctuated by more frequent large flood years.
- Indian Ocean Dipole (IOD), which describes the sea surface temperature in the western Indian Ocean relative to the east. A positive IOD index means drier conditions, particularly in the cool season. There is a recent trend toward more frequent positive values.
- Southern Annular Mode (SAM), which describes the north/south shift of Southern Ocean weather systems. A positive SAM (southward shift) is linked to dry cool season weather over the Basin. There is a recent trend toward more frequent positive values.
- Hadley Cell and the Sub-tropical Ridge, which block cold fronts and low-pressure systems from the south. Trends and modelling show a southwards movement of the Hadley Cell and Sub-Tropical Ridge over recent decades and into the future. The further south this system migrates, the greater the risk of dry periods.

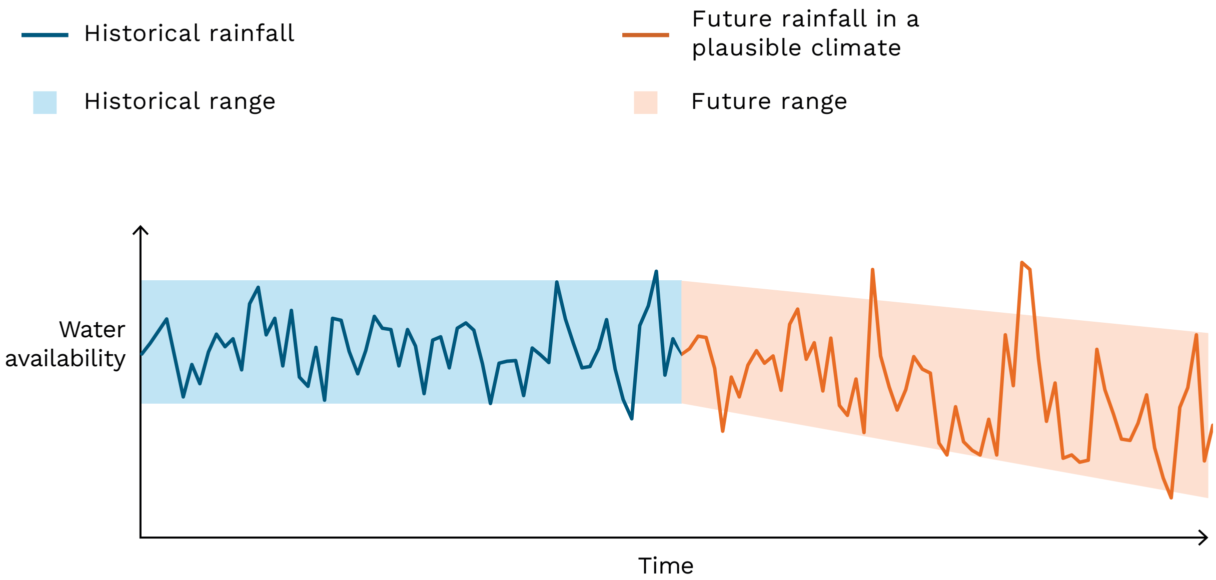
ENSO, IOD and SAM are a current focus of climate research. As understanding of these systems improves, so will estimates of their future impact on Basin water resources.

Climate change models aim to separate the effects of climate variability and existing climate drivers from the effects of climate change. Understanding the overall trends – as well as the trends in the extremes and in the variability itself – shows what can be expected from the future climate.

Climate variability refers to changes to the long-term averages that occur over months, seasons, years and decades. It includes extremes caused by individual events and El Niño and La Niña climate cycles.

Our climate will always be variable.

Climate change refers to the shift in the long-term trend. This affects the range in which variability occurs. Climate change can also affect the level of extremes and of variability.



This diagram shows concepts of climate variability and climate change as they relate to water availability and does not use real data.

SY 2025 climate modelling

> SY 2025 has a pivotal role in developing updated hydroclimate projections for the Basin to support the MDBA and Basin water management. Climate scenarios are plausible projections of future climate variables such as temperature and rainfall.
>
> To provide a robust and comprehensive picture of the future hydroclimate, SY 2025 has developed projections that show 3 possible climate scenarios for the Basin:
>
> - warmer and slightly wetter (becoming hotter and slightly wetter)
> - warmer and drier (becoming hotter and drier)
> - warmer and much drier (becoming hotter and much drier).
>
> SY 2025 has developed projections for the 3 scenarios at 2 time horizons:
>
> - to around 2030, to support the Basin Plan Review and policy
> - to around 2050, to support long-term water planning.

Each of the scenarios becomes more extreme between the time horizons. For example, what was warmer and drier around 2030 in the median scenario, becomes hotter and drier by 2050. This approach ensures we have the information to plan for both the range of futures and the likelihood of ongoing change.

Plausible climate futures

> The SY 2025 scenarios form a 'plausible range' of climate futures, which are defined as those that fall within the range between the 10th and 90th percentiles. In other words, the plausible range excludes improbable scenarios.

It is important to consider the range of plausible climate change futures because we need to ensure that planning is based on real-world considerations. Climate scenarios are projections of what the future climate could look like, not forecasts of what it will look like. Therefore, it is important to consider multiple plausible scenarios to best prepare.

If only the median scenario is considered, decision-making could ignore key impacts and changes that need to be managed. A single model might not capture rapid or extreme climate shifts or the combined effects of shifts, so planners and managers risk being under-prepared if only one scenario is considered. In addition, natural variability is still a key driver of climate impacts, and even the best model cannot predict exact sequences of wet and dry years. Adaptive and resilient planning must account for a range of plausible conditions.

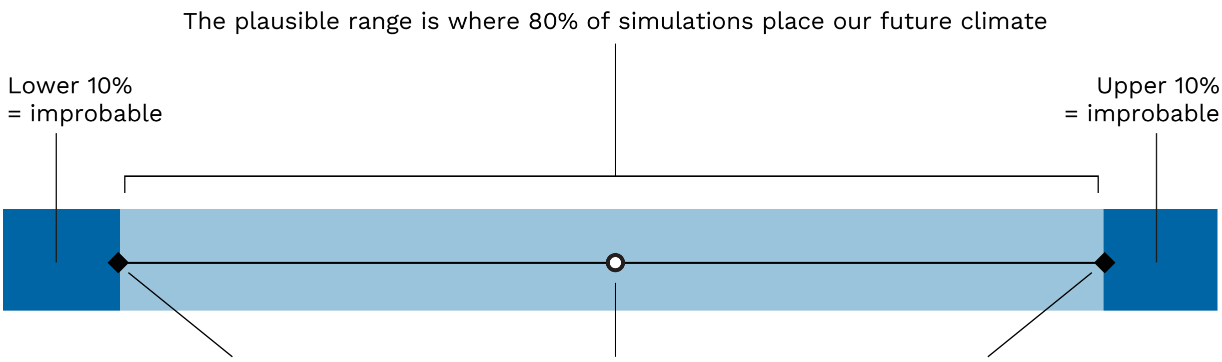
Using a plausible range provides the greatest flexibility in management and adaptation, while still leaving improbable scenarios out of consideration.

SY 2025 considers a **plausible range** of climate futures.

'Plausible' excludes possible futures that are improbable – these are the upper and lower 10% of simulations which represent the extremes of dry and wet conditions.

Because the impacts of climate change are not certain, considering a plausible range of outcomes provides a better understanding of possible future climate to support better planning.

The plausible range of climate futures cover outcomes across 3 scenarios at 2 time horizons.



	10th percentile	Median	90th percentile
~2030	Warmer and slightly wetter	Warmer and drier	Warmer and much drier
~2050	Hotter and slightly wetter	Hotter and drier	Hotter and much drier

In recent years, climate scenarios have been joined by ‘climate storylines’ to better understand and communicate impacts of climate change and support effective adaptation. SY 2025 uses both:

- climate scenarios – quantitative and model-driven representations of future climate states to explore possible long-term futures under varying assumptions (see Climate change in the Basin for the scenario-based results)
- climate storylines – narrative-based, qualitative sequences of plausible events used to understand and communicate plausible events, often focusing on specific risks (see Climate storylines). SY 2025 looked at 2 storylines at the edge of the plausible range of climate futures (hotter and slightly wetter, and hotter and much drier), and one storyline that has lower likelihood but would have a high impact (hotter and drier with extended drought).

SY 2025 modelling methodology

The SY 2025 hydroclimate projection datasets are being used to model climate change impact in the other SY modules and to inform water resources adaptation to climate change in the Basin.

SY 2025 has developed hydroclimate projections using the latest GCMs from the IPCC – the Coupled Model Intercomparison Project phase 6 (CMIP6). 120 GCM simulations from 3 SSPs were analysed (41 for SSP-2.45, 37 for SSP-3.70, 42 for SSP-5.85) at 5x5-km grid cells across the Basin. This provides projected changes in:

- temperature
- potential evapotranspiration (this means how readily the atmosphere evaporates water from surfaces like open water, soil or plants, which affects water availability)
- seasonal and annual rainfall
- very heavy rainfall events
- annual rainfall variability.

Rainfall-runoff modelling was developed for 5x5-km grid cells using historical and future climate series (informed by climate data), to develop projected changes in rainfall and runoff characteristics and impacts.

Climate change in the Basin

The SY 2025 hydroclimate modelling forms the basis of understanding impacts on Basin water resources and planning for the future.

The modelling shows that, with climate change:

- the Basin is virtually certain to be hotter
- annual rainfall is likely to become more variable
- very heavy rainfall events are very likely to become more intense
- cool-season rainfall is likely to decline in the northern Basin and very likely to decline in the southern Basin
- rainfall and runoff variability across years in the Basin will remain high and may increase
- potential evapotranspiration is virtually certain to increase and the Basin is very likely to become more arid.

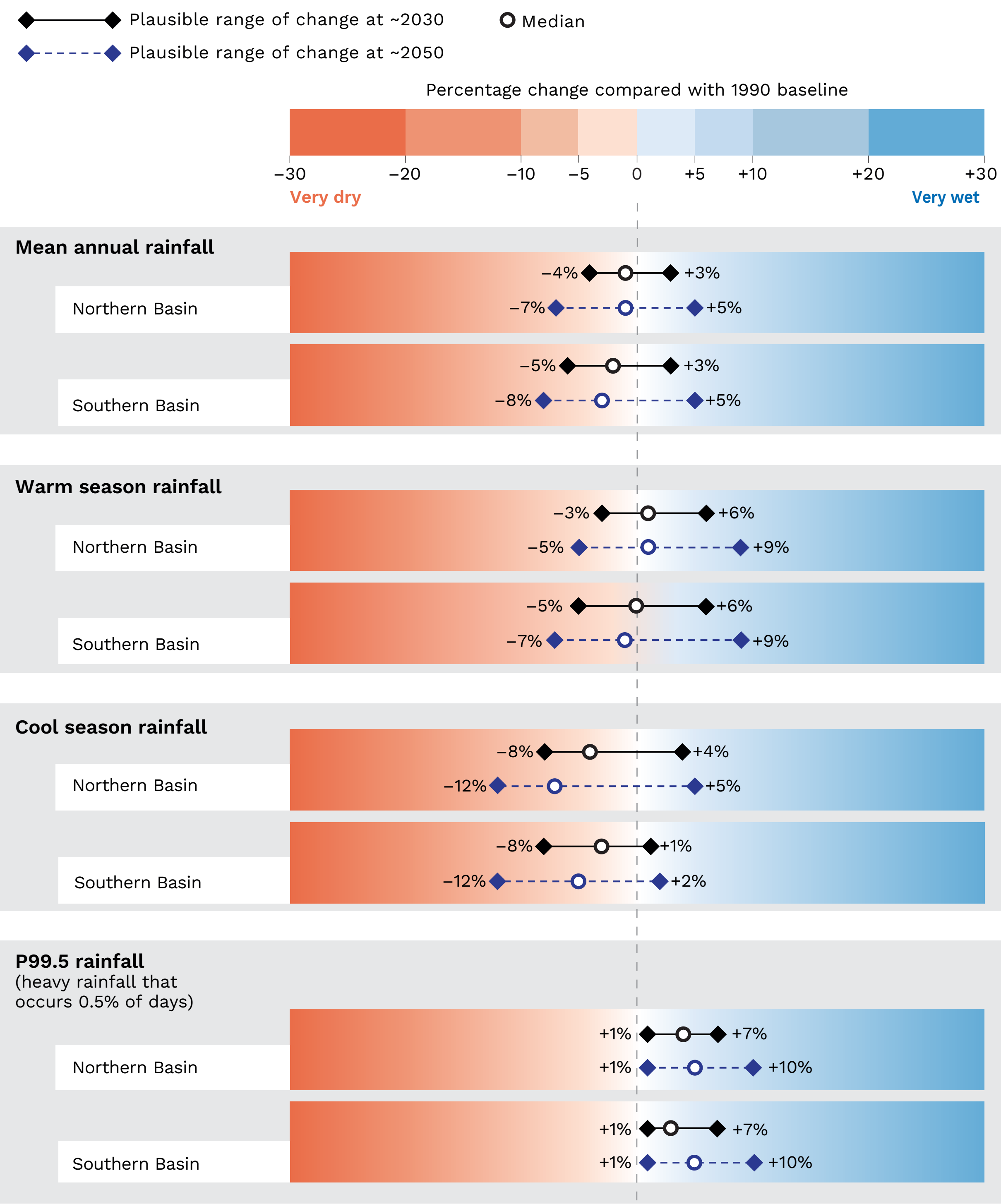
In the Basin, regional trends and future projections indicate a hotter and likely drier future. The Basin is warming faster than the global mean and the mean temperature in the Basin has already increased by around 1.5 °C since 1910. Potential evapotranspiration in the Basin is also increasing, mainly driven by temperature. Under global warming of 2.0 °C, potential evapotranspiration in the Basin is projected to increase by 4–5%.

Compared to temperature and potential evapotranspiration, rainfall projections are more uncertain. Overall, it is likely that average rainfall will decrease, particularly in the south. Observed cool-season (May–Oct) rainfall has declined significantly in southeast Australia and it is very likely that it will continue to decrease. However, there is no significant trend in warm-season (Nov–Apr) rainfall observations and it is not clear whether warm-season rainfall will increase or decrease.

The rainfall and runoff variability experienced in the Basin will remain high and will dominate water availability in the near term. In the longer term, climate change is more likely to lead to overall decreases in rainfall and runoff.

Rainfall

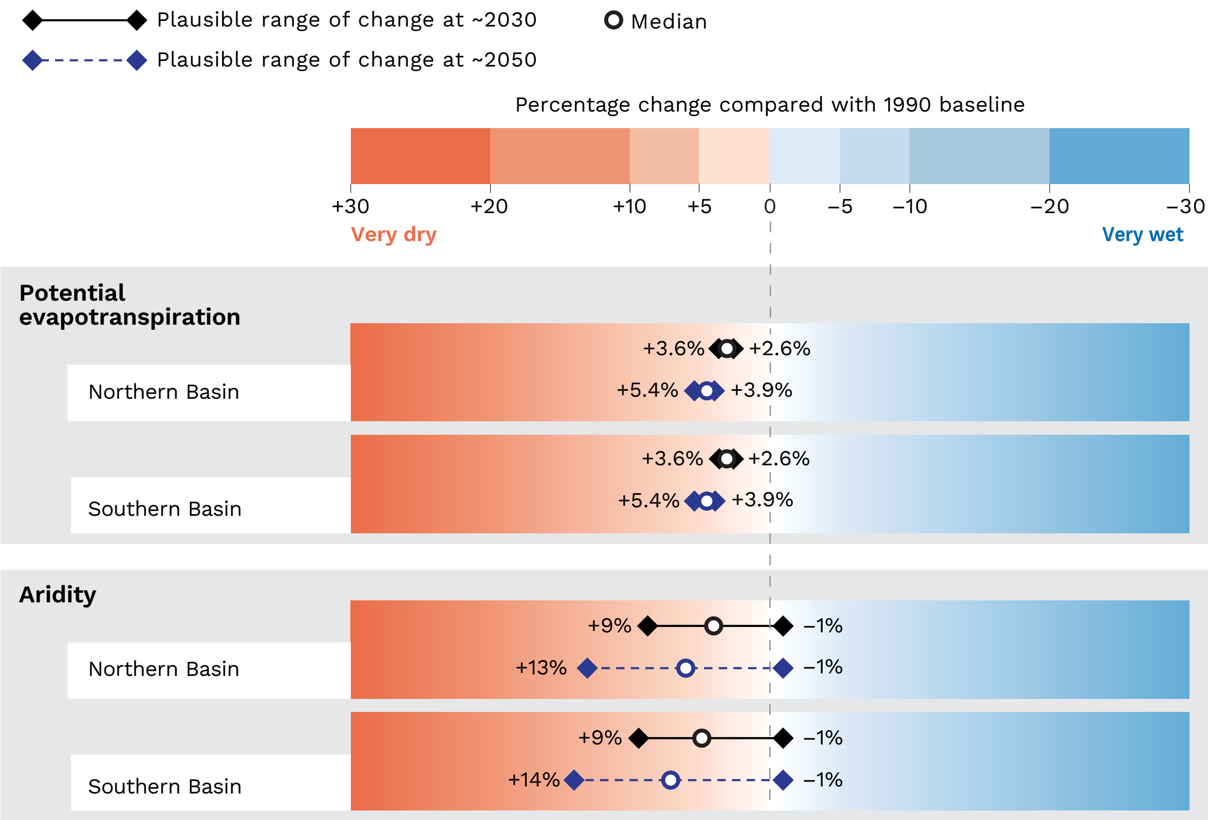
The lines show the projected changes to future rainfall under an increase in temperature of 1.0 °C around 2030 and 1.5 °C around 2050, relative to 1990. The range is considered to be plausible, based on projections that fall between the 10th and 90th percentiles of the SY 2025 modelled climate scenarios. Changes to the median show the direction of change for the future.



The projected decrease in rainfall, coupled with increasing potential evapotranspiration, will lead to more arid conditions in the Basin. Increasing aridity can affect plant productivity and water security and increase competition for natural resources, potentially increasing the spread of arid regions.

Aridity

The lines show the projected changes to future potential evapotranspiration and aridity index (potential evapotranspiration divided by rainfall) under an increase in temperature of 1.0 °C around 2030 and 1.5 °C around 2050, relative to 1990. The range is considered to be plausible, based on projections that fall between the 10th and 90th percentiles of the SY 2025 modelled climate scenarios. Changes to the median show the direction of change for the future.



Impacts to water resources

The changes in the Basin climate will have significant impacts on water resources:

- runoff and water resource availability in the Basin are very likely to decline
- droughts are very likely to become more frequent and severe.
- total groundwater recharge is likely to reduce under climate change, particularly in the southern Basin.

Understanding the impact of climate change on the Basin's water resources is central to the MDBA's role in coordinating how those resources are managed.

The work done to understand the future hydroclimate of the Basin (see Climate change in the Basin) flows on to other SY 2025 work to improve understanding of how the Basin's water resources will be affected by climate change.

Existing differences in the northern and southern Basins

The hydroclimate and landscape in the northern and southern Basins are different. The historical characteristics and trends in water availability in the basins will be amplified with climate change.

Northern Basin

- Lower rainfall, higher potential evapotranspiration
- Warm-season dominated rainfall
- Runoff at all times of the year
- Very high variability in stream flow across years
- Darling River contributes on average about 15% of Basin flows
- Many intermittent and ephemeral rivers
- 20% of public reservoir storage in the Basin

Southern Basin

- Higher rainfall, lower potential evapotranspiration
- Cool-season dominated rainfall
- Runoff mainly in winter and spring
- High variability in stream flow across years
- Murray River contributes on average about 85% of Basin flows
- Large perennial rivers
- 80% of public reservoir storage in the Basin

Runoff

With climate change:

- runoff is very likely to decline, particularly in the south
- hydrological droughts (with reduced runoff and water availability) are very likely to become more severe and occur more frequently, and may be of longer duration
- the frequency of moderate flood inundation is likely to decline, but the height and duration of large floods may increase
- hydroclimate variability will remain high and may increase, and long wet spells and long dry spells will continue to occur.

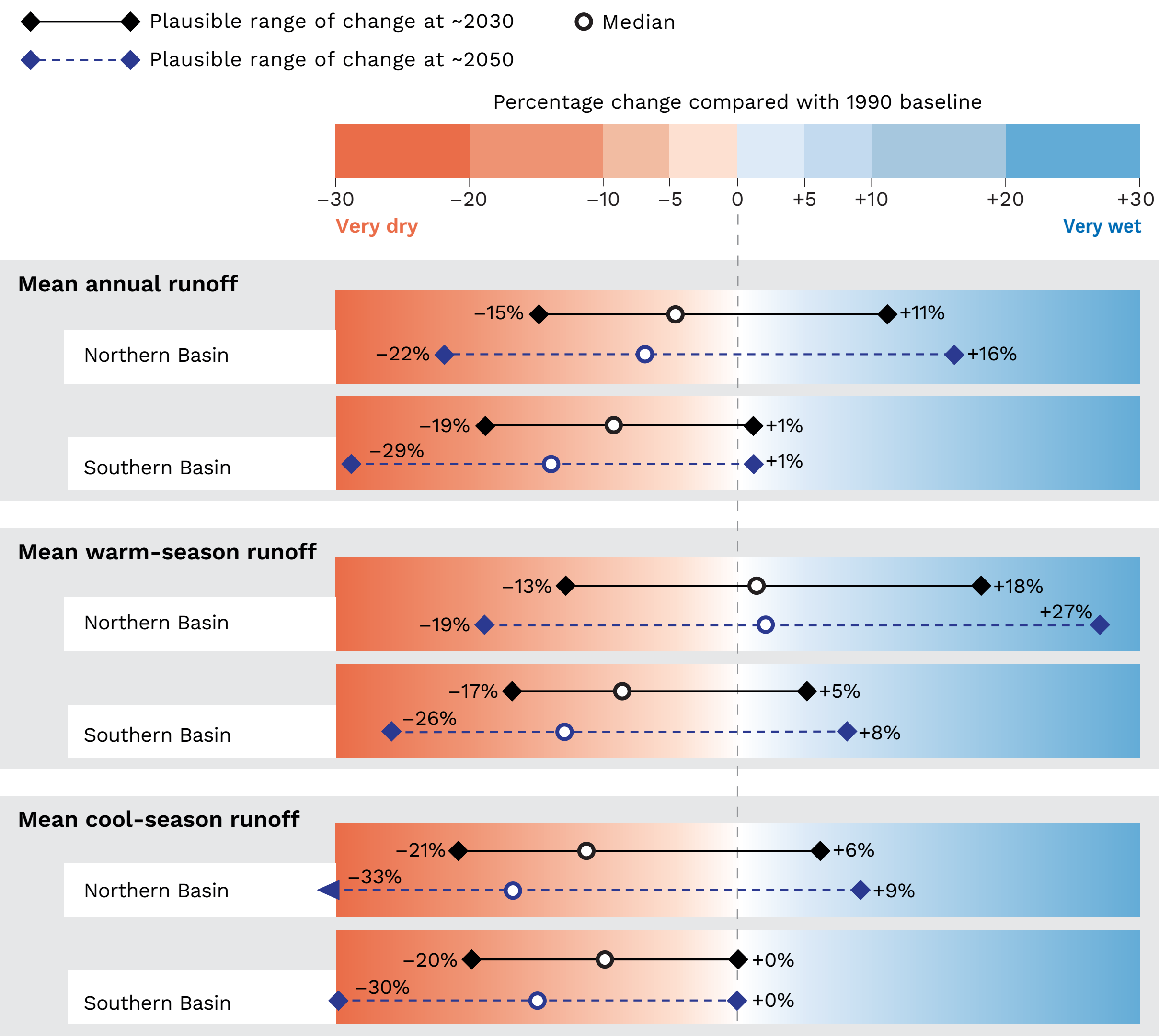
The main climate influences on average annual runoff are average annual rainfall and potential evapotranspiration (see Climate change in the Basin for details of climate change impacts on rainfall and potential evapotranspiration). Averaged across the whole Basin, the proportion of annual rainfall that becomes runoff is about 5% to 6%. A 1% change in mean annual rainfall is generally amplified as a 2% to 4% change in mean annual runoff in the Basin, with greater amplification in drier catchments. Thus, the projected reduction in rainfall and increase in potential evapotranspiration under climate change will also reduce runoff.

In the hotter and drier climate scenario, there is a 7% reduction in mean annual runoff averaged over the northern Basin and 14% reduction averaged over the southern Basin. The projected reduction in runoff is higher in the south because most southern runoff occurs in the winter and spring, thus the projected reduction in cool-season rainfall in the south has a large impact. The projected increase in the intensity of very heavy rainfall events has a larger impact in moderating the runoff reduction in the north.

There is a large range in the runoff projections – from −22% to +16% in the northern Basin, and from −29% to +1% in the southern Basin. This large range occurs mainly because of the uncertainty in future rainfall projections.

Runoff

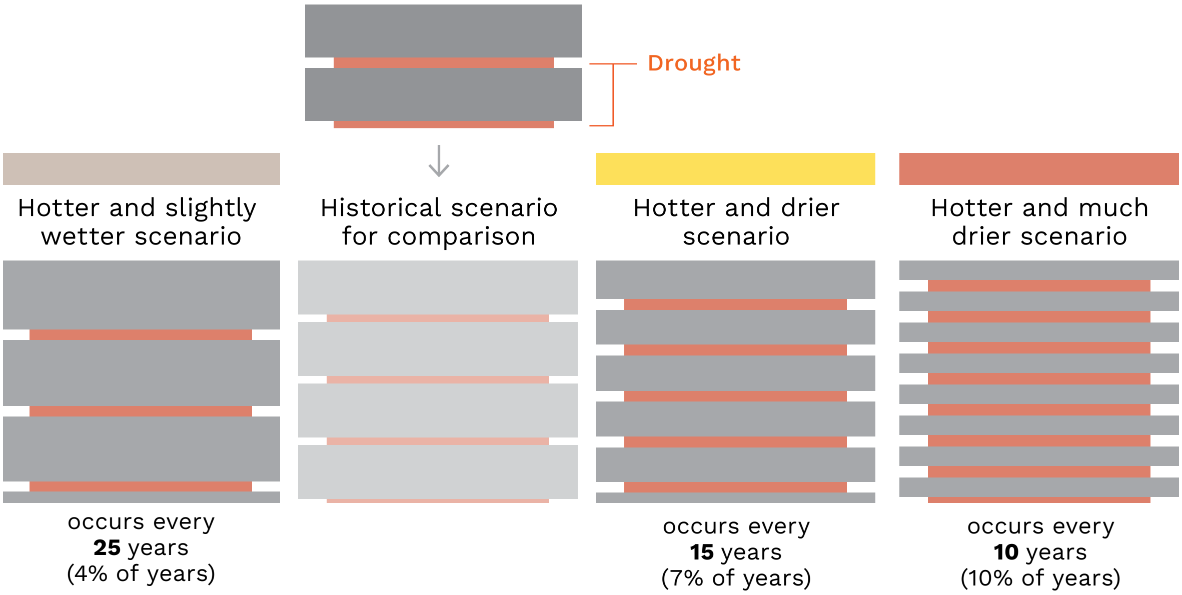
The lines show the projected changes to future runoff under an increase in temperature of 1.0 °C around 2030 and 1.5 °C around 2050, relative to 1990. The range is considered to be plausible, based on projections that fall between the 10th and 90th percentiles of the SY 2025 modelled climate scenarios. Changes to the median show the direction of change for the future.



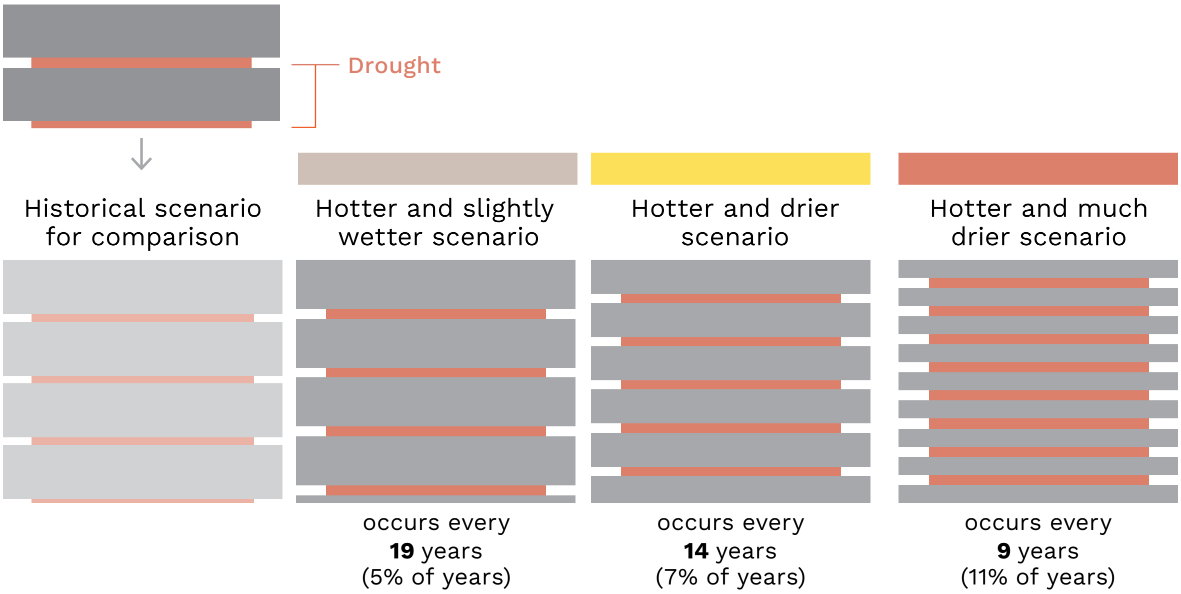
Overall, it is very likely that average runoff will decrease, particularly in the south. This is very likely to bring more severe droughts that will occur more frequently compared with 1910, and that may be of longer duration. These projections relate to hydrological drought (runoff and water availability), rather than meteorological drought (rainfall). The projections align with observed historical data, which show a trend of increased frequency of drought occurrence in recent decades compared with early records.

This diagram shows how the **frequency of droughts** (horizontal lines) changes in the future climate scenarios, compared with the current climate.

In the **Northern Basin**, the type of drought that occurred every **20** years (5% of years)



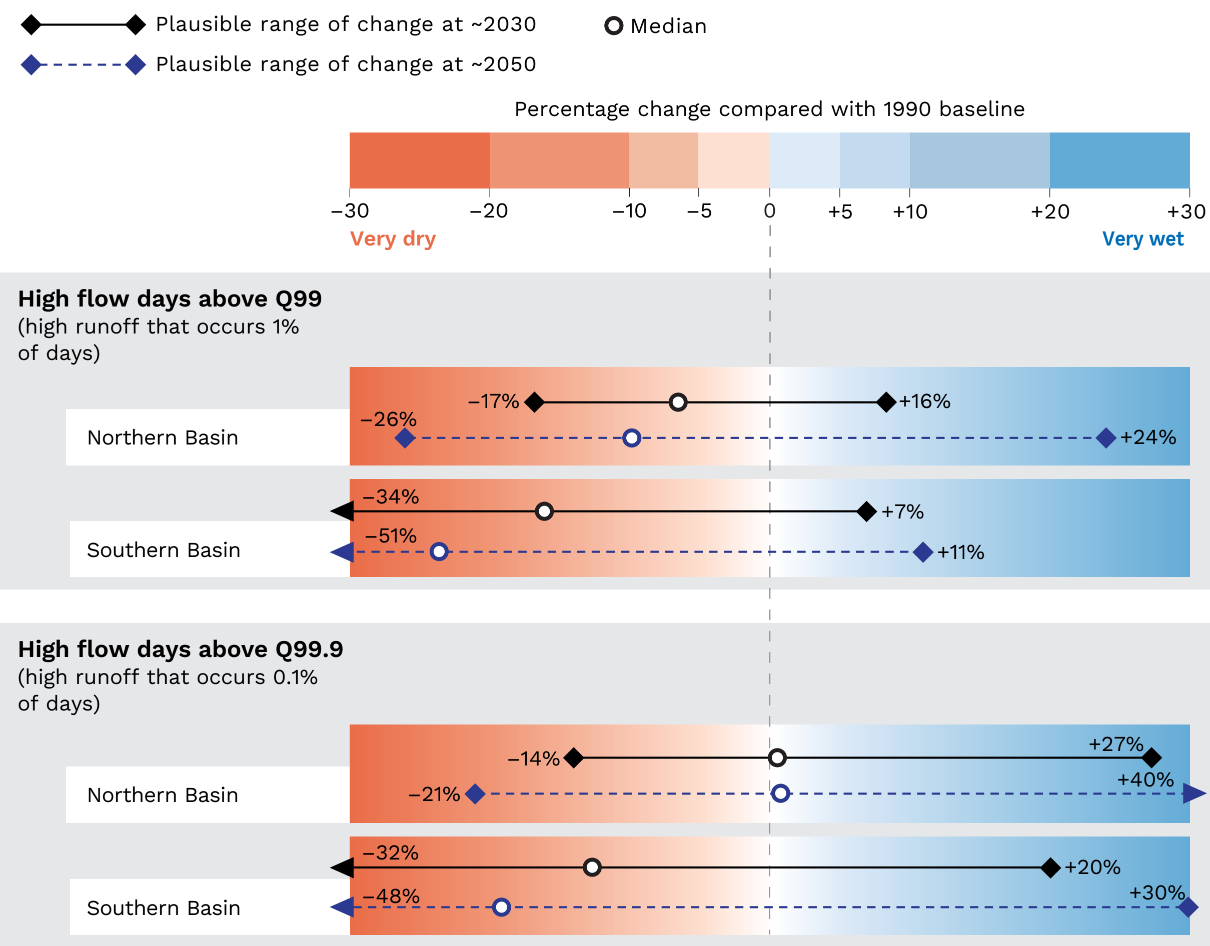
In the **Southern Basin**, the type of drought that occurred every **20** years (5% of years)



Very large floods may increase, particularly in the northern Basin, because very heavy rainfall events will become more intense. Moderate floods will decline. However, the decline is likely to be less than the projected reduction in mean runoff. This is because the increase in high intensity rainfall events will be offset by drying catchments, so high rainfall events may result in less runoff than might be expected.

High flows

The lines show the projected changes to future high flows under an increase in temperature of 1.0 °C around 2030 and 1.5 °C around 2050, relative to 1990. The range is considered to be plausible, based on projections that fall between the 10th and 90th percentiles of the SY 2025 modelled climate scenarios. Changes to the median show the direction of change for the future.



Rivers

> The MDBA coordinates the management of water in the Basin's river systems. Understanding the amount of water available in Basin river systems and its distribution is critical to effective water management.
>
> Under climate change, long-term average annual stream flows are projected to decline. Under current water management arrangements and policy settings, this would have the greatest effect on the non-entitlement water that stays in the river systems. It will also have the greatest effect on water availability for downstream users.
>
> Future planning will need to balance the needs of different water users, including the environment, to achieve more with less water.

The MDBA and Basin states manage water allocations in the Basin, which are influenced by rainfall, inflows and storage levels. Allocations can change throughout the year based on system conditions and are crucial for managing water availability for various users.

River system modelling in the Murray–Darling Basin uses models that have been established for each of the valleys within the Basin states. SY 2025 has modelled river flows for Basin valleys, informed by the 3 climate scenarios and 2 timelines (see SY 2025 climate modelling), against 3 development scenarios:

- without water resource development, no dams, weirs or extractions
- pre-Basin Plan reference as at June 2009, with the conditions of development, operation and water sharing immediately before the Basin Plan
- Basin Plan fully implemented, with maximum plausible future development, including full implementation of sustainable diversion limits (SDLs) and non-relaxed constraints.

Rainfall and thus stream flow have declined across the Basin in the past 50 years. Higher temperatures and drier conditions are expected to continue, increasing in frequency and severity. As hotter and drier years increase in frequency, long-term average annual stream flows are projected to decline.

Using multiple lines of evidence from SY 2009, Basin state initiatives such as the Victorian Water and Climate Initiative and trends observed from the SY 2025 river system modelling, SY 2025 estimates the disproportionate impacts of climate change on the different types of water entitlements.

The total water available in any year includes:

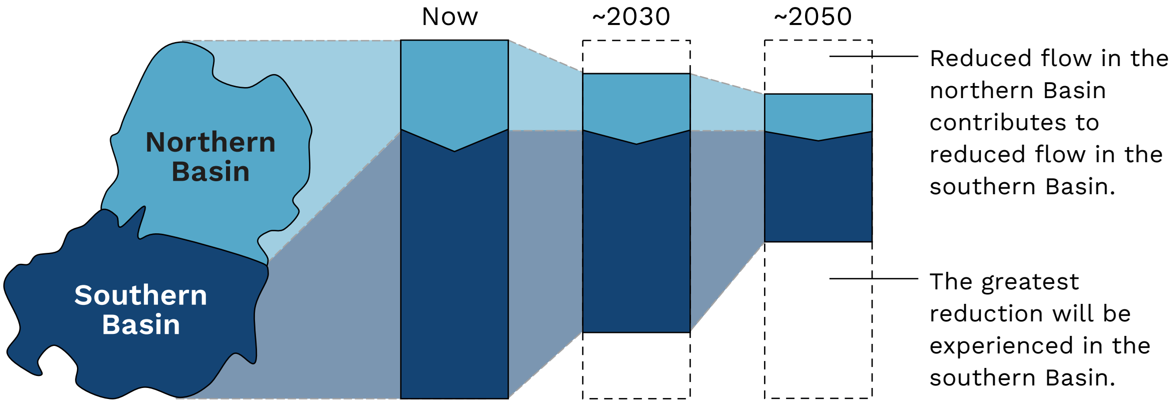
- entitlement water that can be held by individuals, industries and governments. It includes consumptive water rights and environmental water entitlements.
- non-entitlement water that is managed through state water sharing arrangements and is not tied to an entitlement. It provides important environmental and user benefits.

Under current water management arrangements, climate change will disproportionately impact non-entitlement water. Under climate change, the balance between entitlement and non-entitlement water in the Basin is expected to shift. As the total volume of average available water is projected to decrease over time, the proportion that is non-entitlement water is expected to decrease while the proportion that is entitlement water is expected to increase.

Non-entitlement water is comprised of volumes of water that serve a range of purposes and have varying levels of prioritisation in state water sharing arrangements. Although climate change will disproportionately impact non-entitlement water, changes in the volumes and reliability of non-entitlement water will vary between its different types. For example, non-entitlement water for passing flows is to remain relatively reliable, whereas unregulated flows are more at risk from a hotter and drier climate.

The reliability of entitlement water and types of non-entitlement water is an effect of a developed river system. Water infrastructure, such as dams and weirs, and water sharing arrangements are designed for security of supply for entitlement holders and communities. Hence, entitlement water, and types of non-entitlement water that are vital for communities, are generally more reliable or available when required. In contrast, unregulated flows are more exposed to year-to-year variation in climatic conditions and system inflows and are therefore anticipated to experience higher impacts under a hotter and drier climate.

The SY 2025 river system models also estimated the disproportionate impacts of climate change in different parts of the Basin water system. Changes to water availability under climate change will particularly affect downstream users in the southern Basin, as effects accumulate along the course of river systems. Under current policy settings, these outcomes are likely to mainly affect the end of the system, including the Lower Lakes.



The diagram shows the concept of flows across the Basin and does not use real data.

Sea level rise

Climate change is expected to increase sea levels by 2050 due to thermal expansion of sea water and glacial and icesheet melting. Since 1993, the sea level along the southeast coast of Australia has been rising by an average of 3.4 mm/year, and the rate of rise has been gradually increasing. By 2050, relative to 1986–2005, sea level in southern Australia (Victor Harbor) is projected to increase by 14–30 cm (median 25 cm) under SSP-5.85.

Rising sea levels, coupled with storm surges, will affect the Mouth of the River Murray. Impacts include changes to the hydrodynamics and coastal processes of the Coorong and Murray Mouth, and an increased frequency of sea water overtopping the barrages and barrier islands between the Coorong and Lake Alexandrina.

Groundwater

> To ensure that groundwater SDLs are sustainable, it's important to understand whether and how quickly groundwater is replenished after use, and how salinity levels are affected. Despite the importance of groundwater, the rate of groundwater recharge and how recharge processes might be affected by climate change has not been well understood.
>
> SY 2025 models the impact of climate change on groundwater recharge. Total recharge is likely to reduce under climate change, particularly in the southern Basin, but there is large uncertainty in the projections.

Groundwater, stored in aquifers (porous layers of rock, sand or gravel), is an important water resource for many rivers and river ecosystems in the Basin. Water management in the Basin includes groundwater – SDLs set the volume of groundwater that can be used, to protect this important resource.

SY 2025 updates and extends the groundwater recharge modelling conducted in SY 2009. Understanding the relative influence of various processes on groundwater recharge is the first step in understanding how climate change affects each of these processes. The SY 2025 modelling considers 3 components of recharge across the Basin:

- rainfall recharge (also known as diffuse or landscape recharge), from rainfall infiltrating through the soil
- overbank flood recharge, from inundation when rivers break their banks
- in-stream recharge, from stream losses through the bed and banks.

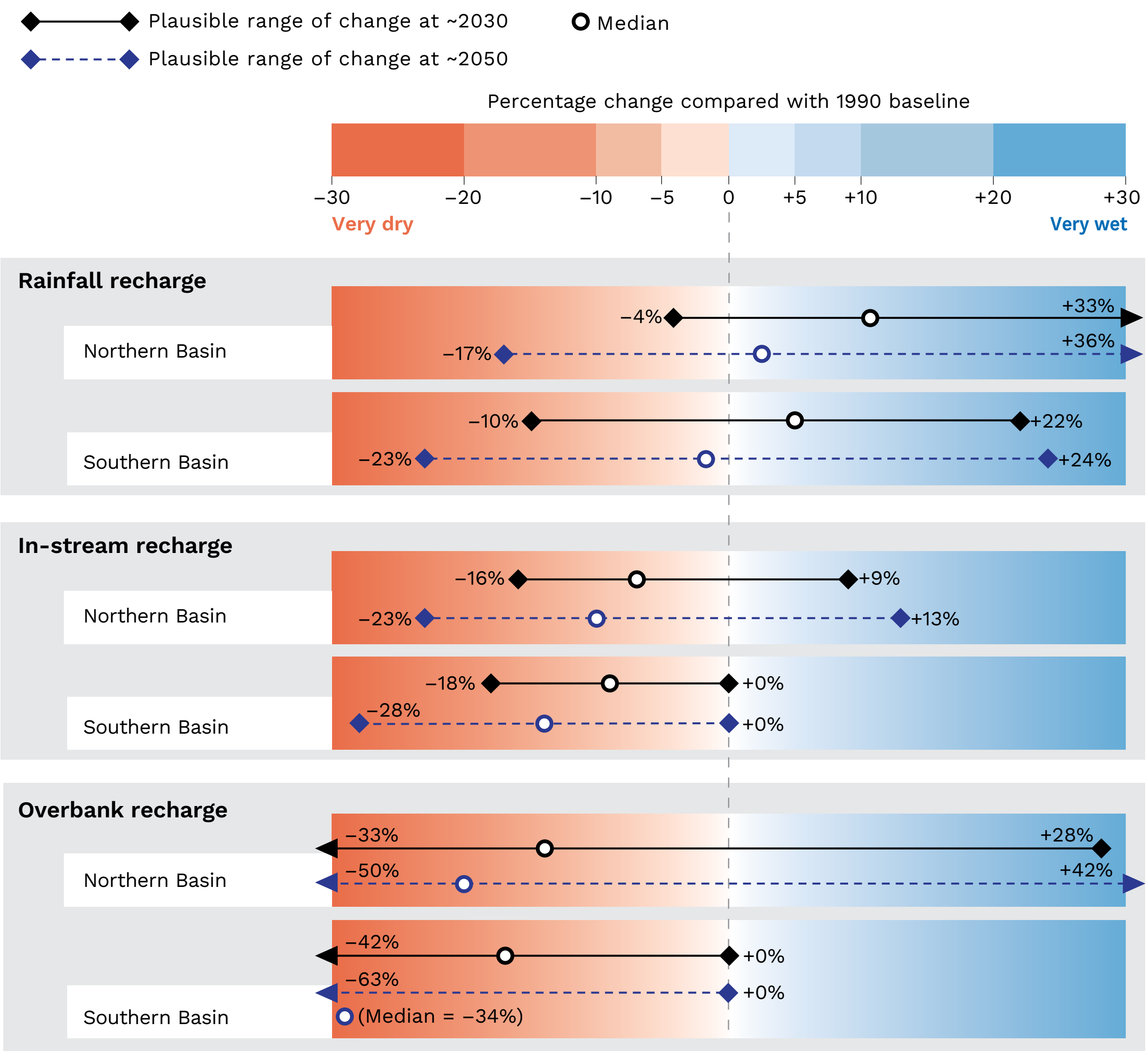
Rainfall recharge is likely to be the largest overall component of recharge, but floodplain recharge may be a significant proportion of total recharge, particularly in wet years and for large floodplains. In-stream recharge is likely to be only a minor component of recharge at a Basin scale but may be important for individual groundwater-dependent ecosystems.

SY 2025 models the changes in the 3 recharge components for the groundwater SDL units under future climate conditions, using the SY climate scenarios for 2050. The change in rainfall recharge under a future climate was modelled using an integrated energy and water balance model (Water Vegetation Energy and Solute Modelling – WAVES), as in SY 2009. The changes in overbank flood recharge and in-stream recharge were modelled from the output of existing river models and river channel and floodplain geometry.

Total recharge is projected to reduce under climate change, particularly in the southern Basin. The 3 recharge components are affected by projected climate change in different ways. For the hotter and much drier scenario, all SDL units have a decrease in recharge for all 3 components. For the warmer and drier scenario, 76% of SDL units increase in rainfall recharge whereas none of the SDL units increase in overbank flood or in-stream recharge. For the warmer and slightly wetter scenario, no SDL units decrease in recharge for any component.

Groundwater

The lines show the projected changes to future groundwater recharge under an increase in temperature of 1.0 °C around 2030 and 1.5 °C around 2050, relative to 1990. The range is considered to be plausible, based on projections that fall between the 10th and 90th percentiles of the SY 2025 modelled climate scenarios. Changes to the median show the direction of change for the future.



Groundwater modelling is complex due to the hidden nature of subsurface conditions and the interactions between groundwater and landscape elements such as soil, vegetation and geological features. The modelling methods used in SY 2025 have limitations because of these complexities. In particular, increases in rainfall recharge and decreases in overbank recharge may not be as large as predicted.

Groundwater is likely to become more important as a resource, as surface water declines under a hotter and drier climate. Research is continuing to more robustly project changes in groundwater recharge under climate change. For each SDL unit, understanding local processes and which recharge component has the largest impact on local recharge will be important to modelling change.

Improving groundwater modelling in the Lower Namoi and Upper Lachlan

A project focused on the Lower Namoi and Upper Lachlan groundwater areas is helping to advance understanding of groundwater processes in the Murray–Darling Basin.

Existing groundwater models have limitations in supporting current water management needs, as they do not include climate change and the impacts on surface water connectivity and local drawdown impact.

In the Lower Namoi and Upper Lachlan Groundwater Modelling Enhancement Project, the MDBA and NSW Department of Climate Change, Energy, the Environment and Water focused on the hydrogeology in the Lower Namoi and Upper Lachlan. These groundwater sources are priority systems for the MDBA and New South Wales, and both have experienced declines in groundwater levels.

The project is developing detailed 3D geological and hydrogeological conceptual models to enable the development of new numerical models. The project has also developed recommendations to improve the data accuracy for calibration of the numerical model in the future.

These models will better characterise surface water and groundwater interactions and climate change risks to groundwater to meet the needs of state and federal water resource management. This includes inputs to the revision of SDLs and water sharing plans, and other management to meet the objectives for sustainable groundwater levels, baseflow to rivers and groundwater-dependent ecosystems.

Planning for the future

> SY 2025 is a significant step forward in providing the information the MDBA will need in planning for the future. However, it is not the final step in this journey.
>
> Ongoing work, both within SY 2025 and across the MDBA, will continue to improve understanding of climate change and its impacts. Internal and external expertise will be used to ensure the MDBA approach is robust and keeps pace with the latest hydroclimate science and technical advancements.

More broadly across the MDBA, the Basin Plan Review is considering the impact that climate change will have into the future after SY 2025 is concluded. The MDBA is preparing for a range of plausible climate futures by:

- assessing the effectiveness of current arrangements and understanding the impacts of climate change on the Basin's water resources across a range of hydroclimate futures
- considering climate change risks to the Basin and developing improved processes and outcomes to address these risks
- better understanding the potential consequences of long-term climate change for the Basin and considering how best to respond.

Moving forward from SY 2025

SY 2025 is continuing work in several modules to inform the 2026 Basin Plan Review and beyond. This work includes:

- rivers, farm dams and groundwater – the modules looking at rivers, groundwater and farm dams are continuing work to build accurate and detailed computer models to better understand related processes and the effects of climate change; this work will be informed by advances in hydroclimate modelling
- ecological impacts – SY 2025 explores key species and species groups that may be affected by climate changes in temperature, rainfall and drought to complement the work done in the Sustainable Rivers Audit, Basin Outlook and elsewhere
- working with First Nations people – it's critical that First Nations people are involved and provide leadership to the design of future work. MDBA is exploring collaborative work with First Nations people that explores the relationship between flows, climate change and First Nations outcomes across the Basin.

Ongoing improvements to hydroclimate and river system models

The MDBA is committed to continued development in understanding hydroclimate risks in the Basin, particularly as they relate to the Basin Plan. MDBA, together with Basin states, is exploring ways to improve future SY assessments including strengthening hydroclimate risk assessments, strengthening modelling capability and governance, and improving fit-for-purpose models and methods. In particular, integrating rainfall-runoff models, river system models and groundwater models will improve understanding and support holistic management of Basin water resources. Improvements will be achieved through:

- future science investment
- internal capability development planning
- program design and delivery
- sharing outcomes with Basin communities to create a shared understanding.

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Likelihood of outcomes

In presenting the expected impacts of climate change, SY 2025 uses the following terms about the likelihood of an outcome, based on the IPCC approach and terminology.

Term	Likelihood
Virtually certain	99–100%
Very likely	90–100%
Likely	66–100%
About equally likely or unlikely	33–66%
Unlikely	0–33%
Very unlikely	0–10%
Exceptionally unlikely	0–1%

Defining sustainable diversion limits

Sustainable diversion limits (SDLs) are fundamental to the Basin Plan. They limit how much water, on average, can be used in the Basin by communities, towns, agriculture and industries, while maintaining the health of rivers and the environment.

SDLs are the long-term average annual limit of consumptive water that can be used in each surface water and groundwater resource unit in the Murray–Darling Basin. An SDL resource unit is a defined area where an SDL is applied to manage water resources.

To ensure the amount of water taken does not exceed the limits, the amount of water taken in each SDL unit each year is recorded and published in a process known as SDL accounting. SDL accounting is a shared responsibility between the MDBA and the Basin states – the Basin states provide information about how much water has been taken, and the data are assessed and synthesised into the SDL accounts.

Contributors

SY 2025 has established dedicated teams within the MDBA to progress each of the modules and has drawn on the expertise and experience of a range of contributors.

In 2023, the Independent Hydroclimate Science Expert Panel (IHSEP) was established to provide advice and guidance to the MDBA and Basin Officials Committee on developing a hydroclimate method that considers climate change and variability in the Basin. This included an initial report on the methodologies, limitations and resources required to deliver the suite of hydroclimate scenarios. The MDBA adopted recommendations from the report wherever possible, and will continue to look for opportunities to implement these recommendations in SY 2025 and more broadly.

CSIRO was engaged to provide hydroclimate projection datasets, which considered advice from IHSEP and input from Basin states. The MDBA Advisory Committee on Social, Economic and Environmental Sciences (ACSEES) also provided important input; ACSEES was established in 2012 to review and advise on the science that informs Basin Plan implementation and the broader scientific context of the MDBA's work. MDBA engaged with the the Australian Climate Service to ensure consistency in approach and methodology with the National Climate Risk Assessment (see www.acs.gov.au/pages/national-climate-risk-assessment for information on climate risks at the national scale). Other expert independent contractors have been engaged to provide specific pieces of work within the modules.

Basin states play a crucial role and have been actively engaged throughout the SY project, contributing to defining objectives and deliverables along with important data, methodology and review. Basin state representatives and independent experts were involved in several groups providing input to the project. The interjurisdictional Strategic Hydroclimate Working Group was established in 2023 to provide advice on developing and applying Basin-scale hydroclimate information. Interjurisdictional advisory panels supported each of the SY modules: Modelling Advisory Group, Groundwater Advisory Panel, Surface Water Advisory Panel, Runoff Dams Working Group. This collaborative approach enables sharing of key information and insights and ensured that SY 2025 was developed with an understanding of the broader Basin context and state initiatives.

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Australian Government

Murray–Darling Basin Authority

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Canberra | *Ngunnawal Country*

Goondiwindi | *Bigambul Country*

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Website: www.mdba.gov.au

Phone: 1800 630 114 (Toll free)

Email: engagement@mdba.gov.au