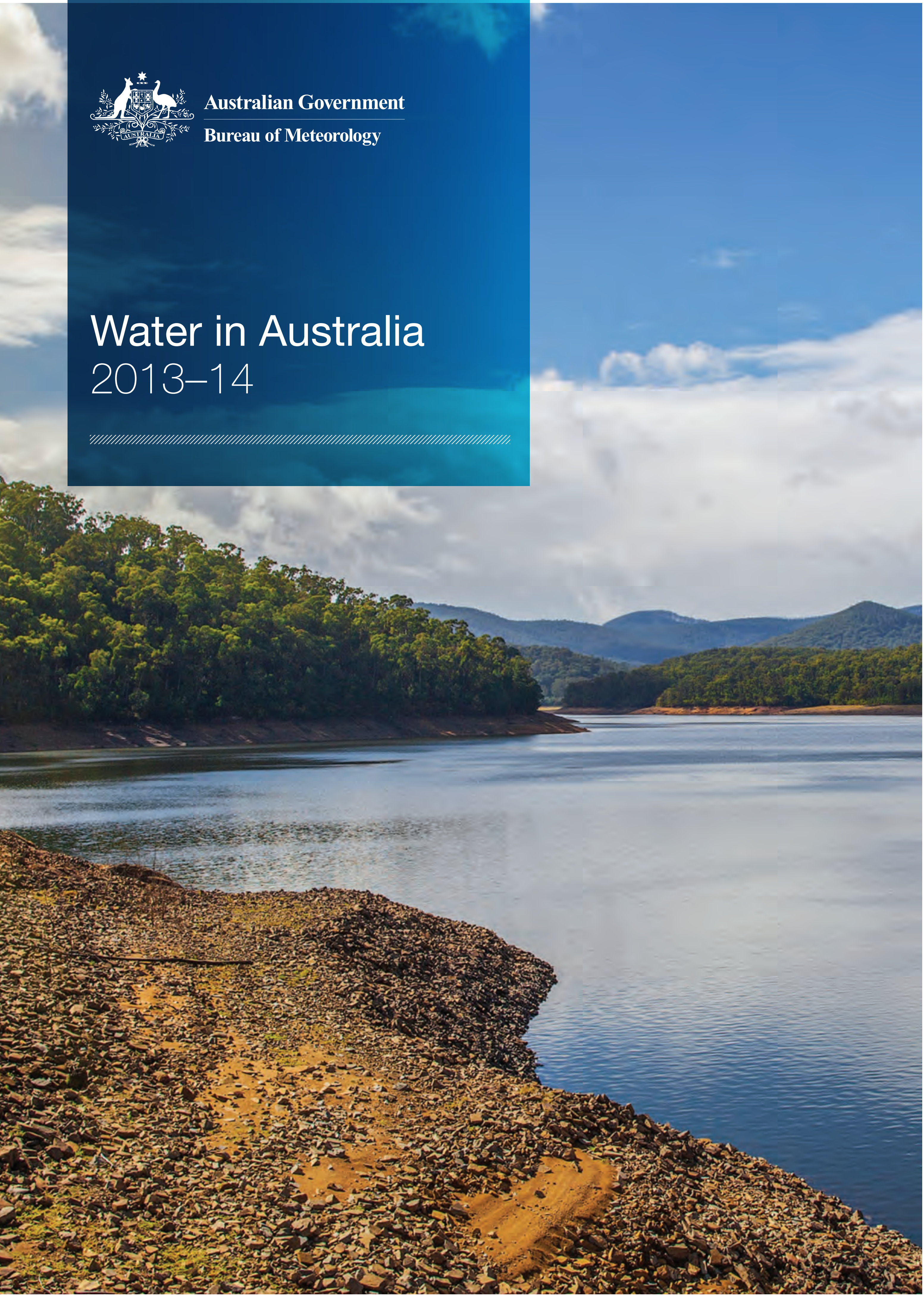
Australian Government
Bureau of Meteorology

Water in Australia
2013–14



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Page 10 photograph:	Irrigation dam near Kurting, Victoria. Courtesy of Alison Pouliot.

CONTENTS


SP73

Australia has one of the most variable rainfall and streamflow regimes in the world. We frequently lurch from drought to flood and back. The hardship faced during extended drought, especially by farmers, is etched in the psyche of each generation—notably during Federation, World War II and, most recently, the Millennium Drought.

At the peak of the Millennium Drought, the Bureau of Meteorology was tasked by the Australian Government 'to provide water data necessary for good decision-making by governments and industry'.

Since 2008, the Bureau of Meteorology has been building capacity to integrate and convey information about weather, climate and water. Australia's droughts and floods make water planning challenging, but situational awareness and forecasting helps governments, water managers and irrigators to better manage these inherent risks.

Water in Australia summarises the water situation across Australia for the previous financial year, in the context of climatic conditions. This report brings together and analyses information from a wide range of sources to paint a richer picture of changes in Australia's water resources than is possible from observational data alone.

We all value localised information, so the national-level *Water in Australia* is complemented by two online products:

- *Regional Water Information*, which provides spatial information down to river region level on the status of water resources and use during the assessment year
- *Monthly Water Update*, which provides a regular snapshot of rainfall and streamflow for the previous month relative to average conditions.

Together, this suite of assessments forms an insightful evidence base to inform water management.

The water information published by the Bureau is based on data supplied by almost 200 organisations from across Australia. This collaborative effort underpins all the water information products available at www.bom.gov.au/water.

The Bureau's water information is now widely used, whether in cities or the bush, for investment or rural financing, infrastructure design, flood mitigation, water supply forecasting, river management and environmental flows, water sharing plans or policy advice. Having comprehensive and independent water information now provides a sound basis for more informed decisions to secure the future for Australia's water resources.

Production of *Water in Australia* has required collaboration and significant effort from many people. I am proud of the dedication, persistence and professionalism of the teams involved. The Bureau's mandate is to report periodically on Australia's water resources. I welcome your feedback so that we can continue to improve our reporting.

Graham Hawke
Deputy Director Environment and Research
Bureau of Meteorology
November 2015

SUMMARY

The Bureau of Meteorology is responsible for producing reports on water resources, availability and use in Australia.

Water in Australia draws on a range of Bureau information to describe the characteristics of the country's water resources, availability and use from 1 July 2013 to 30 June 2014. The report and other supporting documentation are available from the Bureau's website.[1]

PHYSICAL WATER RESOURCE CONDITIONS

Australia has highly variable rainfall from region to region and year to year. Rainfall affects streamflow and groundwater replenishment, which in turn affect the water resources available for human use. The high rainfall variability poses challenges for water resource management. Long-term changes in our climate further exacerbate the challenges.

1 www.bom.gov.au/water

Rainfall patterns across Australia have changed significantly since 1950. Rainfall has increased in Australia's north and northwest, mostly associated with increases in daily rainfall intensity and frequency during the wet season.

In contrast, rainfall has declined along the west coast and most of eastern Australia. This is of great concern because the major population centres and most agricultural activity occur in these areas where, consequently, use of water resources is highest.

In 2013–14, rainfall patterns in many places followed the decadal changes, with reduced rainfall in the west and east, and higher rainfall in the north and in much of Western Australia (Figure S1). Streamflow in these areas responded accordingly. In southern Queensland and northern New South Wales, a severe drought, which started in 2012, continued in 2013–14, with streamflow being very much below average in drought-impacted areas.

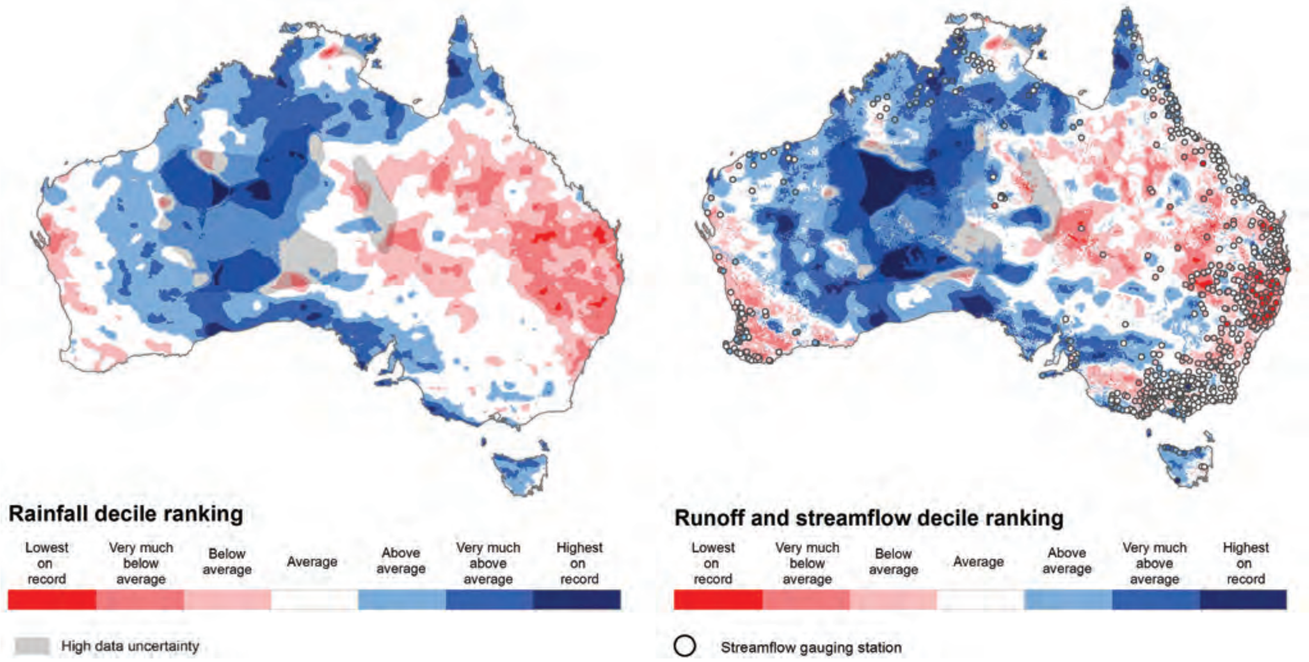


Figure S1. Annual rainfall, runoff and streamflow conditions, 2013–14

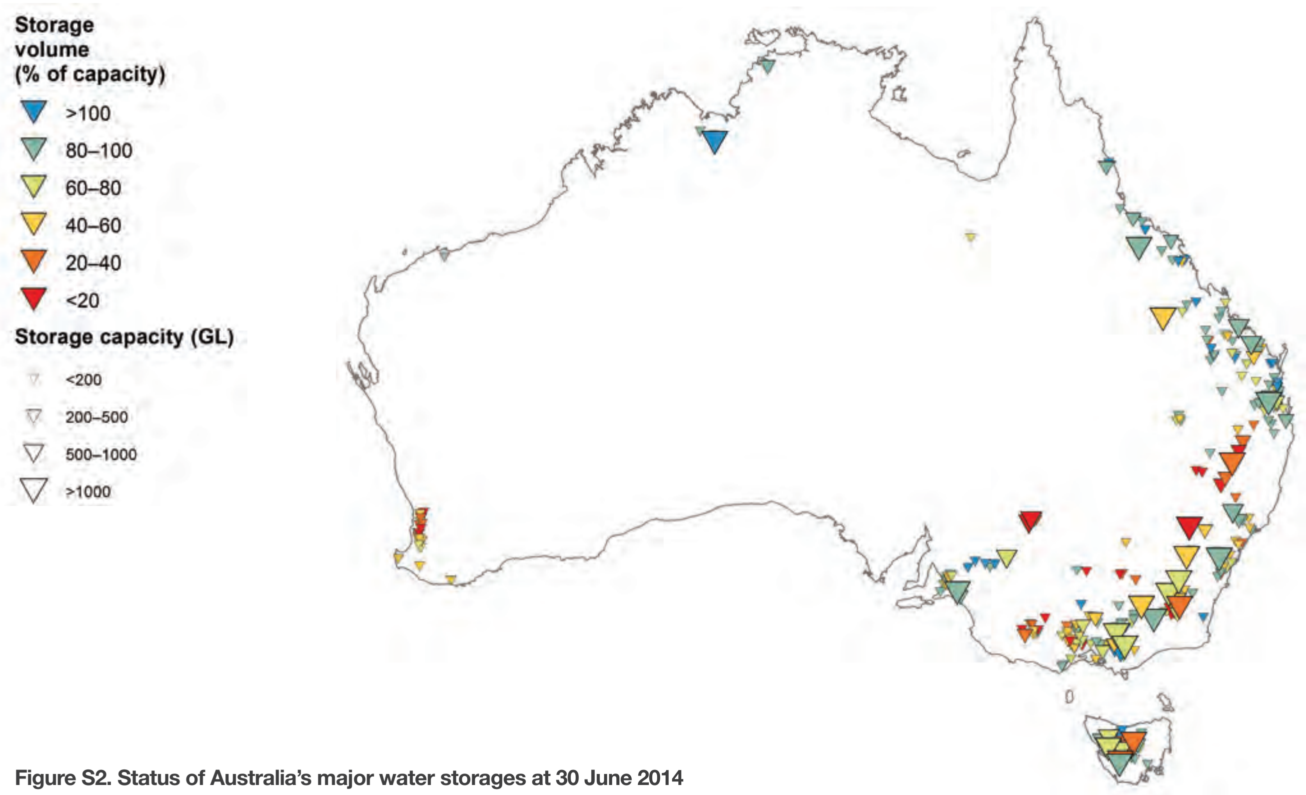


Figure S2. Status of Australia's major water storages at 30 June 2014

In 2013–14, most bores had average groundwater levels, except in South Australia and Queensland, where more than one-third of all bores had an above-average level. Below-average groundwater levels were present in 5–20 per cent of bores in each State and Territory.

WATER AVAILABLE FOR USE

Australia has extensive water supplies, and their use is managed by various institutional arrangements. Water availability is being increased by using recycled and desalinated water. At the same time, greater protection is being afforded to the environment through the purchase of entitlements from water users and investments in water-saving infrastructure.

Table S1 indicates the amounts of water available nationally in various categories. Overlap between categories means that these amounts cannot be added together for a total figure. Figure S2 illustrates the distribution of available water in storage at 30 June 2014.

Table S1. Water available for use across Australia at 30 June 2014

Availability category	Gigalitres
Storages at 30 June 2014 (63% of capacity)	51 600
Surface water entitlements	23 000
Groundwater entitlements	7 000
Marine desalinisation plant capacity	630
Recycling plant capacity	940

Environmental water holders in the Murray–Darling Basin held 3192 gigalitres (GL) of surface water entitlements at the end of 2013–14 (increasing from 3160 GL at the end of 2012–13). Of the total allocated environmental water available in 2013–14, 68 per cent was delivered for environmental purposes and 27 per cent was carried over to 2014–15.

WATER USE

Australia supports its population, agriculture and industry by making water available for various types of uses. The estimated total water use across Australia was 23 500 GL in 2013–14. The top two water uses were irrigation (57 per cent of total use) and urban consumption (17 per cent of total use). Water used nationally is summarised in Figure S3 for the major use categories.

The main irrigation use is in the Murray–Darling Basin and was just over 9500 GL in 2013–14. The estimated total surface water use for irrigation in the Murray–Darling Basin decreased from about 11 000 GL in 2012–13 to about 8400 GL in 2013–14—a drop of 24 per cent. Groundwater use for irrigation increased by 18 per cent to just over 1100 GL because of drier conditions and limited surface water allocation announcements, particularly in the northern Murray–Darling Basin.

Outside the Basin, around 3900 GL was used for irrigation, mainly in the Queensland and Victorian coastal regions, the coastal regions surrounding Perth and Adelaide, northeastern Tasmania, and the Ord irrigation scheme in northern Australia.

Entitlement trade increased in 2013–14 to about 2400 GL, which can be attributed partly to entitlements being transferred to the Commonwealth for the environment and partly to declining water storage levels that prompt buyers into the market to secure more water. Allocation trade in 2013–14 was around 5500 GL.

Total water use in 2013–14 in the major cities shows no significant changes in recent years, with Sydney, Melbourne and South East Queensland all recording slight increases in water use since 2011–12. Sydney, Melbourne and South East Queensland use mainly surface water; Perth and Adelaide are using increasing amounts of desalinated water.

Urban residential use in 2013–14 was 185 kL per property, up 3 per cent from 2012–13. However, use per property has not increased significantly from the levels at the end of the Millennium Drought.

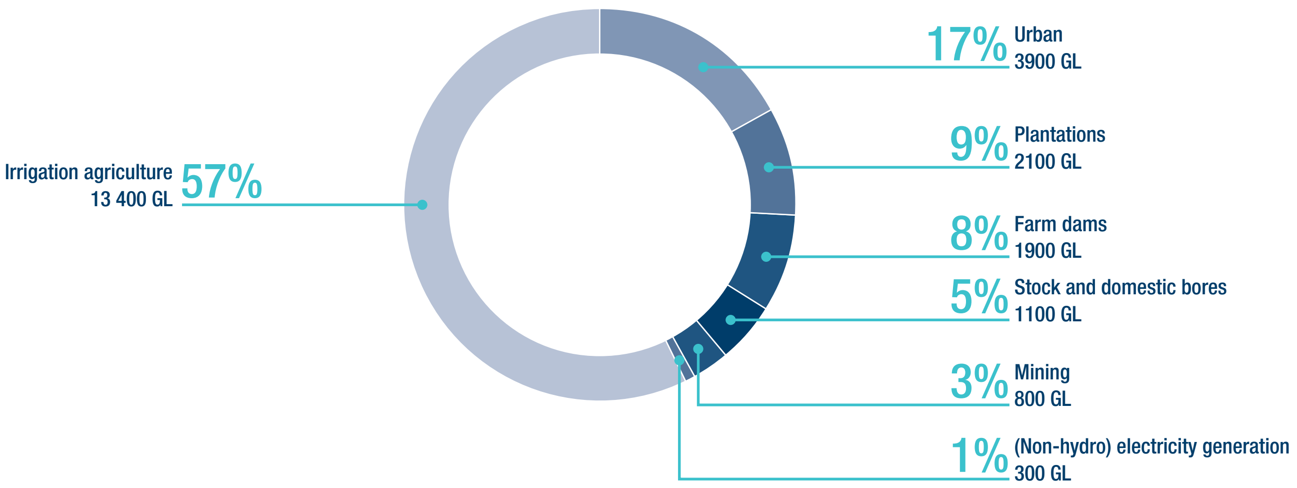


Figure S3. Estimated total water use in Australia, 2013–14

1 INTRODUCTION

AT A GLANCE

The Bureau of Meteorology is responsible for producing reports on water resources, availability and use in Australia. *Water in Australia* draws on a range of Bureau information to describe the characteristics of the country's water situation from 1 July 2013 to 30 June 2014.

Water in Australia 2013–14 is a continuation of earlier assessments by the Bureau (Australian Water Resources Assessment and National Water Account Summary). The report and other supporting documentation, are available from the Bureau's website (www.bom.gov.au/water).

1.1 BACKGROUND

Water is life—it underpins the environmental, economic, social and cultural foundations of Australia.

In times of scarcity, water is a contested resource. The Millennium Drought highlighted that our water supply is vulnerable to climate variability.

It also highlighted the importance of national information to understand the water situation and give adequate warning of emerging issues. National reporting on water resources was sporadic and inconsistent in methods. It did not provide enough information to inform public debate about water resources and support government decisions at a time when it was most needed.

In response to this situation, the Bureau of Meteorology acquired new responsibilities for collecting water data, and compiling and delivering comprehensive water information (Commonwealth *Water Act 2007*).

The Bureau produced the biennial *Australian Water Resources Assessment* (2010 and 2012) and the annual *National Water Account Summary* (2012 and 2013).

1.2 SCOPE

Water in Australia 2013–14 builds on these products by providing a concise overview of water resources, availability and use across the whole country.

Water in Australia examines the climatic conditions and physical hydrology of Australia, as well as how much water is available, and how it is accessed and used.

1.3 APPROACH

This report integrates and summarises data and investigations across the Bureau to examine causal relationships. The information focuses on the period from July 2013 to June 2014, which represents the latest planning year for which national-level water-use data were available at the time of writing.

In this report, the Bureau's Australian Water Resources Assessment Modelling System was used to generate estimates of runoff across the country.[2] The Bureau's Hydrologic Reference Stations[3] data were used to provide information on the hydrologic response to climate because they represent catchments that are unaffected by diversions, storages or any other major uptakes.

2 www.bom.gov.au/water/landscape
3 www.bom.gov.au/water/hrs

Our understanding of water resources and their use across Australia is only as good as the data collected and standardised. We work with data providers to ensure that the data collected are appropriate and of high quality. The Bureau receives a copy of data that water managers collect for their own purposes, then aggregates and analyses these data to provide a larger-scale national picture. We also combine several external sources of information with our own weather and climate data.

1.4 ACCESSING THE REPORT AND SUPPORTING INFORMATION

Water in Australia and related products are available on the Bureau's website (Figure 1).[4] Much of the data used in the report are available for download from the Bureau's *Regional Water Information* web page.[5] This includes metadata on the data source and analysis methodology.

4 www.bom.gov.au/water

5 www.bom.gov.au/water/rwi

Water in Australia is particularly complemented by:

- *Regional Water Information*, which provides spatial information down to river region level on the status of water resources and use during the assessment year
- *Monthly Water Update*, which provides a regular snapshot of rainfall and streamflow for the previous month relative to average conditions.

Other products provide access to more detailed information. They include:

- *Water Data Online*—stream gauge information at approximately 3500 stations, some of which are updated daily
- *Water Storage*—daily update of storage levels for more than 300 major water storages
- *Australian Groundwater Explorer*—bore water levels, and associated data on hydrogeology and groundwater management

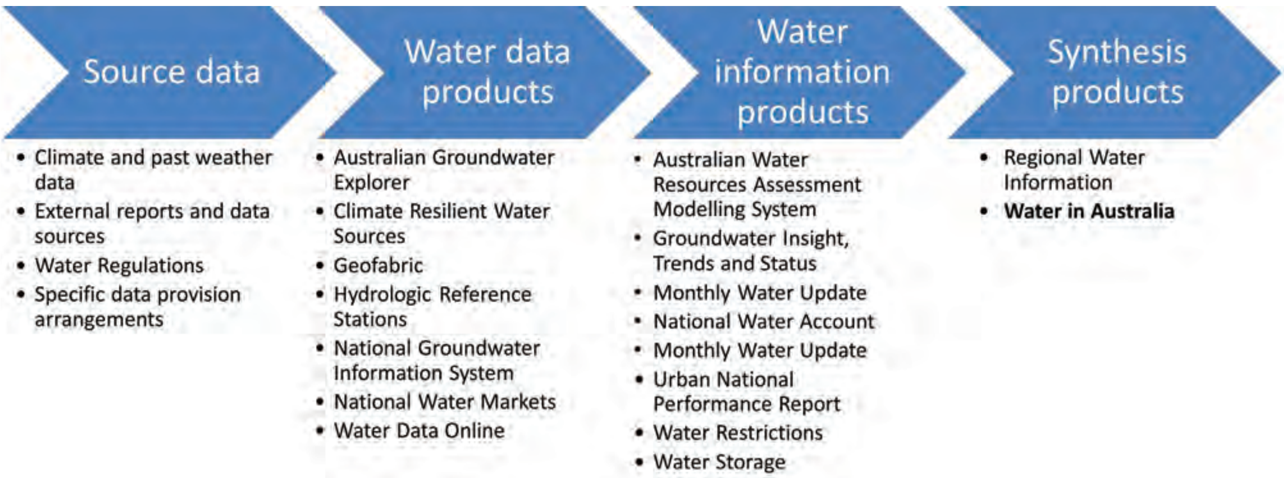


Figure 1. *Water in Australia* and supporting information and products

- *Climate Resilient Water Sources*—an inventory of desalination and water recycling plants across Australia
- *Australian Groundwater Insight*—an interactive portal providing groundwater information such as aquifer types, salinity, bore water level trends and management information
- *Hydrologic Reference Stations*—long-term changes in streamflow at 222 high-quality stream gauging stations
- *National Water Account*—detailed annual accounting of water assets and liabilities for ten key water-use regions
- *Urban national performance report*—annual benchmarking of the performance of 78 major urban water utilities and councils
- *Water market information*—regular water market reports and a regional dashboard, which are part of the National Water Market website.

1.5 TERMINOLOGY

The technical terms used in this report may be found in the glossary of this report or in the *Australian Water Information Dictionary*.[6]

1.6 ACKNOWLEDGMENTS

Water in Australia and the broader Bureau programme for improving water information rely on water data collected by around 200 water management organisations across Australia. In addition, the report has been reviewed by a panel of experts in hydrology, climatology and water resources modelling.

We appreciate the valuable contributions of these organisations and individuals.

6 www.bom.gov.au/water/awid/index.shtml

2 PHYSICAL WATER RESOURCE CONDITIONS

AT A GLANCE

Australia has highly variable rainfall from region to region and year to year. Rainfall affects streamflow and groundwater replenishment, which in turn affects the water resources available for human use. The high rainfall variability poses challenges for water resource management. Long-term changes in our climate further exacerbate the challenges.

Rainfall patterns across Australia have changed significantly since 1950. Rainfall has increased in Australia's north and northwest, mostly associated with increases in daily rainfall intensity and frequency during the wet season.

In contrast, rainfall has declined along the west coast and most of eastern Australia. This is of great concern because the use of water resources for major population centres and agricultural activity is highest in these regions.

In 2013–14, rainfall patterns followed the decadal changes, resulting in drier conditions to the west and east, and wetter conditions in the north and along the Western Australian coast. Streamflow in these areas responded accordingly. In southern Queensland and northern New South Wales, the drought, that started in 2012, continued in 2013–14.

In 2013–14, most bores had average groundwater levels, except in South Australia and Queensland, where more than one-third of all bores had an above-average level. Below-average groundwater levels were present in 5–20 per cent of bores in each State and Territory.

2.1 WATER RESOURCE CHALLENGES

Australia faces many challenges to water resource availability and management. Rainfall variability across regions and over time means that water managers must plan carefully to ensure Australian water users have access to a reliable water supply.

Long-term changes in our climate are exacerbating these challenges. Shifts in climate are leading to regional increases or decreases in rainfall, changes in seasonality and increases in extreme events (Bureau of Meteorology and CSIRO 2014). All these changes can directly affect streamflow.

2.1.1 Rainfall variability

Rainfall, the major input to the replenishment of water resources, is not uniformly distributed across Australia. High rainfall occurs in the northern tropical regions; along the east coast, where the Great Dividing Range runs parallel to the coast; and in western Tasmania. This is in contrast to about 40 per cent of the country, mostly in the centre, which has 300 mm or less rainfall each year.

Australia has high levels of actual evapotranspiration, which is the sum of evaporation and plant transpiration from the land surface to the atmosphere. Because of this, only a small proportion of Australia's rainfall generates significant runoff or replenishes groundwater systems and thus is available for human use.

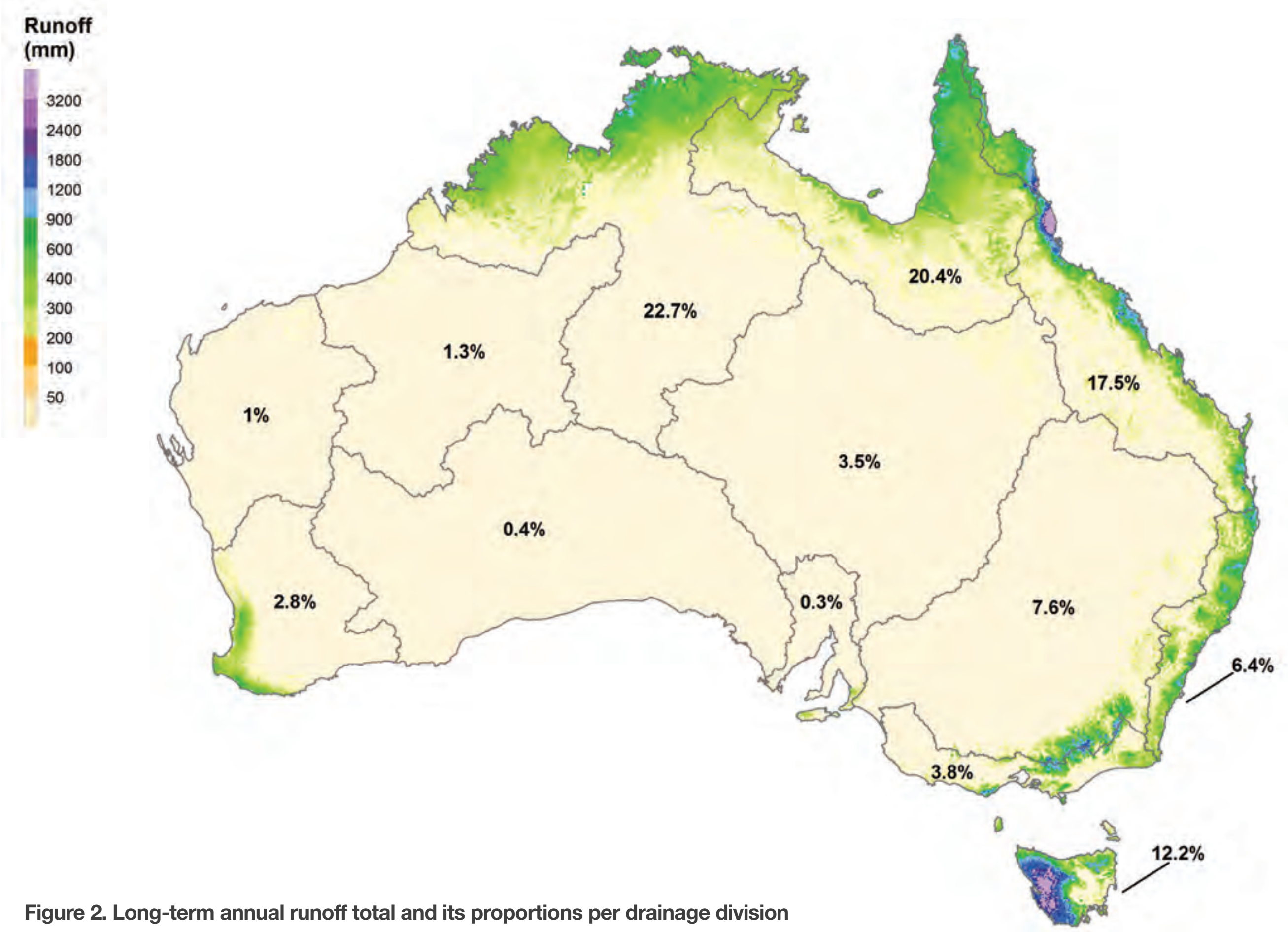


Figure 2. Long-term annual runoff total and its proportions per drainage division

On average, less than 10 per cent of rainfall becomes streamflow in rivers in Australia, with large geographic variations (Figure 2). Higher runoff is generated in the summer-rainfall-dominant area in the north and in winter-rainfall-dominant Tasmania, where, on average, 25–75 per cent of rainfall converts to streamflow. In the low-rainfall areas inland, less than 5 per cent of rainfall converts to streamflow.

A large portion of runoff and groundwater recharge occurs in areas that do not have high population and cultivated land. About 60 per cent of Australia's runoff occurs in northern Australia and coastal Queensland, and about 12 per cent occurs in Tasmania. Only about 7 per cent of runoff is generated in the Murray–Darling Basin, yet this is where more than 50 per cent of Australia's water is used in one of the country's most productive agricultural systems.

Australia also has high rainfall variability across time, as a result of multiple atmospheric and oceanic influences from the Pacific, Indian and Southern oceans. A major characteristic is that Australia's latitude is subject to the subtropical high pressure system—a system creating zones of long-lasting high pressure that lead to clear skies and low rainfall.

Australia is also prone to droughts and floods. Many of these are linked to the El Niño–Southern Oscillation (ENSO), which leads to a major shift in weather patterns due to variations in sea surface temperatures over the tropical eastern Pacific Ocean. Typically, El Niño results in drier conditions with below-average winter and spring rainfall over much of eastern Australia, and La Niña is associated with much higher winter, spring and early summer rainfall over much of Australia.

Many other climate influences exist in Australia, with varying levels of impact in different regions and at different times of the year. Further details on these influences on the Australian climate are available from the Bureau's *Australian Climate Influences* web pages.[7]

Australia's large-scale climate controls interact in complex physical processes that can be represented using dynamic physics-based climate models. These climate models can provide early indications of seasonal variability, including changing rainfall conditions, to support decisions in water resource management and agricultural production. Weekly and seasonal rainfall forecasts can be explored at the Bureau's *Climate Outlooks*[8] and *Agriculture Services*[9] web pages. Seasonal streamflow forecasts are also available.[10]

7 www.bom.gov.au/climate/about
8 www.bom.gov.au/climate/ahead

2.1.2 Decadal rainfall changes

Since 1950, rainfall patterns across Australia have changed significantly (Frederiksen and Grainger 2015). The rainfall changes are generally most pronounced for the high rainfall seasons (summer in the north and autumn–winter in the south), which generate high runoff (Figure 3).

Increasing rainfall has been observed in Australia's north and northwest, mostly associated with increases in daily rainfall intensity and frequency during the wet seasons (Gallant et al. 2014). These combined increases in rainfall have been large enough to increase the total average Australian rainfall by 50 mm in 1970–2013 compared with 1900–1969. However, the mechanisms of the increasing rainfall trend remain uncertain (Bureau of Meteorology and CSIRO 2014).

Along the west coast (particularly southwest Western Australia) and much of eastern Australia, rainfall has declined (Figure 3). This is of great concern, because the

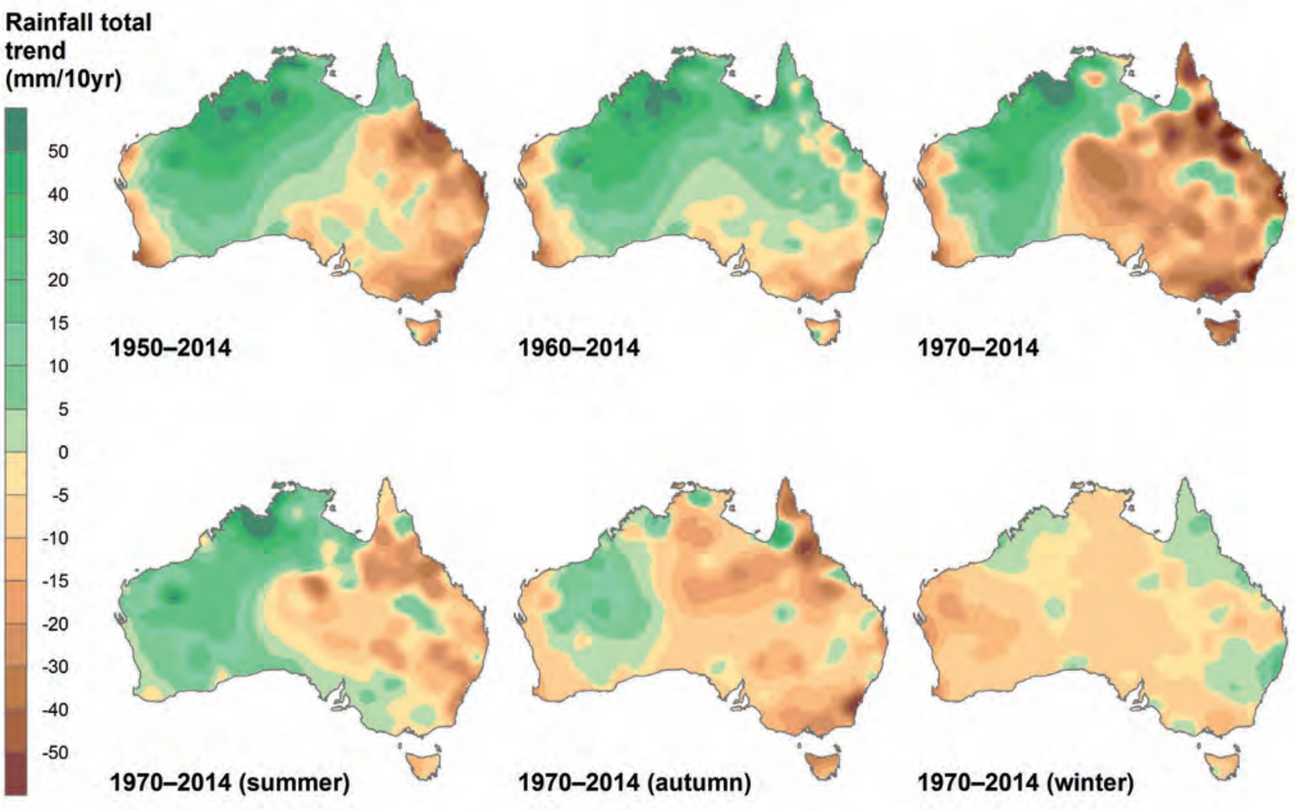


Figure 3. Rainfall total trends for Australia and changes in seasonal summer, autumn and winter rainfall from 1950–, 1960– and 1970–2014

Across southwestern Australia, rainfall has declined by 15–40 mm per decade since 1950. This decline is largely due to failures of late autumn and early winter rainfall (Bureau of Meteorology and CSIRO 2014). It is also associated with the reduction in high-rainfall years since the mid-1990s, caused by a decline in the number of days with rainfall (see Figure 6b). At the same time, summer rainfalls have increased, but not enough to counterbalance the winter rainfall decline, given the high summer evapotranspiration rates.

In much of eastern Australia (including Tasmania), rainfall has declined by 20–50 mm on average per decade since 1950 (Figure 3). In southeastern Australia, 1997–2009 was the driest 13-year period since the start of instrumental records in 1900. In the southeast, the rainfall decline is mainly characterised by a failure of autumn rainfall and, to a lesser extent, winter rainfall (Murphy and Timbal 2008).

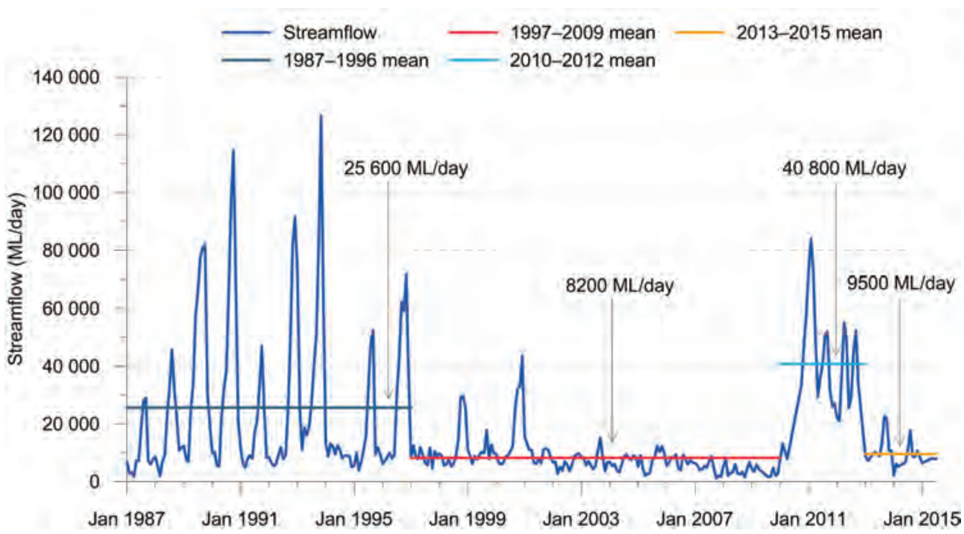
Even during the record-breaking 2010–2012 La Niña years, in which exceptional wet conditions broke the Millennium Drought, the lack of autumn and winter rainfall continued. It was summer rainfall that was very much above average and was not part of a longer-term trend. In Queensland, drying has mainly been caused by a decline in summer and autumn rainfall.

The rainfall decline in southern Australia has, to some degree, been associated with global warming (Timbal et al. 2010). The changes in surface climate are associated with changes in the mean meridional circulation, which is the mechanism for the global transfer of heat from the warmer equatorial region to the cooler polar regions. This change can also be described as an expansion of the tropics (Lucas et al. 2014). In response, high pressure systems that usually sit over the arid centre of Australia have also moved southward and intensified, pushing rain-bearing fronts and low pressure systems south, not allowing them to pass over the continent (Timbal et al. 2006, CSIRO 2012, Timbal and Drosdowsky 2013). These changes can be reproduced in climate models when anthropogenic forces are used, thus linking these global climate changes to global warming (Nguyen et al. 2015). However, uncertainties remain about the mechanisms of this change, and it is an area of active research (Murphy et al. 2014, Hope et al. 2015).

Projections into the future using climate models show continued warming, less rainfall, changes in evapotranspiration and decreased streamflow. More intense drought episodes can be expected in southern Australia, whereas heavier rainfall is projected over the central and northern parts of Australia (Bureau of Meteorology and CSIRO 2014). Trends in various years and seasons can be explored with the Bureau's Australian climate variability and change tracker.[11]

11 www.bom.gov.au/climate/change

Figure 4. Observed streamflow on the River Murray at Lock No. 10 Wentworth station (station ID 425010), 1987–2015



2.1.3 Streamflow variability and response to decadal changes

The combination of climate variability across space and time means that total rainfall each year also varies greatly. As a consequence, Australia has one of the most variable annual streamflow regimes in the world (McMahon et al. 2007). For example, the streamflow at the confluence of the Murray and Darling rivers during the Millennium Drought was only around half of the 1987–2015 long-term mean but was double that during the two La Niña years in 2010–2012, and has returned to relative low flow since then (Figure 4).

High variability in streamflow has important implications for water resource management. It involves designing infrastructure that is able to cope with such variability. It influenced, for example, the size of Australia's major dams—the high streamflow variability, combined with high evaporation rates and the need for flood protection, has led to relatively large storage volumes in some areas. Also, environmental releases have to be considered in dam operations because Australian fauna and flora have evolved around high streamflow variability.

Runoff generation and streamflow volumes have amplified responses to the decadal changes in rainfall. A reduction in rainfall typically results in a proportionately larger decline in streamflow. As a general principle, a 10 per cent decrease in rainfall can result in a 20–30 per cent decrease in streamflow (Chiew 2006). This relationship is likely to vary for individual catchments, as well as over time (Potter et al. 2008).

Increasing streamflow is observed in the north, whereas declining streamflow is observed in the southwest, southeast and east (Zhang et al. 2014).

Reduced rainfall leads to loss of soil moisture, surface runoff and groundwater recharge. In addition, runoff generation and, subsequently, streamflow can be indirectly affected by mostly gradual changes in catchment characteristics such as vegetation cover or soil properties.

In the southeast and on the east coast, trends of declining runoff are strongest in the headwater areas of major river systems (Figure 5). This is a cause of much concern for water resource management because these are areas where the majority of flow is typically generated. For example, the declining streamflow in the southwest since the mid-1970s has caused a 70 per cent decline in annual inflows into reservoirs in this region (Bates et al. 2008), forcing major augmentation of water supplies.

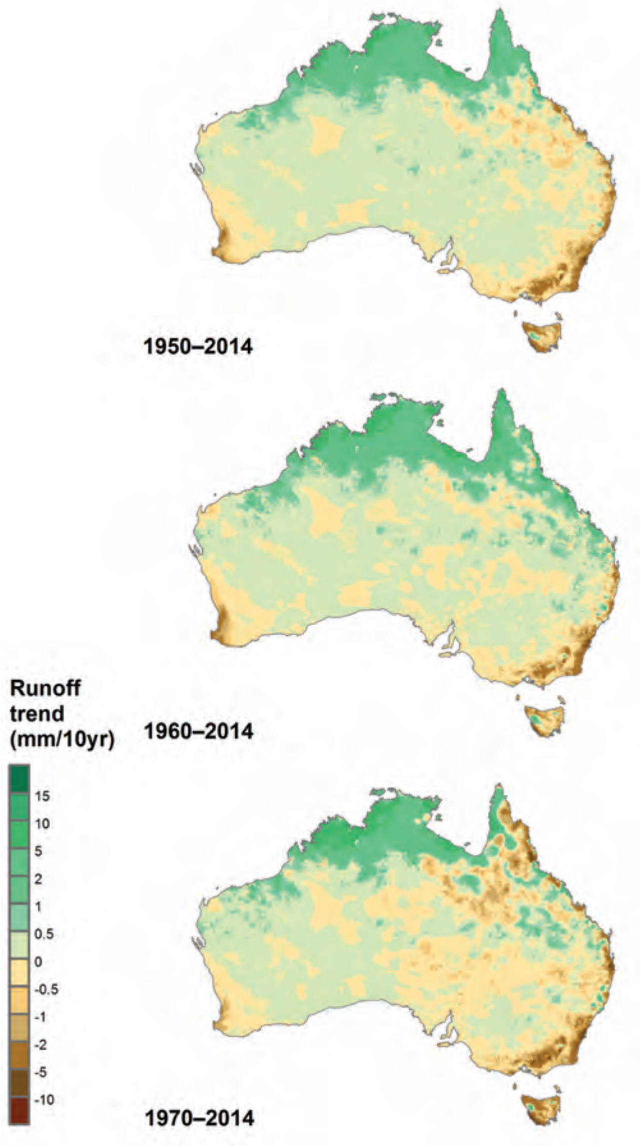
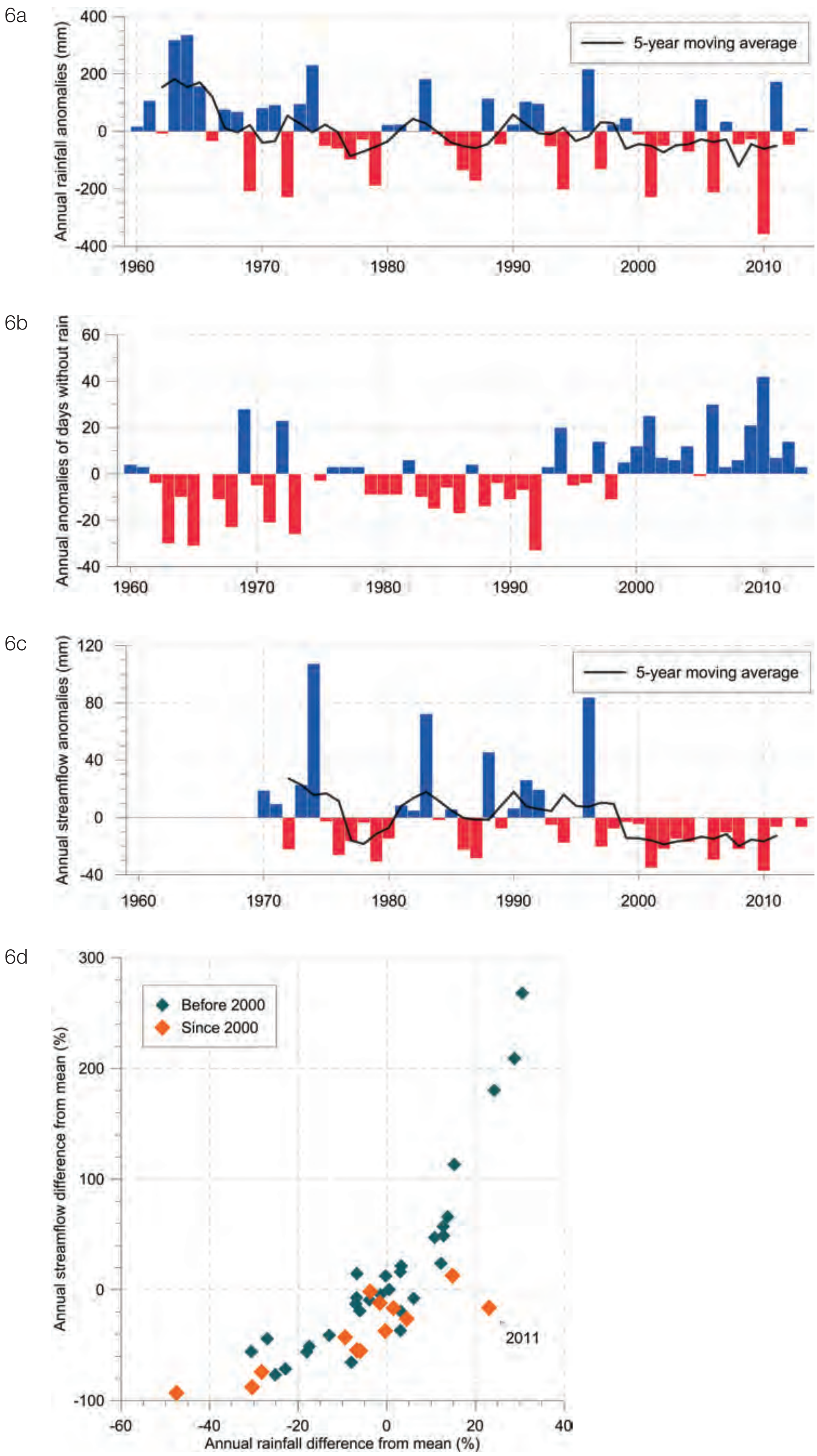


Figure 5. Runoff total trends for Australia from 1950–, 1960– and 1970–2014

Figure 6. Annual observed rainfall anomalies (a), days without rainfall (b), observed streamflow anomalies (c), and the relationship between rainfall and streamflow at Mungalup Tower (station ID 612002) in southwestern Australia, 1960–2014 (d).



Note: Streamflow data only available since 1970.

Many perennial streams in southwest Western Australia have either have either decreased or dried out, causing a decline in water quality and riverine ecosystem health in some areas. Similarly, recharge into aquifers has declined, with many groundwater-dependent ecosystems being altered or under stress (Bond et al. 2008). For example, a disproportionate change in streamflow was observed in response to declining rainfall in the Collie River area in southwestern Australia (Figure 6). Rainfall started to decline, particularly since the 1970s (Figure 6a).

In around 2000, the dry conditions in southwestern Australia appeared to intensify, related to fewer days with rainfall (Figure 6b). Streamflow was continuously below the post-1970 average and even lower than the pre-1970 average (Figure 6c). During the late 1990s, even above-average rainfall has not translated into high streamflow. For example, in 2011, streamflow was below average despite annual rainfall that was 20 per cent higher than the mean (Figure 6d). The disproportionate reduction in streamflow may be due to a number of causes. One of the suggested mechanisms is that more rainfall infiltrates and is stored as soil moisture that can evaporate or be transpired by plants, leaving less available for runoff. Another suggested mechanism is the loss of surface and groundwater connectivity that occurs once groundwater levels fall below a critical threshold, so that groundwater is unable to contribute to streamflow (Kinal and Stoneman 2012). Even with higher rainfall, it takes time to re-establish hydrologic pathways of groundwater contributing to streamflow.

In many rivers, not only streamflow quantities but also flow characteristics have altered in response to the rainfall changes discussed above. Knowledge about changing streamflow regimes is paramount to assessing risks associated with water supply, water usability, flooding or river ecosystems. For example, a reduction in high flows can affect the ecological functioning of the floodplains, wetlands and aquatic ecosystems that rely on those river flows. By contrast, increased high flows can lead to erosion. Increasing high flows could also mean a change for water resource management, such as adapting storage systems to account for increased flooding. Managing low flows is equally important to maintain good ecological conditions and high-quality water.

Changes in streamflow can be detected directly from gauging records at locations that are unaffected by diversions and storages or land change. Such changes have been analysed by the Bureau at Hydrologic Reference Stations (Figure 7), which are sites with long-term, high-quality records.[12] The general patterns in Figure 7 accord with the modelled runoff patterns shown for the whole country in Figure 5.

The Hydrologic Reference Station data also show that more stations have a declining trend than an increasing trend, although monitoring stations are not equally distributed across the country. Increases in streamflow for the north are strongest for low to moderate flow levels, whereas the reductions in the south are stronger for moderate to high flow levels.

12 www.bom.gov.au/water/hrs

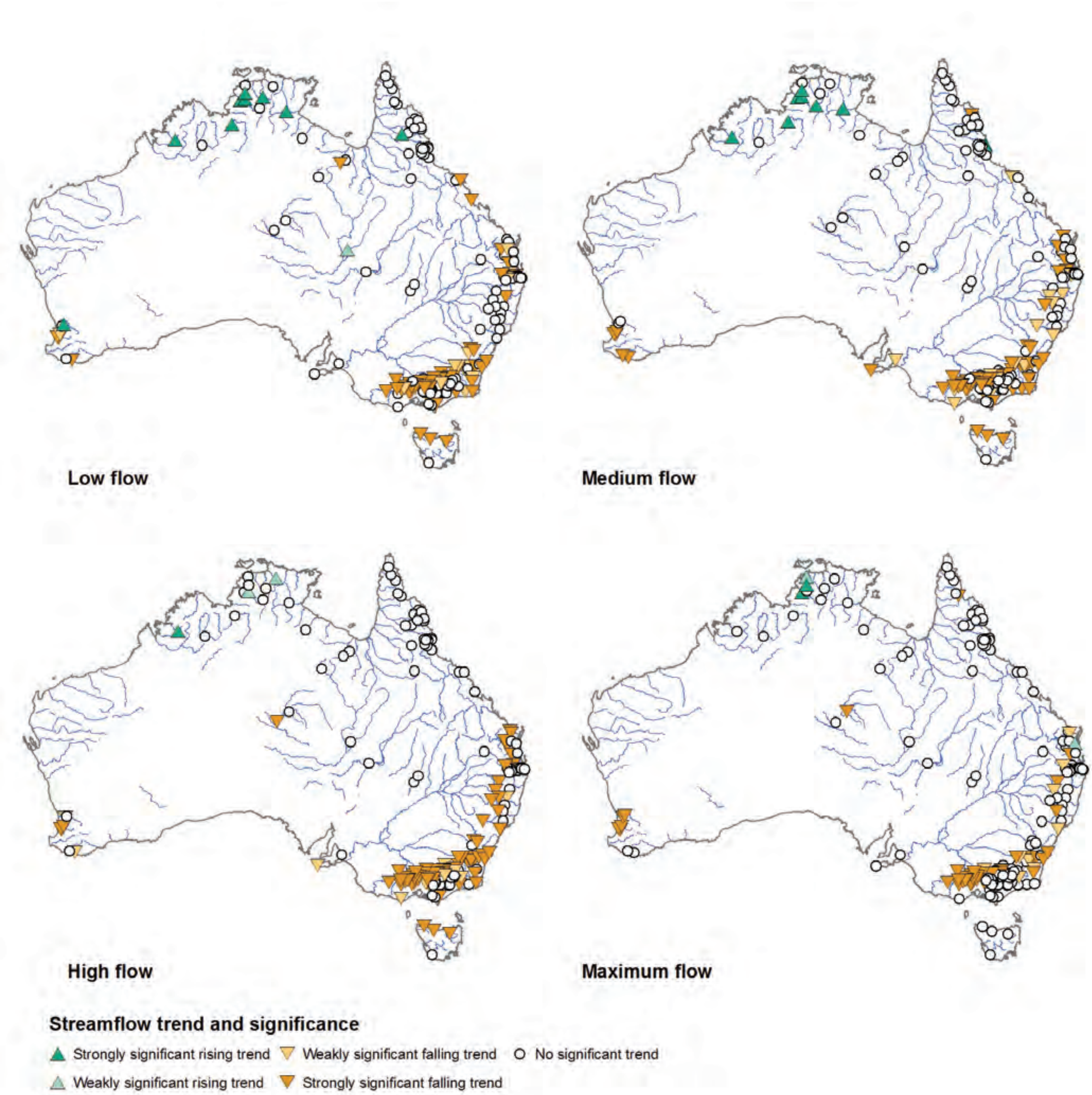


Figure 7. Trends, since 1975, of low, medium, high and maximum streamflow at Hydrologic Reference Stations

2.2 RAINFALL, RUNOFF AND STREAMFLOW CONDITIONS IN 2013–14

With the observed changes in rainfall and runoff over the last few decades—in particular, the decline in surface water availability in some parts of Australia—water resource conditions such as rainfall, streamflow and groundwater need to be closely monitored and assessed. This is achieved by comparing water resource conditions in 2013–14 with the past, and assessing whether these conditions follow an emerging trend or exhibit exceptional characteristics. Surface water responds to rainfall almost immediately; however, the groundwater response to rainfall can take several weeks or months, years, decades or longer. Groundwater conditions are therefore assessed separately.

Neutral ENSO conditions in 2013–14 suggested a return to average rainfall. However, many features of the recent decadal changes, as shown in Figure 3, were observed on a regional level. Two strong regional contrasts were evident in 2013–14: less rainfall to the west and east, and more rainfall in the north and in eastern Western Australia (Figure 8). Many of the wetter conditions were driven by exceptional events or series of events occurring in some months, rather than being persistent seasons. In southern Queensland and northern New South Wales, the severe drought, that started in 2012, continued in 2013–14. Differences in water resource conditions in these regions are explained in more detail in the following sections.

2.2.1 Northern Australia: above-average conditions

In 2013–14, conditions in the north followed the general trend of increasing rainfall and streamflow during the wet season. About 200–400 mm more than the average rainfall was recorded, with some pockets in the far north and northwest receiving more than 800 mm above average (Figure 8). The year had one of the earliest starts to the wet season and an ongoing cycle of cyclone formation. The conditions resulted in very much above average streamflow, particularly for January and February 2014 (Figure 9). During these months, water volumes in Lake Argyle and the Darwin River storage increased rapidly, by 40 per cent, to capacity.

Australia's tropical cyclone season runs from November to the end of April. Since the mid-1980s, Australia's tropical north has experienced an average of 11 cyclones per season, although, on average, four cross the coast and provide rainfall over the continent (Bureau of Meteorology 2014, Haig et al. 2014). In 2013–14, there were ten cyclones, with five coastal crossings, close to the average. There were, however, two category 5 cyclones—the highest category—after two seasons without cyclones in this category.

In March 2014, a tropical low pressure system brought extensive rain across the north coast of the Northern Territory and Queensland but only minor damage. This system eventually developed to become tropical cyclone *Gillian*, a category 5 storm over the Indian Ocean. Tropical cyclone *Ita*, in April 2014, was the most damaging storm of the season. *Ita* brought heavy rain and caused flooding and extensive damage to crops along the northeastern Queensland coast.

2.2.2 Southern Australia

Southwestern Australia: below-average conditions

Hydrologic conditions in southwestern Western Australia followed the overall drying trend for this area. The area received, on average, about 100 mm less than the long-term average rainfall in 2013–14. However, September 2013 had exceptionally high rainfall, ending the otherwise very much below average southern cool, or growing, season (Figure 10). Many sites in far southwestern Western Australia observed their wettest September on record as a result of persistent westerly winds, with the frequent passage of cold fronts, lows and troughs bringing isolated showers and moderate to heavy rainfalls. Streamflow responded accordingly, and 40–85 per cent of the total annual streamflow was generated during this period.

Over the following 2013–14 spring, summer and early autumn months, soil moisture stores were rapidly depleted and streamflow was below average (Figure 10). The 2014 cool season started in May 2014 with above-average rainfall conditions. Soil moisture stores were restored, encouraging winter crop development. Streamflow, however, stayed below average.

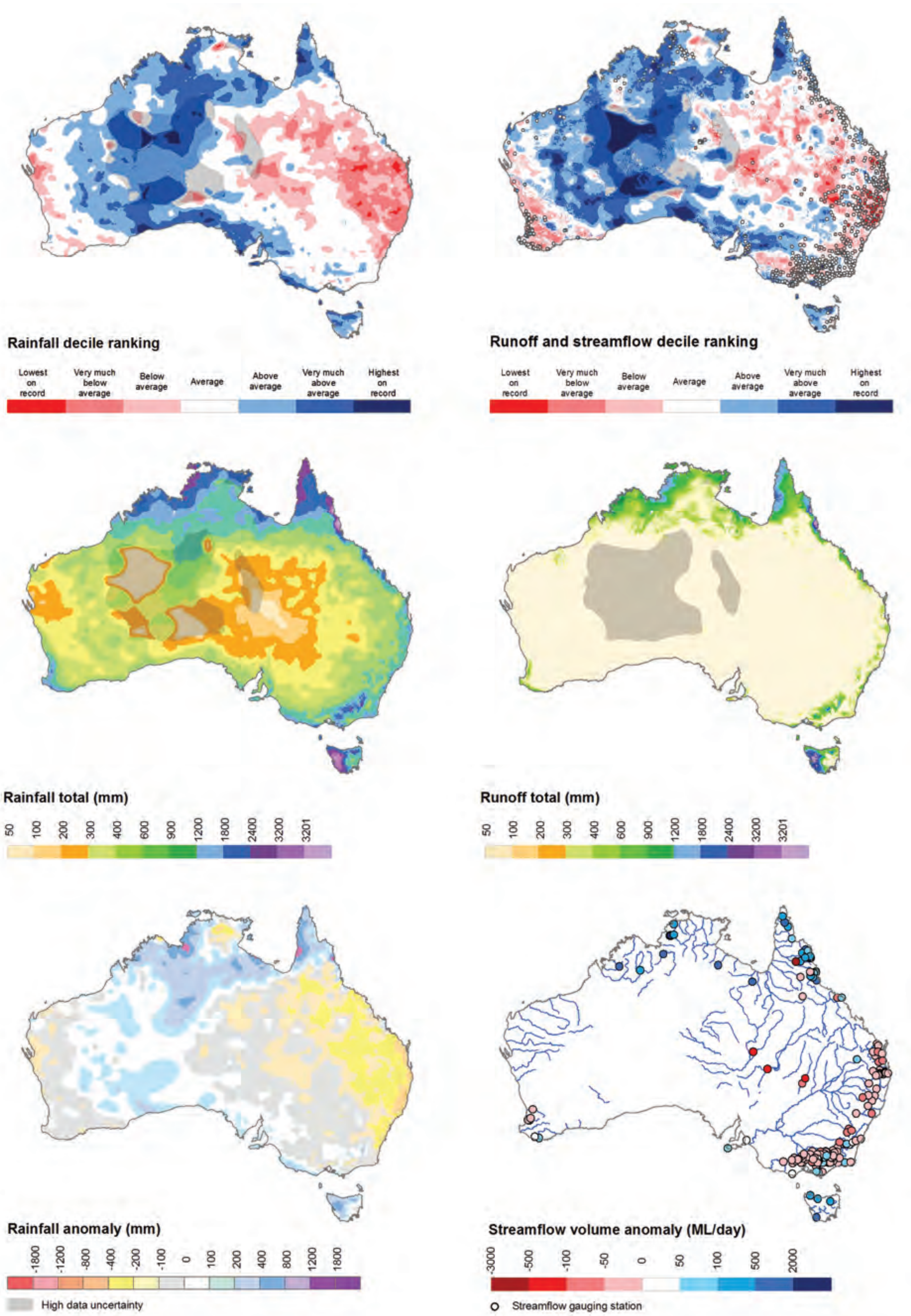


Figure 8. Annual rainfall, runoff and streamflow condition, including decile ranking, total and anomaly, 2013–14

Note: The grey area in the maps is associated with unreliable estimates.

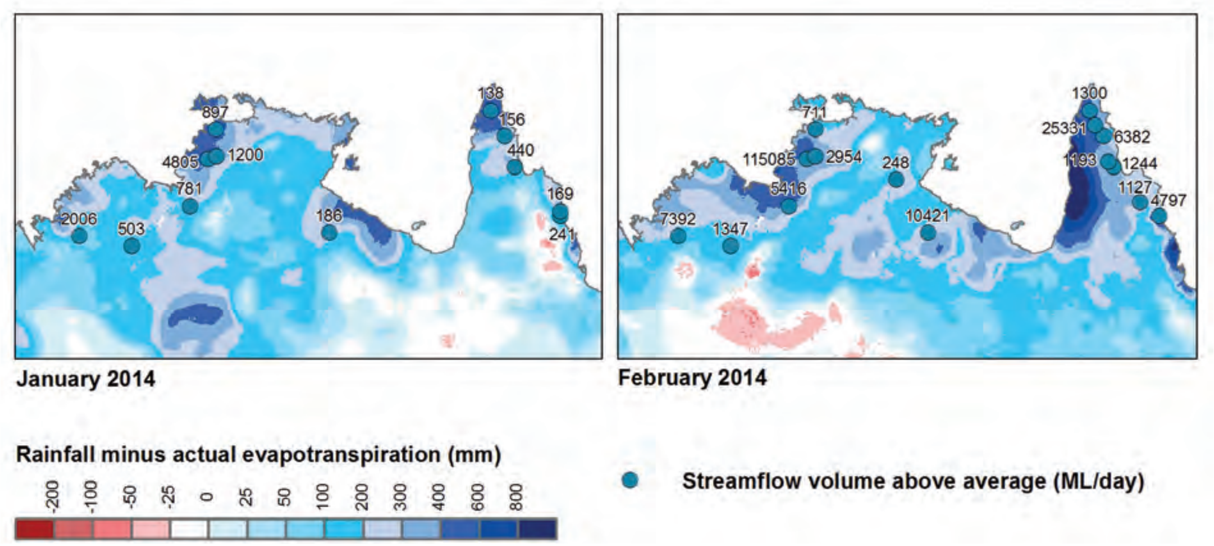


Figure 9. Effective rainfall volumes and corresponding streamflow anomalies for January and February 2014 in the tropical north

Southeastern Australia and Tasmania: above-average conditions

Despite a generally drier trend over the last few decades, South Australia and Tasmania had above-average rainfall and streamflow conditions in 2013–14, due to several exceptional events. In parts of South Australia, rainfall was more than 200 mm above the historical average (Figure 8). These conditions were mostly due to exceptional rainfall in July 2013, in February 2014 and then again at the beginning of the cool season in April and May 2014. They were the result of tropical moisture moving over the southern part of Australia.

The refilled soil moisture store at the end of the 2013 cool season was rapidly depleted in spring and summer 2014, as a result of high temperatures and high evaporative demand. Spring and summer 2014 streamflow was much below average, despite the high rainfall in February 2014 (Figure 11). Autumn 2014 also had wet conditions, which were exceptional in April 2014. Rainfall records were broken across many inland stations in April 2014, with flash flooding occurring. Adelaide had its wettest day in 45 years. However, except for some streams on Kangaroo Island, this rainfall did not contribute to above-average streamflow and hence inflows into storages.

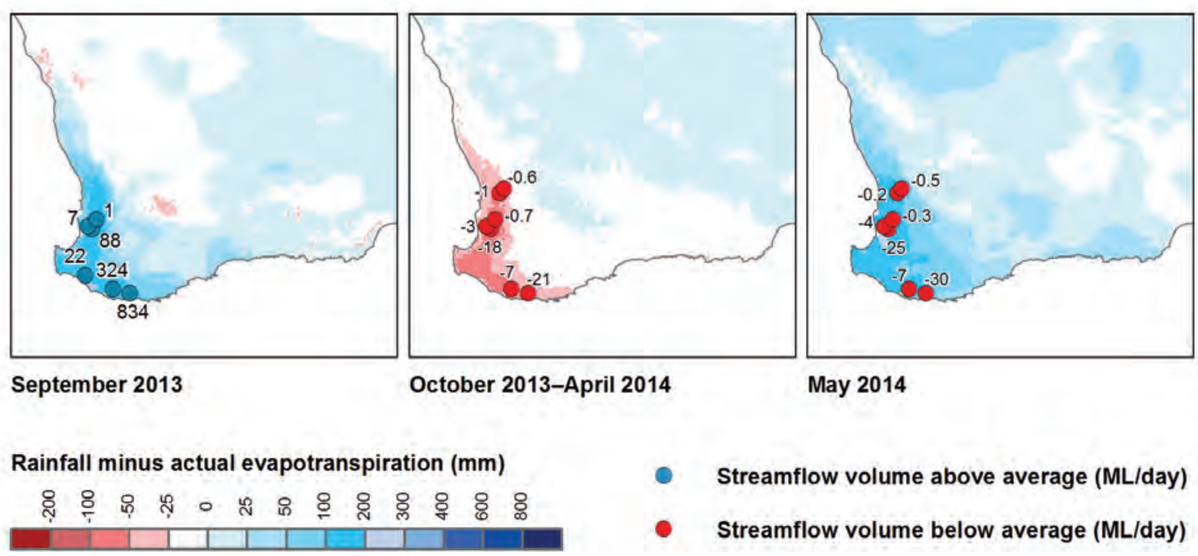


Figure 10. Effective rainfall and streamflow volume anomalies for various months in southwestern Western Australia

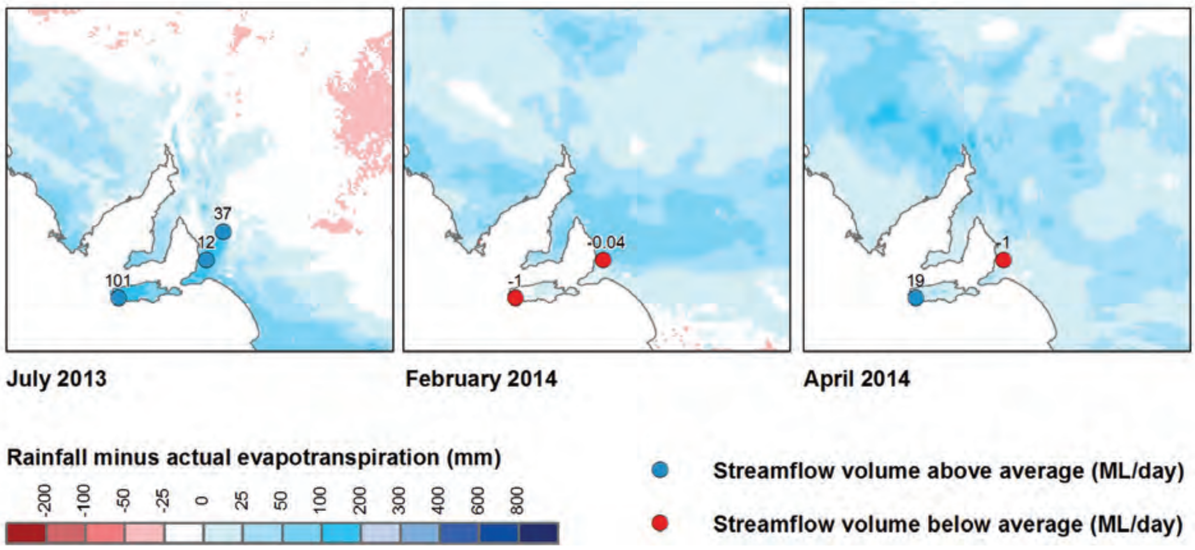


Figure 11. Effective rainfall and streamflow volume anomalies for various months in South Australia

In Tasmania, heavy rain and flooding affected various parts of the State, especially when low pressure systems or cold fronts crossed the State. These systems brought above-average rainfall to the north and west of Tasmania, particularly in August and October 2013, and to all of Tasmania in November 2013, except for the south (Figure 12). Mostly due to the 2013 spring events, rainfall was 200–800 mm (15–40 per cent) above average. During this period, streamflow conditions were very much above average and filled storages to capacity. Soil moisture stores were replenished by the spring events, and soil moisture remained at average levels until late summer 2014, despite below-average rainfall in this period. Autumn 2014 had average conditions.

2.2.3 Drought in southern Queensland and northern New South Wales

A severe drought that began in 2012 persisted in southern Queensland and northern New South Wales. This area had two consecutive years of well-below-average rainfall coupled with well-below-average spring and summer temperatures. Temperatures were 1–2.5 °C above the mean average temperature in this area. This resulted in soil moisture being well below average (Figure 13). Formal drought declarations in affected areas started from April 2013. In terms of rainfall deficiencies, this drought is a one in 10-year or 20-year event over part of inland eastern Australia.

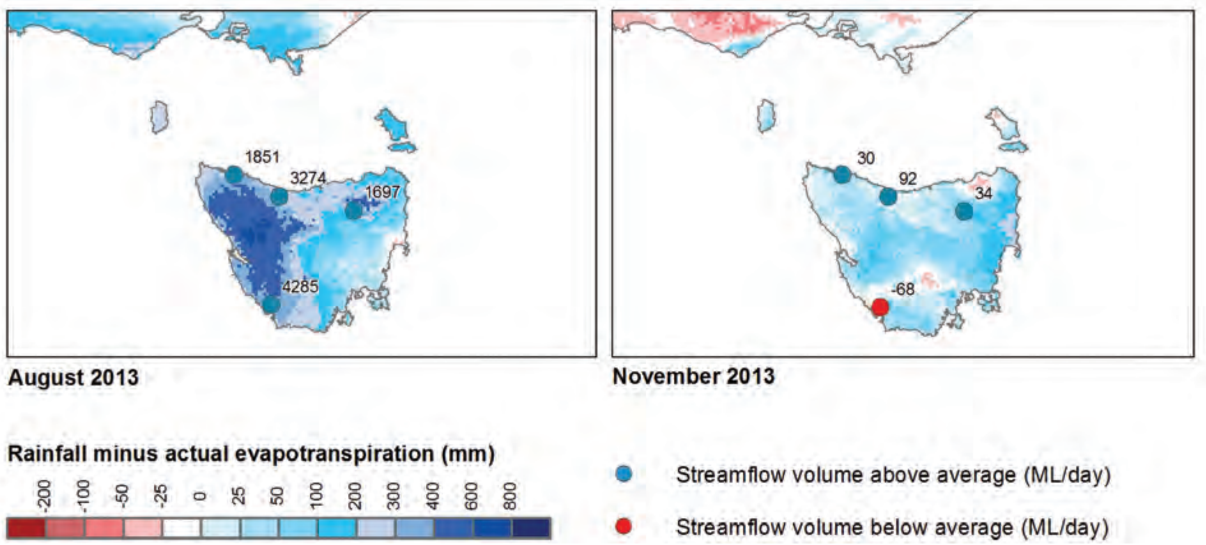
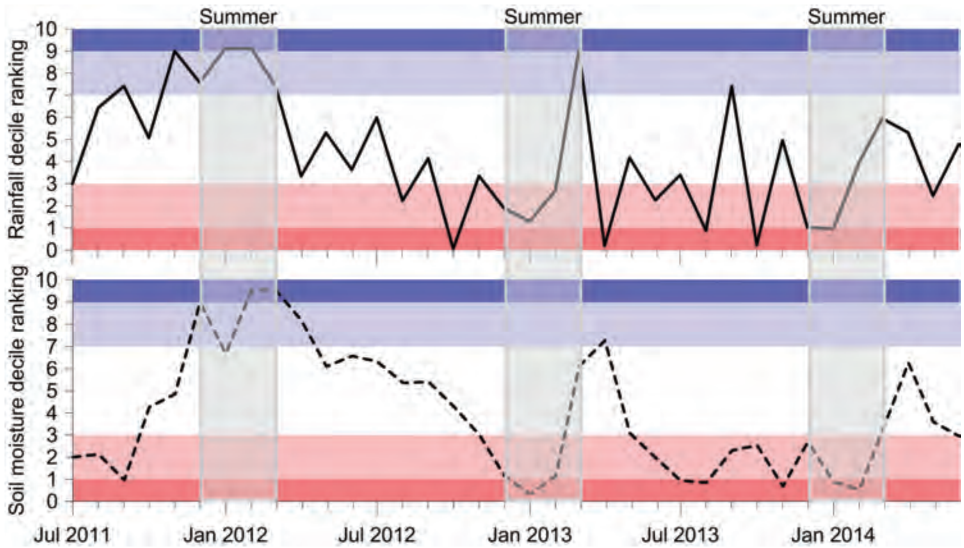


Figure 12. Effective rainfall and streamflow volume anomalies in August and November 2013 in Tasmania

Figure 13. Time series of rainfall and soil moisture deciles between July 2011 and June 2014 at Walgett, northern New South Wales



However, these rainfall deficiencies were the most severe on record for some locations in central Queensland (Bureau of Meteorology 2015a).

Rapid depletion of the soil moisture store occurred in late 2012 due to a lack of summer rainfall (Figure 13) coupled with high evapotranspiration. Rainfall during 2013 was below average, and temperatures were very high in late 2013, further exacerbating the dry soil conditions. High temperatures, along with a generally dry winter to summer 2013–14, led to very low soil moisture throughout the growing season, reducing crop viability and causing crop failures. It also led to reductions in stock of cattle and sheep in these areas.

Large areas within the region had two consecutive years of very much below average streamflow (Figure 14), limiting urban and irrigation water supplies. Some of the northern headwater catchments of the Murray–Darling Basin, such as the Border River, Gwydir, Namoi and Macquarie catchments, as well as the Georges, Clarence and Manning rivers outside the Murray–Darling Basin, had annual streamflows in the lowest 10 per cent on record (Figure 8). In these regions, annual streamflow was 30–100 per cent below the long-term average.

2.3 GROUNDWATER CONDITIONS IN 2013–14

The volume of groundwater stored in aquifers is very large compared with surface water. Groundwater also moves slowly, and local changes in level can take time to extend to other parts of an aquifer. On the other hand, locally reduced groundwater levels caused by short-term influences, such as pumping, can recover once the perturbation has ceased and water can flow in from the surrounding areas. Therefore, it is important to assess the trend in groundwater levels, rather than any short-term, localised changes.

Groundwater levels measured from bores are one of a few direct measurements available to analyse changing groundwater resource conditions. Therefore, groundwater conditions have been assessed using trends and status analysis of water levels at each bore. Because of the slow response of groundwater to rainfall, a five-year trend between July 2009 and June 2014 was chosen to identify meaningful changes in groundwater level. The status analysis compared the average groundwater level in 2013–14 with the levels for the previous 20 years. Tasmania has not been included in these analyses because data for the full five years are not currently available to the Bureau.

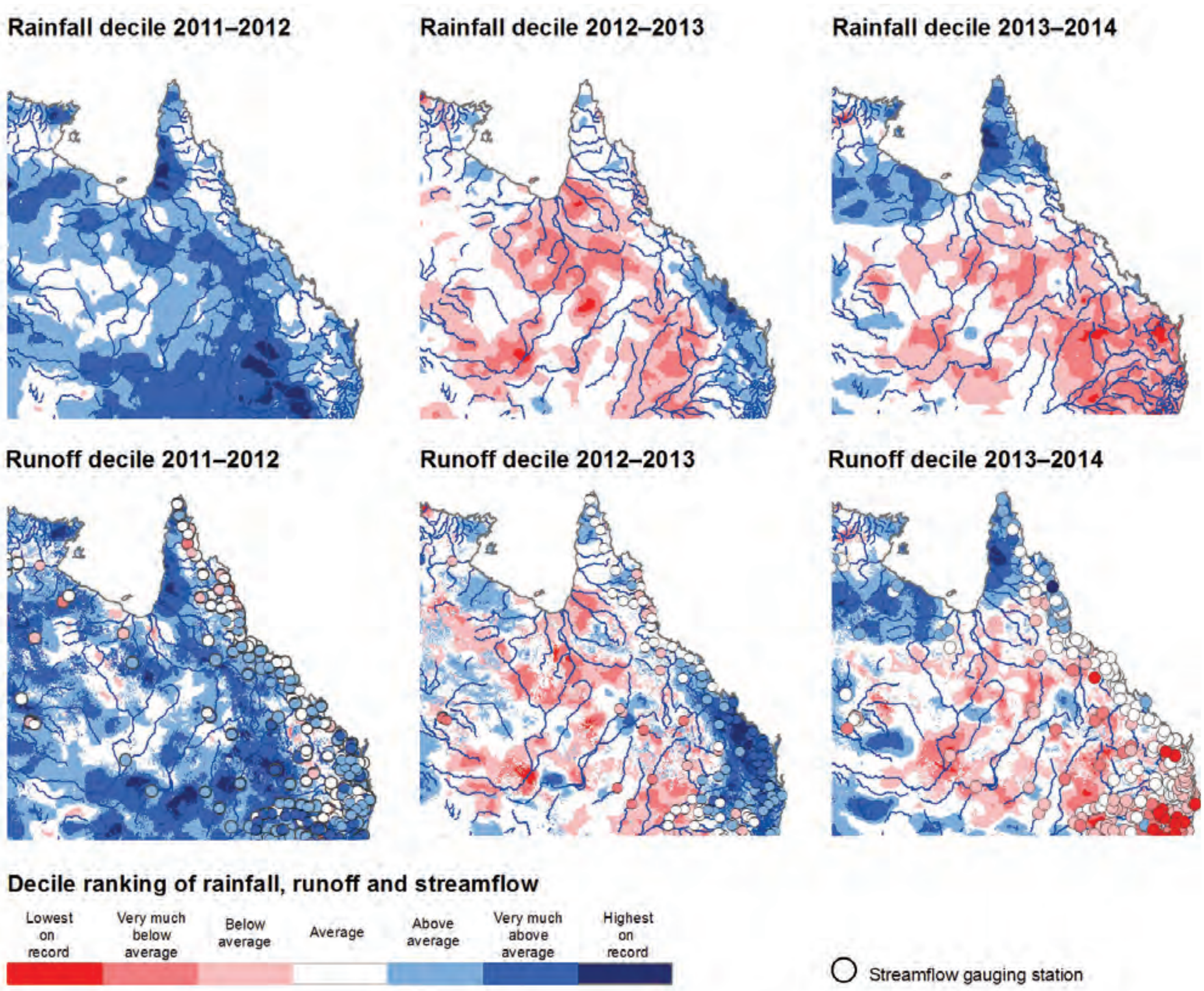


Figure 14. Rainfall, runoff and streamflow conditions in Queensland and northern New South Wales from 2011–12 to 2013–14

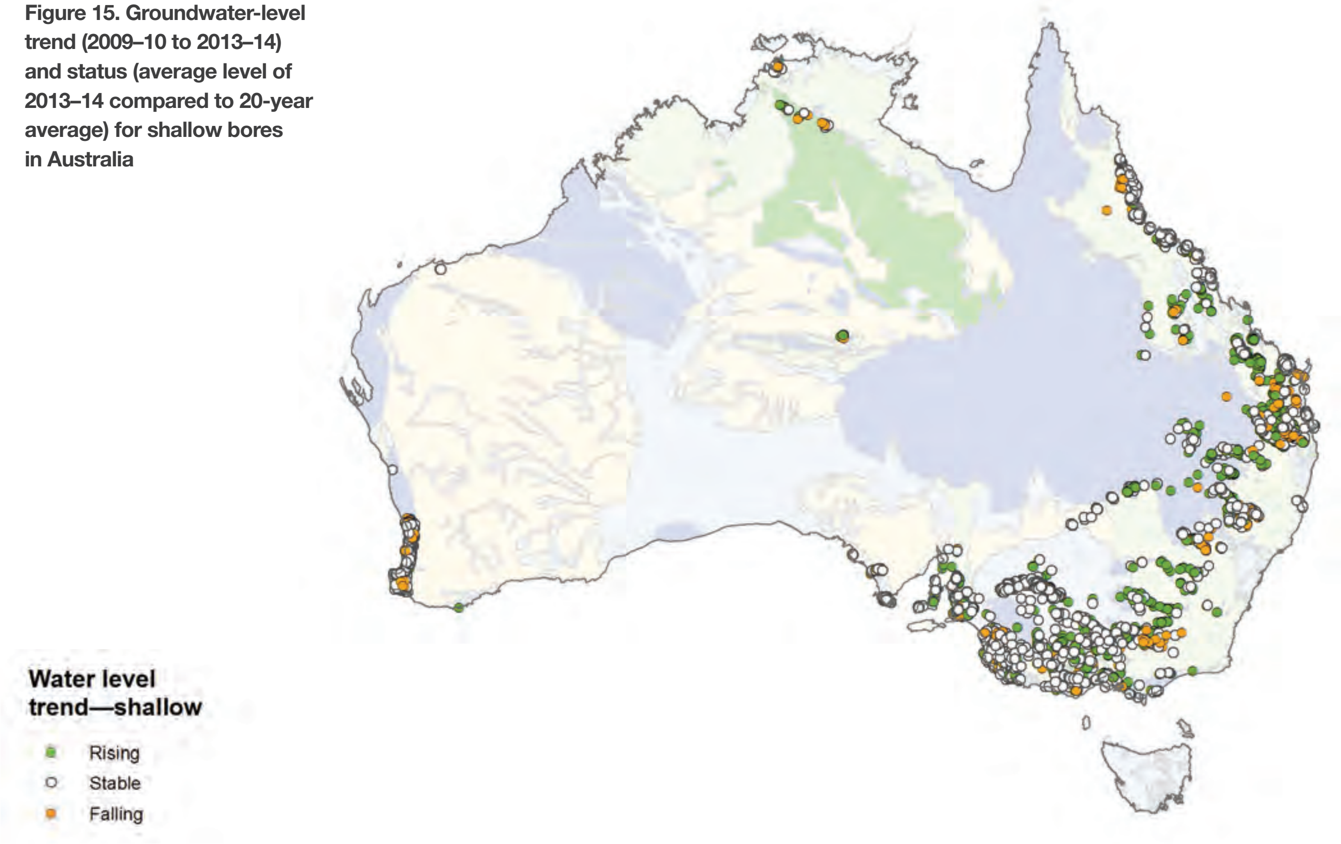
Groundwater-level data for around 800 000 bore locations, bore logs and landscape characteristics can be accessed for an area of interest on the Bureau's *Australian Groundwater Explorer* web page.[13]

The trends and status reflect several factors that influence groundwater, including climate, land use and extractions. These influences vary locally and would typically require local assessments. Trends and status have been assessed for bores shallower than 40 m and for bores deeper than 40 m. This distinction is made because shallow bores can respond to changes in rainfall or surface water levels, while deeper bores are usually not greatly affected by these short-term influences. Changes in levels in deep bores are more likely to respond to groundwater extraction, and long-term climate and land-use changes.

Condition of a groundwater resource can only be assessed for a particular region, in combination with knowledge of the hydrogeology and groundwater management. Rising levels do not necessarily mean that the resource is improving or that more groundwater is available. In fact, rising levels in very shallow watertables can be detrimental by posing a risk of salinisation. Similarly, declining levels do not necessarily mean a depleted resource or mismanagement. Figures 15 and 16 show the distribution of trends and the status of groundwater levels at bores across Australia.

13 www.bom.gov.au/water/groundwater/explorer

Figure 15. Groundwater-level trend (2009–10 to 2013–14) and status (average level of 2013–14 compared to 20-year average) for shallow bores in Australia



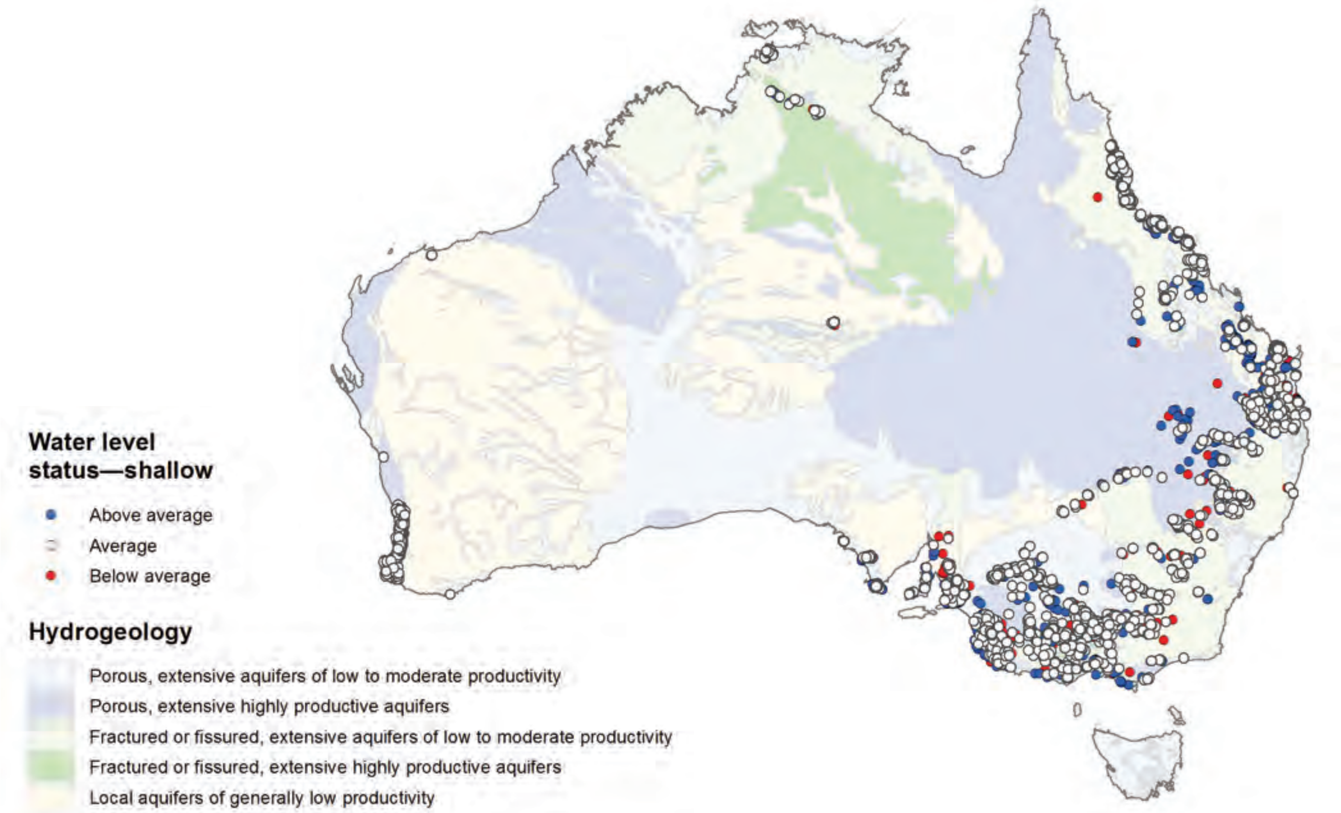
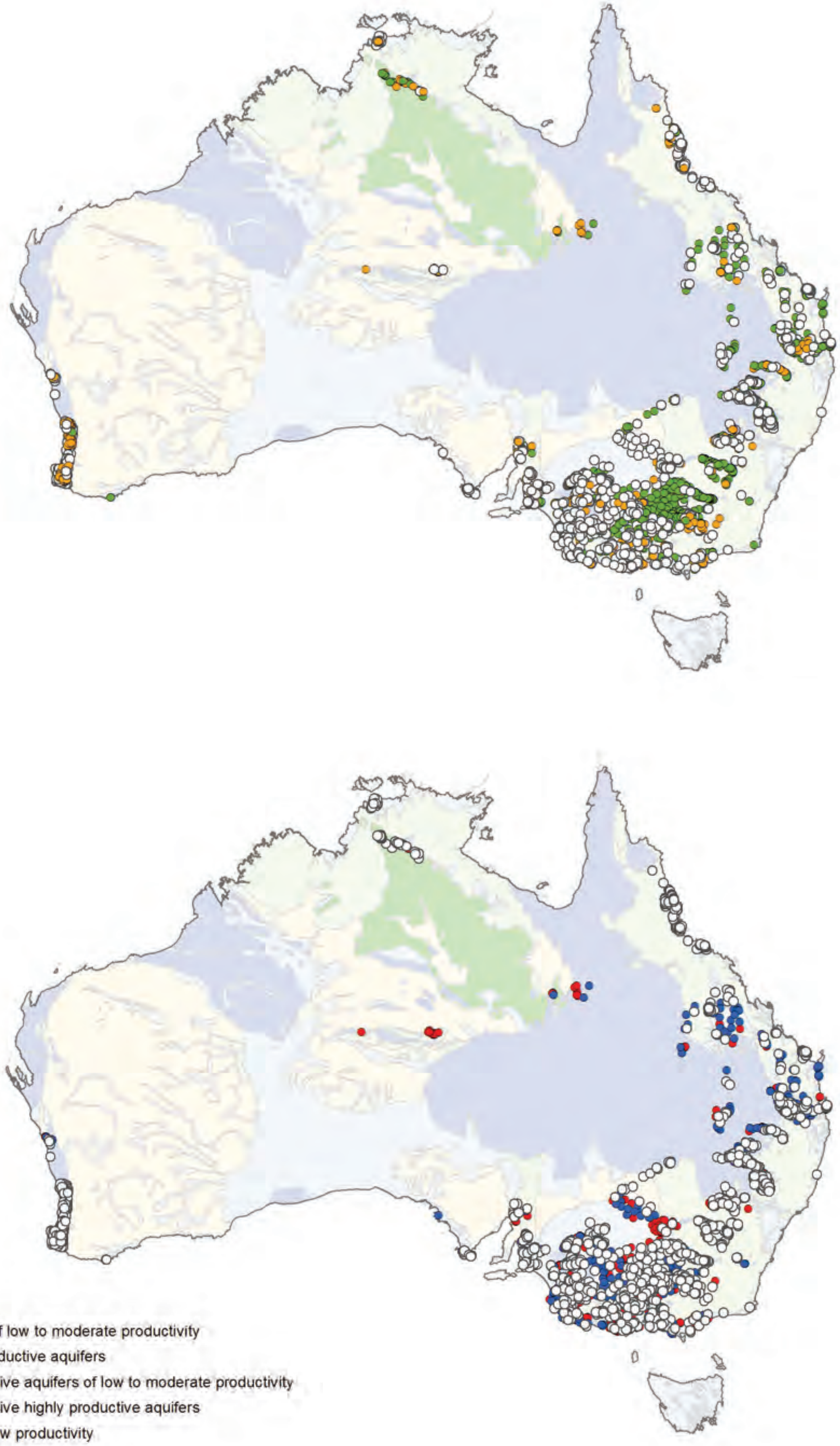


Figure 16. Groundwater-level trend (2009–10 to 2013–14) and status (average level of 2013–14 compared to 20-year average) for deep bores in Australia



Water level trend—deep

- Rising
- Stable
- Falling

Water level status—deep

- Above average
- Average
- Below average

Hydrogeology

- Porous, extensive aquifers of low to moderate productivity
- Porous, extensive highly productive aquifers
- Fractured or fissured, extensive aquifers of low to moderate productivity
- Fractured or fissured, extensive highly productive aquifers
- Local aquifers of generally low productivity

Figure 17 is a summary of groundwater conditions by State and Territory.

Across all the bores analysed, the majority were in the average range in 2013–14 (Figure 17). The exceptions were in South Australia and Queensland, where more than one-third of bores had an above-average level. Below-average levels were present in 5–20 per cent of bores in each State and Territory. Victoria had the largest rate of below-average bores, with just over 30 per cent of deep bores recording below-average levels. These percentages are influenced by the location of monitoring bores, which are typically in areas where monitoring is needed because groundwater use is high.

Groundwater resources along the west coast of Western Australia have been under stress, mainly as the result of below-average rainfall since around 1970.[14] Because of this, alternative sources of water, such as desalinated water, have been used since 2006. Currently, about half of the shallow bores (52 per cent) and 30 per cent of deep bores show average status, with stable trends (Figures 15 and 16).

Australia's southeastern and southern regions were under the influence of the Millennium Drought from 1997 to 2009. The very much above average rainfall during La Niña years in 2010–2012 alleviated these conditions to some extent. This is reflected in the average or above-average groundwater levels, with either stable or rising trends in the shallow and deep bores in New South Wales, Victoria and South Australia showing a combination of increased replenishment and decreased pumping during La Niña years. However, the drier conditions occurring since 2012 will likely cause a return to the declining trend and below-average levels.

Queensland experienced above-average rainfall until 2012. This is reflected by the majority of shallow bores (around 60 per cent) that have average or above-average groundwater levels and rising trends (Figure 17). This is repeated to a lesser extent for deep bores. The impacts of the last two years of drought in this region are not yet reflected in the groundwater system because of its slow response to any increase in extractions and decreased recharge resulting from the drier climatic conditions.

14 See the *National Water Account* for 2010–2014 (www.bom.gov.au/water/nwa)

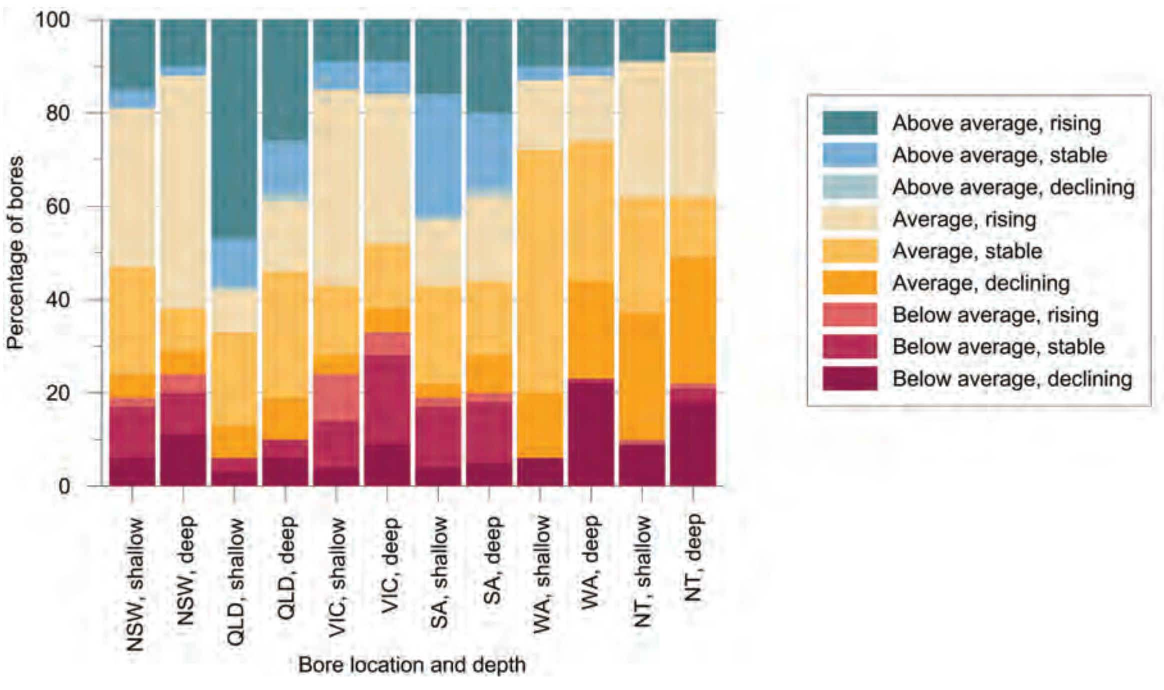


Figure 17. Summary of combined groundwater-level trends (2009–10 to 2013–14) and status (average level for 2013–14 compared to 20-year average) by State and Territory

3 WATER AVAILABLE FOR USE

AT A GLANCE

Australia has extensive water supplies and their use is managed by various institutional arrangements. Availability is being increased by using recycled and desalinated water. At the same time, greater protection is being afforded to the environment through the purchase of entitlements from water users and investments in water-saving infrastructure.

Surface water storages held 51 600 GL of water (63 per cent of capacity) at 30 June 2014. In 2013–14, the total volume of surface water entitlements under issue was about 23 000 GL.

The total set groundwater extraction limit, where explicitly stated in plans, is about 10 000 GL. The total volume of groundwater entitlements under issue is about 7000 GL.

Desalination plants in Australia can supply at least 630 GL of purified sea water per year. In 2013–14, desalinated water use in major urban centres represented 32 per cent of the desalination capacity of these centres.

The total effluent treatment capacity of recycling plants in Australia is at least 940 GL. Large urban centres typically recycle about 10 per cent of their effluent; Adelaide differs and recycles about 28 per cent of its effluent, mainly for irrigation.

Environmental water holders in the Murray–Darling Basin held 3192 GL of surface water entitlements at the end of 2013–14 (increasing from 3160 GL at the end of 2012–13). Of the total allocated environmental water available in 2013–14, 68 per cent was delivered for environmental purposes and 27 per cent was carried over to 2014–15.

3.1 INTRODUCTION

'Water available for use' in Australia are the water resources that can be put to human use (e.g. for urban supplies, industry and irrigation). It includes:

- surface water—collected from rivers, storages, etc.
- groundwater—accessed through bores
- desalinated and recycled water—produced through processing plants.

The amount of water available for use is limited by various factors, including:

- how much water is provided by rainfall, which puts an absolute limit on how much water is available
- whether it is practical to extract the water (e.g. many floodwaters cannot be harvested, groundwater may be inaccessible)
- whether it is cost-effective to treat the water; if the water quality is too poor, the cost of treating the water to make it usable may be too high
- the need for sufficient water to be available to maintain healthy environments and for Indigenous, cultural, recreation and amenity requirements.

Water available for use is also managed by institutional arrangements that are in place across Australia to manage the above factors, to ensure water use is sustainable and to share water among users. These include:

- water management plans, which limit the amount of water that can be extracted from a resource
- water rights and entitlements, which manage how the extractable water is shared between users
- water allocations, which reflect seasonal and annual water extraction allowances

- water trade, which allows for the temporary or permanent redistribution of extractable water between users within the limits of the water management plan
- water quality regulations.

Water available for use is therefore defined as the portion of the total water resources that is not only practically extractable, but available as a statutory right within a water year (Figure 18).

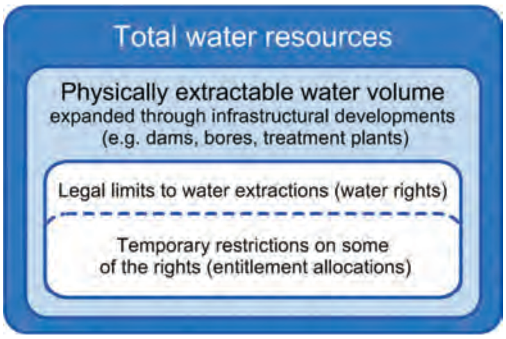


Figure 18. Concept of water availability

3.2 SURFACE WATER

To understand the current state of Australian surface water resources, it is important to examine both surface water entitlements (water extraction rights) and storages (how much water is available in storages).

3.2.1 Surface water entitlements

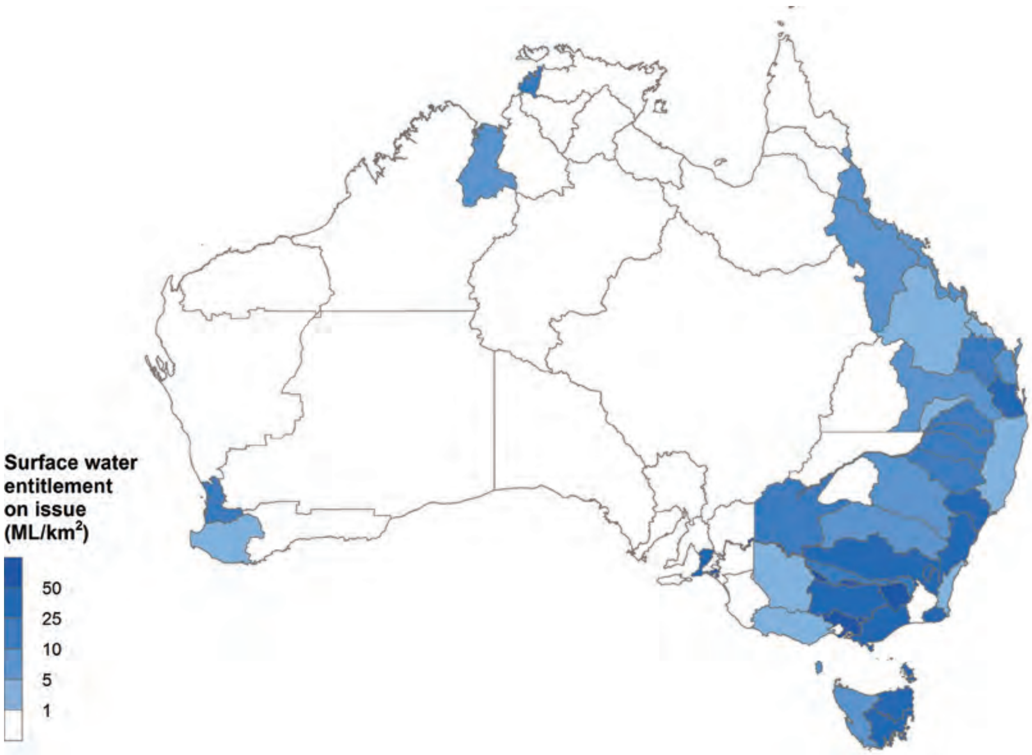
In 2013–14, the total volume of surface water entitlements under issue was estimated to be 23 000 GL.[15]

This estimate does not include entitlements that were bought by the Commonwealth and States and Territories for environmental purposes, particularly in the Murray–Darling Basin (see Section 3.5), since these are largely excluded from water rights reserved for human use; only portions of this are occasionally traded for consumption. Also excluded are entitlements that consisted of supplementary extraction rights during high flow or flood conditions, because their volumes could not be determined nationally.

Most entitlements are held in eastern Australia, where surface water is the main source of water. This is also where most people, industries and irrigation are concentrated. The distribution of entitlements is shown in Figure 19, using 63 sub-areas that are based on the Bureau's ten National Water Account regions and water planning areas.

15 The estimate is based on a variety of sources, including the Bureau's *National Water Account 2014* (www.bom.gov.au/water/nwa), water licence registers of various States and Territories, water sharing plans and local reports.

Figure 19. Surface water entitlements under issue (excluding environmental entitlements), 2013–14



For most of these regions, the total volume of surface water entitlements issued reflects the limits set by water sharing plans. However, additional entitlements can be issued in future in areas where the set extraction limit of the surface water resource is larger than the existing entitlement pool, or where infrastructure developments have improved the availability of the resource.

3.2.2 Storages

Most of the water for surface water entitlements is extracted from rivers supplied by releases from storages. Australia has around 500 major storages. Figure 20 shows 310 of these, which hold around 81 000 GL, or 97 per cent of Australia's publicly owned water storage capacity greater than 1 GL.[16]

Tasmania has the highest concentration of large storages. These mainly provide water for hydro-electricity generation.

On the mainland, storages are concentrated in the southeast, reflecting the suitability of climate and topography. This region has the largest irrigation and major urban areas, so water in this area is mainly used for agricultural, urban, industrial and commercial purposes.

16 www.bom.gov.au/water/waterstorage/index.shtml

Much of central and western Australia does not have major surface water storages. These regions depend mostly on groundwater resources, although unregulated streamflow is used when and where it is available. One major development in the north has been the construction of the Ord River dam in the early 1970s and the development of a large irrigation area downstream. The development of additional storages in Australia's north is under consideration, as presented in the *White paper on developing northern Australia* (Australian Government 2015).

The volume of water held in major storages indicates how much surface water is available for use. At 30 June 2014, the storages held 51 600 GL of water (63 per cent of capacity).

After the 2010–2012 La Niña period, many storages were close to full. By the end of June 2014, storage levels had fallen as a result of low rainfall and substantial water use, because of high carryover and significant allocations at the start of 2013–14 in many regions. In southeastern Queensland and northeastern New South Wales (northern Murray–Darling Basin), rainfall was below or well below average, resulting in dry catchments and below-average runoff.

Figure 20. Status of Australia's major water storages at 30 June 2014

Urban storages are usually managed to provide secure supply over several years, while many rural storages used for irrigation are drawn down significantly each year. This is particularly noticeable during dry periods, often associated with El Niño events, when the usual wet season replenishment does not occur. Figures 21 and 22 illustrate this for relevant periods for which data were available.

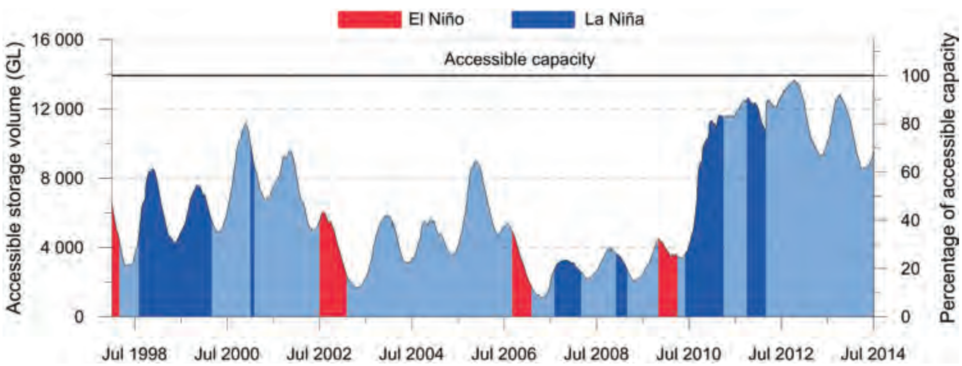
During El Niño periods in recent decades, the six largest upstream storages in the southern Murray–Darling Basin did not receive the inflows they normally would in average-to-wet winters. Storage levels dropped sharply during the following growing season, and overall water availability in the next year was significantly reduced (Figure 21).

The northern Murray–Darling Basin was substantially affected by El Niño periods. At 30 June 2014, the total combined storage volume in the upstream reservoirs of the northern Murray–Darling Basin was 29 per cent of total capacity (Figure 22). This was significantly lower than that in the southern part of the Basin (69 per cent of capacity) and is similar to the levels recorded during the Millennium Drought. In response to this, no water allocations were made for general security licence holders in parts of the Macquarie–Castlereagh, Namoi, Gwydir and Border rivers regions at the start of 2014–15.

3.3 GROUNDWATER

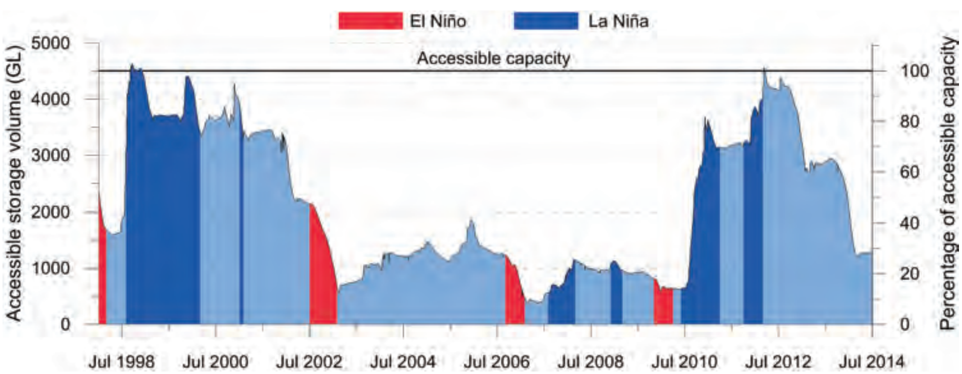
Groundwater is often seen as a resource that can be drawn on when surface water is scarce. However, despite large volumes stored in aquifers, it is not an infinite resource, and both groundwater and surface water supplies must be used sustainably (National Water Commission 2012a). The potential for groundwater use depends on water quality and replenishment rate, how easily water can be pumped from an aquifer (i.e. the physical availability) and local groundwater management rules (i.e. the legal availability).

Figure 21. Storage volumes of the six major reservoirs in the southern Murray–Darling Basin, 1998–2014



Note: The six major reservoirs are Lake Eildon, Lake Dartmouth, Lake Hume, and Blowering, Burrinjuck and Wyangala dams.

Figure 22. Storage volumes of 12 upstream reservoirs in the northern Murray–Darling Basin, 1998–2014



Note: The storages are Glenlyon, Pindari, Chaffey, Windamere, Burrendong, Copeton, Split Rock, Keepit, Leslie, Coolmunda and Cooby Creek reservoirs, and Chinchilla Weir.

Groundwater management areas have been established by States and Territories to facilitate management of groundwater. Groundwater management areas can cover all aquifers below the surface, or can be layered and related to a specific aquifer or depth range.

The total identified extraction limit, where explicitly stated in plans, across Australia is about 10 000 GL. The total groundwater entitlements under issue in 2013–14 were about 7000 GL.[17] Figure 23 presents the difference between the management area's extraction limit and the entitlements issued.

The limits set out in groundwater management plans vary significantly across jurisdictions in how they are calculated, enforced and interpreted. Therefore, comparing the total extraction limit and the total entitlements under issue is not simple because some areas do not have an extraction limit but still issue entitlements. For example, some areas are managed by rate of decline in levels and still have entitlements on issue. Generally, the total groundwater entitlements are set below the limits in the groundwater management plan. However, a few groundwater management areas are fully allocated, including the Pilbara, some aquifers in the Murray–Darling Basin and some smaller areas in southwestern Victoria and near Perth and Adelaide.

3.4 DESALINATED AND RECYCLED WATER

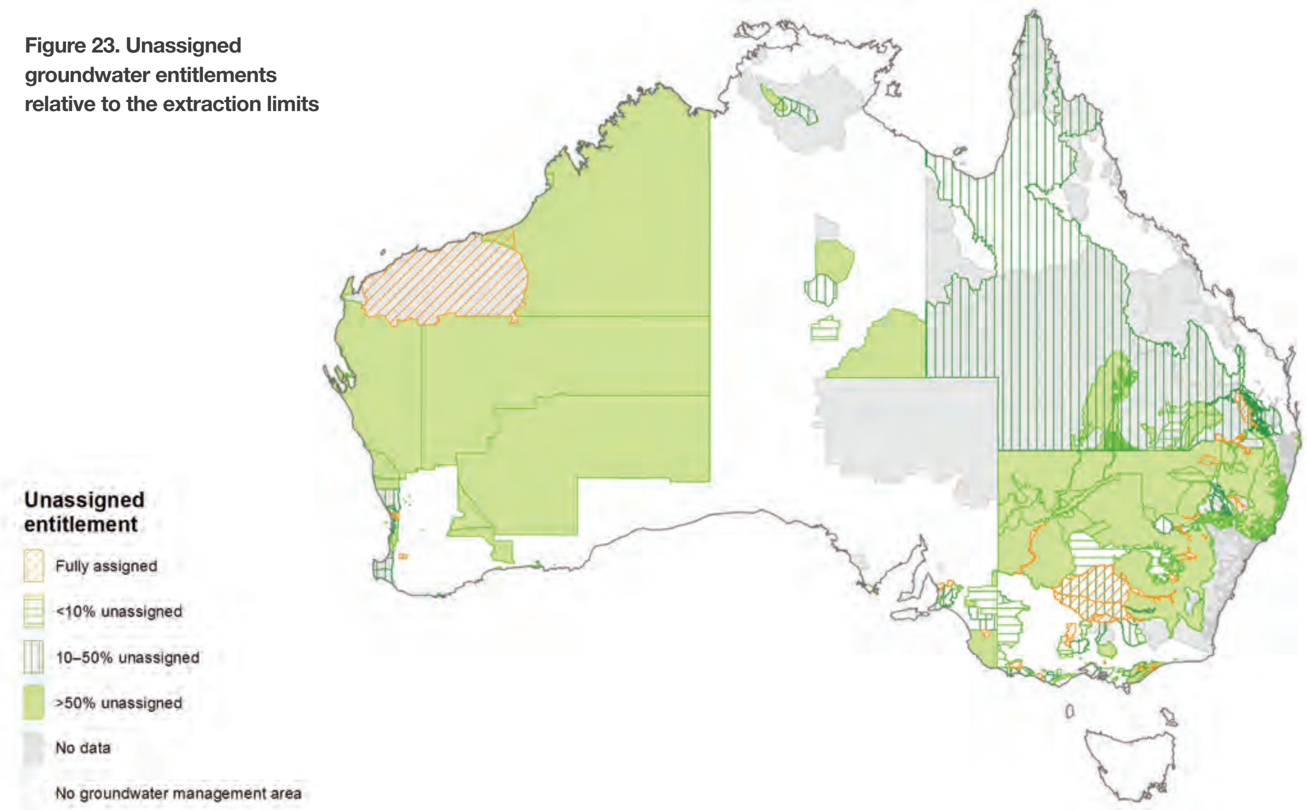
A growing need for water from resources that are not dependent on climate conditions has meant new technologies are being adopted to make low-quality water—including saline water and sewage effluent—fit for use. Treatment plants are used by urban water utilities as well as industries such as mining and energy production.

At the end of 2013–14, total marine desalination plant capacity in Australia was at least 630 GL of purified water per year.[18] The water available for marine desalination is almost unlimited, but the high costs of the process, including both high construction and ongoing operational costs, has resulted so far in only a moderate build-up of capacity and use throughout the country.

17 National Groundwater Information System (www.bom.gov.au/water/groundwater/ngis)

18 Climate Resilient Water Sources (www.bom.gov.au/water/crews)

Figure 23. Unassigned groundwater entitlements relative to the extraction limits



The five major cities of Australia have a total marine desalination capacity of 550 GL, which includes:

- Sydney (built in 2010), with a capacity of 91 GL
- Melbourne (built in 2012), with a capacity of 150 GL
- Perth (built in 2006 and 2012, expanded in 2013–14), used to supplement restricted surface water availability, with a total capacity of 164 GL per year; desalinated water contributed 39 per cent of urban water supply in 2013–14
- South East Queensland (built in 2009), with a capacity of 45 GL
- Adelaide (built in 2012), built to overcome restricted surface water availability and reduced water availability from the River Murray, with a total capacity of 100 GL per year; desalinated water contributed 38 per cent of urban water supply in 2013–14.

Desalination plants that supply purified water to industries and mines are generally running close to their capacities, often caused by physical or legal limitations on their use of other water resources.

The total effluent treatment capacity of recycling plants in Australia is at least 940 GL.[19] Recycled water from wastewater treatment plants is generally used year-round to take advantage of the consistent flows, and is mainly used for non-potable purposes such as irrigation. All major cities except Adelaide recycle about 10 per cent of their effluent for various uses (Figure 24). Adelaide recycles 28 per cent of its effluent, mainly for irrigation.

19 Climate Resilient Water Sources (www.bom.gov.au/water/crews)

3.5 ENVIRONMENTAL WATER

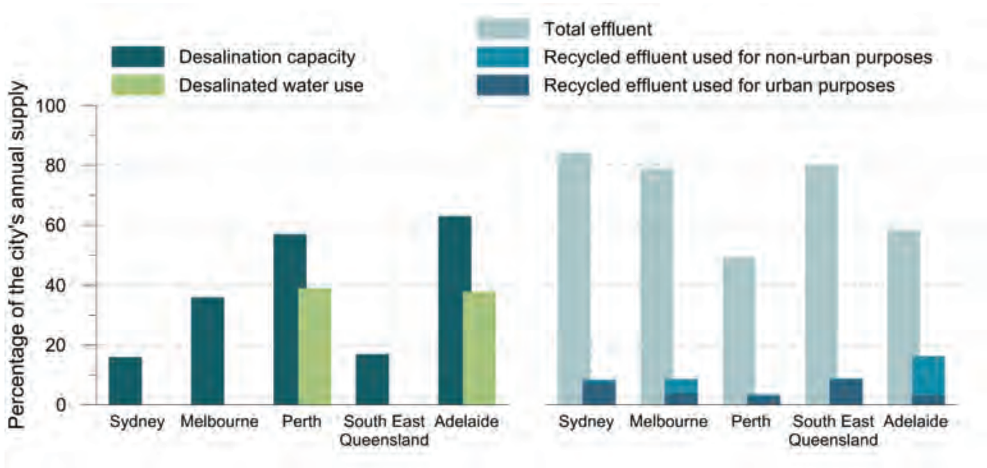
As well as ensuring sustainable water supply for human needs, water resources are managed to ensure that environmental needs are met. Environmental water management is achieved through:

- restrictions on human use to ensure that sufficient water is left in rivers and aquifers
- entitlements to water owned and managed by Commonwealth and State organisations for the benefit of the environment.

The second type of environmental water management occurs mainly in the Murray–Darling Basin. The Basin Plan (MDBA 2012) identifies new surface water and groundwater extraction limits for each of its sub-areas to achieve more sustainable river flows and groundwater levels for the environment.

The new limits are 2750 GL below 2009-approved diversions, which generally means that Basin governments need to reduce water allocations and use by 2750 GL before the Basin Plan is fully implemented in 2019. To achieve this, local and Basin-wide water recovery requirements have been set out for each water management area to meet a newly set cap on the area's entitled diversions, called the sustainable diversion limit of the management area.

Figure 24. Volumes of desalination capacity and 2013–14 use, effluent recycling potential and 2013–14 use as a percentage of total urban water use for Australia's five major urban centres



Source: Bureau of Meteorology 2015b

To meet the sustainable diversion limits, the Commonwealth and States can purchase entitlements from water users or invest in water-saving infrastructure. A limit of 1500 GL has recently been set on the amount that can be obtained by direct purchase. Additionally, the 2750 GL target may be reduced by up to 5 per cent if new studies demonstrate more efficient achievements of environmental outcomes. In April 2014, the Murray–Darling Basin Authority estimated that around 42 per cent of the 2750 GL has been recovered through purchasing entitlements, about 20 per cent through infrastructure developments (completed or under contract), and 8 per cent through other State and Commonwealth programmes (Department of the Environment 2014).[20]

The Commonwealth Environmental Water Holder (CEWH) is the major environmental water entitlements holder. Figure 25 shows the historical overview of the build-up and relationship between entitlements, the corresponding estimated long-term average annual yield, and the allocation and application volumes of the CEWH up to 2013–14.

20 A current assessment of progress towards achieving the sustainable diversion limits in each management area of the Basin Plan can be found at the Murray–Darling Basin Authority's website (www.environment.gov.au/system/files/resources/4ccb1c76-655b-4380-8e94-419185d5c777/files/water-recovery-strategy-mdb2.pdf).

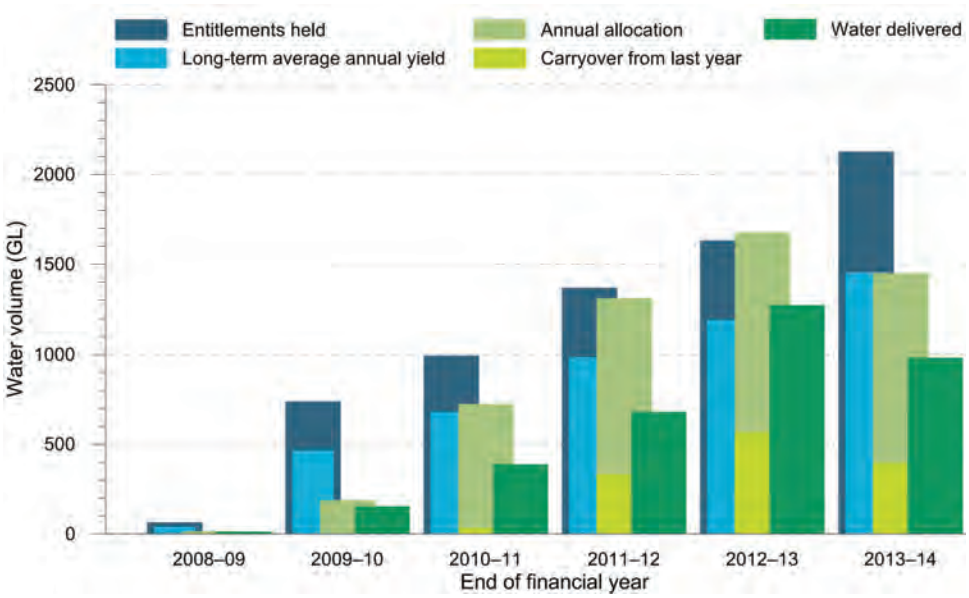
By the end of 2013–14, the CEWH had acquired a long-term average annual recovery yield of nearly 53 per cent or 1454 GL of the Basin Plan's 2750 GL target.

Of the total allocated water available to the CEWH in 2013–14, 68 per cent was delivered for environmental purposes and 31 per cent was carried over to next year.

At the end of 2013–14, 3192 GL of surface water entitlements were held by environmental water holders in the Murray–Darling Basin.[21] This is a small increase from holdings of 3160 GL calculated for the end of 2012–13. These figures include water held by the CEWH, water recovered under the Living Murray Initiative and environmental water held by Basin States. Environmental water is generally not available for other uses. However, in some years, environmental water holders are not able to use the water to benefit the environment and are allowed to trade some of the annual allocation to other users. This occurred during 2013–14, with 10 GL of allocated water sold in the drought-affected Gwydir region and 340 ML in the Peel district (Department of the Environment 2015b).

21 Bureau of Meteorology *National Water Account 2014* (www.bom.gov.au/water/nwa/2014)

Figure 25. Commonwealth environmental water holdings, environmental water availability and use, 2008–09 to 2013–14



Source: Department of the Environment 2015a

4 WATER USE

AT A GLANCE

Water is used for various purposes across Australia, including agriculture, industry and human consumption. The estimated total water use across Australia was 23 500 GL in 2013–14. The top two water uses were irrigation (57 per cent of total use) and urban consumption (17 per cent of total use).

The main irrigation use is in the Murray–Darling Basin and was just over 9500 GL in 2013–14. The estimated total surface water use for irrigation in the Murray–Darling Basin decreased from about 11 000 GL in 2012–13 to about 8400 GL in 2013–14—a drop of 24 per cent. Groundwater use for irrigation increased by 18 per cent to just over 1100 GL because of drier conditions and limited surface water allocation announcements, particularly in the northern Murray–Darling Basin.

Outside the Basin, around 3900 GL was used for irrigation, mainly in the coastal regions of Queensland, New South Wales and Victoria, the coastal regions surrounding Perth and Adelaide, northeast Tasmania, and the Ord irrigation scheme in northern Australia.

Total water use in 2013–14 in the major cities shows no significant changes in recent years, with Sydney, Melbourne and South East Queensland all recording slight increases in water use since 2011–12. Sydney, Melbourne and South East Queensland use mainly surface water; Perth and Adelaide are using increasing amounts of desalinated water.

Urban residential use in 2013–14 was 185 kL per property, up 3 per cent from 2012–13. However, use per property has not increased significantly from the levels at the end of the Millennium Drought.

Other water uses include mining, electricity production (excluding hydro-electricity), stock and domestic groundwater, plantations and farm dams. Combined, these constitute about 6200 GL, or 26 per cent of total water use across Australia.

Some progress is being made in considering and making provision for Indigenous needs relating to water.

Entitlement trade increased in 2013–14 to about 2400 GL, which can be attributed partly to entitlements being transferred to the Commonwealth for the environment and partly to declining water storage levels that prompt buyers into the market to secure more water. Allocation trade in 2013–14 was around 5500 GL.

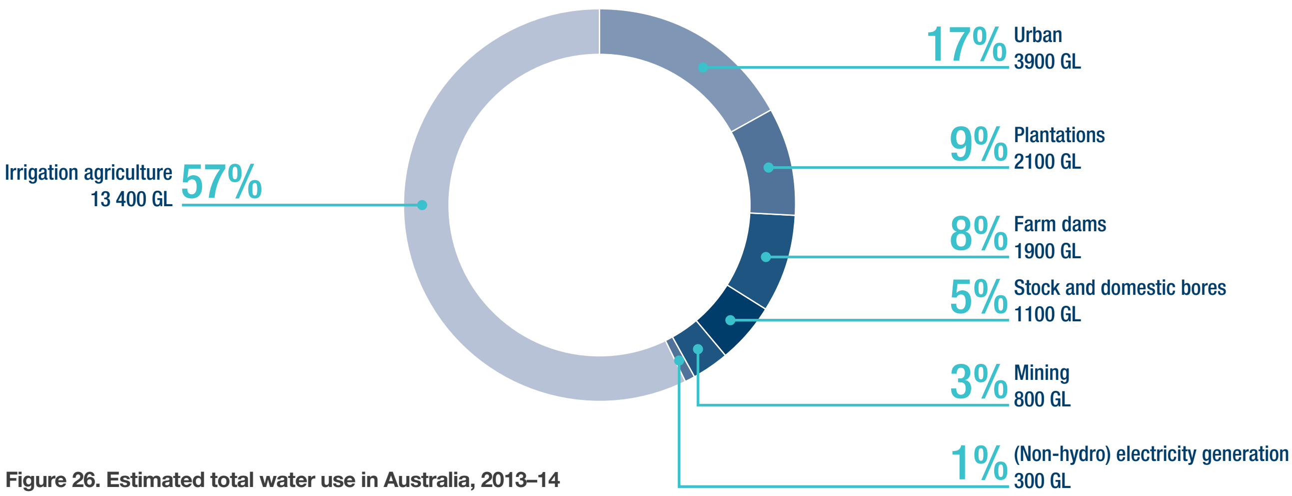


Figure 26. Estimated total water use in Australia, 2013–14

Note: Details on how the volumes are estimated are available from the Bureau's *Regional Water Information* website (www.bom.gov.au/water/rwi). The 2013–14 estimates are based on the following sources, supplemented by local reports and consultation with local jurisdictions: irrigation—*National Water Account 2014* (www.bom.gov.au/water/nwa/2014); urban water use—Bureau of Meteorology 2015b and ABS 2014; plantations and stock and domestic bores—National Water Commission 2010; farm dams—ABS 2015; mining and electricity generation—ABS 2014.

4.1 INTRODUCTION

The estimated total water use across Australia was 23 500 GL in 2013–14. Water use can be classified into broad categories based on key uses (Figure 26), irrigation being by far the largest use.

In this report, the major types of use exclude the following large water applications:

- Environmental water—this is not included as a use, even though held environmental water is taken from the entitlement pool to meet environmental watering requirements at key sites in the Murray–Darling Basin and parts of Victoria.
- The hydro-electricity sector—although this is the biggest user of water in Australia (in 2012–13 it used around 62 500 GL; ABS 2014), because there is no net consumption of water, hydro-electricity generation is not included as a use of water. The process returns water to the rivers, meaning that the water is available for other purposes after it has passed through the turbines of the hydro-electricity station.
- Floodplain harvesting—this is the taking of water from a floodplain (i.e. after it leaves a watercourse during a flood). This water is only available infrequently, but it can involve significant volumes and is licensed in some areas. Water collected through floodplain harvesting in the Murray–Darling Basin needs to be reported under the Basin Plan, but data to estimate these volumes are not readily available.

Reflecting the fact that the main types of use are irrigation and urban consumption, water use is highest in the southern Murray–Darling Basin, then parts of the northern Basin, the major metropolitan centres, Tasmania, and most other southern and eastern coastal regions (Figure 27). Note that although use is illustrated as uniformly spread across a whole region, it is often locally concentrated.

Figure 27. Total annual water use across Australia, 2013–14

Note: Farm dam water use is excluded because of the absence of a spatial distribution of farm dam information at the time of publication.

Source: See note for Figure 26.

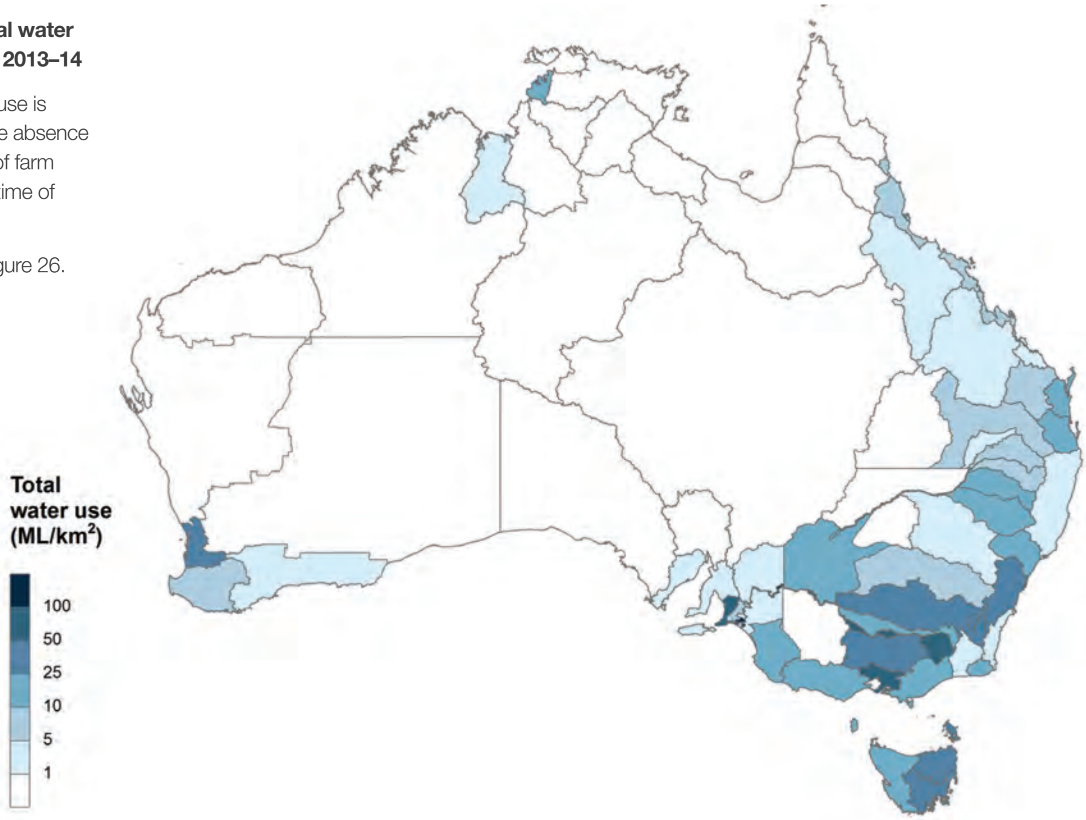
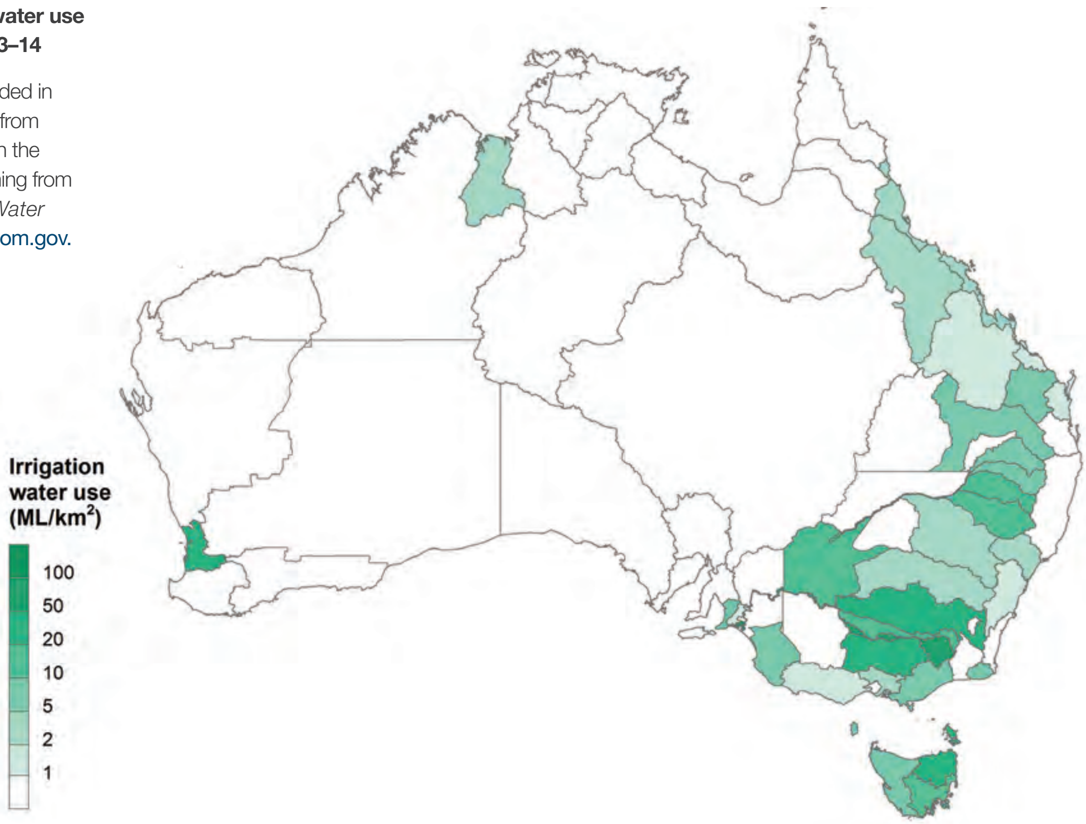


Figure 28. Irrigation water use across Australia, 2013–14

Source: Estimates provided in this figure are compiled from a variety of sources, with the largest component coming from the Bureau's *National Water Account 2014* (www.bom.gov.au/water/nwa/2014).



4.2 IRRIGATION WATER USE

Irrigated land is only a small fraction of Australia's total agricultural land (around one per cent); however, irrigation constitutes Australia's largest water use, estimated to be 13 400 GL in 2013–14. The revenue from irrigated agriculture is about one-third of the total agricultural production in Australia, and contributes to the economy and well-being of many regional communities (ABS 2013).

The majority of irrigated water use in Australia is part of regulated river systems, where controlled releases from storages allow large volumes of water to be provided with good reliability. Associated licences and allocations are managed by various jurisdictions with different regulatory frameworks, terminologies, and data capture and storage systems.

Australia's main irrigation districts are located in the southern Murray–Darling Basin (Figure 28), and the total Basin-wide irrigation water use was just over 9500 GL in 2013–14.[22]

In 2013–14, the estimated total surface water diverted for irrigation use in the Murray–Darling Basin decreased from about 11 000 GL in 2012–13 to about 8400 GL[23] in 2013–14—a drop of 24 per cent. Groundwater use for irrigation increased by 18 per cent to just over 1100 GL because of drier conditions and limited surface water allocation announcements, particularly in the northern Murray–Darling Basin.

Outside the Basin, around 3900 GL was used for irrigation, mainly in the Queensland, New South Wales and Victorian coastal zones, the coastal zones surrounding Perth and Adelaide, Tasmania, and the Ord irrigation scheme in northern Australia.

Irrigation water use is dependent on demand, which is linked to factors such as farm cropping strategies, and on supply or availability, which is linked to climatic conditions. The latter determines the allocation announcements during the year. Irrigators are also able to supplement diversions with water carryover from previous years or traded between regions (Figure 29). Total diversions in a particular year can therefore be quite different to annual allocations.

22 This number differs from the number in *National Water Account 2014*, because it includes South Australian surface water diversions, which were not available at the time the *National Water Account 2014* was published.

23 This number differs from the number in *National Water Account 2014*, because it includes South Australian surface water diversions, which were not available at the time the *National Water Account 2014* was published.

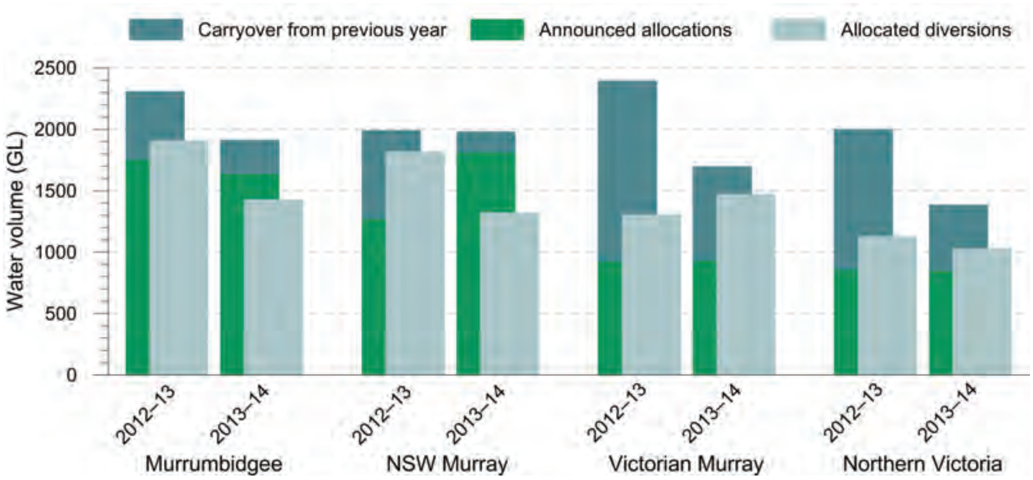


Figure 29. Diversions compared with carryover and allocations in the four major irrigation regions between 2012 and 2014

Source: *National Water Account 2014* (www.bom.gov.au/water/nwa/2014)

Irrigation water allocations in Victoria tend to be more consistent between years because of the prevalence of high-security, or high-reliability, water entitlements. General security water entitlements, which dominate the allocations in New South Wales, are affected by fluctuations in water in storages and predicted inflows.

4.3 URBAN WATER USE

Urban water use was estimated to be 3900 GL in 2013–14, which accounts for 17 per cent of total water use in Australia.[24]

4.3.1 Sources of urban water

Sydney, Melbourne and South East Queensland (which includes Brisbane and the Gold Coast) use mainly surface water (Figure 30). In Perth and Adelaide, the use of desalinated water is growing because surface water resources have been insufficient to sustainably meet demand.

Population growth in urban areas is expected to increase water use each year. However, weather has a major impact on annual water demand. Total water use in 2013–14 in the major cities shows no significant changes in recent years, with Sydney, Melbourne and South East Queensland all recording slight increases in water use since 2011–12.

Sydney, Melbourne, Canberra and South East Queensland rely on storages to provide a secure water supply, with storage capacites totalling more than four times the total annual use (Figure 31). The cities with low storage volumes and capacities with respect to their use—Adelaide and Perth—rely on groundwater and desalination as well. Adelaide also relies on River Murray diversions.

24 Urban water use and a set of performance indicators are reported annually through the Bureau's *National performance reports* (www.bom.gov.au/water/npr). The Bureau took over responsibility for delivery of the annual report from the National Water Commission in 2013–14.

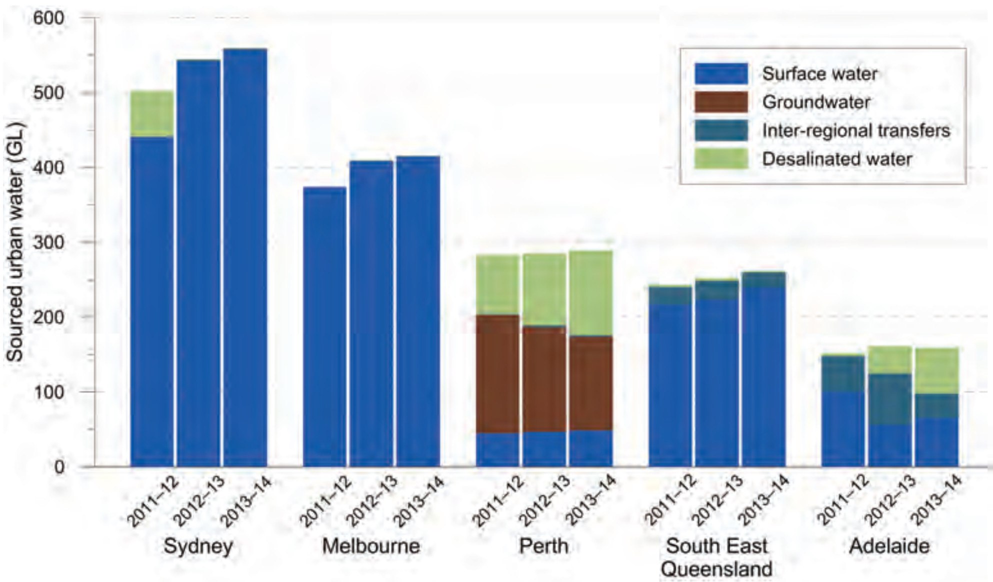


Figure 30. Water sources (excluding recycled water) for Australia's five major urban centres, 2011–12 to 2013–14

Source: *National Water Account 2014* (www.bom.gov.au/water/nwa/2014) and Bureau of Meteorology 2015b

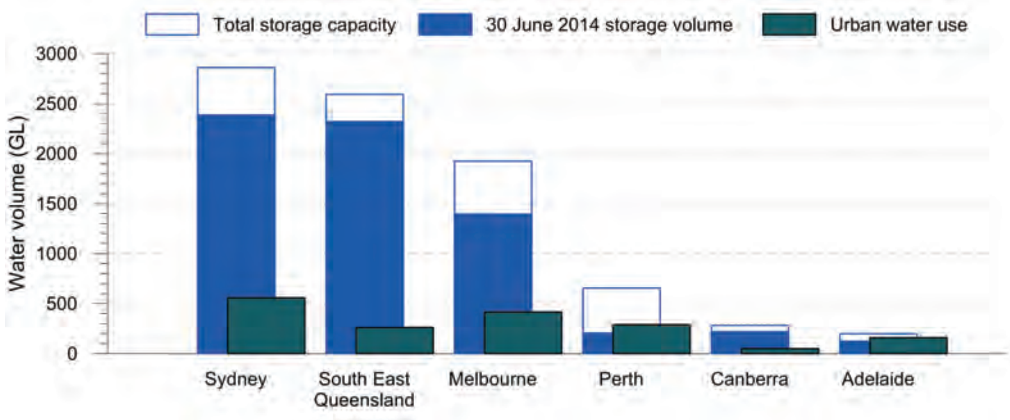


Figure 31. Comparison of urban water use and storage volumes in Australia's six largest cities or regions

Source: *National Water Account 2014* (www.bom.gov.au/water/nwa/2014)

4.3.2 Residential water use

In 2013–14, water utilities supplied an average of 185 kL per property, up 3 per cent from 179 kL per property in 2012–13 (Figure 32). This was the third consecutive year of increases in water use.

These increases are associated with high temperatures, average or below-average rainfall and the easing of temporary water restrictions across Australia. Dry and warm weather is arguably the most influential factor affecting residential use, and drier conditions were compounded by above-average temperatures in 2013 and 2014, which were Australia's hottest and third-hottest years, respectively, since official temperature records began in 1910.

However, use per property has generally not increased significantly from the levels at the end of the Millennium Drought, and has not returned to the high levels of 2005–06 and 2006–07, despite the lifting of temporary water restrictions after the drought. This is probably the result of several factors, including:

- the introduction of permanent water conservation measures
- increased use of water-saving devices
- increased use of alternative sources such as rainwater tanks
- higher-density living in most urban centres, which should reduce the water demand per property.

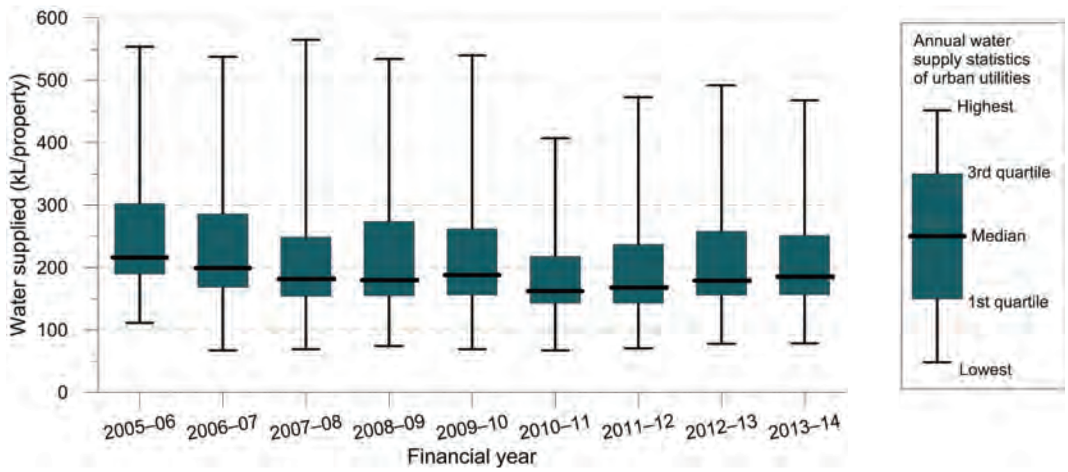


Figure 32. Annual residential water supplied, 2005–06 to 2013–14

Source: Bureau of Meteorology 2015b

4.4 OTHER WATER USE

Other water uses include mining, electricity production, stock and domestic groundwater, plantations and farm dams. Combined, these constitute about 6200 GL, or 26 per cent of total water use in Australia during 2013–14. In the discussion below, the sources of information are those given in Figure 26, except where otherwise noted.

4.4.1 Mining

Mining water use is estimated to be 800 GL, or 3 per cent of total use. However, at local scales, it can be a major consumer of a region's available resources.

In Western Australia, around 17 per cent of estimated water use is by the mining sector. In the Pilbara, one of the world's largest iron ore areas, close to 90 per cent of water extracted in the region is for mining operations. In the Hunter Valley of New South Wales, around 15 per cent of total estimated water use is by the mining sector.

Water extracted during the production of coal seam gas is not included in this report because there is no nationally comprehensive dataset. Coal and coal seam gas developments in coal-rich areas of Australia are likely to give rise to increasing levels of water extraction for mine dewatering and other mining-related uses. More details on this topic will became available with the undertaking of the Bioregional Assessment project by the Australian Government Department of the Environment, the Bureau of Meteorology, CSIRO and Geoscience Australia. The project's aim is to assess the cumulative impacts of coal resource development proposals on water resources against a baseline condition.

4.4.2 Electricity production

Water use for electricity production (excluding hydro-electricity) is estimated to be 300 GL, or 1 per cent of total use.

In the Hunter Valley, energy production is estimated to account for 20 per cent of water extraction. Victoria's main coal power generators in Gippsland are estimated to account for 20 per cent of water used in the region.

4.4.3 Stock and domestic bores

In 2010, bore water extracted under stock and domestic rights was estimated to be about 1100 GL, or 5 per cent of total use.

Bore water extraction is a relatively consistent annual use, because it is essential for rural Australian properties that do not have alternative sources of water for stock and domestic purposes. Improving estimates would support our understanding of critical human water requirements across the country.

4.4.4 Plantations

Plantation water use is the reduction in rainfall contribution to groundwater and surface water resources due to interception and evaporation in the canopy of the trees. In 2010, forest plantation interception was estimated to be about 2060 GL, or 9 per cent of total use.

Use is highest along the south coast and in Tasmania, where the more temperate climate allows for highly productive plantation forests. Commercial plantations in the Murray–Darling Basin have estimates of use included in the sustainable diversion limits for planning areas. South Australia has required water licensing for commercial forestry since 2012.

4.4.5 Farm dams

In 2013–14, farm dam and tank water use through farming practices (excluding evaporation losses) was estimated to be about 1900 GL, or 8 per cent of total water use, based on the results of the Australian Bureau of Statistics' Water Use on Australian Farms surveys (ABS 2015).

As with stock and domestic groundwater use, it is assumed to be a relatively consistent annual use, because it is essential for rural Australian properties that generally do not have alternative sources of water.

Farm dam water use in the Murray–Darling Basin (referred to in the Basin Plan as take by runoff dams) is included in the sustainable diversion limit of each water management area.

4.5 WATER FOR INDIGENOUS CULTURAL USE

In the cosmologies of Australian Aboriginal people, water is a sacred and elemental source and a symbol of life (Langton 2006). The First Peoples' Water Engagement Council has said that Aboriginal water is an all-encompassing concept, describing the water requirements for the enhancement and protection of Aboriginal peoples' physical, spiritual, cultural and social wellbeing. This covers the amount, location, quality, flow rate, temperature, flow frequency and timing, and decision-making structures necessary to sustain country and culture (First Peoples' Water Engagement Council 2012).

Indigenous people have common-law rights to maintain customary use and access to places and resources, including water. The National Water Initiative requires governments to consider Indigenous people's water use. However, meeting cultural values in water allocation planning and decision-making is challenging for water managers.

Virtually no information can be found on water being made available for Indigenous water use. The following two case studies, for the Daly River region and the Murray–Darling Basin, are examples of the progress that is being made. New South Wales is also progressing with its Our Water Our Country initiative (NSW Office of Water 2012).

4.5.1 Daly River region

Many of the Aboriginal sacred sites recorded within the Daly River region of the Northern Territory are associated directly with the Daly River and its tributaries. Aboriginal people have customary obligations associated with water, including the responsibility of keeping the water clean, protecting access to particular places along the river, protecting cultural knowledge, providing cultural education, and sharing songs and stories involving the river.

Water planning in the region has gone some way to providing for Aboriginal values, along with other water-dependent environmental, economic and recreational values. The water allocation plan for the Tindall limestone aquifer aims to protect the ecosystems that depend on the aquifer, which are also important for Indigenous cultural values. The Aboriginal community has been actively involved in formulating the plan.

The plan's strategies include an annual assessment of the extraction limit, based on rainfall and recharge, to ensure that environmental flows are protected in drier years, to protect low flows in the Katherine River, and to maintain spring discharge from the aquifer. The plan also addresses the economic aspirations of Aboriginal people in the Daly region by making provision for water for future economic development should native title be recognised within the period of the plan.

Several factors have contributed to the consideration of Aboriginal values and aspirations in the plan. These include the relatively undeveloped nature of the resource, the vibrancy of Aboriginal traditions in the area and a relatively high level of documentation of Aboriginal values about water (e.g. Jackson et al. 2011).

4.5.2 Murray–Darling Basin

In the Murray–Darling Basin, providing for Indigenous needs is more challenging. This is partly because the water resources are fully allocated and partly because provision for Indigenous and other beneficial uses has not been historically considered when sharing resources.

Consideration of Indigenous social, spiritual and cultural water values and uses is likely to increase as a result of Basin Plan requirements. They must also be taken into account by the Commonwealth Environmental Water Office when evaluating priorities for watering.

4.6 WATER ENTITLEMENT AND ALLOCATION TRADING

Entitlement holders may trade water with other entitlement holders. Australia's water market facilitates the buying and selling of water entitlements and allocations to allow water to move between various urban, agricultural and environmental uses. Nationally, the value of market turnover has been estimated at $1.4 to $2.6 billion per year (National Water Commission 2009–2013). Entitlement trades involve permanent transfers of a water access entitlement. Allocation trades involve the buying and selling of allocated water during a particular year.

Water trading is subject to various legislative and administrative arrangements. Typically, trading occurs between water users within connected hydrological systems. These range from small isolated markets such as Melbourne or southeastern Queensland to more widespread, physically connected markets such as the southern Murray–Darling Basin.

The ability to trade and move water between different users has been bolstered by recent reforms. For example, the delivery of commitments made under the National Water Initiative 2004 has led to water entitlements and allocations being more readily tradeable products.

Surface water trading accounted for 88 per cent and 97 per cent of total entitlement and allocation trade, respectively, in 2013–14. Groundwater trade is only a small proportion of trade because groundwater only accounts for around 20 per cent of total entitlements on issue and trade is also restricted to reduce what are known as third-party impacts of trade. For example, trade can change the extraction location of water, which could cause local groundwater levels to drop and make it more difficult to extract water from neighbouring bores, or affect local groundwater-dependent ecosystems.

4.6.1 Entitlement water trading

Surface water entitlement trading in Australia over the past eight years has been dominated by activity in the Murray–Darling Basin, which was responsible for around 80–90 per cent of total entitlement trades (Figure 33).

Multi-year climatic conditions influence entitlement trading activity. During the Millennium Drought, market participants looked to secure access to water, with a spike in trade in 2008–09. From 2009–10, water management decisions such as government acquisition of entitlements for the environment also heavily influenced trading activity. Since a return to higher water availability and higher annual allocations in 2010–11, volumes of entitlement being traded have been steady.

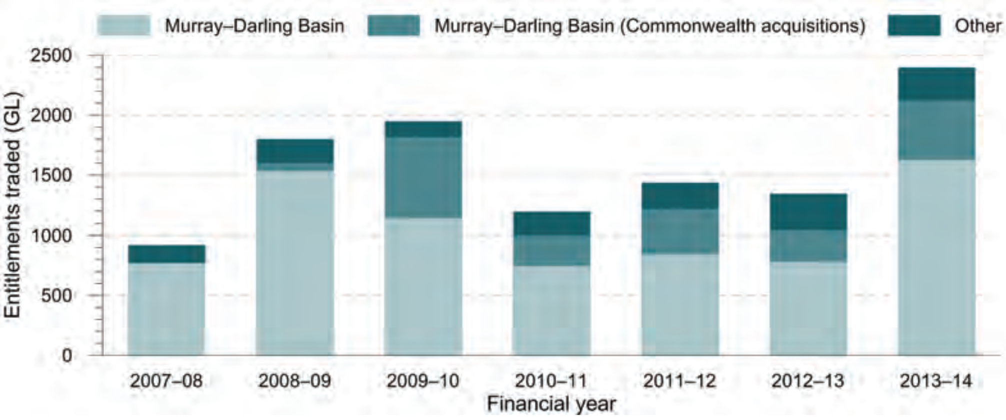


Figure 33. Water entitlement trades in Australia, 2007–08 to 2013–14

Source: Extracted from the National Water Commission's Australian water markets report series 2007–08 to 2012–13 (see www.nwc.gov.au); 2013–14 data taken from the Bureau's *National Water Account 2014* (www.bom.gov.au/water/nwa/2014)

Note: Acquisition includes buy-backs and water savings from infrastructure upgrades.

Entitlement trade increased in 2013–14, which can be attributed partly to entitlements being traded to the Commonwealth for the environment and partly to a drier outlook and declining water storage levels that prompted buyers into the market to secure more water.

4.6.2 Allocation water trading

Allocation trading is also dominated by activity in the Murray–Darling Basin, which was responsible for 87–98 per cent in recent years, particularly trade in the southern part of the Basin (Figure 34). Data from areas where irrigation water use is expanding, such as Tasmania, indicate a relatively low level of allocation trade compared with the Basin (about 3 GL compared with more than 5000 GL).

Nationally, allocation trading volumes increased each year from 2007–08 to 2012–13, driven by internal (or intrastate) trading (Figure 35). Allocation trade levels dropped slightly in 2013–14 to around 5500 GL. For many irrigators, water trading has become a normal business tool to manage and take advantage of both low and high water availability.

With drier conditions in 2013–14, water availability has declined, putting pressure on allocation prices in many irrigation areas. Trading volumes remained high, with some irrigators selling water because it was more profitable than irrigating crops such as rice, while others purchased water for higher-margin crops (such as cotton or horticulture) or to supplement lower levels of allocated water.

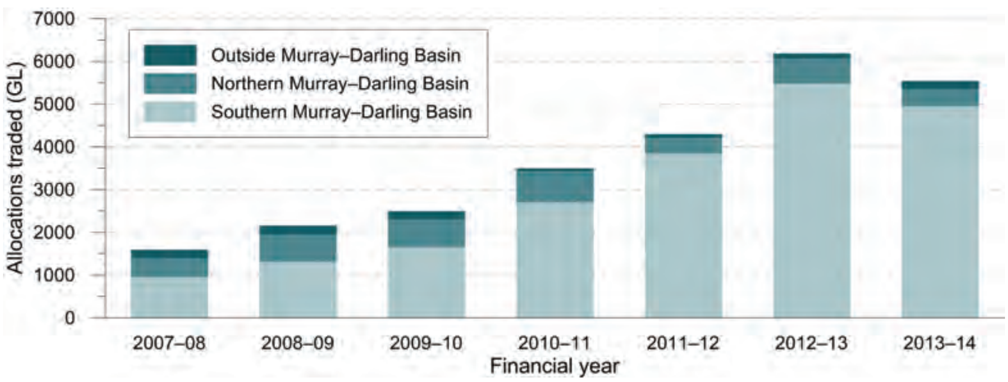


Figure 34. Water allocation trades in Australia between 2007–08 and 2013–14

Source: Extracted from the National Water Commission's Australian water markets report series 2007–08 to 2012–13 (see www.nwc.gov.au), and the Bureau's *National Water Account 2014* (www.bom.gov.au/water/nwa/2014).

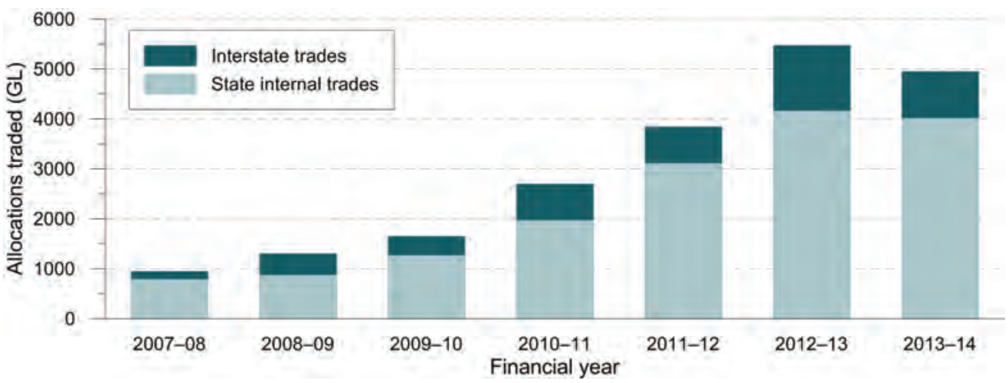


Figure 35. Internal versus interstate water allocation trades in the southern Murray–Darling Basin, 2007–08 to 2013–14

The ability to trade water between hydrologically connected regions and States has increased following water reforms such as the National Water Initiative in 2004. The growth in interstate allocation trade from 2007–08 was initially in response to drought conditions until 2009–10 (irrigators with permanent plantings sought to buy more water to keep their long-lived tree assets alive, while some annual croppers found it more profitable to sell their allocations than to grow a crop).

Since about 2010–11, the number and volume of interstate allocation trades has increased, partly as a result of increased environmental water holding transfers to different regions within the southern Murray–Darling Basin. During 2013–14, large volumes of allocations (more than 600 GL) were transferred into South Australia, much of which was to facilitate environmental watering along the River Murray and lower lakes (Figure 36).

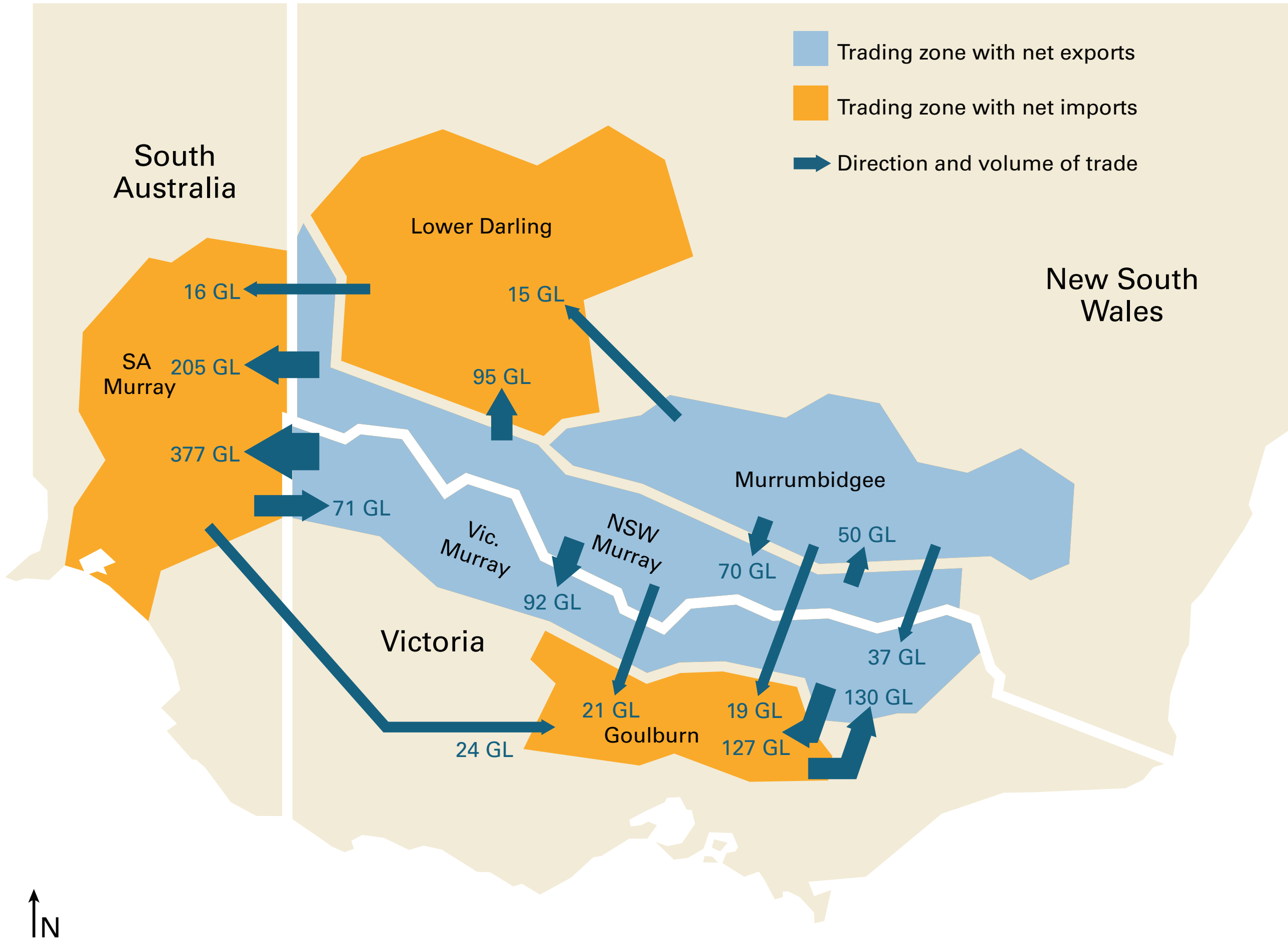


Figure 36. Volume and direction of significant interregional allocation trades in the southern Murray–Darling Basin, 2013–14

Notes:
1. Includes only trades with total volume more than 10 GL.
2. This figure is based on the *National Water Account 2014* data but differs in its presentation by only showing trade directions where total volume is more than 10 GL (the National Water Account only presents trade directions between States).
3. Goulburn includes Broken, Campaspe, and Loddon trading zones.

5 CONCLUDING REMARKS

AT A GLANCE

This report draws on a range of Bureau information to describe the characteristics of the country's water resources, availability and use from 1 July 2013 to 30 June 2014 in the context of the past.

Rainfall patterns are changing in Australia. For water resource managers, the most significant change is the declining rainfall in the southern States.

5.1 DECADES OF DRYING IN SOUTHERN AUSTRALIA

At the time of writing (October 2015), most water storages are in reasonable condition. However, in the Murray–Darling Basin, where much of Australia's irrigation occurs, storage levels are below average. Capital cities from Brisbane to Melbourne had high water storage levels at 68–89 per cent of capacity. In contrast, Adelaide and Perth had relatively low storage levels (62 per cent and 31 per cent, respectively) but have alternative sources of supply.

Most water use in Australia occurs in the Murray–Darling Basin and around the major metropolitan cities. These areas, with the exception of Adelaide, experienced drier than average conditions in 2013–14, with generally below-average rainfall and runoff, especially in the autumn to spring seasons when most runoff usually occurs.

These dry cool-seasons across southern Australia are part of below-average rainfalls that have been among a set of complex changes occurring since the 1970s, associated with systematic change in atmospheric circulation patterns over Australia. High pressure systems have intensified and shifted south, which forces rain-bearing weather systems south of Australia and brings dry weather.

There is evidence that runoff has been reduced in southern Australia even more than expected from the rainfall decline. The decline in rainfall seems to be drying the landscape and dropping groundwater levels so that rainfall that used to generate runoff no longer does so (e.g. Kinal and Stoneman 2012).

The persistence of dry cool-seasons in southern Australia, and their attribution to changes in climate that are projected to continue, means that it is likely that cool-season runoff will continue to be frequently below the historical average in future. This has significant implications for future water supplies.

5.2 WATER SECURITY IN SOUTHERN AUSTRALIA

A dry 2013–14 in southeastern Australia has been followed by a similar year in 2014–15, except in Sydney and Brisbane, which had above-average rainfall. The El Niño conditions expected for much of 2015–16 are typically associated with substantially below average winter and spring rainfall, although not always. Thus, at the time of writing (October 2015), there is a prospect of three consecutive years of average to below-average rainfall and runoff across much of southeastern Australia.

At the end of 2013–14, the rainfall deficiencies were not as severe as at the peak of the Millennium Drought. More importantly, water supplies were more secure for the major metropolitan cities. The 2015–16 year began with relatively high water storage levels at 68–89 per cent of full capacity for Brisbane, Sydney and Melbourne. These storage volumes are sufficient to provide several years of supply. In addition, supplies have been augmented in all cities since the Millennium Drought—desalination plants can supply 10–60 per cent of urban water supplied to all capital cities in mainland southern Australia except Canberra, which has augmented its supplies in other ways.

Adelaide and Perth ended 2013–14 with relatively low storage levels of 62 per cent and 31 per cent, respectively, but they are the cities that are least reliant on surface water stores and have alternative sources of supply. Perth has experienced lower than historically average inflows into its dams continuously since the mid-1970s and, as a result, obtains a large component of its water from groundwater and two desalination plants. Adelaide relies heavily on transfers of water from the River Murray as well as desalination.

In the Murray–Darling Basin, where much of Australia's irrigation occurs, storage levels were lower than average at the end of 2013–14 across the entire Basin. Winter and spring is when the large dams in the southern Basin refill, but, in an El Niño year, the refilling is typically (but not always) negligible, and storage levels decline during the following summer.

In the southern Murray–Darling Basin, storage levels in the drier months are not as low as at the peak of the Millennium Drought and, since the drought, there has been a maturing of the water market. This means that, with continually increasing volumes of seasonal water allocations being traded as an adaptation to variable water security, impacts on agricultural production may not be as marked.

The river ecosystems of the Basin have been better catered for since the Millennium Drought as a result of nearly 70 per cent of the Basin-wide water recovery requirements being met by 30 June 2014. Some of this has come from purchase of entitlements from irrigation, so less surface water is now used for irrigation. However, carryover of environmental entitlements means that, given a particular storage level, the water in storage for consumptive purposes is less than might have historically been assumed for that same level.

GLOSSARY

aquifer	An underground layer of saturated rock, sand or gravel that absorbs water and allows it free passage through pore spaces.
bore	A hole drilled in the ground, a well or any other excavation used to access groundwater. May be used for observing groundwater (including water level, pressure or water quality).
catchment	The land area draining to a point of interest, such as a water storage or monitoring site on a watercourse.
climate	The average long-term weather conditions in a particular area. See the Weather and Climate web pages (www.bom.gov.au/climate/glossary/climate.shtml) for more information.
confined aquifer	An aquifer overlaid by a confining bed. The confining bed has significantly lower hydraulic conductivity than the aquifer. Typically, groundwater in a confined aquifer is under pressure that is significantly greater than atmospheric pressure.
dead storage	In a water storage, the volume of water stored below the level of the lowest outlet (the minimum supply level). This water cannot be accessed under normal operating conditions.
desalination	The process of removing salt from brackish or saline water.
drought	A long period of abnormally low rainfall, especially one that adversely affects agriculture and other human activities. See the Climate web page on drought (www.bom.gov.au/climate/glossary/drought.shtml) for more information.
ecosystem	A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.
El Niño	The extensive warming of the central and eastern Pacific Ocean that leads to a major shift in weather patterns across the Pacific. In Australia (particularly eastern Australia), El Niño events are associated with an increased probability of drier conditions. See the Weather and Climate web page on El Niño (www.bom.gov.au/watl/about-weather-and-climate/australian-climate-influences.shtml?bookmark=elnino) for more information.
El Niño–Southern Oscillation (ENSO)	The oscillation between the El Niño climate phase and the La Niña climate phase, or opposite phase, usually over several years. See the Weather and Climate web page on ENSO (www.bom.gov.au/watl/about-weather-and-climate/australian-climate-influences.shtml?bookmark=enso) for more information.
entitlement system	A jurisdictional gazetted instrument (e.g. water sharing plan), subordinate to the overarching State or Territory water rights legislation, intended to share the portion of the total water resource it covers.
environmental flow	The streamflow required to maintain appropriate environmental conditions in a waterway or water body.

evaporation	A process that occurs at a liquid surface resulting in a change of state from liquid to vapour. In relation to water resource assessment and water accounting, evaporation refers to the movement of water from the land surface (predominantly liquid) to the atmosphere (water vapour). The liquid water at the land surface that may be available for evaporation includes surface water, soil water, water within vegetation, and water on vegetation and paved surfaces.
evapotranspiration	The sum of evaporation and plant transpiration from Earth's land surface to the atmosphere.
farm dam	Small water storage, usually managed by the landowner, with a capacity usually less than 100 ML. The volume includes dead storage.
floodplain	Flat or nearly flat land next to a stream or river that experiences occasional or periodic flooding.
groundwater	Subsurface water in soils and geological formations that are fully saturated.
groundwater level	The level of groundwater in an aquifer, typically measured in a groundwater bore. In the case of an unconfined aquifer, the groundwater level is equal to the watertable level.
groundwater management plan	A document providing information about groundwater access for users. It may include rules about transferring licence entitlement, and contain arrangements that allow carryover of groundwater entitlement. It may also outline water sharing arrangements during times of water shortage.
Indigenous water	Water resources of an area that are recognised or used by local Indigenous people for their social, spiritual and cultural values.
irrigation right	A right issued by an irrigation entity and granted from the entity's bulk water access entitlement.
La Niña	The extensive cooling of the central and eastern Pacific Ocean. In Australia (particularly eastern Australia), La Niña events are associated with an increased probability of wetter conditions. See the Weather and Climate web page on La Niña (www.bom.gov.au/watl/about-weather-and-climate/australian-climate-influences.shtml?bookmark=lanina) for more information.
major storage	Any water storage that has a total storage capacity of 1000 million litres or more.
Millennium Drought	The prolonged period of dry conditions experienced in much of southern Australia from late 1996 to mid-2010.
rainfall	The total liquid product of precipitation or condensation from the atmosphere, as received and measured in a rain gauge.
recycled water	Treated sewage effluent. Includes water extracted by sewer mining and subsequently treated, but does not include treated urban stormwater.
regulated river	River on which a licensed entitlement regime exists with centralised allocation, and from which orders may be placed for upstream release of a licensed allocation. A necessary, but not sufficient, condition for a river to be regulated is that it is located downstream of a surface water storage. Note: The term river can be replaced by channel with the same meaning.
residential water	The total amount of metered and estimated non-metered, potable and non-potable water supplied to residential properties.
runoff dam	A dam or reservoir that collects surface water flowing over land. Note: In New South Wales, a runoff dam may also collect water from a first- or second-order stream.

security licence	A permission to use water at a prescribed level of reliability, for example: • high-security licences provide greater reliability for special needs, such as household water, electricity generation, some industry and some perennial high-value crops • on-channel general security licences have lower reliability and mean that holders of these licences—usually irrigators of annual crops—are more susceptible to reductions in water availability.
soil moisture	The water content in the unsaturated zone of a soil profile.
stock and domestic water use	Use of water for domestic consumption (e.g. drinking, cooking, washing, watering household gardens, and filling swimming pools associated with domestic premises) and to water stock on a property. Does not include water used for irrigating crops that will be sold; bartered; or used for stock fodder, washing down machinery sheds or intensive livestock operations.
storage	A pond, lake or basin, whether natural or artificial, for the storage, regulation and control of water.
storage volume	The volume of water stored at a particular time and date. It excludes the dead storage volume and hence is the volume of water that can be accessed under normal circumstances without the installation of additional infrastructure.
streamflow	The flow of water in streams, rivers and other channels.
surface water	Includes: • water in a watercourse, lake or wetland • any water flowing over or lying on land; - after having precipitated naturally; or - after having risen to the surface naturally from underground.
sustainable diversion limit	The limit on how much water can be sustainably taken from a catchment, aquifer or basin as part of the Murray–Darling Basin Plan.
transpiration	The giving off of water vapour from parts of plants, especially through the stomata of leaves.
unconfined aquifer	An aquifer whose upper surface is a watertable that is free to fluctuate in equilibrium with atmospheric pressure.
unregulated river	A river where there is no entitlement system, or where there is an entitlement system that does not allow orders to be placed for upstream release of a licensed allocation. Note: The term river can be replaced by channel with the same meaning.
urban water	The total residential, commercial, municipal, industrial and other water supplied by urban water utilities.
urban water supply	The volume of water (potable, non-potable and recycled water) supplied to customers over a reporting period.
water access entitlement	A perpetual or ongoing entitlement to exclusive access to a share of water from a specified consumptive pool, as defined in the relevant water plan.
water allocation	The specific volume of water allocated to water access entitlements in a given season or given accounting period, defined according to rules established in the relevant water plan.
water management area	An area defined for the purposes of water management, including a water resource plan area.

water quality	The physical, chemical and biological characteristics of water. It is most frequently used by reference to a set of standards against which compliance can be assessed. Common standards used are those for drinking water, safety of human contact and the health of ecosystems.
water reform	Actions to achieve a more cohesive national approach to the way Australia manages, measures, plans for, prices and trades water.
water resource	All natural water (surface water or groundwater) and alternative water sources (such as recycled or desalinated water) that has not yet been abstracted or used.
water resource plan	A plan for the management of a water resource.
water restrictions	Any constraints or restrictions placed on water use by an infrastructure operator, local council or State or Territory government.
water right	A generic term for the range of different tradeable and non-tradeable water rights across Australia. These might include, but are not limited to, water access entitlements, water allocations, water-use rights, delivery rights, irrigation rights and works approvals.
water sharing plan	A legislation plan that establishes rules for managing and sharing water between ecological processes and environmental needs of the respective water source (river/aquifer). It manages water access licences, water allocation and trading, licences and extraction, operation of dams, and the management of water flows, use and rights of different water users.
water storage	A pond, lake or basin, whether natural or artificial, for the storage, regulation and control of water.
watertable	The groundwater surface in an unconfined aquifer or confining bed at which the pore pressure is atmospheric. It can be measured by installing shallow wells extending a few metres into the saturated zone and then measuring the water level in the wells.
water trade	A transaction to buy, sell or lease a water right, in whole or in part, from one legal entity to another.
water-use right	A right that allows use of water by specifying the location of the use (plot) and/or purpose of the use.
water year	1 July to 30 June.
wetland	An area of land whose soil is saturated with moisture either permanently or intermittently. Wetlands are typically highly productive ecosystems. They include areas of marsh, fen, parkland or open water, whether natural or artificial, permanent or temporary, with water that is static or flowing fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six metres.

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