Draft Regional Water Strategy

Murray: Strategy

April 2022

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Cover image: Image courtesy of iStock. Murray River, Moama.

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Acknowledging Aboriginal people: The NSW Government acknowledges Aboriginal people as Australia's first people, and the traditional owners and custodians of the country's lands and water. Aboriginal people have lived in NSW for over 60,000 years and have formed significant spiritual, cultural and economic connections with its lands and waters. Today, they practise the oldest living cultures on earth.

The NSW Government acknowledges the Bangerang, Barkandji, Barapa Barapa, Maljangapa, Maraura, Mutthi Mutthi, Ngiyampaa, Nyeri Nyeri, Tati Tati, Wadi Wadi, Wemba Wemba, Weki Weki, Wiradjuri, Yorta Yorta, Ngarigu, Walgalu, and Bidhawal people as having an intrinsic connection with the lands and waters of the Murray Regional Water Strategy area.

The landscape and its waters provide these people with essential links to their history, and help them to maintain and practise their culture and lifestyle.

The NSW Government recognises that the Traditional Owners were the first managers of Country and that incorporating their culture and knowledge into management of water in the region is a significant step for closing the gap.

Photography
Image courtesy of Department of Primary Industries.

Minister's foreword

The NSW Government is committed to managing our state's water, improving water security and better preparing our communities for future droughts. Our towns, industries, and natural and cultural assets all rely on water, and the way we manage it deeply affects the lives and livelihoods of the people of NSW. Water is our most precious resource.

That is why we are investing in cutting-edge scientific modelling to bolster our knowledge and understanding of our waterways and enhance our policies and long-term planning, so we can manage our water for the benefit of everyone.

The Murray is the 8th largest region of NSW, home to 110,000 people and the thriving regional centres of Albury, Deniliquin, Corowa, Moama and Jindabyne.

Farms and agriculture are a significant driver of the Murray's $9.6 billion a year economy, providing jobs for the region and producing food and fibre for our state. Water drives agriculture, supports towns and ensures a healthy local environment, which in the Murray includes seven nationally important wetlands, two of which are Ramsar-listed.

Through the development of the Murray Regional Water Strategy, we have gained significant knowledge of the region's unique water needs and challenges and considered how much water the Murray will need to meet future demand.

Working closely with the community, we are now making decisions around future investments that will optimise water management and help ensure a safe, secure and resilient supply in the decades to come.

Engaging with our Aboriginal communities is vital, given water is an essential part of their connection to Country and culture. Ensuring that these communities have access to water and cultural water holdings will be crucial to creating local jobs into the future.

Local government has contributed greatly to the draft strategy, and I thank councils for their engagement and support. We will continue to partner with them to ensure the strategy addresses the needs of all communities across the Murray.

Our state is no stranger to extremes; we have always had to manage our water resources through prolonged floods and droughts. In the face of an increasingly variable climate future, we must prepare for even longer and more severe wet and dry periods. During 2017-2020, the NSW Murray region—alongside other NSW regions—experienced severe drought conditions. This experience taught us a great deal about managing our water resources and we need to put these lessons to good use in preparing for future extreme weather events.

This draft strategy, alongside 11 other regional and two metropolitan strategies across the state, has been developed using the best and latest scientific evidence to ensure we can understand and mitigate risk even in the most extreme climactic circumstances.

We engaged leading academics, including experts from the University of Adelaide, to undertake paleoclimate-informed rainfall and evaporation modelling. This climate modelling is based on a deliberately conservative 'dry' scenario that is intended to 'pressure test' the effectiveness of the strategy in a worst-case scenario. Such climate scenarios may not necessarily eventuate, but they give us an idea of the possible climate risks and will allow us to begin planning to mitigate these risks should they arise. With the help of other state and federal governments, we are currently running the river system models with this new data to see how our water resources respond.

The Murray Regional Water Strategy will put forward the best mix of solutions to address the region's water-related challenges and support environmental, social and economic outcomes. We will assess all options, including infrastructure, water recycling, improved water efficiency and policy and regulatory and operational changes.

To complement the regional water strategies, the NSW Government is delivering the Future Ready Regions Strategy, which aims to improve resilience and drought preparedness in regional NSW by drawing on lessons learnt from previous droughts.

In short, the evidence and information we now have means we can better plan for the future to ensure this precious shared resource is managed to sustain secure regional lifestyles, create jobs, support industry and protect our precious natural environment.

There is no 'one size fits all' policy to manage water in our regions. I encourage all members of the community and stakeholders in the Murray to get involved and have their say to help improve the draft strategy. Water is for everyone, and we are ensuring our water management policies support the future of the NSW Murray and all of NSW.

We need healthy rivers, healthy farmers and healthy communities. The way we manage water deeply affects the livelihoods of people in NSW.

The Hon. Kevin John Anderson, MP
Minister for Lands and Water, and
Minister for Hospitality and Racing

Photography
Image courtesy of Destination NSW.
Kosciuszko National Park, NSW.

Photography
Image courtesy of Neil Andrews.
Olsens Lookout, Geehi Valley – Snowy Mountains.

Contents

Snapshot

The NSW Murray region

110,000
population

40,400
km² area

First Nations
Bangerang, Barkandji, Barapa Barapa, Maljangapa, Maraura, Mutthi Mutthi, Ngiyampaa, Nyeri Nyeri, Tati Tati, Wadi Wadi, Wemba Wemba, Weki Weki, Wiradjuri, Yorta Yorta, Ngarigu, Walgalu and Bidhawal

Key regional centres:
Albury, Deniliquin, Corowa, Moama and Jindabyne

Major river systems:
Murray, Edward/Kolety–Wakool, Snowy and Swampy Plains rivers
Plus a number of unregulated rivers and creeks

Main groundwater systems:
Upper and lower Murray Alluviums, Kanmantoo Fold Belt, Lachlan Fold Belt, Murray–Darling Basin Porous Rock and Oaklands Basin

Smaller regional towns:
Tumbarumba, Tocumwal, Wentworth, Howlong, Finley, Mulwala, Buronga, Bombala, Dalgety, Delegate and Berridale

Connections:
Snowy Scheme, Victoria, South Australia and the Murrumbidgee and lower Darling regions

Major investments:
Snowy Mountains Special Activation Precinct, Albury Regional Job Precinct and Inland Rail Project

Major water storages:
Dartmouth Dam (situated in Victoria) with a storage capacity of 3,856 GL

Hume Dam (situated on the NSW-Victorian border) with a storage capacity of 3,005 GL

Menindee Lakes (situated on the Darling River) with a storage capacity of 1,731 GL

Lake Victoria (situated in south-western NSW close to the South Australian border), with a storage capacity of 677 GL

Additional dams in the Snowy Scheme

Key environmental assets:
Millewa Forest, Werai Forest, Blue Lake and Koondrook-Perricoota Forest (Ramsar sites), NSW portion of the Chowilla Floodplain, Murray and Snowy rivers and Kosciuszko National Park

Approximately 159 plant and animal species listed as threatened, vulnerable, endangered, critically endangered or presumed extinct

Gross Value Added (2018/19):

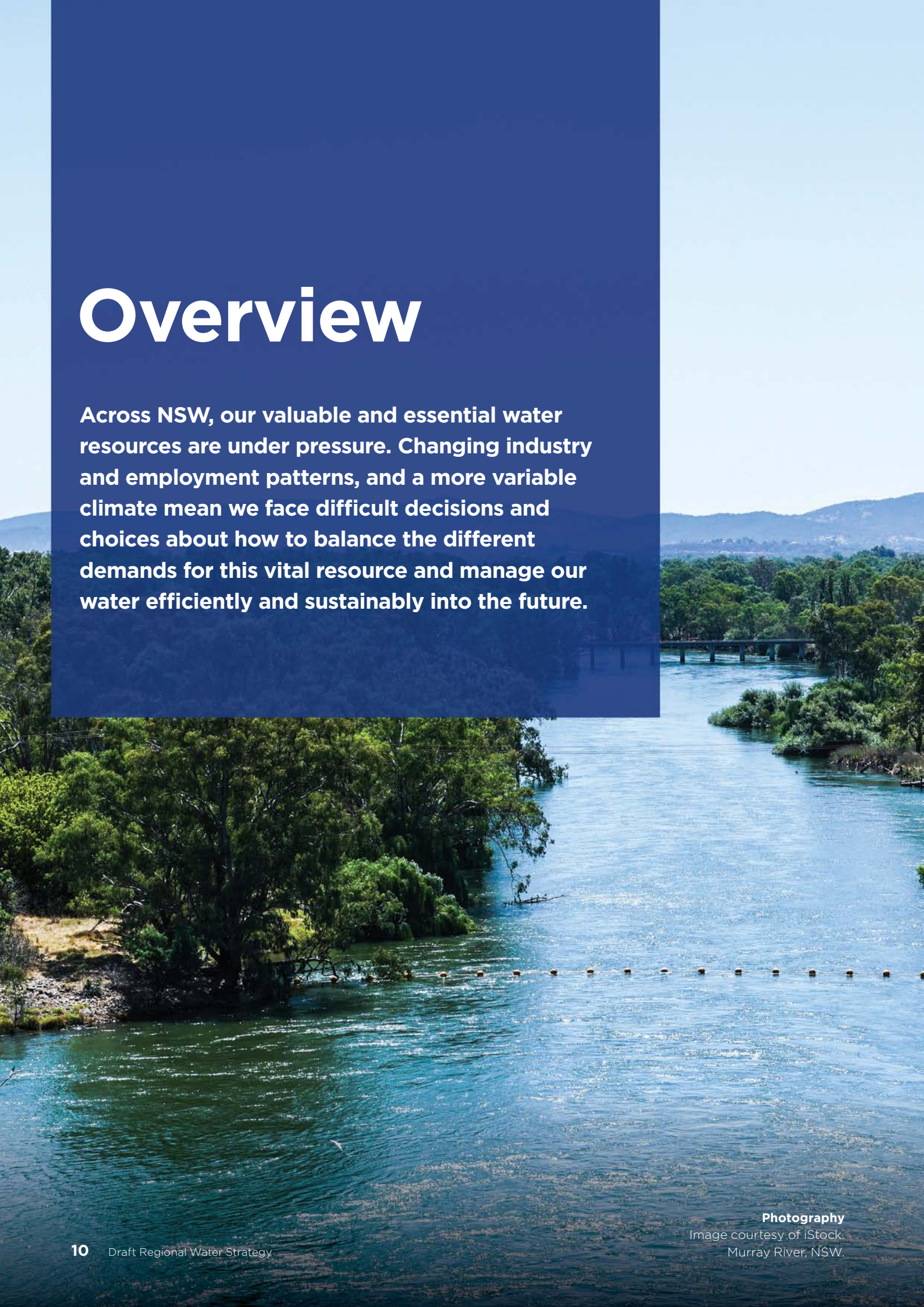
$9.6 billion

Key sectors and engine industries:
Agriculture, manufacturing, health care and tourism

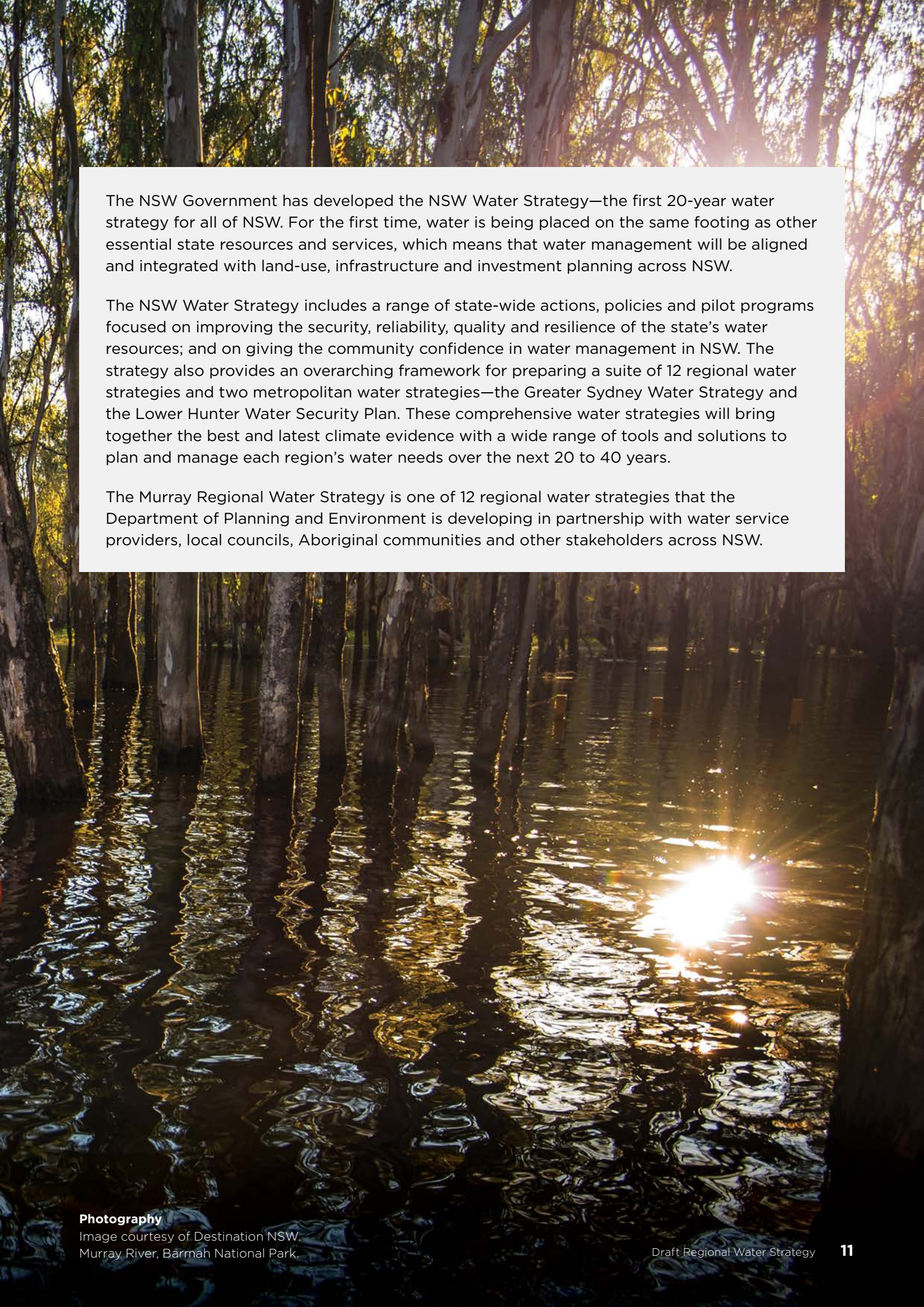
Photography
Image courtesy of iStock.
Township, Albury.

Overview

Across NSW, our valuable and essential water resources are under pressure. Changing industry and employment patterns, and a more variable climate mean we face difficult decisions and choices about how to balance the different demands for this vital resource and manage our water efficiently and sustainably into the future.



Photography
Image courtesy of iStock.
Murray River, NSW.



The NSW Government has developed the NSW Water Strategy—the first 20-year water strategy for all of NSW. For the first time, water is being placed on the same footing as other essential state resources and services, which means that water management will be aligned and integrated with land-use, infrastructure and investment planning across NSW.

The NSW Water Strategy includes a range of state-wide actions, policies and pilot programs focused on improving the security, reliability, quality and resilience of the state's water resources; and on giving the community confidence in water management in NSW. The strategy also provides an overarching framework for preparing a suite of 12 regional water strategies and two metropolitan water strategies—the Greater Sydney Water Strategy and the Lower Hunter Water Security Plan. These comprehensive water strategies will bring together the best and latest climate evidence with a wide range of tools and solutions to plan and manage each region's water needs over the next 20 to 40 years.

The Murray Regional Water Strategy is one of 12 regional water strategies that the Department of Planning and Environment is developing in partnership with water service providers, local councils, Aboriginal communities and other stakeholders across NSW.

Photography
Image courtesy of Destination NSW.
Murray River, Barmah National Park.

The NSW Murray region

The NSW Murray region (Figure 1) runs along the southern border of NSW from the Snowy River valley on the eastern side of the Great Dividing Range to the far west. The region varies from mountainous terrain in the east to open plains in the west. Extending across 40,400 km^2, the region is home to around 110,000 people and the key regional centres of Albury, Deniliquin and Moama, as well as smaller regional towns like Corowa and Jindabyne. The region is bounded by the Murrumbidgee and Darling river catchments to the north, Victoria to the south and east, as well as South Australia to the west.

Over the next 20 to 40 years we expect to see changes in the region. Based on the NSW Government Common Planning Assumptions, the population of the region is estimated to grow by between 5,200 to 19,000 people between 2016 and 2036.[1] More localised planning indicates the potential population growth could be up to 8,250 additional people by 2041 in the Albury area,[2] with potential growth in Jindabyne-Berridale of around 4,800 people by 2060 and almost double the number of annual visitors to the Snowy Mountains region by 2060.[3]

The NSW Murray region is the eighth largest region in NSW in terms of economic output, population and employment. The economic output for local government areas in the NSW Murray region was $9.6 billion in 2018/19 and accounted for 1.7% of NSW's output, measured by Gross Value Added.[4] Agriculture drives the regional economy, together with value-added manufacturing, health care and tourism.

The region's industry mix is also changing—horticulture is expanding, tourism is increasing and value-adding agricultural industries are expected to grow in coming decades. The Snowy Mountains Special Activation Precinct, the Inland Rail Project, Albury's Regional Growth Precinct and work on the Snowy 2.0 project[5] will encourage further industry development, drive further job growth and create opportunities to meet NSW's future energy needs through hydro-electricity generation, solar and emerging industries such as hydrogen.

1. The range of population projections gives an idea of the different possible futures that might arise due to variations between the NSW Common Planning Assumptions and other sets of assumptions, such as fertility, mortality and migration rates at the whole-of-state level.
2. Department of Planning and Environment, www.planning.nsw.gov.au/Research-and-Demography/Population-projections/Projections
3. Department of Planning, Industry and Environment 2021, *Snowy Mountains Special Activation Precinct—draft Master Plan*. Growth in annual visitors compared to 2019 figures. Retrieved from www.planningportal.nsw.gov.au/snowymountainssap
4. REMPLAN 2019, *REMPLAN Economy: Custom data*. Retrieved from www.remplan.com.au/economy
5. Snowy Hydro Limited, *Snowy 2.0*. Retrieved from www.snowyhydro.com.au/snowy-20/about/

The NSW Murray region is located within the traditional lands of the Bangerang, Barkandji, Barapa Barapa, Maljangapa, Maraura, Mutthi Mutthi, Ngiyampaa, Nyeri Nyeri, Tati Tati, Wadi Wadi, Wemba Wemba, Weki Weki, Wiradjuri, Yorta Yorta, Ngarigu, Walgalu and Bidhalwal people. Water is deeply entwined with Aboriginal culture and Aboriginal peoples' connection to Country. As the first managers and carers of this natural resource, Aboriginal people have rights and a moral obligation to care for water under their law and customs, and water is an essential part of Aboriginal people's culture and heritage.

The NSW Murray region is home to seven nationally important wetlands, including two Ramsar sites[6] covering around 4.6% of the region's area. Alpine glacial lakes, including lakes Albina, Cootapatamba, and the Ramsar site of Blue Lake and Hedley Tarn are rare, near-natural alpine wetlands in the Kosciuszko National Park. The region is also home to Koondrook, Werai and Millewa forests, which are the three subsites of the NSW Central Murray Forests Ramsar site. Many threatened and iconic species inhabit the area, including the southern bell frog and corroboree frog, the Australasian bittern and Australian painted snipe; as well as native fish species like the Murray cod, Australian bass, river blackfish, trout cod, golden perch and southern pygmy perch.

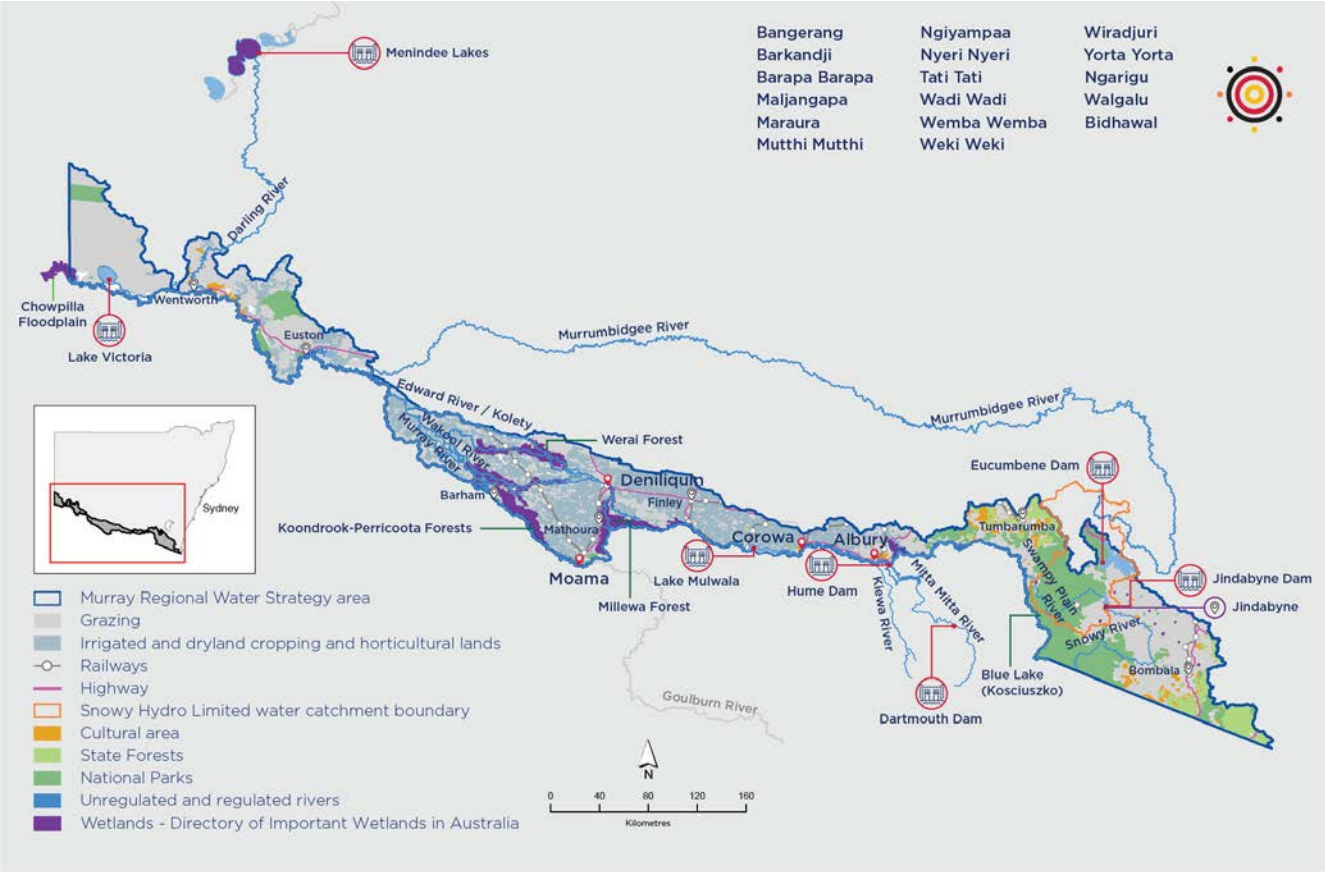
The region has some unique features that pose both challenges and opportunities for managing water resources:

- The NSW Murray region is part of the broader 'southern connected basin',[7] linked hydrologically and through water management arrangements to the Darling and Murrumbidgee rivers; and to Victoria, Queensland and South Australia.
- The Snowy Scheme provides inflows to both the Murray and Murrumbidgee regions under the requirements of the Snowy Water Licence.[8] On average, the Murray derives around 8% of total inflows via Hume Dam from the Snowy Scheme, and up to 33% of total inflows during drought years.[9]
- The Murray Regional Water Strategy boundary does not fully align with the water sharing plan boundaries for the Murray River (Figure 1). It also does not align with local government area boundaries, regional plan or regional economic development strategy boundaries. Several council areas overlap with the Murrumbidgee, Western and South Coast regional water strategies. Several regional water supply schemes, including Riverina Water, also extend into the NSW Murray region.

The complexities of the system and the unique linkages between the Murray River and the broader southern connected basin have resulted in a substantial work program that is currently being carried out by the NSW Government. The regional water strategies will account for and integrate this existing work, and seek to identify opportunities to improve how existing programs are delivered.

6. Australian Government, Department of Agriculture, Water and Environment, *Australian Wetlands Database*. Retrieved from www.environment.gov.au/water/wetlands/australian-wetlands-database
7. The southern connected basin includes the Murrumbidgee, Lower Darling and Murray catchments in NSW, Victoria and South Australia.
8. The Snowy Water Licence was issued to Snowy Hydro Limited in 2002 under Part 5 of the *Snowy Hydro Corporation Act 1997* (NSW) for a period of 75 years. The Snowy Water Licence is the primary legal document defining how Snowy Hydro Limited is to account for and release water. It defines the rules for releases into the Murray and Murrumbidgee rivers and other montane rivers. www.legislation.nsw.gov.au/#/view/act/1997/99
9. Snowy Hydro Limited 2008, *Snowy Hydro Water Operations Reference Report*. Retrieved from www.snowyhydro.com.au/about/reports/

Figure 1. Map of the NSW Murray regional water strategy area



Water in the NSW Murray region

The Murray River is Australia's longest river, originating in the Australian Alps and running a course of approximately 2,500 km to the Southern Ocean at Goolwa in South Australia.[10] The region is supported by multiple sources of water, including the regulated Murray River, the Edward/Kolety–Wakool rivers and the Niemur River; outflows from the Murrumbidgee River, Billabong Creek and Lower Darling River; as well as from Victorian tributaries including the Mitta Mitta and Kiewa rivers. There are also a range of unregulated rivers and creeks that support the region. This includes the Geehi, Swampy Plains and Tooma rivers and Tumbarumba Creek in the upper Murray; and the Eucumbene, Thredbo, Mowamba, Snowy, Bombala and Delegate rivers in the Snowy Genoa catchments, as well as several groundwater sources.

Managing water in the NSW Murray region is highly complex. Interstate agreements and rules govern how water in the Murray River catchment is shared between NSW, Victoria and South Australia (including releases from the Snowy Scheme). The Murray–Darling Basin Authority is responsible for managing the jointly owned assets (waterways, storages, weirs and locks) of the Murray River system in accordance with the Murray–Darling Basin Agreement ('the Agreement') and the direction of the NSW, Victorian and South Australian governments.

10. Murray–Darling Basin Authority, *Central Murray Snapshot*. Retrieved from www.mdba.gov.au/water-management/catchments/central-murray

High in the Australian Alps, the upper Murray has several unregulated rivers and creeks, as well as small pockets of groundwater in shallow alluviums and fractured and porous rocks, which support a diverse environment from alpine grasslands and wetlands to heavily timbered forest.

Most of this area is designated national park and state forest and, hence, sparsely populated. However, it is a popular tourist destination for skiers and bushwalkers that was recognised through the 2019 announcement of the Snowy Mountains Special Activation Precinct. The precinct covers an area of over 70,000 ha surrounding Jindabyne town centre and areas of high tourism interest within the Kosciuszko National Park, including Thredbo, Perisher and Charlotte Pass. Water availability in most rivers and creeks in the upper catchment is closely linked to the variability of rainfall; and the area is susceptible to short, intense droughts and intense bushfires. Changes in winter and spring rainfall/snowmelt also have implications for users downstream, as the upper catchment generates much of the run-off into the region's major storages.

From Hume Dam (upstream of Albury) to Wentworth, the mid-Murray consists of expansive floodplains and anabranches, including the Edward/Kolety–Wakool and Niemur rivers that eventually return to the Murray River further west. In this part of the catchment, the Murray River is also joined by significant tributaries from Victoria (the Kiewa, Ovens, Goulburn and Campaspe rivers). Groundwater occurs in shallow and deep alluvium associated with the major rivers and creeks as well as in underlying porous rocks. This area is highly developed, containing some of the region's largest centres including Albury, Deniliquin and Moama. Many significant dryland and irrigated agricultural industries are located within the region. Water availability in the mid-Murray is highly dependent on inflows into the southern connected storages (including storages outside of the NSW Murray region) and the rules of the Murray–Darling Basin Agreement.

The Lower Murray starts at the confluence of the Murrumbidgee River with the Murray River, flows along the semi-arid Mallee plains and is joined by the Darling River as it flows to the South Australian border. Although not part of the Murray Regional Water Strategy area, the Menindee Lakes system is an important southern connected storage that is used together with Lake Victoria to meet consumptive and environmental demands in the Lower Murray and Lower Darling rivers. Significant growth in irrigated nut plantations (both on the NSW and Victorian side of the Murray River) has occurred within this area in recent years. Large quantities of often highly saline alluvium groundwater also occur in this part of the Murray catchment.

The east-to-west extent of the catchment stretches from mountainous terrain with high rainfall to very flat, semi-arid plains in the west, resulting in large variations in rainfall and climate conditions. Rainfall in winter and spring (July to November) and additional spring snowmelt in elevated areas of the east are critically important for inflows into Hume Dam. This reliance on winter–spring rainfall contrasts with the summer-dominated rainfall and storms experienced in northern NSW.

Rainfall in the NSW Murray region varies year-to-year and shows distinct dry and wet periods in observed historical records—some spanning 10 to 20 years. Although the recent drought between 2017 and 2020 was less severe in the NSW Murray region than in northern NSW, the region has experienced an overall decline in inflows over the past 20 years, which has reduced water availability in the region. To illustrate: half of the driest years on record have occurred in the past 20 years.

The development of water resources and the extensive regulation of the river system have altered the flow regimes and impacted key environmental assets in the region. With the construction of the Snowy Scheme, the health of the Snowy River declined significantly for decades. In response, the Snowy Water Inquiry was held in 1998 and resulted in environmental flow rules that would see more water and higher flows delivered to the Snowy River from a new outlet at Jindabyne Dam. Environmental flows have improved the health and condition of the Snowy River by removing fine sediment and restoring scouring pools and riffles—providing essential habitat for water dependent animals including native fish, platypus and macroinvertebrates.

Similarly in the Murray River, the construction and operation of dams and weirs combined with extraction of significant volumes of water have negatively impacted the riverine environment, its ecosystems, and flora and fauna. In particular, the floodplain forests, and fish and waterbird populations have declined significantly in terms of their extent and resilience.

The NSW regulated Murray River has a large volume of licensed environmental water (421 GL in registered entitlements is managed by the Commonwealth Environmental Water Holder and around 252 GL that is managed by NSW).[11] These entitlements is managed for the benefit of the environment to deliver water to specific sites (such as wetlands) and support ecosystem functions. In addition, there are also the River Murray Increased Flows and Snowy River Increased Flows,[12] and the Barmah–Millewa Forest Environmental Water Allocation.

Planned environmental water in the NSW Murray region is equally important to the environment, and is managed through several rules in the NSW water sharing plans.

Effective delivery of environmental water is a challenge because of:

- physical constraints and barriers
- associated flow management within the regulated river
- demand and timing of water delivery to a large number of users whose needs must be balanced with the needs of the environment.

Aboriginal people in the region rely on water for their health, wellbeing and connection to Country. Aboriginal people consider that current cultural water access licences are unable to meet the full spectrum of their spiritual, cultural, environmental, social, and economic needs, as defined by the 2007 Echuca Declaration.[13] Aboriginal people also seek more opportunities to manage water using their cultural knowledge, and for improved economic opportunities either as licence holders or as partners in decision making. The Murray Regional Water Strategy is an opportunity to consider how to better meet the needs and aspirations of Aboriginal people in the region.

The Murray Regional Water Strategy also provides an opportunity to better understand the challenges facing the region's water resources; and to explore the best ways to share, manage and use these resources in the future.

11. Includes surface water NSW Regulated and Unregulated NSW Murray River water sources, Environmental Water Register. Retrieved from www.industry.nsw.gov.au/water/environmental-water-hub/public-register/environmental/licences
12. River Murray Increased Flow and Snowy River Increased Flows are held environmental water entitlements with water released from the Snowy Scheme for environmental purposes in the Murray and Snowy rivers.
13. The Echuca Declaration. See www.mldrin.org.au/what-we-do/cultural-flows/

Definitions

We are using the following definitions in the regional water strategies:

Water security in the context of town water supplies refers to the acceptable chance of not having town water supplies fail. This requires community and government to have a shared understanding of what is a 'fail event' (for example, no drinking water, or restrictions below a defined level for longer than a defined period, or unacceptable water quality) and the level of acceptability they will pay for.

The NSW Government's guidance around an appropriate level of security for town water supply is the '5/10/10 rule'. Under this approach, the total time spent in drought restrictions should be no more than 5% of the time, restrictions should not need to be applied in more than 10% of years and when they are applied there should be an average reduction of 10% in water usage. This allows full demand to be met in most years and also allows for water restrictions to be implemented infrequently to conserve supplies.

Water reliability refers to how often an outcome is achieved. It is often considered to be the likelihood, in percentage of years, of receiving full water allocations by the end of a water year for a licence category. For example, a 60% reliability means that in 60% of years a licence holder can expect to receive 100% of their licensed entitlement by the end of the water year. Other measures of volumetric reliability could also be used: for example, the percentage of allocation a licence holder could expect to receive at a particular time of the year as a long-term average. Reliability may also refer to how often an acceptable level of water quality is available. A reliable water supply gives some clarity to water users and helps them plan to meet their water needs.

Resilient water resources mean water users are able to withstand extreme events, such as drought and flood, and/or adapt and respond to changes caused by extreme events.

Photography
Image courtesy of Destination NSW.
Murray River, Moama.

Future climate risk

The NSW Government is investing in new climate datasets and improved modelling to provide a more sophisticated understanding of the historic climate variability in the NSW Murray region, as well as likely future climate risks. This means that we can move from making decisions that are based largely on a single 'worst-case' scenario to a much more comprehensive understanding of natural variability and potential extreme events.

We will be able to better predict and plan for plausible future climate scenarios (such as the possible frequency, duration and severity of extended droughts), better understand climate risks faced by water users and the environment across NSW, and better manage our water resources over the medium and long term to mitigate these risks.

This new information is the basis for preparing robust new water strategies for our regions, and offers fresh evidence for examining our existing NSW water policies, operational rules and management plans.

Existing climate studies and the new climate data developed for this draft regional water strategy suggest that the NSW Murray region could see:

- changed seasonality of precipitation, with a significant reduction of critical winter and spring precipitation and snowmelt
- reduced average annual precipitation
- increased evapotranspiration across the region
- more frequent and prolonged droughts with extreme low-rainfall periods.

We also need to gain a better understanding of the flood intensity and frequency in the region, as well as the impact of the new climate modelling on groundwater. The hydrologic models being developed for the regional water strategies are surface water resource planning models, which do not directly represent surface water–groundwater interactions, and cannot represent complex flood behaviour or floodplain inundation. Despite these limitations, the new climate datasets and modelling provide an important first step in advancing our understanding of the risks to surface water systems across NSW. The Murray Regional Water Strategy provides an opportunity to highlight areas of future work that could improve our understanding of the region's climate and how to better prepare for future extreme events.

The new climate datasets and modelling are under development and will be released in the future as we progress to the final version of the Murray Regional Water Strategy.

Southern region integrated hydrologic modelling

In parallel with the development of new climate datasets for the southern regions, significant improvements are being made to the department's hydrologic models as part of the Murrumbidgee, Murray and Western regional water strategies. These improvements reflect the inter-jurisdictional complexities and linkages with Victoria, the ACT and the Snowy Scheme, and the physical connectivity of the southern connected basin. This important piece of work brings these separate models into an integrated modelling framework for the first time.

This new, integrated model will provide a more robust tool for understanding climate risks and for assessing the broader benefits and impacts of our options across the southern regions.

We have worked collaboratively with the Murray–Darling Basin Authority; Victoria's Department of Environment, Land, Water and Planning; Snowy Hydro Limited; the Australian Capital Territory Government; Icon Water; and South Australia's Department for Environment and Water to enhance our model integration and functionality, and to ensure we have state of the art models which will allow us to better understand the risks to water security and reliability.

Photography
Image courtesy of Department of Primary Industries.

Making choices for the future

Like most regions across Australia, the NSW Murray region faces choices and challenges in balancing different water uses, both current and emerging, as climate conditions change. The region's towns, industries and rural communities have adjusted to variable annual rainfall and river flows, and past droughts have led to government and industry investment in water use efficiency improvements and more diverse and inter-connected water supplies.

Communities, local councils and local water utilities in the region have already demonstrated an awareness of the need for action to secure water in a drier, more variable climate. There is an appetite to develop more enduring partnerships, and to better understand future climate risks to build resilience in the region. This will put the NSW Murray region in a good position to deal with the region's other key challenges, that include:

- inadequate water management framework to meet the needs and aspirations of Aboriginal people, which also prevents Aboriginal people from fulfilling their rights and obligations to care for Country under their law and customs
- historical water sharing arrangements that are based on only 125 years of recorded data, which limits our understanding of how vulnerable the region could be to future extreme events
- insufficiently integrated land and water planning and management, which can lead to population and industry growth occurring in areas that have pre-existing water availability constraints
- vulnerable town water supplies and amenity, which are key factors in fostering liveable and vibrant regional towns and maintaining the wellbeing of communities
- degradation of riverine and floodplain ecosystems, which has led to a loss of native vegetation and wetlands, and a decline in the conditions of fish communities and waterbird habitats
- limits to water availability in times of drought and as climate changes, which increases competition for water, and could hinder growth and prosperity of the region's industries.

The Murray Regional Water Strategy aims to address these challenges and provide options to better use, share, store and deliver water in the NSW Murray region.

A new, comprehensive water strategy for the NSW Murray region

The Murray Regional Water Strategy will guide how we address future water resource challenges, make the right policy and infrastructure choices, support regional development and growth, and open up new opportunities for the region.

The strategy will bring together all the tools we have—policy, planning, behavioural, regulatory, technology and infrastructure solutions—in an integrated package. This package will be based on the best available evidence and respond to the region's risks and challenges. It will seek to optimise the delivery and sequencing of existing commitments; and build on investments and new work that will improve water security and reliability for all water users, including the environment.

The strategy will cover the whole NSW Murray region and all water sources (regulated and unregulated rivers, creeks and groundwater). As part of the southern connected basin, the Murray Regional Water Strategy will necessarily also touch on broader regional issues and, hence, inform and be informed by the work on the Murrumbidgee and Western regional water strategies.

The Murray Regional Water Strategy covers an area that differs from the water sharing plan boundaries for the Murray River. The first major difference is the inclusion of the Snowy Scheme and the Snowy and Genoa rivers because of their significant hydrologic connection to the Murray River. Secondly, the Menindee Lakes and Lower Darling River have been included in the Western Regional Water Strategy area to reflect the strong hydrologic linkages with the Barwon–Darling system upstream.

Our vision for the strategy

Our vision for the Murray Regional Water Strategy is to support the delivery of healthy, reliable and resilient water resources for a liveable and prosperous region. To achieve this, we need to position the region so there is the right amount of water of the right quality available for people, Aboriginal communities, towns, industries and the environment.

In line with the objectives we have set for all regional water strategies, the Murray strategy has a strong focus on working closely with communities to deliver healthy, reliable and resilient water resources that:

- deliver and manage water for local communities
- enable economic prosperity
- recognise and protect Aboriginal people's water rights, interests and access to water
- protect and enhance the environment
- are affordable.

The final strategy will set out clear and accountable actions for all levels of government to maximise opportunities and tackle the challenges facing the NSW Murray region. The strategy will seek to maximise opportunities to support the Snowy Mountains Special Activation Precinct, the Albury Regional Job Precinct and the Inland Rail Project.

The final strategy will help improve the integration of water reforms and water planning actions across southern NSW regions to ensure they are implemented effectively.

This will ensure all existing and new actions and investments are integrated and aligned to achieve the best possible outcomes for regional towns and communities, Aboriginal people, the environment and industries.

A detailed implementation plan that contains actions and timeframes will be developed as part of the final Murray and Murrumbidgee regional water strategies.

The options

A long list of potential options that focus on the key challenges in the region is presented as part of this draft strategy.

These options build on the NSW Government's current and planned investment in water planning and infrastructure in the region, including the new Refreshing River Management Project,[14] investments in critical water and wastewater treatment plant upgrades, and funding to support integrated water cycle management planning. They also complement and build on state-wide reforms to introduce non-urban water metering, improve compliance with NSW water sharing rules and enhance transparency. Where relevant, we included references to where the potential options could advance the priorities and actions of the NSW Water Strategy.

Recognising the challenges and risks facing the region, the long list of options emphasises the need to:

- better meet the needs and aspirations of Aboriginal people in the region
- improve the reliability and access to surface water and groundwater for towns and water users
- better understand groundwater sources and processes in the region; and develop solutions to support the long-term sustainability of these sources
- build resilience of the region's industries to future climate variability and changing climatic conditions
- improve river flows and flows across floodplains, and remove constraints to water reaching vital environmental assets
- use water more efficiently and make greater use of non-climate-dependent water sources.

The strategy considers how government and local councils can adopt a more integrated approach to managing surface water, groundwater and their catchments. It also acknowledges that improving the efficiency of water use and the effectiveness of water delivery is key to optimising shared benefits in the region—such as supporting regional economic growth, improving liveability, and protecting the region's rich environmental and cultural assets.

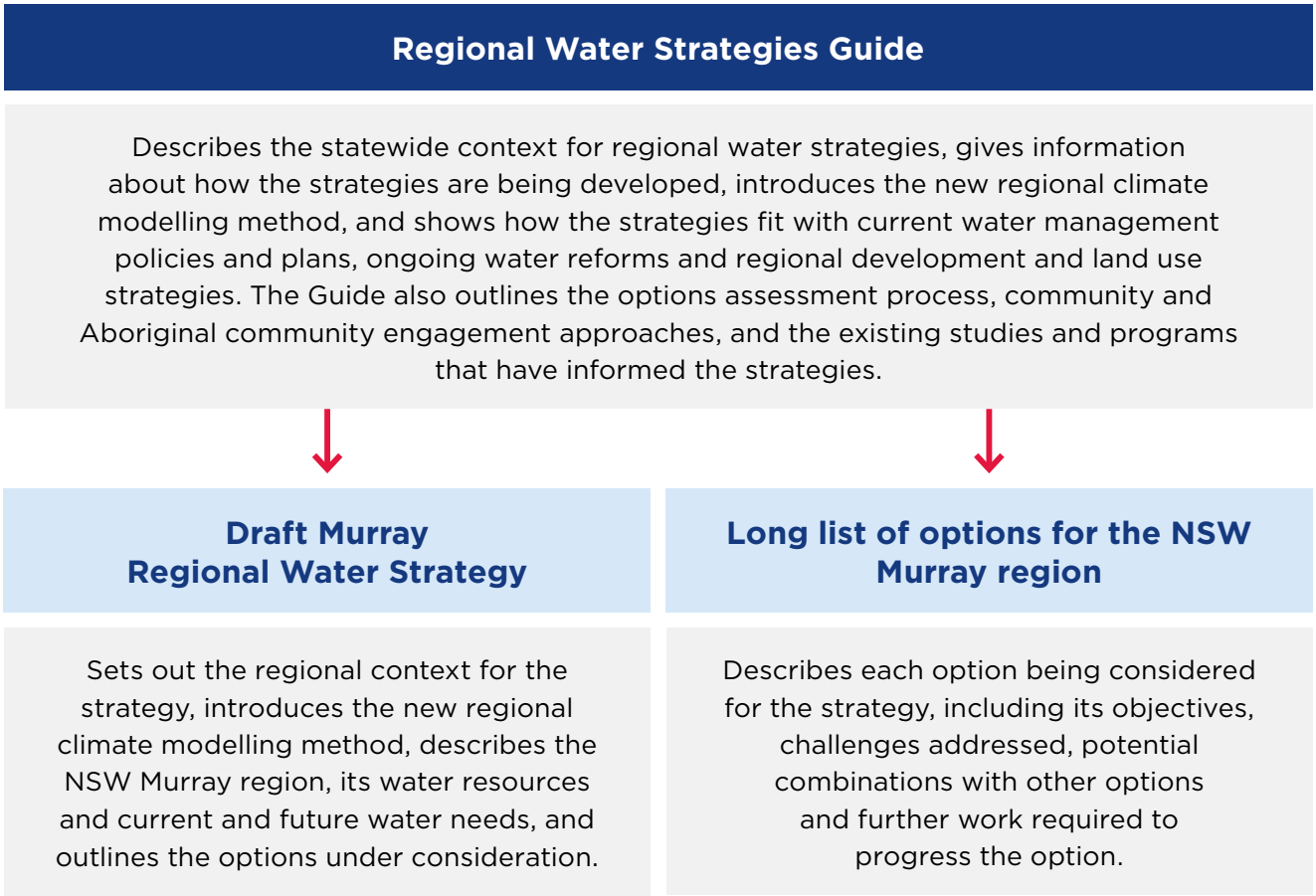
Several of the options could have an impact beyond the NSW Murray region and, hence, their net benefit would need to be assessed across the southern NSW regions and may require inter-jurisdictional discussions. In addition, many of the options are interrelated. This means that to get the most benefit out of these options—and make the best use of the region's water resources—the options may need to be combined.

Not all options will be progressed and many have not been costed. Following feedback on the draft strategy, we will conduct an evidence-based assessment to identify the best actions for the NSW Murray region. These actions will form the final, comprehensive Murray Regional Water Strategy.

The Draft Murray Regional Water Strategy is accompanied by a more detailed description of the long list of options and an overarching explanatory guide that outlines the broader context for the development of regional water strategies across NSW (Figure 2).

14. Department of Planning, Industry and Environment 2021, *Refreshing River Management project*. Retrieved from www.environment.nsw.gov.au/funding-and-support/nsw-environmental-trust/grants-available/river-connections/refreshing-river-management-to-improve-river-health

Figure 2. Draft Murray Regional Water Strategy



Consultation and COVID-19

Due to the COVID-19 pandemic, our face-to-face engagement with Aboriginal communities in the NSW Murray region has been severely hindered. We are committed to having ongoing conversations with Aboriginal people to ensure their views are reflected in the final Murray Regional Water Strategy and options are developed that meet their needs and aspirations with respect to water.

Chapter 1

Context

Photography
Image courtesy of Department of Planning and Environment.

Snapshot

We are preparing comprehensive regional water strategies across NSW, bringing together the best and latest climate evidence with a wide range of tools and solutions to plan and manage each region's water needs over the next 20 to 40 years.

- The regional water strategies will assess future water needs of each region, identify the challenges and choices involved in meeting those needs, and set out the actions we can take to manage risks to water security and reliability.
- Through better strategic planning, the NSW Government aims to provide and manage water for towns and communities, support regional industries, enable economic prosperity, and safeguard and enhance the environment. The strategies will also recognise and protect Aboriginal people's cultural values, rights and assets.
- The Murray Regional Water Strategy is one of 12 regional water strategies and two metropolitan strategies—the Greater Sydney Water Strategy and the Lower Hunter Water Security Plan—the Department of Planning and Environment is developing in partnership with local councils, local water utilities, Aboriginal people, communities and other stakeholders across NSW.

New climate data, plans, studies and investments have also influenced the direction of the Murray Regional Water Strategy. New hydrologic modelling will strengthen this.

- A significant amount of work since the Millennium Drought has improved our understanding of the risks affecting water resource management in the NSW Murray region. Community engagement over the last few years has also given insights into the best way to prepare for future droughts and floods in the region.
- The NSW Government is investing in new climate datasets and improved modelling to provide a more robust and sophisticated understanding of future climate risks in the NSW Murray region. NSW is also undertaking work to integrate the hydrologic models for the Murray, Murrumbidgee and Snowy Mountains system in collaboration with Snowy Hydro Limited, the Murray–Darling Basin Authority, and other basin governments. By integrating these models, NSW will be able to undertake a more detailed climate risk assessment for the Murray and Murrumbidgee regional water strategies. These modelling results will be released in the future as we progress the Murray and Murrumbidgee regional water strategies to their finalisation.
- The regional water strategies will build on existing NSW Government commitments to improve water security, resilience and reliability across regional NSW, including investment in water infrastructure, a range of state-wide water reforms.

1.1 Purpose of regional water strategies

Regional water strategies bring together the most up-to-date information and evidence with a wide range of tools and solutions to plan and manage each region's medium- and long-term water needs.

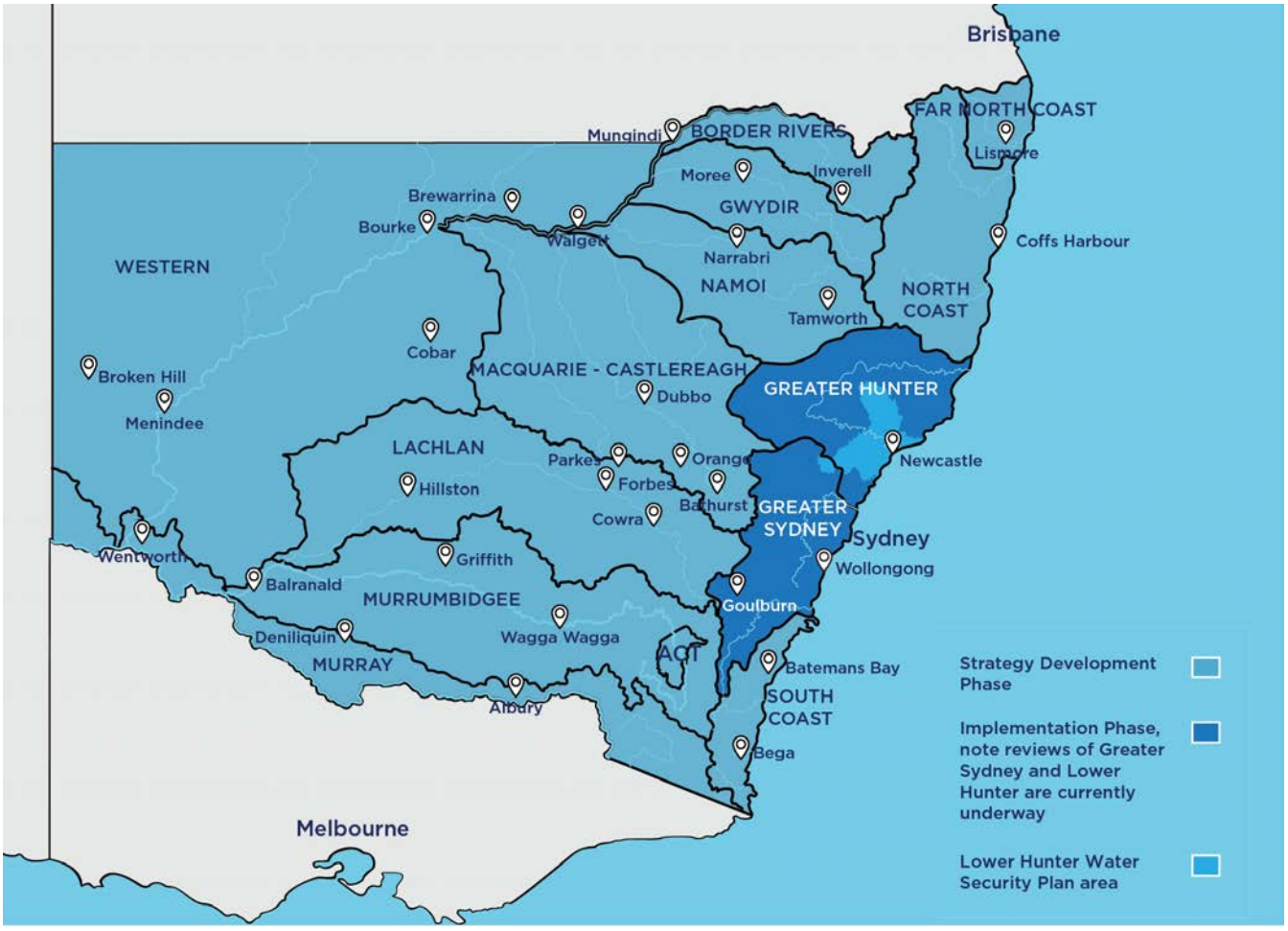
The strategies look out over the next 20 to 40 years, and identify the challenges and choices involved in meeting the region's future water needs. They also determine the actions we can take to manage risks to water availability and secure healthier, more reliable water sources.

The strategies also explore new solutions to tackle these issues. These solutions have the potential to add value to the way we manage water, generate community-wide benefits and create new economic opportunities for each region.

With improved strategic planning for water, the NSW Government aims to achieve resilient water resources for towns and communities, industry, Aboriginal people and the environment.

The Murray Regional Water Strategy is one of 12 regional water strategies the Department of Planning and Environment is developing in partnership with local councils, local water utilities, Aboriginal people, communities and other stakeholders across NSW (Figure 3).

Figure 3. Map of NSW regional water strategy regions



1.2 Objectives of regional water strategies

Regional water strategies will set out a long-term 'road map' of actions to deliver five objectives (Figure 4).[15]

Figure 4. NSW regional water strategies: objectives

Deliver and manage water for local communities

Improve water security, water quality and flood management for regional towns and communities.

Enable economic prosperity

Improve water access reliability for regional industries.

Recognise and protect Aboriginal water rights, interests and access to water

Including Aboriginal heritage assets.

Protect and enhance the environment

Improve the health and integrity of environmental systems and assets, including by improving water quality.

Affordability

Identify least cost policy and infrastructure options.

15. The objective of affordability will be assessed through cost–benefit analysis to estimate the economic, social and environmental costs, and benefits of options in monetary terms. This assessment is part of the final strategy development.

Options selected for inclusion in the final strategy for each region will need to address at least one of these objectives. Our aim is for each strategy to have a comprehensive, balanced package of options that delivers on all of these objectives and also aligns with the strategic priorities of the NSW Water Strategy (Table 1), the Future Ready Regions Strategy[16] and the regional goals set out in the Riverina Murray,[17] Far West,[18] and South East and Tablelands[19] Regional Plans 2036 (Table 2).

16. The Future Ready Regions Strategy, 2021, supports the NSW Water Strategy and the regional water strategies, www.nsw.gov.au/regional-nsw/future-ready-regions
17. The Riverina–Murray Regional Plan includes the local government areas of Albury City Council, Berrigan Shire Council, Bland Shire Council, Carrathool Shire Council, Coolamon Shire Council, Cootamundra-Gundagai Regional Council, Edward River Council, Federation Council, Greater Hume Shire Council, Griffith City Council, Hay Shire Council, Junee Shire Council, Leeton Shire Council, Lockhart Shire Council, Murray River Council, Murrumbidgee Shire Council, Narrandera Shire Council, Snowy Valleys Council, Temora Shire Council, Wagga Wagga City Council, www.planning.nsw.gov.au/Plans-for-your-area/Regional-Plans
18. Balranald Shire Council and Wentworth Shire Council
19. The South East and Tablelands Regional Plan area includes the local government areas of Hilltops Council, upper Lachlan Shire Council, Wingecarribee Shire Council, Goulburn-Mulwaree Council, Eurobodalla Shire Council, Bega Valley Shire Council, Snowy Monaro Regional Council, Queanbeyan-Palerang Regional Council and Yass Valley Shire Council, www.planning.nsw.gov.au/Plans-for-your-area/Regional-Plans

Photography
Image courtesy of Department of Primary Industries.

Table 1. State and regional water strategies: priorities and objectives

NSW Water Strategy core objectives	NSW Water Strategy strategic priorities	Regional water strategy objectives
Protecting public health and safety	**Priority 1** Build community confidence and capacity through engagement, transparency and accountability	**Aligned with all** regional water strategy objectives.
Liveable and vibrant towns and cities	**Priority 2** Recognise First Nations/ Aboriginal people's rights and values and increase access to and ownership of water for cultural and economic purposes	**Recognise and protect Aboriginal water rights, interests and access to water—**including Aboriginal heritage assets.
Water sources, floodplains and ecosystems protected	**Priority 3** Improve river, floodplain and aquifer ecosystem health, and system connectivity	**Protect and enhance the environment**—improve the health and integrity of environmental systems and assets, including by improving water quality.
Cultural values respected and protected	**Priority 4** Increase resilience to changes in water availability (variability and climate change)	**Aligned with all** regional water strategy objectives.
Orderly fair and equitable sharing of water	**Priority 5** Support economic growth and resilient industries within a capped system	**Enable economic prosperity**—improve water access reliability for regional industries.
	Priority 6 Support resilient, prosperous and liveable cities and towns	**Deliver and manage water for local communities**—improve water security, water quality and flood management for regional towns and communities.
Contribute to a strong economy	**Priority 7** Enable a future focused, capable and innovative water sector	**Aligned with all** regional water strategy objectives.

Affordability—identify least cost policy and infrastructure options

Alignment between regional water strategies and the purpose of regional (landuse) plans

The objectives of the regional plans cover similar themes to the regional water strategies, including managing and conserving water resources for a healthy environment, increasing resilience against natural hazards and climate change, sustainable management of water for economic opportunities, coordinating infrastructure in a cross-border setting, and building connected and healthy communities.

Table 2 shows how the objectives of the Murray Regional Water Strategy align with the goals and directions of the *Riverina Murray Regional Plan 2036* (shaded in orange),the *South East and Tablelands Regional Plan 2036* (shaded in blue) and the *Far West Regional Plan 2036* (shaded in red).[20]

Table 2. Alignment between regional water strategy objectives and the relevant regional (landuse) plans

Regional water strategy objective	Regional plan goal	Regional plan directions
Deliver and manage water for local communities: improve water security, water quality and flood management for regional towns and communities	Goal 3: Efficient transport and infrastructure networks	Direction 21: Align and protect utility infrastructure investment
	Goal 4: Strong, connected and healthy communities	Direction 22: Promote the growth of regional cities and local centres Direction 23: Build resilience in towns and villages Direction 28: Deliver healthy built environments and improved urban design
	Goal 3: Healthy and connected communities	Direction 22: Build socially inclusive, safe and healthy communities
	Goal 4: Environmentally sustainable housing choices	Direction 25: Focus housing growth in locations that maximise infrastructure and services Direction 26: Coordinate infrastructure and water supply in a cross-border setting
	Goal 3: Strong and connected communities	Direction 26: Manage and conserve water resources for communities
Enable economic prosperity: Improve water access and reliability for regional industries	Goal 1: A growing and diverse economy	Direction 10: Sustainably manage water resources for economic opportunities
	Goal 3: Efficient transport and infrastructure networks	Direction 21: Align and protect utility infrastructure investment
	Goal 1: A connected and prosperous economy	Direction 5: Promote agricultural innovation, sustainability and value-add opportunities Direction 6: Position the region as a hub of renewable energy excellence
	Goal 1: A diverse economy with efficient transport and infrastructure networks	Direction 1: Grow the agribusiness sector, value-added manufacturing opportunities and supply chains Direction 9: Sustainably manage water resources for economic opportunities

20. The five-yearly reviews of the Riverina Murray, Far West and the South East and Tablelands Regional Plans 2036 are currently being undertaken. The Regional Plans 2041 are expected to be finalised by late 2022.

Table 2. Alignment between regional water strategy objectives and the relevant regional (landuse) plans (continued)

Regional water strategy objective	Regional plan goal	Regional plan directions
Recognise and protect Aboriginal peoples' water rights, interests and access to water, and their assets	Goal 4: Strong, connected and healthy communities	Direction 29: Protect the region's Aboriginal and historic heritage
	Goal 1: A growing and diverse economy	Direction 8: Enhance the economic self-determination of Aboriginal communities
	Goal 1: A connected and prosperous economy	Direction 10: Strengthen the economic self-determination of Aboriginal communities
	Goal 1: A diverse economy with efficient transport and infrastructure networks	Direction 10: Enhance the economic self-determination of Aboriginal communities
	Goal 2: Exceptional semi-arid rangelands traversed by the Barwon–Darling	Direction 18: Respect and protect Aboriginal cultural heritage assets
Protect and enhance the environment: Improve the health and integrity of environmental systems and assets, including by improving water quality	Goal 2: A healthy environment with pristine waterways	Direction 13: Manage and conserve water resources for the environment Direction 14: Manage land uses along key river corridors Direction 15: Protect and manage the region's many environmental assets Direction 16: Increase resilience to natural hazards and climate change
	Goal 2: A diverse environment interconnected by biodiversity corridors	Direction 14: Protect important environmental assets Direction 15: Enhance biodiversity connections Direction 16: Protect the coast and increase resilience to natural hazards Direction 17: Mitigate and adapt to climate change Direction 18: Secure water resources
	Goal 2: Exceptional semi-arid rangelands traversed by the Barwon–Darling	Direction 13: Protect and manage environmental assets Direction 14: Manage and conserve water resources for the environment Direction 15: Manage land uses along key river corridors Direction 16: Increase resilience to climate change Direction 17: Manage natural hazard risks
Affordability: Identify least cost policy and infrastructure options	Goal 3: Efficient transport and infrastructure networks	Direction 21: Align and protect utility infrastructure investment
	Goal 4: Environmentally sustainable housing choices	Direction 25: Focus housing growth in locations that maximise infrastructure and services Direction 26: Coordinate infrastructure and water supply in a cross-border setting

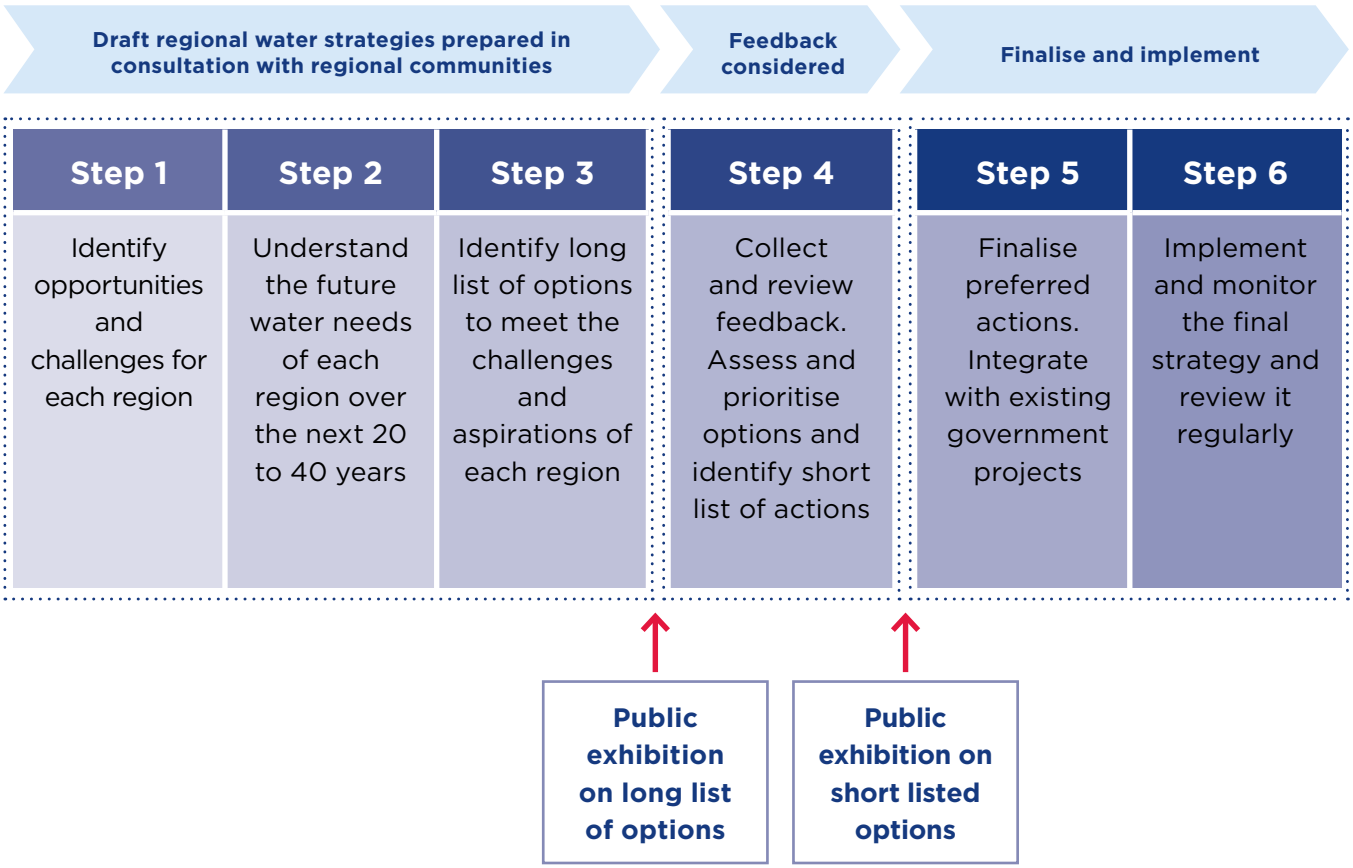
Although the regional water strategies will aim to meet all their objectives, it needs to be stressed that the order of the objectives does not reflect the priority of how we manage water in the state under the *Water Management Act 2000*. It is also important to note that when formulating water sharing plans, the NSW Government must take all reasonable steps to prioritise the protection of the water sources and their dependent ecosystems.[21]

This means that during normal times, the needs of the environment and basic landholder rights are the highest priorities in water sharing. After these needs are met, water for towns, local water utilities, stock and domestic users will be allocated, followed by high security and general security entitlement holders. During extreme droughts or severe water shortages, the *Water Management Act 2000* provides rules for water sharing plans to be suspended, during which time the priority for water sharing changes to secure critical human water needs, and then secure basic landholder rights and essential town water supplies. More detail is provided in Section 2.3.

Through the regional water strategies, we aim to be better prepared for the future and manage these extreme events effectively and equitably for all water users in the region.

The NSW Government is taking a six-step approach to preparing and implementing the regional water strategies, as shown in Figure 5. However, due to the time required to complete the complex hydrologic modelling for the Murray Regional Water Strategy, steps 1 and 2 are expected to be finalised at the same time as step 4.

Figure 5. Six step approach to NSW regional water strategies



21. Subsections 9(1)(b), 5(3)(a) and 5(3)(b) of the *NSW Water Management Act 2000.*

1.3 What has informed the draft regional water strategies?

To ensure we are using the best evidence and most recent data, and fully considering ideas and options for each region, we have used a wide range of sources to inform each strategy.

1.3.1 New climate datasets and improved modelling

Until now, water management in NSW has been based on historical data and observations going back to the 1890s. This has provided a limited understanding of extreme events. The NSW Government is investing in new climate datasets and modelling to develop a more sophisticated depiction of past and future climate conditions. These improved datasets integrate recorded historical data with paleoclimate data (data reconstructed from before instrumental records began, using sources such as tree rings, cave deposits and coral growth) to give us 500 years of climate data. A stochastic modelling method uses this extended data to generate 10,000 years of synthetic climate data. When combined with other sources of climate data—such as climate change projections—we are better able to understand natural climate variability, including the probability of wet and dry periods in each region, and estimate risks to future water availability.

This new method is an important advance on previous climate datasets and models. The improved modelling means that we will move from making decisions based heavily on a single 'worst case' scenario drawn from a short climatic record, to a much more comprehensive understanding of the distribution, length and frequency of past wet and dry periods.

Through this work, we will be able to assess and plan for the impacts of changes in flows and water security over a much wider range of climatic conditions than if we had only considered the observed historical records.

A pilot study is underway to test whether there has already been a step-change in climatic conditions in the southern Basin (see Section 2.1.2).

Chapter 2 sets out the preliminary climate data and observed trends in water resources for the NSW Murray region. Hydrologic modelling using the new climate data is under development and will be released in the near future. Trends from hydrologic modelling for other inland regional water strategies, where applicable, have been used to infer potential climate impacts for the NSW Murray region. The updated climate information was used to develop the draft strategy and, together with the improved modelling, will assist in the assessment of the long list of options. It will also support all water users in making more informed decisions to better plan and prepare for climate risks.[22]

Ongoing analysis will yield more specific and robust results, including an updated understanding of the risks to town water supply as well as industry and environmental water availability in the NSW Murray region. The final Murray Regional Water Strategy will use this new data and modelling to identify the best ways to share, manage and use water to manage these risks.

22. More information about this modelling is provided in the *Regional Water Strategies Guide.*

1.3.2 Community engagement

Over the last few years, the NSW Government has been consulting on a range of water-related issues, including water resource plans,[23] metering reforms, environmental water management, the Sustainable Diversion Limit Adjustment Mechanism (SDLAM), floodplain harvesting and drought. Through these engagements, we have heard many ideas about how to be better prepared for future droughts and floods, and a more variable climate.

Due to the COVID-19 pandemic, we had to redesign our engagement program, replacing some face-to-face consultation with virtual, online and contactless methods.

We have continued to talk with local councils, local water utilities and joint organisations of councils, as well as NSW government agencies, about their thoughts on what the focus of the Murray Regional Water Strategy should be. Face-to-face engagement with Aboriginal communities in the NSW Murray region was significantly hindered due to the pandemic. As we progress the development of the Murray Regional Water Strategy we will continue to engage with Aboriginal people in the region to ensure their voices are heard.

Further information about the outcomes of these initial meetings can be found in Attachment 1.

23. Over 100 meetings were held with First Nations across the Murray and Murrumbidgee regions for the Water Resource Plans.

Photography
Image courtesy of Destination NSW.
The Diggings, Kosciuszko National Park.

What local councils, local water utilities and joint organisations have told us so far

- Councils generally support the use of the new climate data and updated hydrological modelling, but there is a need for more clarity around how it may be used in future water management and planning decisions. Local water utilities are interested in how the data could be shared and used, and how the work of the regional water strategies will align with their Integrated Water Cycle Management Strategies (IWCM).
- Many councils and joint organisations raised the need for more clarity on the roles and responsibilities of different agencies involved in water management.
- There is a need for the regional water strategies and the NSW Government to be clear and transparent about how water is allocated, traded and licensed. Some local councils would like to be able to expand their trading opportunities without penalty, including local water utility entitlements, wastewater discharges and excess bulk water.
- Some councils suggested that the management of water for the environment could be improved and there is a desire for more information and transparency about the use of water for the environment. The delivery of water for the environment and other users needs to be improved around the Barmah Choke.
- The Murray and Murrumbidgee regions are highly connected, but each region has specific issues that need to be addressed in the respective strategy. The waterways of the NSW Murray region are the life-blood of communities and support economic activities, recreational opportunities, amenity and culture and a sense of community.
- Councils queried how the regional water strategies will take account of and integrate existing government commitments and other water management policies and plans. Some councils feel that the lack of integration and sequencing of the existing government commitments and other ongoing programs leads to delays and sub-optimal water management outcomes. There is also significant frustration with the SDLAM projects in some areas.
- Councils welcomed the engagement on the regional water strategies but suggested that the conversation needed to be broadened to also include water access licence holders and other local groups with an interest in water.
- Securing town water security is important given the predicted population growth and changes in the regional economy. There is concern over the difference between local population projections and the projections developed through the NSW Government Common Planning Assumptions.

What Aboriginal people have told us so far

- Aboriginal people emphasised the cultural significance of water and the significance of traditional medicines and the need to protect native plants. There were concerns that the water management framework lacks an understanding of the importance of the rivers and the sacred and spiritual connection of Aboriginal people to water.
- There are concerns that Aboriginal people are locked out of culturally significant sites and have limited access to water entitlements. In addition, Aboriginal people told us that they find it difficult and confusing to apply for Aboriginal Cultural Access Licences and that the application process need to be improved.
- The health of the rivers and waterways in the region has been affected by long-term land and water management. Traditional Owner knowledge needs to be incorporated into water resource management and planning.
- Aboriginal people stressed the importance of meaningful consultation with Aboriginal communities when developing the regional water strategies, including promoting engagement activities to ensure greater participation. There is continued frustration regarding ongoing consultations with Aboriginal communities regarding water and perceived inaction.
- There is an interest to improve how Aboriginal people could play a more active role in water management.

Photography
Image courtesy of iStock.
Edward River, Deniliquin.

1.3.3 Building on existing commitments and reforms

The Murray and Murrumbidgee regional water strategies are being developed against the backdrop of significant water reforms since the mid-1980s. These reforms, together with other drivers, have led to a significant program of works that is currently being carried out by the NSW Government. The ongoing work program is extensive, complex and—in some cases—requires inter-regional and inter-jurisdictional engagement and cooperation.

Although not exhaustive, the Murray and Murrumbidgee regional water strategies will need to consider the existing programs and projects currently underway, including the SDLAM projects the relevant water sharing plans, the water resource plan implementation programs and the Snowy Water Licence Review implementation plan.

Reconnecting River Country Program

The NSW Government has announced the Reconnecting River Country Program to achieve a balance of economic, social, cultural and environmental outcomes across southern NSW by improving wetland and floodplain connectivity. The program is part of SDLAM and reimagines the previous Constraints Measures Program and was developed based on extensive feedback from the local community.

The program focuses on relaxing or removing some of the constraints or physical barriers impacting the delivery of water for the environment in the following areas of the southern connected Murray–Darling Basin:

- Hume to Yarrawonga (Murray River)
- Yarrawonga to Wakool (Murray River)
- Murrumbidgee River.

The program aims to more efficiently deliver water for the environment, to connect rivers to floodplains more often without the need for further water purchases.

The regional water strategies will need to factor in commitments made by the NSW Government, including those made under the NSW Water Strategy and the proposed state-wide Aboriginal water policy and NSW Groundwater Strategy.

We also need to ensure we reflect progress on commitments associated with the 2017 Water Reform Action Plan (such as improving compliance and transparency around water use and access, and introducing robust new metering laws) and joint Basin government initiatives.

In the NSW Murray region, the NSW Government has committed to:

- integrated water cycle management strategies for Edward River Council, Snowy Monaro Regional Council, Greater Hume Shire Council, Murray River Council, Wentworth Shire Council and Balranald Regional Council
- projects under the Safe and Secure Water Program for Bombala, Jindabyne, Khancoban, Albury, Jindera, Finley and Gol Gol
- projects in the Restart NSW suite including the Lake Wallace Dam Construction Project
- a range of projects to improve water and sewage services for Aboriginal communities.

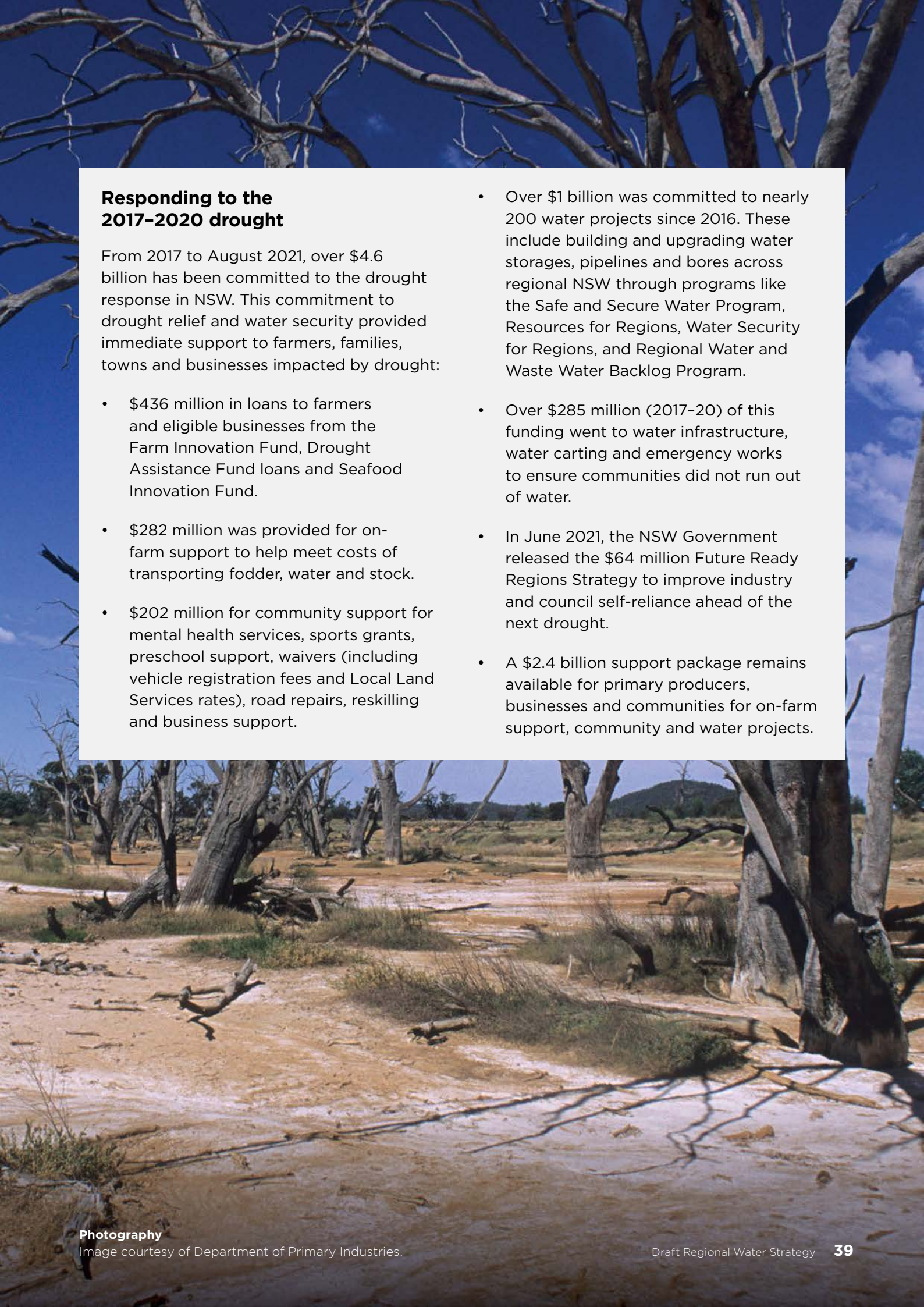
These and other investments will be supported by a new Town Water Risk Reduction Program,[24] which will identify long-term solutions to challenges and risks in providing water supply and sewerage services in regional NSW.

The regional water strategies also need to consider work by other agencies and government departments which relate to the NSW Murray region, including:

- the Future Ready Regions Strategy,[25] which will support the 20-year Economic Vision for regional NSW and commits to building stronger communities and diversified regional economies to be better prepared for future droughts[26]
- the scheduled reviews of the South East and Tablelands, Far West and Riverina Murray regional plans 2036
- the regional economic development strategies for Snowy Monaro, Snowy Valleys, Albury–Wodonga, Murray and Western Murray
- the Snowy Mountains Special Activation Precinct, the Albury Regional Job Precinct and work underway for the Inland Rail Project
- efforts underway for Snowy 2.0.

Bringing in the work of other agencies will help to target and narrow down the draft long list of options for the regional water strategy to take full advantage of the opportunities that arise in the NSW Murray region.[27]

24. Department of Planning and Environment, *Town Water Risk Reduction Program*. Retrieved from www.industry.nsw.gov.au/water/plans-programs/risk-reduction
25. Regional NSW, *Future Ready Regions Program*. Retrieved from www.nsw.gov.au/regional-nsw/future-ready-regions
26. Several commitments in the strategy address drought readiness challenges identified in the NSW Murray region and align with some of the options.
27. More information about this work is in the *Regional Water Strategies Guide*.



Responding to the 2017–2020 drought

From 2017 to August 2021, over $4.6 billion has been committed to the drought response in NSW. This commitment to drought relief and water security provided immediate support to farmers, families, towns and businesses impacted by drought:

- $436 million in loans to farmers and eligible businesses from the Farm Innovation Fund, Drought Assistance Fund loans and Seafood Innovation Fund.
- $282 million was provided for on-farm support to help meet costs of transporting fodder, water and stock.
- $202 million for community support for mental health services, sports grants, preschool support, waivers (including vehicle registration fees and Local Land Services rates), road repairs, reskilling and business support.
- Over $1 billion was committed to nearly 200 water projects since 2016. These include building and upgrading water storages, pipelines and bores across regional NSW through programs like the Safe and Secure Water Program, Resources for Regions, Water Security for Regions, and Regional Water and Waste Water Backlog Program.
- Over $285 million (2017–20) of this funding went to water infrastructure, water carting and emergency works to ensure communities did not run out of water.
- In June 2021, the NSW Government released the $64 million Future Ready Regions Strategy to improve industry and council self-reliance ahead of the next drought.
- A $2.4 billion support package remains available for primary producers, businesses and communities for on-farm support, community and water projects.

Photography
Image courtesy of Department of Primary Industries.

1.4 Policy and planning context

Each regional water strategy sits within a broader policy and planning context. This includes a range of policies and plans that guide the management of water resources in NSW (Figure 6).

The NSW Government has developed a 20-year NSW Water Strategy, which establishes guiding principles and sets strategic priorities to improve the security, reliability, quality and resilience of the state's water resources; and to continue to rebuild community confidence in water management in NSW. As outlined in Table 1 (Section 1.2), the NSW Water Strategy identifies seven strategic priorities focused on meeting core objectives based on the NSW *Water Management Act 2000*. The Act provides a clear direction that NSW must provide for the sustainable and integrated management of the water sources of the state for the benefit of present and future generations.

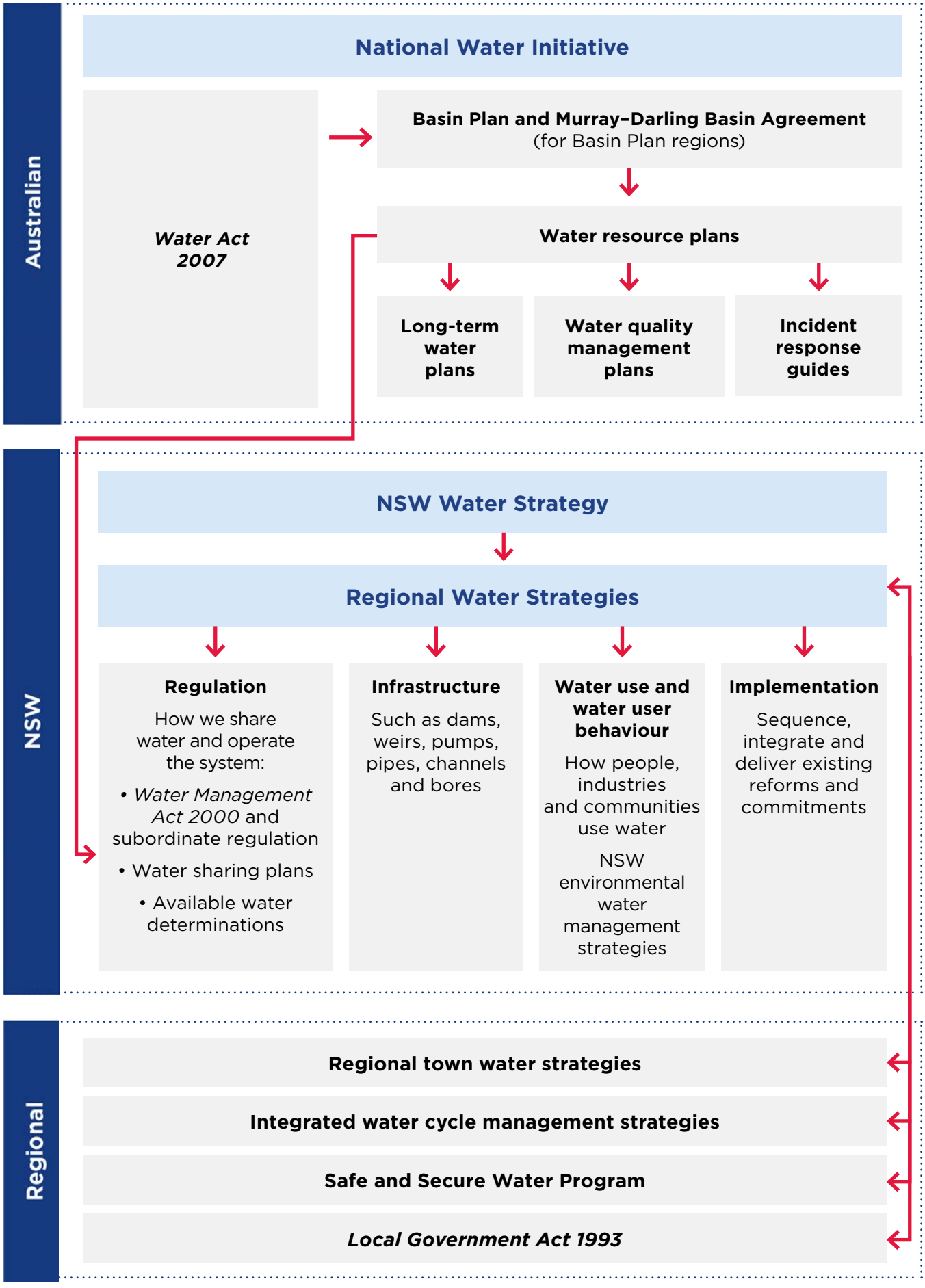
The regional water strategies also align with the NSW Government's broader strategic planning priorities and will be integrated with current land use and regional plans.[28] This includes local strategic work being done by joint organisations and local councils' integrated water cycle management plans.

Regional water strategies are an opportunity to explore how we can bring together existing commitments; and better integrate and shape these plans, policies and investment for improved water outcomes.

28. More information about how the strategies relate to strategic, regional and water planning is in the *Regional Water Strategies Guide*.

Photography
Image courtesy of Department of Primary Industries.

Figure 6. The NSW water policy and planning context



Chapter 2

The NSW Murray region, its climate and water resources

Photography
Image courtesy of Department of Planning and Environment.

Snapshot

Changing climatic conditions are placing the region's water resources under pressure. Declining rainfall, snowfall and changing seasonal conditions coupled with increasing temperatures and evaporation has significantly reduced inflows into the region's water storages.

- The NSW Murray region has a highly variable climate between the upper eastern areas and lower western areas, and precipitation patterns are changing with climate change. The seasonality of precipitation is changing—with winter and spring rainfall potentially decreasing by 5–10%, while summer (with high evaporation rates) and autumn rainfall may increase by around 10–20% by 2060–79.
- Severe fire conditions are expected to worsen over both spring and summer, which increases the risk of short-term pollution of waterways and long-term reduction in run-off.
- The Millennium Drought, stretching from 2002 to 2010, was the longest and most severe drought recorded in the NSW Murray region, with inflows from 2006 to 2010 half of the previously recorded minimum.
- Demand for and pressure on the region's fully committed alluvial groundwater sources increases during periods of drought. Aquifer levels are noticeably declining in localised areas of the mid-Murray River alluvial groundwater sources, while there are salinity issues in the Lower Murray River alluvial groundwater sources.
- The NSW Murray region has experienced significant flood events over the past 122 years; the most recent significant flood occurred in spring 2016. Hume and Dartmouth dams both play a role in reducing the frequency and duration of flooding. These structures, coupled with levee banks, provide mitigation of flood impacts on life and property in the NSW Murray region. However, these measures have reduced natural flood attenuation processes that also protect downstream communities, and impacted the ecosystems of the floodplain and river system.
- Managing water in the southern connected basin is complex, and governed by interstate agreements and rules governing how water in the Murray is shared between NSW, Victoria and South Australia. With a decline in inflows into the Murrumbidgee and Murray systems over the last two decades and the risk of a further decline under climate change, we need inter-jurisdictional dialogue about the existing settings of the Murray–Darling Basin Agreement through existing forums.

Managing, sharing and delivering water is challenging in a long, complex and contested transborder river system with a long history of water reform.

- The broad water sharing arrangements of the Murray–Darling Basin Agreement between NSW, Victoria and South Australia were established in 1914, with the last substantive change in 1970. Compared with today, the 1970 amendments were made with different consumptive demand patterns, higher water availability, no water trade and no environmental water delivery. These differences present several challenges for the current management of the shared Murray water resources.

- The Snowy Scheme contributes crucial flows to the Murray River via Hume Dam, but inflows to the scheme have reduced over the last 20 years. Eight of the driest 13 years have occurred in the past 20 years. Likewise, median outflows from the Murrumbidgee River and Billabong Creek into the lower Murray River have reduced by two-thirds over the past 20 years, compared with the previous century.

- Delivery constraints in the mid-Murray River and an expansion of permanent plantings and environmental water use downstream means getting water to where it is needed is often difficult, and there is the potential for future supply shortfalls. Daily delivery rates from the Hume Dam have had to be reduced because the capacity of the Barmah Choke has fallen progressively over the past three decades from 11,500 ML/day in the 1980s to 9,200 ML/day in 2019.

- The associated water demand arising from recent increases in permanent plantings in the lower Murray River has primarily been sustained by inter-valley water allocation trade. This increased demand has offset reductions in consumptive water use in the lower Murray that were expected from recovering environmental water from consumptive use under the Basin Plan.

- The vast majority of NSW Murray River irrigators hold general security entitlements. Due to the highly variable climate, the amount of water allocated each year to general security entitlements has varied widely. There have been recent consecutive years of low allocations, and water use restrictions have applied in several years. Average annual allocations declined from 86% during 1895–1999 to 56% during 2000–18.

- In the southern connected basin, water allocations can be traded between the Murrumbidgee, NSW Murray, Lower Darling, and Victorian and South Australian regulated river water sources. Recently proposed changes to Goulburn inter-valley trade rules that limit the volume of traded water (to address environmental impacts) may place increased pressure on the Murrumbidgee inter-valley trade account.

- Water quality is managed through several legislative and regulatory instruments, and by various agencies. Current challenges include salinity, elevated nutrient levels, blue-green algae, hypoxic blackwater and cold water pollution. These challenges require a suite of integrated management options targeted at source catchments, rivers and infrastructure.

2.1 What we know about the NSW Murray region's climate

2.1.1 Today's climate

The NSW Murray region has a highly variable climate, ranging from temperate and alpine conditions in the east to semi-arid conditions in the west. Temperature varies widely, with cold winters in the Snowy Mountains that see significant snowfall accumulating on the ground for many months, and hot summers in the west with an average of 16 days per year above 38°C. In areas of the Monaro and mid-Murray River, temperatures are more moderate compared to the Snowy Mountains and far western parts, but these areas can also experience hot summers and cool-to-cold winters.[29, 30]

We have seen an increase in periods of hot weather across the region. Since 1989, Albury has experienced an average of seven days a year above 38°C, compared to an average of four days from 1959 to 1988. In addition, there have been unprecedented temperatures occurring, with Mildura (on the Lower Murray River in far west Victoria) reaching 46°C six times since 1989. Previously, that extreme had never been observed in the historical records (the last 125 years).[31]

Precipitation is also highly variable across the region. The Snowy Mountains experience around 2,000 mm each year, much of it as snow that generates significant snowpack. Annual precipitation in the Snowy Mountains and Victorian Alps, which are key watersheds for the major dams of the Murray River, is highly variable, with the driest 10% of years experiencing less than 1,209 mm and the wettest 10% of years exceeding 3,300 mm at Charlotte Pass. In the far west, rainfall is much lower, with an average of 286 mm at Wentworth, which is among the lowest rainfall average in NSW.[30, 31]

Average annual rainfall across the central areas of the NSW Murray region (Figure 7) has remained fairly stable over the recorded period, but there have been rainfall reductions during the cooler months when evaporation rates would normally be lower.[28] Over the past 30 years, winter rainfall (April–October) for Albury was 428 mm; 51 mm lower than the average for the 30 years prior to 1988. There have been similar reductions for areas around Deniliquin, Tumbarumba and the Monaro.[31]

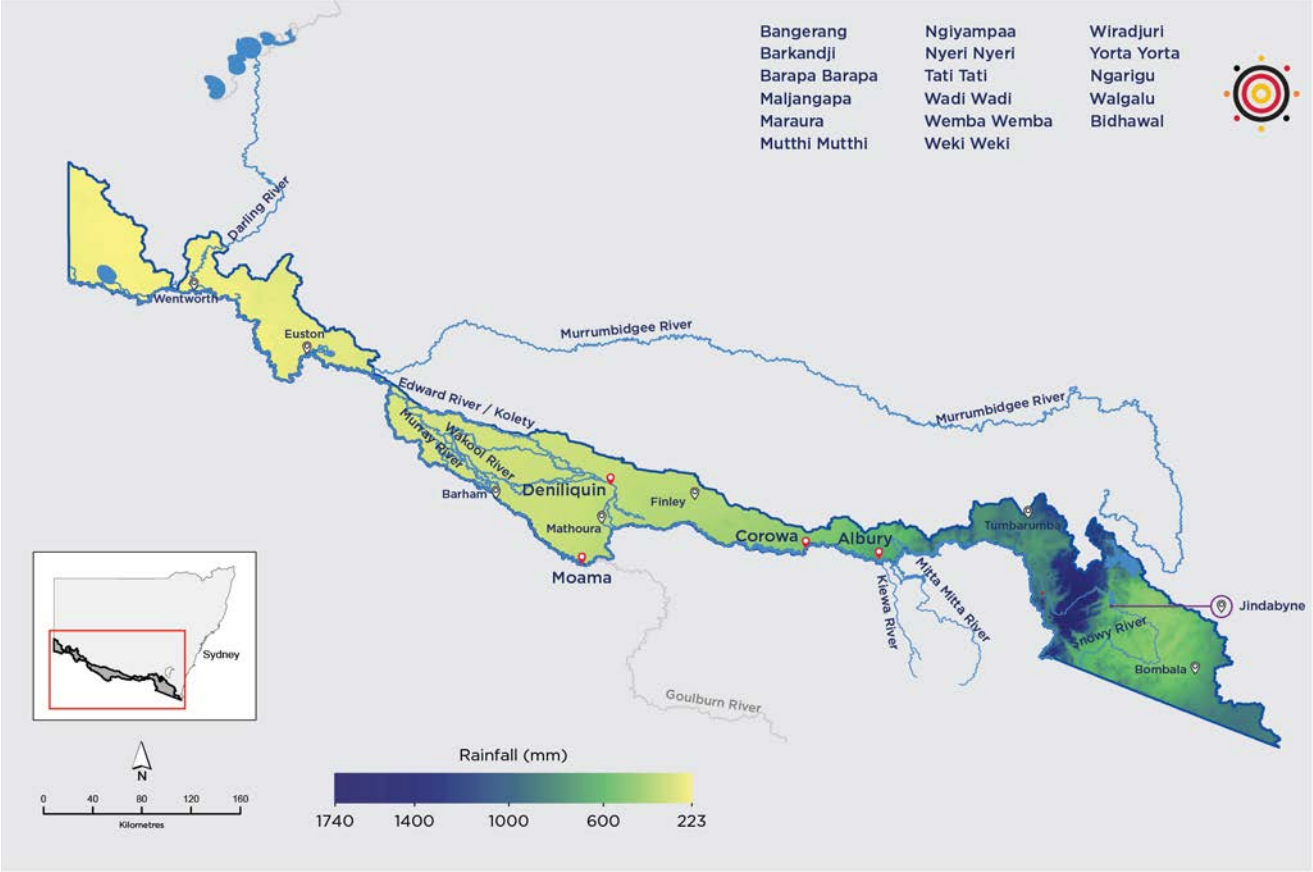
On average, the Snowy Scheme receives 50% of its inflows from snowmelt and spring rainfall. This amount varies each year due to losses to evaporation or groundwater, depending on the prevalent climate conditions.

Maximum snow depths in the Kosciuszko National Park have shown a downward trend over the last 50–60 years, declining by around 10% from 1961 to 2001, and 15% from 2001 to 2013.[31] The major factors responsible for these declines are increasing minimum temperatures[32] and a reduction in winter rainfall. Over the last 25 years, maximum snow depth and the total number of light snow days[33] has declined, mainly in spring, due to higher temperatures. Higher temperatures in recent years have also reduced suitable conditions to generate snowpack.[34]

29. Bureau of Meteorology 2021, *Climate Data Online*. Retrieved from www.bom.gov.au/climate/data/
30. Bureau of Meteorology 2021, *Climate Guides*. Retrieved from www.bom.gov.au/climate/climate-guides/
31. Sonya L. Fiddes, Alexandre B. Pezza and Vaughan Barras. 2014, *A new perspective on Australian snow*. See www.snowyhydro.com.au/generation/live-data/snow-depths/
32. The proportion of precipitation falling as snow is related to the minimum temperature.
33. 'Light snow days' are considered to be days of snowfall between 1 cm and 10 cm.
34. Acacia S. Pepler, Blair Trewin and Catherine Ganter. 2015, *The influences of climate drivers on the Australian snow season*. See www.researchgate.net/publication/286912716_The_influence_of_climate_drivers_on_the_Australian_snow_season

In addition to the amount of snowpack, snowmelt is strongly influenced by weather conditions in late winter and spring, and small changes in the weather can lead to vastly different outcomes for inflows. For example, heavy rain falling on a dense snowpack melts the snow quickly and maximises run-off; and hot, dry air can lead to higher evaporation and, hence, reduce run-off into rivers.

Figure 7. Observed average annual rainfall in the NSW Murray region (2000–20)



Source: Bureau of Meteorology

Average evapotranspiration[35] ranges from around 1,000 mm in the Snowy Mountains to 1,150 mm in the west. Evapotranspiration is strongly seasonal across the region: around four to five times higher in summer compared with winter.[36]

Evaporation[37] varies from 1,200 mm in the east to 2,000 mm in the west, and has increased between 2.5% to 5% since 1970 throughout the year, with most evaporation experienced during spring.[38]

35. Evapotranspiration figures are for areal potential evapotranspiration. Evapotranspiration is the combined process of water surface evaporation, soil moisture evaporation and plant transpiration. It is affected by climate, availability of water and vegetation. Areal potential evapotranspiration is the evapotranspiration that would take place, under the condition of unlimited water supply, from an area so large that the effects of any upwind boundary transitions are negligible and local variations are integrated to an areal average. A large area is defined as an area greater than 1 km^2.
36. Bureau of Meteorology 2021, *Average annual and monthly evapotranspiration*. Retrieved from www.bom.gov.au/jsp/ncc/climate_averages/evapotranspiration/index.jsp
37. Evaporation figures are for pan evaporation. Pan evaporation is a measurement that combines or integrates the effects of several climate elements: temperature, humidity, rainfall, drought dispersion, solar radiation and wind.
38. Bureau of Meteorology, *Climate change—trends and extremes*. See www.bom.gov.au/climate/change/

Cloud seeding

Cloud seeding in the Snowy Mountains is a weather-modification technique that involves introducing a seeding agent (silver iodide) into suitable clouds to encourage ice crystals to form and grow. This is done at particular times when atmospheric conditions are suitable, and to increase the amount of snow falling from the cloud over a 2,110 km^2 target area of the Snowy Mountains each year.

Following a trial from 2004 to 2012, Snowy Hydro has been conducting cloud-seeding operations since 2013. An independent assessment by the NSW Natural Resources Commission found that cloud seeding trials resulted in a 14% increase in precipitation for targeted weather events over target areas.[39] Environmental monitoring undertaken each year has found no impacts to potable water supplies or ecosystems.

The additional snowfall provides improved snow conditions for winter sports, as well as more meltwater for energy production and subsequent release to the Murray and Murrumbidgee rivers for irrigation, town water supply and the environment. The regional water strategy presents an opportunity to investigate expanding such activities (refer to Option 41: Investigation into expansion of cloud seeding in key water supply catchments).

The region has experienced both short, intense and extended drought periods, often ended by intense wet periods

The NSW Murray region has experienced extreme droughts over the past 125 years of observed records. The most well-known are the Federation Drought (1895 to 1902), the World War II Drought (1937 to 1945) and the Millennium Drought (1997 to 2009) (Figure 8 and Figure 9). A review of the observed historical records indicates that persistent droughts have commonly and increasingly ended with significant rainfall events. For example, significantly above average rainfall in 2010, 2016 and 2020 effectively ended years of below average rainfall.

The most recent drought (2017 to 2020) includes one of the lowest 24-month rainfall period across the region and took place against a backdrop of rising temperatures, increasing evaporation and record low root-zone soil moisture (Figure 9). In the 24 months to January 2020, rainfall in the region was 30 to 40% below average.[40] Later in 2020 and beyond, the region experienced above average rainfall and southern Murray-Darling Basin water storages saw significant increases during 2020—rising from 36.8% in March 2020 to 68.8% at the end of November.[41]

39. The number of cloud seeding opportunities varies each year depending on the weather conditions, and are limited to when conditions are such that seeding will result in snowfall and not rain. In addition, there is a large variation in the number of opportunities between years—for example during El Niño or positive Indian Ocean Dipole (typically 'dry') years, there will be reduced opportunities compared with 'wet' years.
40. See www.bom.gov.au/climate/drought/ and Bureau of Meteorology 2019, *Special Climate Statement 70 update—drought conditions in Australia and impact on water resources in the Murray-Darling Basin.*
41. Bureau of Meteorology 2020, *2020 Annual Climate Statement*, media.bom.gov.au/releases/807/2020-annual-climate-statement/

Figure 8. Lowest ten-year average rainfall in the NSW Murray region

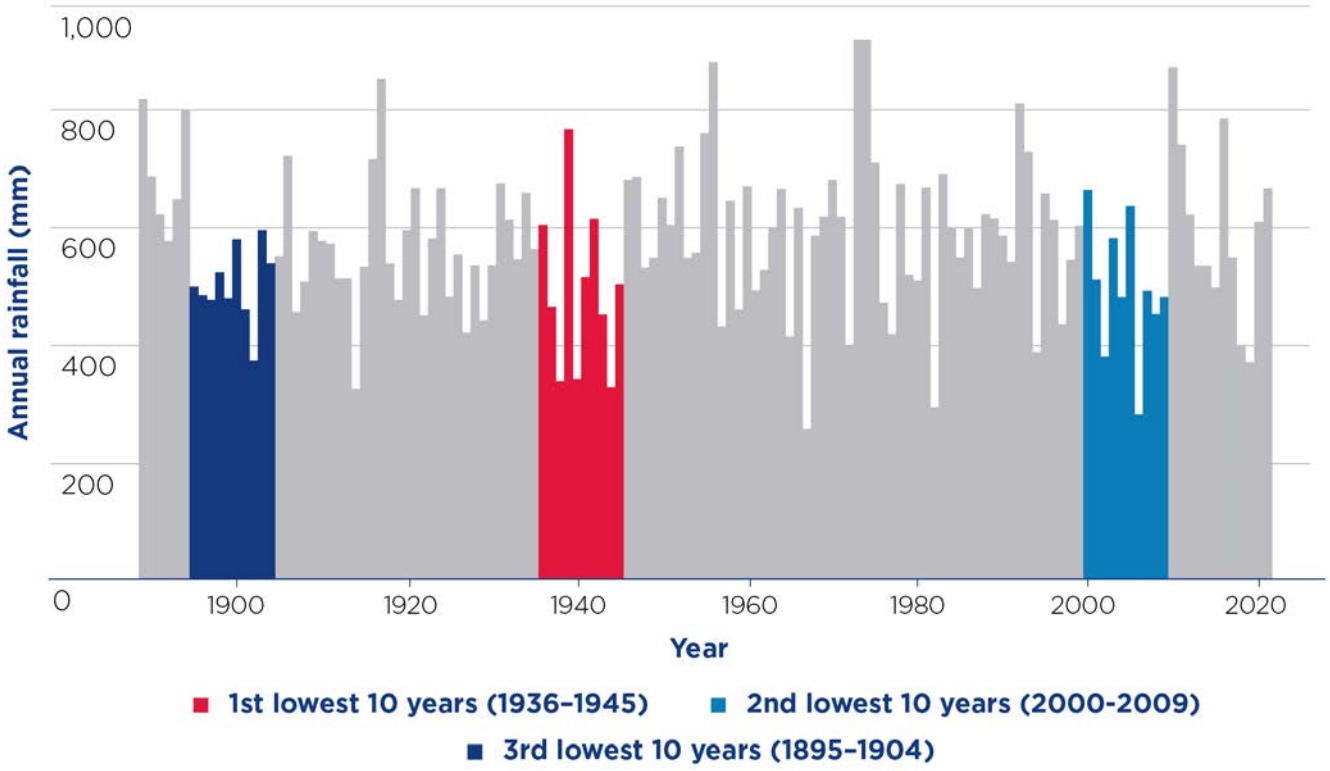
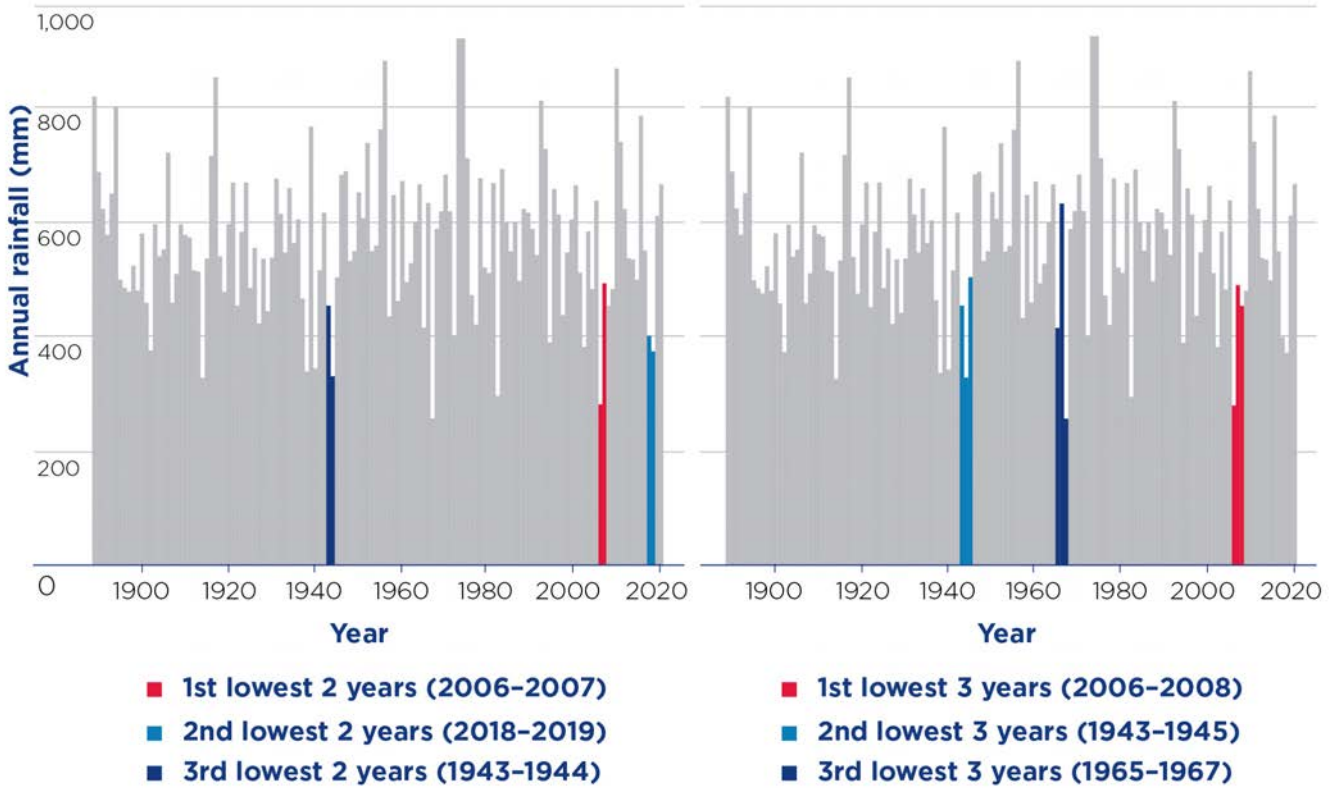


Figure 9. Lowest two and three-year average rainfall in the NSW Murray region



2.1.2 A better understanding of long-term natural climate variability and future climate change

Our new climate datasets and updated modelling provide a better understanding of the natural variability of the Murray's climate beyond the observed historical records. This section compares observed climate data with long-term natural climate variability and plausible future climates, including potential changes to the amount and seasonality of rainfall, snowmelt and evapotranspiration; and potential changes to wet and dry cycles.

The impacts of increasing climate variability and climate change on the region's water resources, and the direct challenges for future water resource management are discussed in Section 2.2.1.

Wet and dry cycles have occurred in the past

The new climate datasets show that the wet and dry cycles we have seen over the last 125 years are fairly normal when compared to the long-term climate beyond historical records. The stochastic datasets indicate that there have been more extreme dry and wet conditions in the long-term past than we have seen in the last 125 years. If the region's future climate is like its long-term historical climate, we could see more variability in rainfall, particularly in winter, and more variable inflows to our dams.

In the southern Basin, we are already seeing a shift in climate over the last 20 years. Trends of decreasing autumn and early winter rainfall of 10-20%, decreasing number of wet days in southeast Australia since the mid-1990s, and temperature increases in this region, especially post 1960 were at least partly attributable to climate change.[42] Further information concerning the impact on recorded inflows is presented in 2.2.1 below. More work is being done by Adelaide University to further analyse non-stationarity in new climate datasets for the next stages of the Murrumbidgee and Murray regional water strategies to help us to more accurately assess current and future drought risk.

A future climate could be drier and more variable

Our new climate change datasets[43] suggest that, if the worst-case dry climate change scenario eventuates, the NSW Murray region could experience:

- **Changing precipitation patterns—**average winter rainfall may drop by nearly 20% by 2079. Increases in early autumn rainfall may be offset by equivalent reductions in late autumn. Summer may see increases in precipitation by up to 17% and decreases by up to 30% in spring (Figure 10).
- **Higher evapotranspiration—**average evapotranspiration could increase by up to 2% by 2039 and up to 5% by 2079, compared to levels between 1990 and 2009 (Figure 11).

These changes in precipitation and evapotranspiration may affect agricultural operations and crop selection, total dam inflows and the ability to optimally manage environmental releases.

42. Anjana Devanand, Michael Leonard, Seth Westra. 2020, *Implications of Non-Stationarity for Stochastic Time Series Generation in the Southern Basin*.
43. Further information about how these forecasts have been used in combination with the new climate datasets is provided in Attachment 2 of the *Regional Water Strategies Guide*.

Figure 10. Average monthly changes in precipitation across the NSW Murray region for the periods 2020–39 and 2060–79, compared to the period 1990–2009

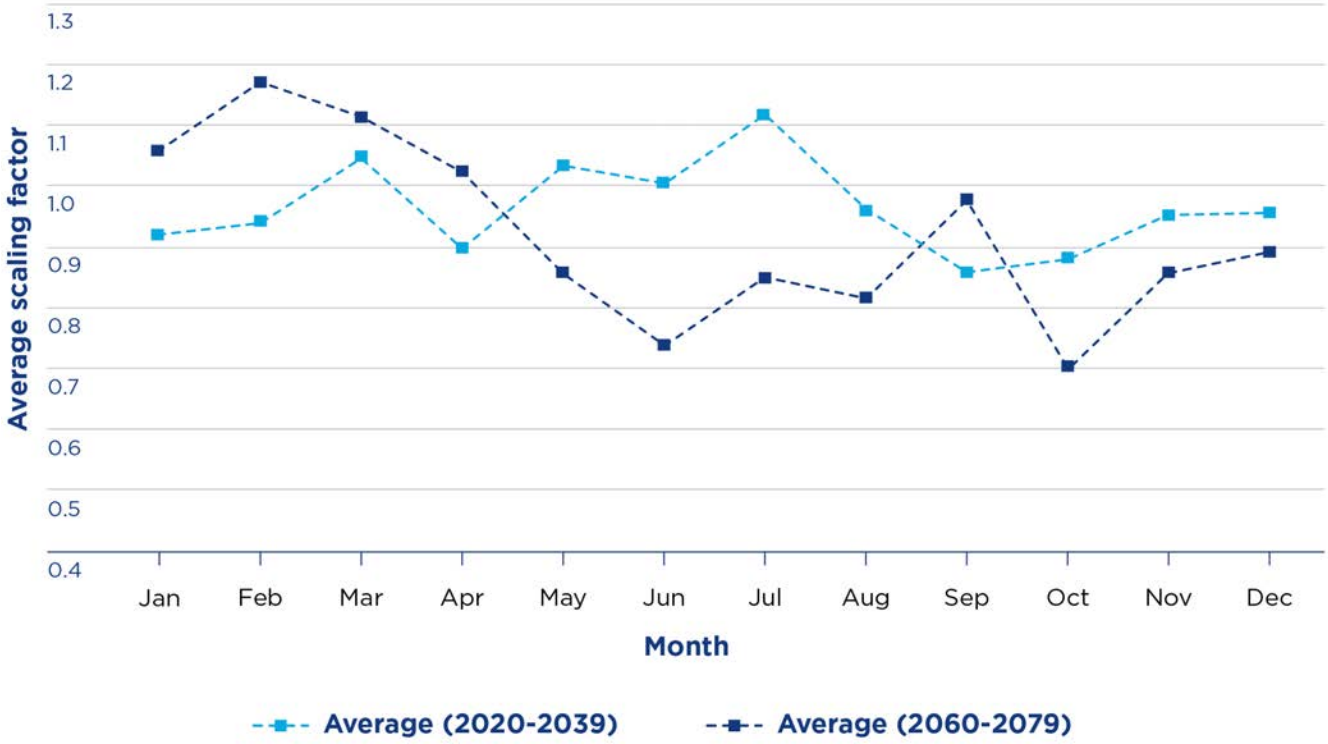
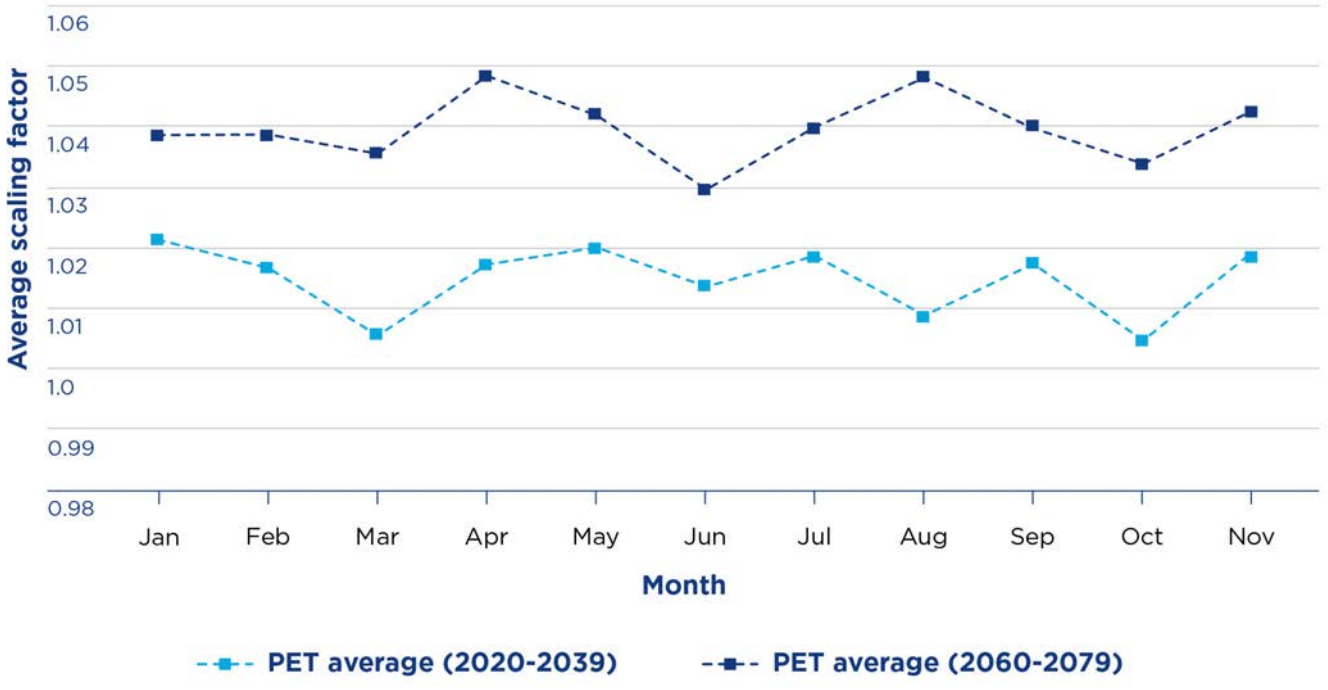


Figure 11. Average monthly changes in potential evapotranspiration (PET) across the NSW Murray region for the periods 2020–39 and 2060–79, compared to the period 1990–2009



In addition, climate change snapshots for the region,[44] which take the average of a range of plausible future changes in climate, suggest that the NSW Murray region could experience:

- **Either decreases or increases in seasonal precipitation—**seasonal rainfall projections for 2030 span both drying and wetting scenarios for summer (–18% to +20%), autumn (–12% to +38%) and winter (–12% to +10%). By 2070 the projections are: summer –8% to +33%, autumn –6% to +45%, and winter –20% to +11%. All models agree that spring rainfall will decrease between –1% and –17% by 2030, and –2% to –19% by 2070.

- **Reduced or increased groundwater recharge, depending on location—**by 2070 groundwater recharge may decrease across many parts of the region, with the highest reductions expected in the Snowy Mountains. Such declines could reduce baseflows of unregulated rivers and creeks. A modest increase in recharge of up to 20% could occur in areas between Balranald and Deniliquin. Areas along the eastern boundary of the region and Cooma to the south suggest a similar increase in recharge.[45]

- **Higher temperatures—**average temperatures are expected to rise by 0.7°C by 2030 across the NSW Murray region.[39] By 2070, average temperatures in the Snowy Mountains are projected to rise by 3°C in the Snowy Mountains and by 1.5°C across the central and western Murray and Monaro areas.[39, 46]

- **More hot days and warm spells—**on average, an additional 8 days per year above 35°C are projected across the central and western Murray by 2030. This is projected to increase to an additional 23 days by 2070.[39]

- **More 'severe fire weather' days—**severe fire weather is measured by a combination of temperature, humidity and windspeed; resulting in a Forest Fire Danger Index score of 50 or greater. This is expected to worsen continually over both spring and summer through 2030 and 2070. In the far west of the region there is expected to be an additional three days of severe fire weather each year, with one or two more days in the central part of the region, and up to an additional one day in the east of the region (including the Snowy Mountains) by 2070.[39]

- **Decreased snowfall and snowmelt—**the expected temperature increases and reduced number of cold nights in the Australian Alps is expected to substantially decrease snowfall. The snowpack is expected to decrease by about 15% by 2030, and 60% by 2070.[47] The expected decrease in spring rainfall is expected to reduce snowmelt.

A projected future with less rainfall in key run-off areas such as the Snowy Mountains, higher evapotranspiration, higher temperatures, and more severe fire conditions will change the volume of water available across the region. These changes are discussed throughout this regional water strategy.

44. Office of Environment and Heritage 2014, *Climate projections for your region*. Retrieved from www.climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Climate-projections-for-your-region
45. Department of Planning, Industry and Environment Adapt NSW, *Groundwater recharge and surface run-off*. Retrieved from www.climatechange.environment.nsw.gov.au/water-resources
46. Department of Planning, Industry and Environment, *NSW and ACT alpine region*. Retrieved from www.climatechange.environment.nsw.gov.au/sites/default/files/2021-08/Climate%20change%20impacts%20Alpine%20-%20Projected%20climate-Revised.pdf?la=en&hash=D91FAC555ACFDB5BD6D8FD910D997FEE4E8D45C4
47. Alejandro Di Luca, Jason P. Evans, Fei Ji. 2017, *Australian snowpack in the NARCliM ensemble: evaluation, bias correction and future projections*. See www.ccrc.unsw.edu.au/sites/default/files/NARCliM/publications/dilucaetal2018.pdf

Using climate change projections in water modelling work

Climate change projections are being used in several ways to test the effectiveness and resilience of options proposed in the regional water strategies and to inform other water management reforms and decisions. These are summarised below and further details are provided in the Regional Water Strategies Guide and on the department's website at www.industry.nsw.gov.au/water/plans-programs/regional-water-strategies/climate-data-and-modelling

NARCliM 1.0

The NSW and ACT Governments' NARCliM 1.0 (climate change) datasets[48] include a range of different future climate scenarios. The NARCliM 1.0 projections were generated from four global climate models, which were downscaled by three regional climate models to provide a total of 12 models. The NARCliM 1.0 projections have been used to develop regional climate snapshots and for the development of our new regional water strategies' climate change datasets. The snapshots and the new climate change datasets for the regional water strategies are not directly comparable due to the use of different models, assumptions and spatial resolution, and they have been developed for different purposes.

Regional climate change snapshots

In 2014, the NSW Government used NARCliM 1.0 projections to develop regional climate change snapshots, including snapshots for the Murray Murrumbidgee and South East and Tablelands regions.[49] For these snapshots, the 12 models were run using a single, representative emissions scenario defined by the Intergovernmental Panel on Climate Change. The 12 models were run for three time periods: a baseline period (1990 to 2009), a near future (2020 to 2039) and a far future (2060 to 2079). The snapshots present climate projections from all 12 models, spanning the range of likely future changes in climate.

Regional water strategies—climate change datasets

To assess future climate risk, we are using the stochastic datasets representing natural climate variability of rainfall and evapotranspiration, adjusted using monthly factors derived from NARCliM 1.0 modelled results. We have selected the most conservative result from NARCliM 1.0, using the global climate model scenario that represents the greatest reduction in average monthly rainfall.[50] While the results of the other scenarios in the current version of NARCliM are arguably equally appropriate and probable, we intend to stress test the water system and understand the worst-case climate scenario for strategic water planning.

48. The NSW and ACT Regional Climate Modelling (NARCliM) Project is a partnership between the ACT and NSW Governments to provide high-resolution climate projections for southeast Australia, including the ACT
49. Department of Planning and Environment, *Climate projections for your region*, climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Climate-projections-for-your-region
50. This is the global climate model result that represents the greatest reduction in the mean of the three regional climate models' monthly rainfall for the 2060-2079 period compared to the 1990–2009 period.

Future climate work for the regional strategies

A pilot study is being progressed by Adelaide University to inform the generation of new climate datasets for the Murrumbidgee and Murray regional water strategies.[51] The aim of the pilot study is to determine whether changes in climate in recent decades affect the estimates of present-day climate risk compared with climate risk based on the whole observed historical record. To date, the study has demonstrated that observed rainfall and temperature records in the southern Basin experienced statistically significant change over time. Trends of decreasing autumn and early winter rainfall of 10–20% in southeast Australia since the mid-1990s, and an accompanying decrease in the number of wet days, were at least partly attributable to climate change.

New climate datasets incorporating these results will improve the representation of natural climate variability and climatic trends, helping us to better assess current and future drought risk.

Updating to NARCliM 1.5

The NARCliM Project completed NARCliM 1.5 datasets in 2020, delivering updated and expanded projections that use more recent global climate models and two emission scenarios to provide projections out to 2100. These improvements will further advance our understanding of plausible future climate conditions and inform future regional water strategies.

51. Devanand, A., Leonard, M., & Westra, S. 2020, *Implications of Non-Stationarity for Stochastic Time Series Generation in the Southern Basins*, Pilot Study undertaken by Adelaide University.

Photography
Image courtesy of Destination NSW.
The Diggings, Kosciuszko National Park.

2.2 The landscape and its water

The NSW Murray region covers approximately 40,400 km^2 in southern NSW and accounts for around 5% of the state. It is bounded by the Murrumbidgee catchment to the north, and the Victorian and South Australian borders in the south and west.

The upper Murray River[52] and Snowy River catchments occur in both narrow and wide valleys of the Southern Tablelands and Snowy Mountains, with small pockets of groundwater in shallow alluviums and fractured and porous rocks. The upper catchments generate much of the run-off for the major dams of the Murray system.

The mid-Murray River begins at Hume Dam and the country flattens out westward onto a large floodplain with many breakouts, including the Edward/Kolety–Wakool rivers that eventually return to the Murray further west. The Murray River is also joined by significant tributaries from Victoria. Groundwater occurs in alluvium associated with the major rivers and creeks, and in underlying porous rock.

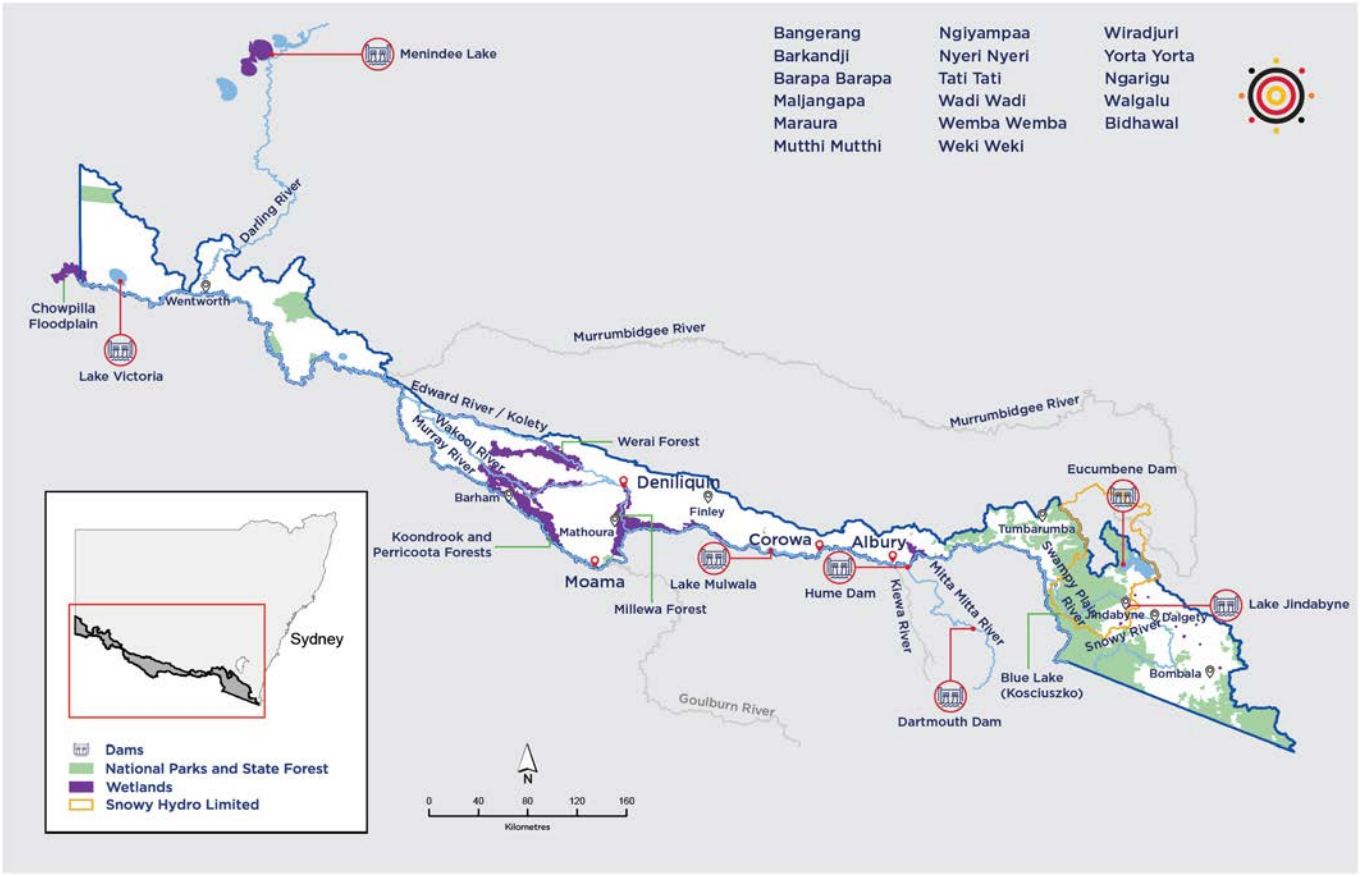
The Lower Murray River starts at the confluence with the Murrumbidgee River and flows along the semi-arid Mallee plains past the Darling River junction, all the way to the South Australian border. Groundwater occurs here in large quantities but becomes quite salty in places.

The region's towns, communities, environment and industries rely on water from multiple sources (Figure 12), including:

- the NSW share of the regulated Murray River system, including the Murray, Edward/Kolety–Wakool rivers
- unregulated rivers and creeks, including the Snowy River and Murray River upstream of Hume Reservoir
- groundwater from alluvial, porous and fractured rock aquifers
- rainfall and run-off within the catchment and key watersheds, and local run-off captured in farm dams
- reused and recycled water used by several regional councils for non-potable uses.

52. Note that the Murray–Darling Basin Agreement recognises the upper Murray River as upstream of the South Australian border, which differs from the interpretation here.

Figure 12. Key surface water resources and infrastructure in the NSW Murray region



Photography
Image courtesy of iStock.
Edward River.

2.2.1 Major regulated rivers and dams, and the impacts of a changing, more variable climate

Within the NSW Murray region, there are two major regulated water systems: the network of dams, aqueducts and tunnels that make up the Snowy Scheme, and the regulated Murray River system that runs its course through NSW, Victoria and South Australia.

The Snowy Scheme, owned and operated by Snowy Hydro Limited, diverts large volumes of water from the headwaters of the Snowy, Eucumbene and Murrumbidgee rivers westward through the Great Dividing Range.

The scheme consists of nine power stations, 16 major dams, 80 km of aqueducts and 145 km of interconnected tunnels. The system has a very large active storage volume of 5,300 GL, which is used to generate electricity before it is released downstream into the Murray, Murrumbidgee and Snowy rivers for consumptive and environmental water uses. Major dams in the Snowy Scheme that hold water for use in the NSW Murray region, Murrumbidgee Valley, Victoria and South Australia include:

- Eucumbene Dam, which is located on the Eucumbene River and can store up to 4,367 GL for use in both the Murray and Murrumbidgee regions
- Jindabyne Dam, which is located on the Snowy River, can store around 389 GL and is the release point for environmental flows to the Lower Snowy River.

Other Snowy Scheme storages located in the NSW Murray region include Island Bend, Guthega, Murray and Khancoban pondages; and Geehi and Tooma reservoirs.

The regulated Murray River system is a network of rivers, large dams, weirs and natural lakes that have been converted into off-stream storages. It supplies water to three states, principally for industry, environmental and town water supplies. River management policy and operations are coordinated through the Australian, NSW, Victorian and South Australian governments. The principal features of this system (see Figure 12) are:

- Dartmouth Dam, located in Victoria on the Mitta Mitta River, which can hold up to 3,856 GL. This dam is ideal for long-term water storage—it is located at the top of the system, has a very deep storage and has limited evaporation from a comparatively small surface area
- Hume Dam, located at the junction of the Murray and Mitta Mitta rivers near Albury, holds over 3,005 GL and is the release point for water into the regulated Murray River
- the Murray, Edward/Kolety–Wakool rivers and their many weirs and offtakes, provide the principal conduit to the irrigation schemes, towns and environmental assets all the way to the Southern Ocean in South Australia. The Murray River is also joined by the Murrumbidgee and Darling rivers and large tributaries from Victoria, such as the Goulburn River, which contribute to Murray River flow. Features such as its long length, lack of mid-river storage, high evaporation rates and constricted channel points make delivery of water in this river challenging, particularly during dry periods
- Menindee Lakes[53] and Lake Victoria, have maximum storage levels of 1,731 GL and 677 GL respectively. The lakes are both naturally-occurring, with modifications to enable them to be used as off-river storages. They are used to meet consumptive and environmental demands in the Lower Murray and Lower Darling systems.

There is also a large system of canals owned and operated by irrigation companies such as Murray Irrigation Limited that are used to distribute water from the main river systems to farms and other water users.

53. Menindee Lakes sits within the area of the Western Regional Water Strategy, but is part of the storage system for the Murray River system.

Snowy Scheme Interlinkages

The Snowy Scheme is an integrated water and hydro-electric power utility located in Australia's Southern Alps which is operated and maintained by Snowy Hydro Limited. Completed in 1974, it was designed to collect, store and divert water from east of the Dividing Range to the western river catchments of the Murray and Murrumbidgee rivers for irrigation and industry. It is also essential for generating hydro-electricity, providing around 32% of all renewable energy available to the eastern mainland grid of Australia.[54]

The Snowy Scheme has highly variable annual inflow, with average spring run-off and snowmelt contributing around 50% of the total scheme inflow.[55] The total active storage capacity of 5,300 GL enables the scheme to capture water during wet years, store this water and release it during dry years.

The Snowy Scheme comprises two major developments: the southern Snowy–Murray Development and the northern Snowy–Tumut Development (Figure 13).

The Snowy Water Licence sets the Scheme's obligations to make annual and environmental releases to both the Murrumbidgee, Snowy and Murray rivers. These releases from the Snowy Scheme are critical for the Murray and Murrumbidgee regions as they include:

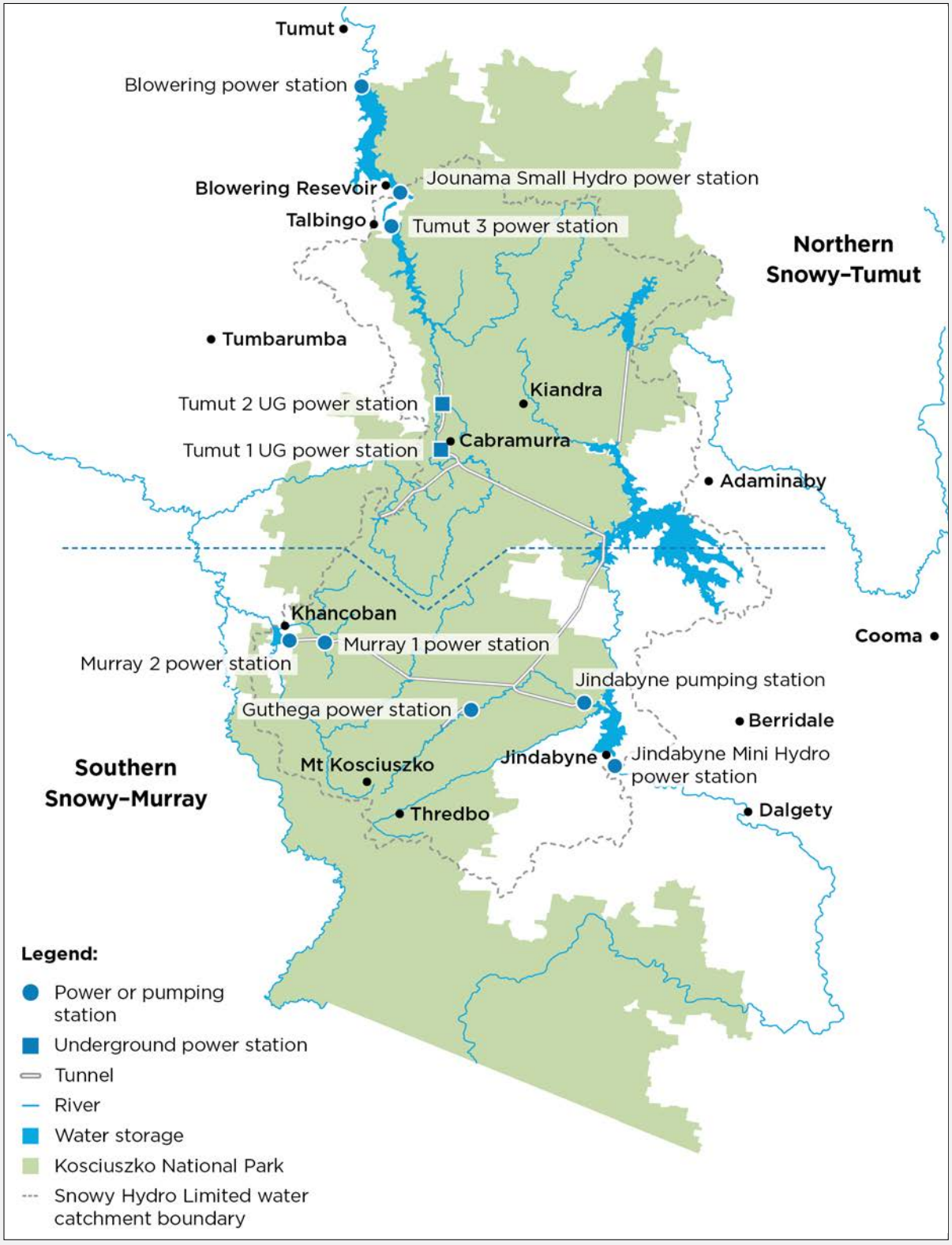
- required annual releases of a nominal 1,026 GL/year to the Murrumbidgee River via Blowering Dam
- required annual releases of a nominal 1,062 GL/year to the Murray River via Hume Dam
- base passing flows that target release of annual volumes of 9 GL to the Snowy River
- environmental releases into the Murrumbidgee River catchment
- environmental releases to the Snowy River, Geehi River and the Murray River.

Required annual releases from the Snowy Scheme are re-regulated for extractive and environmental uses by the Murray–Darling Basin Authority in the Murray River; and by WaterNSW in the Murrumbidgee River, through releases from Blowering Dam.

The most recent review of the Snowy Water Licence resulted in a range of recommendations, including some amendments to the licence, and further investigating options to better manage environmental flows and improve current water release rules. The Murrumbidgee and Murray regional water strategies will be able to integrate the review's work with other options identified in the strategies. Several provisions in the Snowy Water Licence have rules with hydrologic or operational links to the upper Murrumbidgee, the regulated Murrumbidgee and the Murray rivers.[56] For the regional water strategies, this means that hydrologic models for both the Murray and Murrumbidgee regions need to be run iteratively and integrated with the Snowy Scheme hydrologic model.

54. Snowy Hydro Limited website 2020, *The Snowy Scheme*. Retrieved from www.snowyhydro.com.au/generation/the-snowy-scheme/
55. Snowy Hydro Limited website 2020, *Water*. Retrieved from www.snowyhydro.com.au/generation/water/
56. The required annual release volumes from the Snowy Scheme are influenced by any inter-valley transfers, callouts from Drought Accounts, compensation releases and downstream wet sequence protection volumes. Some environmental releases are linked to allocations in the Murray and Murrumbidgee.

Figure 13. The Snowy Scheme developments[57]



Source: www.snowyhydro.com.au/our-energy/hydro/the-scheme/

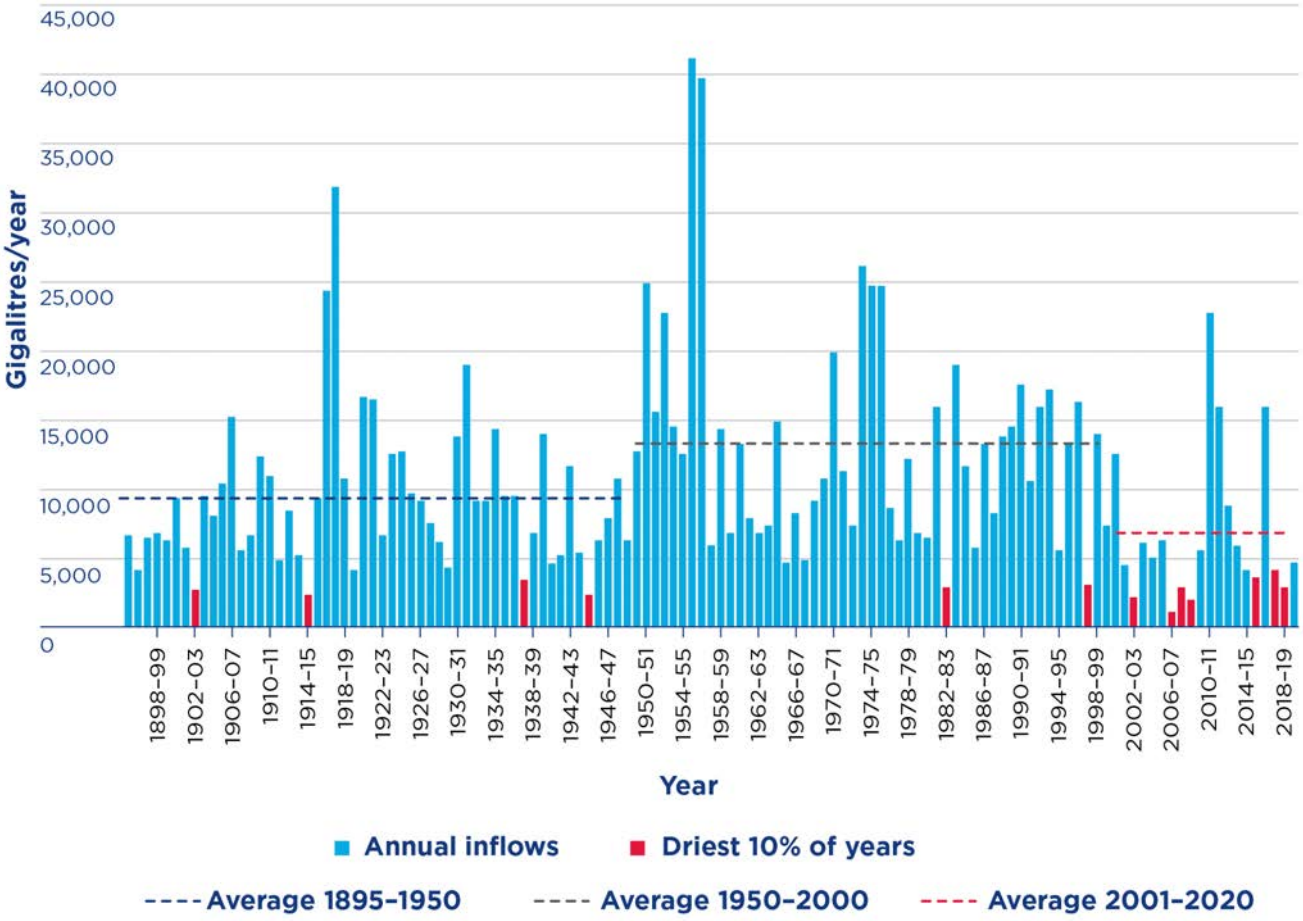
The Murray River supports towns, a large agricultural sector and environmental assets. It is also fundamentally important for the wellbeing of Aboriginal people with tens of thousands of years of continuous connection to it, as well as a tourist industry that supports 20% of jobs in local communities on both sides of the Murray River.[58]

57. Snowy Scheme. Retrieved from www.snowyhydro.com.au/our-energy/hydro/the-scheme/
58. Department of Industry 2018, *Ten-year review of the Snowy water licence, Final report*. See www.industry.nsw.gov.au/water/basins-catchments/snowy-river/corporate-licence/review

The impacts of a changing, variable climate on the regulated Murray system

Inflows to the region are highly variable. As shown in Figure 14, annual regulated Murray system inflows averaged around 9,000 GL in the first half of the twentieth century, but increased to around 13,000 GL in response to higher rainfall in the latter half. However, the past 20 years have seen long term declines, with significantly less median annual inflow to the Murray River system than the preceding century. Further, dry years are now more common, with half of all the driest years on record occurring in the past 20 years.[59]

Figure 14. Annual inflows to the shared Murray River resources



Source: Murray–Darling Basin Authority

59. Interim Inspector-General of Murray–Darling Basin Water Resources 2020, *Impact of lower inflows on state shares under the Murray–Darling Basin Agreement*.

Median annual inflows into Dartmouth and Hume dams from 1895 to 2000 were close to 5,000 GL, however, these have reduced to around 3,500 GL over the last 20 years. Eight of the driest 13 years ever recorded have occurred in the past 20 years.[60] This is reflective of a changing climate, with drier years being becoming more prevalent, leaving less water for agriculture, towns and the environment.

Hydrologic modelling, based on the new climate datasets, for the NSW Murray region is still underway and will contribute to the final Murray Regional Water Strategy. However, it is possible to view trends in similar modelling results for the nearby Lachlan region which is affected by the same key climate drivers. For example, inflows into Wyangala Dam could be lower in all months under dry future climate projection scenarios. The most obvious changes are significantly lower average inflow in winter and spring.[61]

Other key findings for the Lachlan region include:

- The high variability of climate conditions seen historically is fairly normal when viewed against the long-term records.
- Droughts similar to the Millennium Drought have occurred in the past.
- Storage levels in Wyangala Dam could be consistently lower, based on future climate projections.
- Times between droughts could shorten, and periods between when dams are full could lengthen.[58]

Considering these trends in the Lachlan region, the observed recent reductions to inflows in the NSW Murray region, the potential reductions in winter rainfall and increases in evapotranspiration across the year (see Figure 10 and Figure 11), the Murray Regional Water Strategy presents an opportunity to address these challenges while seeking to achieve the five regional water strategy high-level objectives.

A note of caution about modelling

The scenarios that will be modelled will not necessarily eventuate. They are potential scenarios with a level of uncertainty.

This type of modelling is complex and has a number of limitations and uncertainties which need to be taken into account as part of the water planning and decision making process.

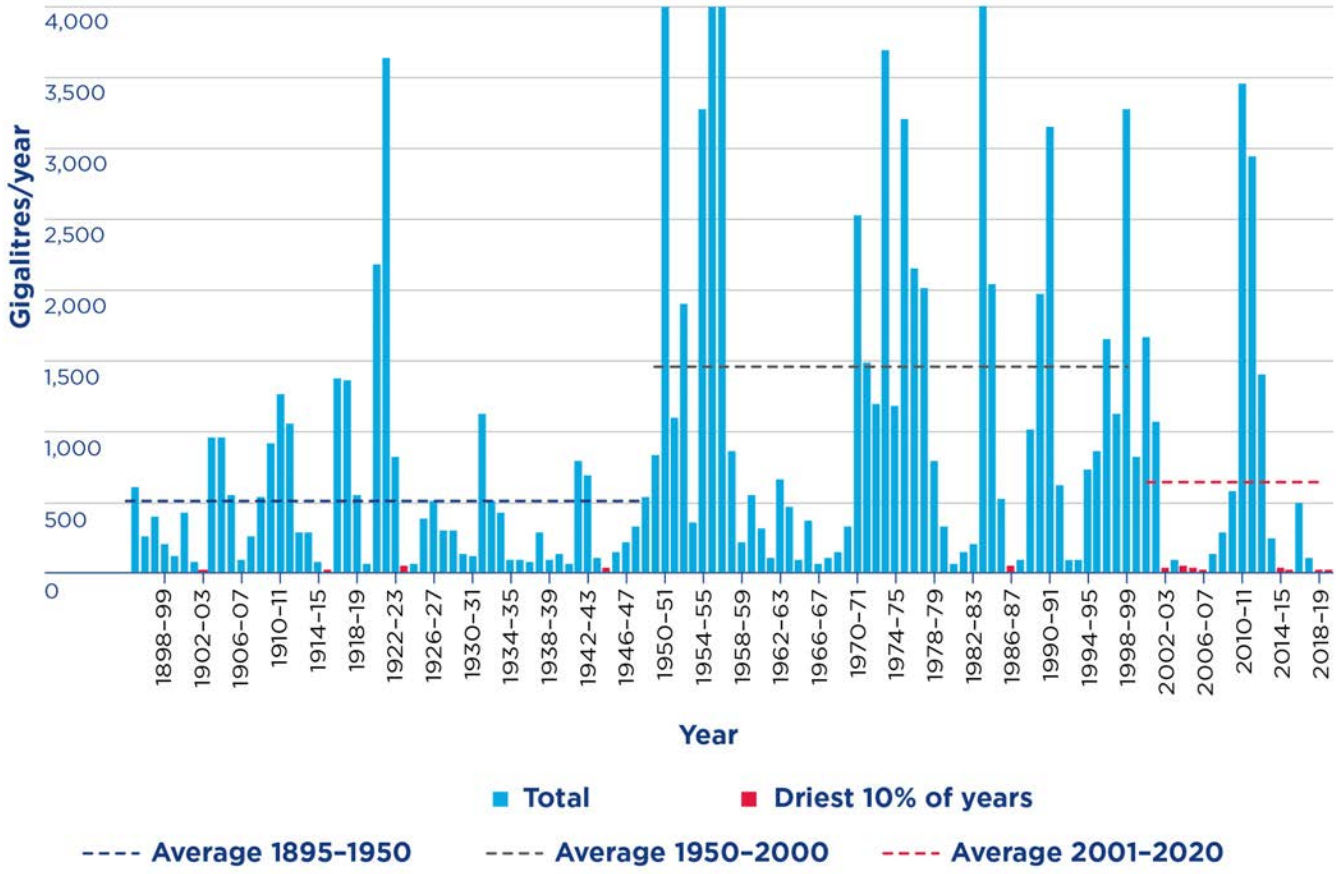
In some instances, this may mean managing risks to our water security by being fully prepared and resilient to all possibilities, rather than relying on firm predictions and hard numbers.

Further information about the new climate risk modelling is provided in the Regional Water Strategy Guide and at water.dpie.nsw.gov.au/plans-and-programs/regional-water-strategies/climate-data-and-modelling

60. Interim Inspector-General of Murray–Darling Basin Water Resources 2020, *Impact of lower inflows on state shares under the Murray–Darling Basin Agreement*. Canberra. CC BY 4.0.
61. Department of Planning, Industry and Environment 2020, *Draft Regional Water Strategy: Lachlan*. See www.industry.nsw.gov.au/__data/assets/pdf_file/0019/324514/lachlan-strategy.pdf

The period 1895–1950 saw the lowest average inflows (around 500 GL) from the Lower Darling River into the Murray River, as shown in Figure 15. During the wetter period from 1951–2000, these inflows increased significantly to around 1,400 GL, but declined again significantly to around 600 GL after 2000. This shows that the long-term climate is quite variable.

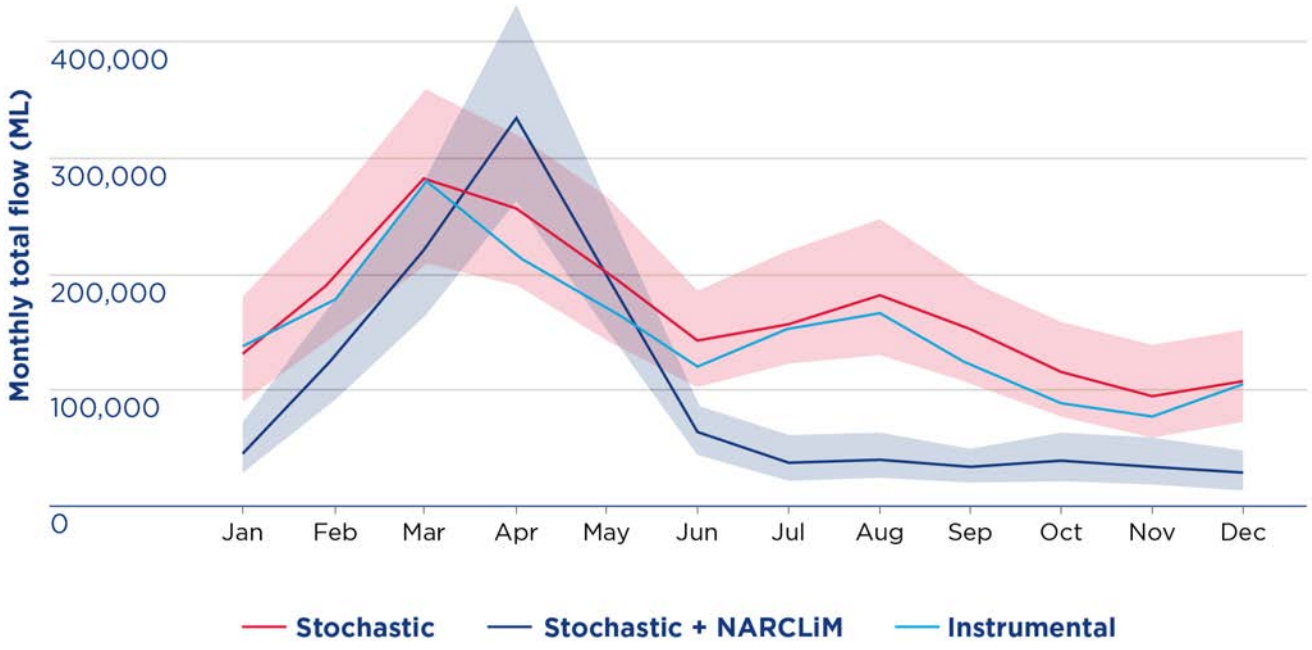
Figure 15. Inflows to the Murray from the Lower Darling River at Burtundy, 1895–2020. The driest 10% of years comprises the 12 driest years out of the total 121-year record period. This also includes years of no flow, which do not have any bars



The climate is also highly variable over shorter timescales. Between late 2016 and early 2020, Menindee Lakes did not receive any significant inflows. From the end of 2018, the lakes were at less than 2% capacity for over 12 months. However, by October 2021, the lakes had filled and exceeded capacity to reach 114% (1,980 GL).

Our new climate datasets and modelling, which are informing the Draft Western Regional Water Strategy, suggest that inflows into the Menindee Lakes system have been equally variable in the more distant past (stochastic record) compared to the inflows we have seen over the recorded historical records. In addition, overlaying conservative climate change projections from NARCliM 1.0 (see breakout box 'Using Climate change projections in water modelling work' in Section 2.1.2), we could observe, on average, a significant decrease in winter and spring Menindee inflows, with an increase in late summer and autumn inflows (Figure 16).

Figure 16. Average monthly inflows to Menindee Lakes



Median outflows of NSW-owned water from the Murrumbidgee River and Billabong Creek into the Murray River have reduced by two-thirds over the past 20 years, compared with the previous century. Periods of higher inflows from these tributaries have tended to arise from flood events, with limited ability to regulate these flows once they reach the Murray River.[30]

The region has experienced extended droughts with extreme low-inflow periods

The NSW Murray region has experienced extreme droughts[62] over the past 129 years of observed records. The most well known are the Federation Drought (1895–1902), the World War II Drought (1937–1945), and the Millennium Drought (2002–2010).[63] A review of the observed historical records indicates that persistent droughts have commonly and increasingly ended with significant high-rainfall events.

62. Drought is defined in terms of periods of rainfall deficit (meteorological drought), low catchment streamflow (hydrologic drought) and soil moisture depletion (agricultural drought). This strategy discusses meteorological and hydrologic drought.
63. Bureau of Meteorology, *Previous droughts*. Retrieved from www.bom.gov.au/climate/drought/knowledge-centre/previous-droughts.shtml

The Millennium Drought was the longest and most severe drought recorded in the NSW Murray region, with the lowest annual inflows recorded in 2006/07.

In 2006, at the height of the Millennium Drought, the inflows to the Snowy Scheme also fell below the previously recorded minimums (1936–46), which were used to set the volume of required annual releases from the Snowy Scheme.[64] This meant that the Snowy Scheme was not able to provide the required annual releases in 2006/07 for the first time since the scheme was completed in 1974. From November 2006 to September 2011, the Water Sharing Plan for the *New South Wales Murray and Lower Darling Regulated River Water Sources 2003* was suspended due to these severe water shortages.

The 2017–19 drought again saw severe rainfall deficiencies, particularly in the cooler months. This period resulted in some of the lowest two- and three-year rainfall totals recorded for the Riverina and the Monaro areas. The Snowy Mountains and Victoria's alpine region, all key places for Murray River inflow generation, also had their driest years on record. Over the same period, potential evapotranspiration across the region was above average to very much above average.[65, 66, 67]

Periods of extreme climate and very low inflow conditions, such as those described above, can critically stress water supplies. During the Millennium Drought, a range of contingency measures were developed by states and the Murray–Darling Basin Authority to manage interstate water sharing during the unprecedented conditions, including:

- increasing the drawdown of weir pools along the Murray River
- reducing releases from storages below previously established minimum levels at key points within the regulated river system
- changing water accounting between the states, principally for inflows from the Lower Darling River when the Menindee Lakes were solely under NSW control.

The Millennium Drought also highlighted a need for collective arrangements to manage drought in the Murray system, and these arrangements are now embodied in the Murray–Darling Basin Agreement via a new Schedule H included in the Agreement in 2011. These new provisions require NSW and Victoria to maintain a conveyance reserve (currently 225 GL), and set out three tiers of operation:

- Tier 1—all states can meet critical human water needs under normal operation
- Tier 2—normal operation cannot ensure collective conveyance requirements
- Tier 3—at least one state cannot provide critical human water needs, and emergency management by the Ministerial Council is required that includes the potential for negotiation of 'advances' between states.

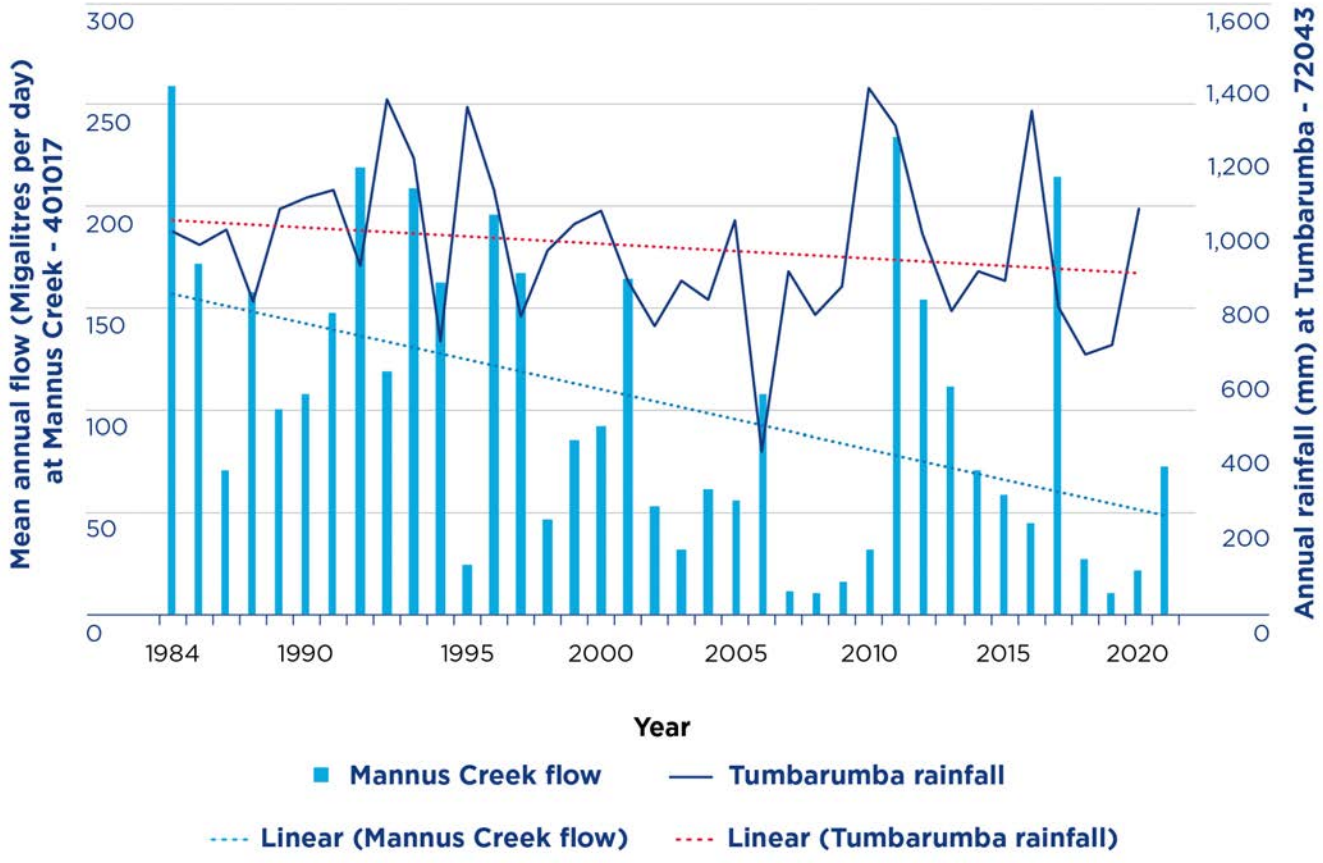
It is expected that extreme droughts will continue to periodically impact the NSW Murray region and its water resources. Accordingly, a range of challenges and opportunities are presented throughout this strategy, which seek to achieve better water resource management outcomes in a future with a highly variable and changing climate.

64. Department of Industry 2018, *Ten-year review of the Snowy water licence Final Report*. Retrieved from www.industry.nsw.gov.au/__data/assets/pdf_file/0003/209109/ten-year-review-of-the-snowy-water-licence-final-report.pdf
65. Bureau of Meteorology. n.d. *Special Climate Statements*. Retrieved from www.bom.gov.au/climate/current/statements/
66. Bureau of Meteorology 2020, *Special Climate Statement 70—supplementary information*. Retrieved from www.bom.gov.au/climate/current/statements/scs70-supplementary-tables.pdf
67. Bureau of Meteorology 2020, *Special Climate Statement 70 update—drought conditions in Australia and impact on water resources in the Murray–Darling Basin*. Retrieved from www.bom.gov.au/climate/current/statements/scs70.pdf

2.2.2 Unregulated rivers and creeks, and the impact of a changing, more variable climate

A series of unregulated rivers and creeks run throughout the NSW Murray region, particularly in the elevated areas east of Albury; including Tumbarumba and Mannus creeks, Bombala and Delegate rivers. Like the regulated rivers, unregulated watercourses in the NSW Murray region have also experienced a decline in flow, which is reflective of the drying pattern observed across the region. Figure 17 shows a very large decline in average annual flows in Mannus Creek against a more modest decline in annual rainfall since 1984. Factors such as seasonality of rainfall, land-use changes and bushfires also impact the amount of run-off and streamflow. For more information on such processes, refer to 'Catchments and key watersheds' (see Section 2.2.1).

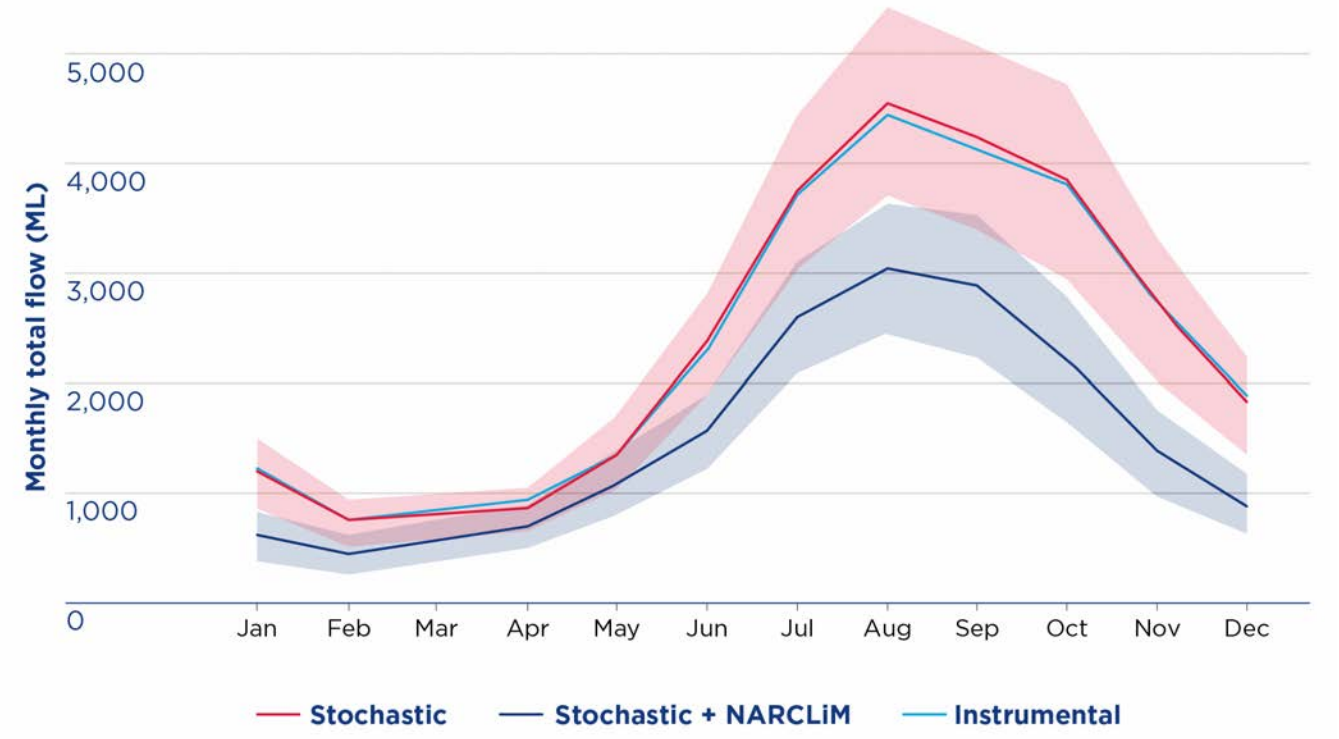
Figure 17. Average annual flow in Mannus Creek compared with annual rainfall at nearby Tumbarumba



Source: realtimedata.waternsw.com.au/

Our new climate modelling shows a continuation of this observed trend of reduced flows. For nearby Tumbarumba Creek with a significant decline in flows throughout the year, we see even more of a reduction in the winter/spring period (Figure 18).

Figure 18. Modelled inflows into Tumbarumba Dam from Tumbarumba Creek



Many smaller towns such as Tumbarumba, Bombala, Nimmitabel, Delegate and the alpine resorts generally rely upon water from unregulated surface water supply, and some towns have a backup groundwater supply.

Most of these rivers are perennial or near-perennial, but sometimes there is insufficient surface flow to provide a reliable supply. Further discussion on town water supplies is provided in Section 2.3.2.

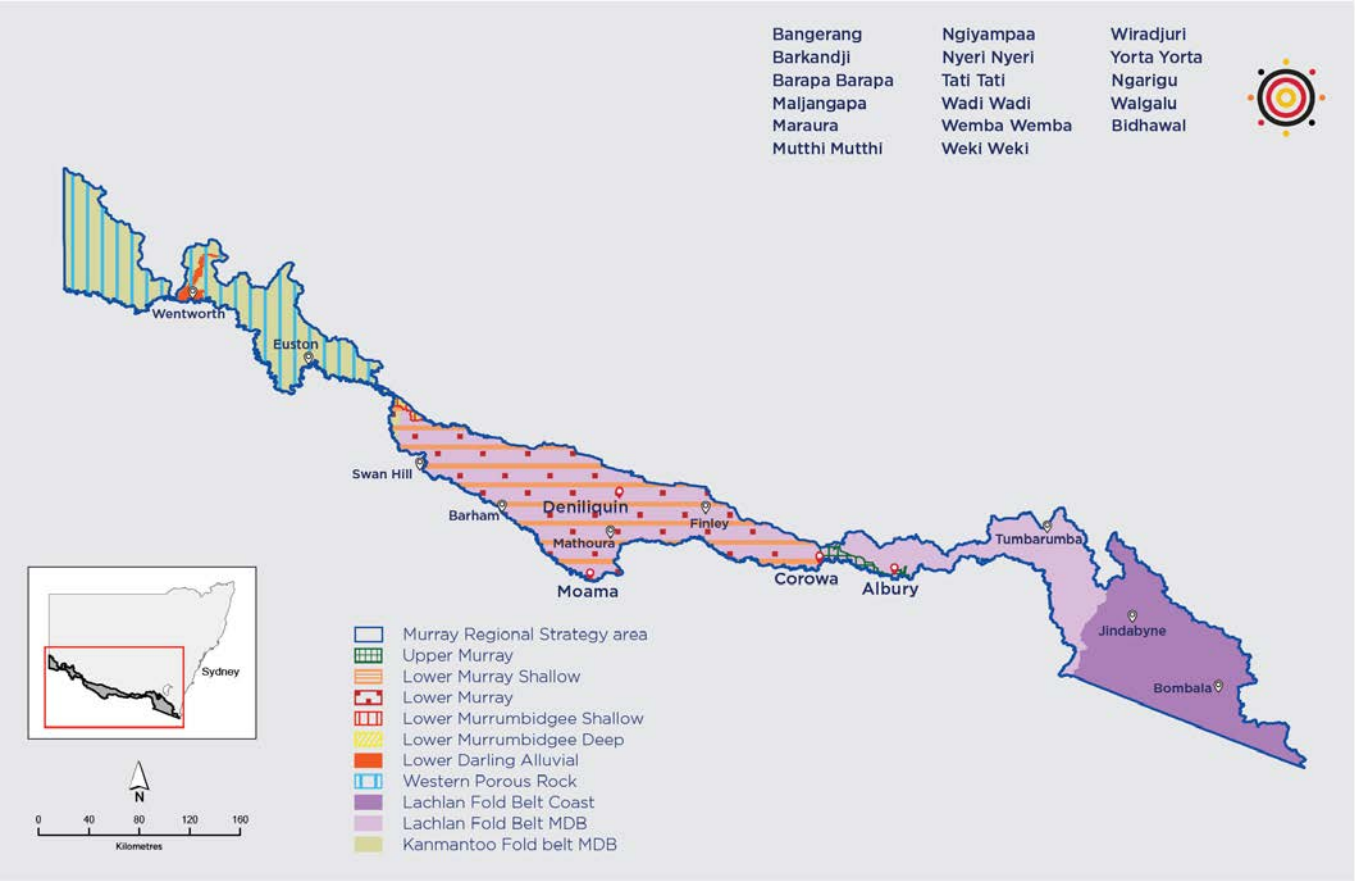
2.2.3 Groundwater

Groundwater is an important water source for towns, industries and the environment in the NSW Murray region (Figure 19).

Groundwater availability and quality varies across the region according to the geology and location. Groundwater in the region is found in different geological layers:

- The lowest (basement) formations are the fractured rocks of the Lachlan Fold Belt MDB Groundwater Source and Kanmantoo Fold Belt MDB Groundwater Source.
- Overlying the fractured rocks are the porous rocks of the Western Murray Porous Rock Groundwater Source and the buried Oaklands Basin Groundwater Source.
- Alluvial sediments are the topmost formation, and are associated with major rivers in the lower catchment.

Figure 19. Groundwater resources of the NSW Murray region



Alluvial groundwater sources

The upper Murray Alluvium consists of sediments associated with the Murray River, extending from Hume Dam near Albury, to Corowa further west. There is no regular groundwater quality monitoring of the upper Murray Alluvium, however, ad hoc water quality measurements indicate that salinity is low, especially within five kilometres of the Murray River. Higher-salinity groundwater can be found further away from the river. Overall, groundwater in the upper Murray Alluvium is good quality and easy to access.

There are many groundwater bores in the upper Murray Alluvium. Most groundwater bores (approximately 730) are used for stock and domestic purposes. However, there are also around 120 bores used for irrigation that can extract moderate to high volumes of water each year. Groundwater from this source is also used as the main water supply for the township of Balldale. Concentrated pumping of groundwater around Howlong and Corowa has resulted in small declines in groundwater levels.

From upstream of Corowa to Kyalite in the west, the alluvial sediments are divided into two groundwater sources:

- Lower Murray Shallow Alluvium—from 0 to 20 m deep.
- Lower Murray Deep Alluvium—from 20 m depth to bedrock (base).

There is heavy reliance on the Lower Murray Deep Alluvium for irrigation, particularly east of Wakool to Finley. High pumping yields and low salinity mean that groundwater is easy to access and requires minimal treatment.

There have been large groundwater level declines around Deniliquin and Finley.[68] Seasonal fluctuations can be up to 10 m, but there is an overall declining trend in groundwater levels in some monitoring bores. Option 12 from the long list would develop a policy with a series of escalating management actions corresponding to stages of water level decline. It would help provide certainty to all water users about what actions the NSW Government will plan to take and when.

Large declines in groundwater levels can result in sediment compaction, which occurs when too much water is extracted and the spaces between the sediments collapse in on themselves. Sediment compaction can cause the land surface to subside; damage infrastructure such as roads, pipelines and foundations; and can cause the collapse of bores. It can permanently reduce how much water can be stored within an aquifer. There is no evidence of this occurring in the Lower Murray Deep Alluvium, but a long-term monitoring program is needed to help ensure it does not occur in the future (see Option 19: Monitor sediment compaction over the long term).

Another key challenge in the Lower Murray Deep Alluvium is increasing salinity between Deniliquin and Tocumwal.[69] This changed the water's suitability for irrigating some crops. The increasing salinity could be due to concentrated groundwater extraction in the area. There needs to be more investment in groundwater quality monitoring in the NSW Murray region, and this is addressed by Option 17.

68. Department of Industry 2019, *Appendix A: Murray Alluvium Water Resource Plan—Ground Water Resource Description*. See www.industry.nsw.gov.au/__data/assets/pdf_file/0004/230674/appendix-a-murray-alluvium-wrp-groundwater-resource-description.pdf
69. NSW Office of Water 2011, *Characterisation of hydrogeochemistry and risks to groundwater quality*. Impact of groundwater pumping on groundwater quality. National Water Commission—Raising National Water Standards Program. See www.industry.nsw.gov.au/__data/assets/pdf_file/0003/151770/Characterisation-of-hydrogeochemistry-and-risks-to-groundwater-quality.pdf

In 2005, the Achieving Sustainable Groundwater Entitlements Program addressed unsustainable groundwater use in the NSW Murray region. Entitlements were reduced by 69%, taking account of each individual licence holder's history of extraction. Where a licence holder's history of extraction was greater than their reduced entitlement, a supplementary water access licence was granted and gradually reduced over 10 years to zero.

Groundwater resources rarely fall neatly within the boundaries of surface water catchments and local government areas. The boundaries for the regional water strategies are no exception. Several groundwater sources span across the Murrumbidgee and Murray regions, and/or are accessed by communities in multiple regions and across state boundaries. This highlights the necessity for the Murray and Murrumbidgee regional water strategies to be well-coordinated to ensure sustainable management, particularly when shared groundwater sources are accessed by water users in different regions.

The Lower Murray Shallow Alluvium is generally very saline, although there are some pockets of moderate-yielding, fresh groundwater. Irrigation is concentrated around the Berriquin Irrigation District, but there is a greater reliance on the Lower Murray Deep Alluvium for irrigation purposes.

One of the key challenges for the Lower Murray Shallow Alluvium is rising groundwater levels, which is causing waterlogging and land salinisation. This is managed in some areas—for example, by the Wakool Tullakool Subsurface Drainage Scheme, with a water entitlement of 20,000 ML to reduce groundwater levels.

The Billabong Creek Alluvium is made up of alluvial sediments (clay, silt, sand and gravel) associated with the Billabong Creek, which flows along the northern boundary of the NSW Murray region. This groundwater source is relatively small, with a low level of use compared to the upper Murray Alluvium and Lower Murray Deep Alluvium. The groundwater is mainly used for stock and domestic purposes, with some use for irrigation and town water supplies for Walbundrie, Walla Walla, Culcairn and Holbrook. The key challenge for the Billabong Creek Alluvium is a narrowing of the alluvium north of Walla Walla, forcing relatively high saline groundwater to the surface and discharging it into Billabong Creek. This is currently managed by the Billabong Creek Salt Interception Scheme, which pumps fresh groundwater from deep alluvium to reduce deep groundwater pressure and prevent shallow, saline groundwater entering the creek.

Options presented in this draft regional water strategy aim to address challenges in alluvial groundwater sources by:

- investigating land use change impacts on water resources and improving monitoring of the resource (Option 36: Improve the understanding of groundwater sources and processes, risks and impacts)
- providing sustainable access to groundwater for all users (Option 11: Review of groundwater extraction limits)
- reducing the risk of sediment compaction due to over-extraction of groundwater (Option 19: Monitor sediment compaction over the long term).

Porous rock groundwater sources

Groundwater from the Western Murray Porous Rock source is used for mining, stock and domestic purposes. Using this source can be limited by low to moderate bore pumping yields and salinity. Highly saline groundwater has the potential to flow to surface water sources; and this flow can also be influenced by river regulation, like the operation of locks and weirs, as well as off-river storages (e.g. Lake Victoria). Since the 1980s, salt interception schemes have been placed on the southern border of the source to intercept the saline groundwater before it reaches the Murray River.

The Oaklands Basin is another porous rock groundwater source in the NSW Murray region. Groundwater from this source is not used, as it is highly saline, and difficult and expensive to access. The Oaklands Basin is a completely buried groundwater source and any extraction of groundwater would deplete the resource, because there is negligible recharge. Although there have been petroleum exploration licences issued, there has been minimal exploration of the basin since it was discovered in 1916.

Additional investigation is needed to understand porous groundwater sources and their potential as non-potable water sources (Option 36: Improve the understanding of groundwater sources and processes, risks and impacts and Option 42: Undertake joint exploration for groundwater with the NSW Geological Survey).

Fractured rock groundwater sources

The Lachlan Fold Belt MDB Groundwater Source is a fractured rock groundwater source that underlies the eastern part of the NSW Murray region, whereas the Kanmantoo Fold Belt MDB Groundwater Source is located in the west. Currently, Tumbarumba supplements its town water supply with groundwater from the Lachlan Fold Belt MDB Groundwater Source.

When compared to the alluvial and porous rock groundwater sources, fractured rock groundwater sources generally have lower yields and are more variable in water quality—but higher yields are possible. An option to undertake joint exploration of fractured rock systems for minerals and groundwater with NSW Geological Survey has been included to maximise the use of this water resource (Option 42: Undertake joint exploration for groundwater with the NSW Geological Survey).

Groundwater opportunities

NSW has a robust groundwater management framework that has undergone significant reform. However, opportunities still exist to improve how we manage groundwater resources.

During periods of drought with limited surface water availability, water users more often rely on groundwater. A changing climate, increasing population and economic growth may lead to greater demand for groundwater in the future. The ability of groundwater sources to meet this demand may be limited, because most of the good-quality, easily accessible groundwater sources in the NSW Murray region are fully committed.

Managed aquifer recharge may be able to be developed in the NSW Murray region. Managed aquifer recharge is the intentional recharge of water into aquifers (through infiltration or direct injection) for later use or environmental benefit. It could improve the drought resilience of groundwater resources and improve water security, as it offers a water storage solution during wet years and increases groundwater availability during dry periods. It can improve storage efficiency because it reduces the amount of water lost to evaporation.

Managed aquifer recharge can be an efficient way to manage and dispose of treated wastewater. However, there are significant technical, economic, policy, interstate and regulatory challenges that need to be addressed if managed aquifer recharge is to be considered as a realistic water security solution in NSW. Option 21: Managed aquifer recharge investigations and policy, proposes developing a policy, and regulatory framework to enable storage and recovery of this water.

Groundwater opportunities in the NSW Murray region rely on better understanding the resource, improving industry and local council understanding of groundwater systems, and providing greater transparency around how regulators and government will make groundwater management decisions.

Given the expected, continuing demands on groundwater, increasing our understanding of the interaction between surface water and groundwater resources in the NSW Murray region will help to improve our management of connected water sources. We need to better understand how a change in groundwater use can influence flows to rivers and vice versa.

We also need to understand how our changing climate is impacting the replenishment of groundwater resources. Generally, the larger groundwater resources are resilient and respond more slowly to changes in climate, but this means the impact of present-day activities on groundwater may not be realised for decades. Under a future dry climate change scenario, lower rainfall will likely result in less recharge to groundwater resources. Recharge from rivers is also likely to be reduced if surface flows are lower and there are fewer floods.

The draft strategy includes options to improve our understanding of groundwater processes (Option 36: Improve the understanding of groundwater sources and processes, risks and impacts), and provide training opportunities about groundwater and the likely impact of climate change on groundwater sources (Option 38: Develop targeted education and capacity building programs).

Options are also proposed to protect ecosystems that depend on groundwater resources, including Option 26: Improved protection of groundwater dependent ecosystems and Option 7: Incorporate Aboriginal history of water and culture in the southern Basin into water data.

An extensive groundwater monitoring network exists across regional NSW, with data going back to the 1970s. In the NSW Murray region there are over 1,000 monitoring bores; however, many of these bores are old and need maintenance or replacement. We need to ensure ongoing investment in the groundwater monitoring network, so we have the water level and quality information we need to manage the resource into the future.

Gaining knowledge about groundwater availability across the entire NSW Murray region, not just in areas where it is usually accessible, and providing this information to local water utilities and industries could significantly improve planning for drought. It could also help communities make informed decisions about which water sources to access at different times.

2.2.4 Key catchments and watersheds

The way in which rainfall interacts with the region's diverse landscapes varies significantly. This is because when rain falls onto land it can either be absorbed and held in the soil; be taken up by plants; evaporate back into the air; infiltrate deeper into the ground; or pool on the surface and run off into gullies, creeks and rivers. Factors influencing where the water goes include rainfall intensity and amount, snowfall, temperature, wind, ground slope, soil-moisture conditions, soil permeability, vegetation cover and maturity, leaf-litter cover and soil-surface properties.

Changes to catchment conditions and land use have contributed to run-off and water quality issues in the region. Run-off from cropping and grazing areas, erosion of soil and nutrients from stream banks, and discharge from localised saline areas have led to increased turbidity, salinity, sedimentation and nutrient loads. These in turn can degrade aquatic ecosystem health. Major catchment-scale issues in the NSW Murray region are outlined below.

Intense bushfires can reduce the quality and volume of run-off

Shortly after an intense bushfire, loose soil, ash, debris and nutrients often wash into watercourses causing short-term but serious impacts such as fish deaths and contamination of town water supplies.[70] Over periods lasting up to and exceeding a century, there can be significant declines in run-off volumes as forests regrow. The catastrophic 2003 bushfires in the Snowy Mountains and Victorian Alps led to one estimate[71] of a reduction by 859 GL/year in average Murray River streamflow (downstream of the Ovens River confluence) by about 2026.

It is important to note that there has been more than one recent major bushfire in the key run off–generating catchments of the Murray River, with notable ones occurring in 2003, 2006/07 and 2019/20. In addition, the impacts of each fire are different, depending on the location and intensity of the burn, as well as the type of vegetation burnt and other factors. As such, each of these fires will have a different impact on run-off rates over time.

Furthermore, given a warming climate and an increased risk of severe fire weather (Section 2.1.2), bushfire risk is expected to worsen over the coming decades.

As such, we need to better manage our key catchments and watersheds to avoid adverse fire regimes and associated water-quantity and water-quality impacts. Option 44: Consider hydrologic processes considered in bushfire management, seeks to investigate how bushfire management can be strengthened in priority areas by including protection of rainfall run-off processes as a key bushfire management priority.

70. ewater.org.au. 2020, *Bushfire Impacts on Hydrology*. Retrieved from www.ewater.org.au/bushfire-impacts-on-hydrology/
71. Hill, P.I., Mordue, A. Nathan, R.J., Daamen, C.C., William, K., Murphy, R.E. 2008, *Spatially Explicit Modelling of the Hydrologic Response of Bushfires at the Catchment Scale*. Australian Journal of Water Resources Vol 12. No. 3 and Water Down Under 2008. 1472–1480. www.tandfonline.com/doi/abs/10.1080/13241583.2008.11465354

Improving soil carbon content provides local and downstream benefits

Carbon or organic matter in the soil is a very important factor in how a landscape functions to retain moisture, carry it through drought, and release water to our creeks and rivers. Soil carbon is typically related to the amount of vegetation material both above and below the land surface.

When a landscape has experienced poor management, such as grazing or cropping regimes beyond its capacity, vegetation and soil carbon is depleted. Soils that have had their carbon levels depleted do not hold moisture or cycle nutrients well, leading to reduced drought tolerance and reduced productivity for farms. Depleted soils can also create faster rainfall run-off, which results in localised erosion, high sediment loads running through watercourses, poor water quality and reductions in baseflows. This can cause watercourses to flow for shorter time periods and cease to flow more frequently.

As such, we can simultaneously improve the productivity of farmlands, the health of our waterways and the quality of water for downstream water users by improving carbon levels in our landscapes. Refer to Option 31: Develop a river and catchment recovery program for the NSW Murray region.

Dryland salinity causes a range of local and downstream impacts on land and water resources

Dryland salinity occurs when rising groundwater mobilises salt in the landscape and redistributes it closer to the soil surface and into waterways. Groundwater levels can rise under dryland agriculture because of increasing rates of leakage and groundwater recharge; replacing deep-rooted perennial species such as native trees, shrubs and pasture with shallow-rooted, annual species; and incorporating long fallows into a cropping rotation.

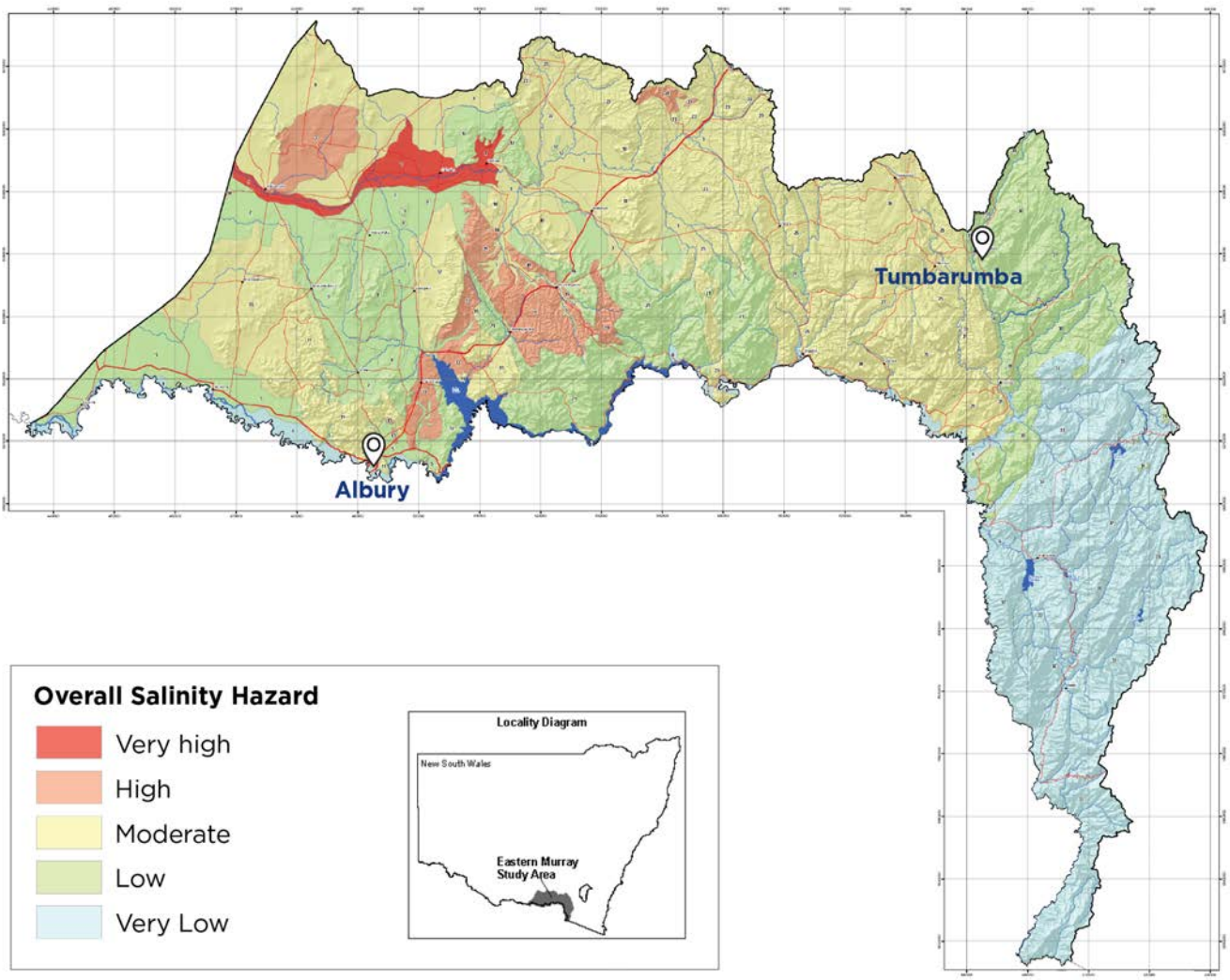
As the groundwater rises, salts found naturally in rocks and soil are dissolved and move toward the soil surface. Salt that reaches the soil surface will concentrate as the groundwater evaporates and can be mobilised into waterways—creating water quality problems downstream.[72]

Areas of high dryland salinity hazards exist in the areas to the south-east and north-east of Hume Dam, as shown in Figure 20. There are also areas of very high salinity in the Billabong Creek system further north, which are located within the Murrumbidgee region.

Much work has been done to manage dryland salinity over many decades, yet there are further opportunities—such as working with farmers to build awareness of ways to harness the natural functioning of their landscapes to address dryland salinity—that have benefits for farm profitability and other natural resource management outcomes. Further research is also needed to address knowledge gaps concerning groundwater dryland salinity. Refer to Option 31: Develop a river and catchment recovery program for the NSW Murray region.

72. Industry.nsw.gov.au 2009, *Prime Facts: Dryland salinity—causes and impacts*. Retrieved from www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/309381/Dryland-salinity-causes-and-impacts.pdf

Figure 20. Overall salinity hazard in the eastern Murray catchment



Source: Murray Catchment Management Authority, University of Canberra and NSW Office of Environment and Heritage.

Improving riparian and aquatic condition provides whole-of-catchment benefits

This is a key priority for areas of private land in the upper parts of the catchment, where there has been degradation of vulnerable riparian areas and waterways through uncontrolled stock access; clearing for agriculture or urban development; invasion by pests and feral animals such as rabbits, and weeds such as privet; or overuse from recreational activities.

Clearing riparian vegetation and reducing large woody debris deposits into waterways has led to loss of riffles, channel bed erosion, reduced in-channel water storage, and downstream water quality issues including algal blooms and turbidity issues. These impacts affect a wide range of beneficial water uses. Refer to Option 31: Develop a river and catchment recovery program for the NSW Murray region.

Floods in the region

Flooding is a vital, natural process that supports the NSW Murray region's ecological and agricultural productivity, and facilitates longitudinal and lateral connectivity along river systems. Floods provide flows that connect wetlands and floodplains with the river such as the NSW Central Murray Forests Ramsar site.

Floods distribute nutrient-rich material to the soils of the region's floodplains. Flood pulses also flush floodplains of any build-up of organic matter, salinity and nutrients that accumulate during the time between floods, which then fuel river ecosystems downstream. They provide important reproductive cues; and support breeding and recruitment for many fish, waterbirds, amphibians and invertebrates. Floods also assist groundwater recharge, help to fill dams, and improve water availability for consumptive and environmental water users.

However, floods can have significant detrimental impacts on people and businesses located on the NSW Murray region's floodplains—creating safety hazards; damaging public and private infrastructure; and causing other financial and economic loss through stock, fodder, crop and pasture losses. They can also cut transport links, restricting the movement of goods and people through a region.

The NSW Murray region has experienced significant flood events over the past 122 years of observed records, notably in 1906, 1931, 1956, 1975, 1993, 2010, and in 2011 when Jindabyne dam spilled for the first time since 1975.[70] The most recent significant flood occurred in spring 2016 when flows in November peaked at over 113,000 ML/day at Euston.[73]

Poor catchment management and excessive vegetation clearing can exacerbate the negative impact of floods. Floods that occur after extended dry periods can cause land degradation, soil erosion and damage to riverbank vegetation due to rapid wetting of the banks. If the period between floods becomes too long, floodplain organic matter can accumulate to such high levels that when a flood finally eventuates, it is washed into the river all at once, causing widespread hypoxic blackwater events. Such events occurred in 2011 and 2016, which resulted in widespread fish deaths and impacted recreational activities and town water supplies. Climate change is expected to make this phenomenon worse, with increasing temperatures and greater extremes of both long droughts and large, intermittent floods.

Hume and Dartmouth dams both play a role in reducing the frequency of flooding and influencing the timing of flood peaks in the Murray River, principally in the reaches closer to the dams. The overall result is a reduction in peak flow for smaller flood events, particularly winter and early spring floods that occur at a time when the dams have the capacity to store these flows. However, Hume Dam's ability to mitigate the peak flow of large floods is negligible when it is at or near full-supply level, because there is no additional capacity for flood flows.[74]

The intensity of heavy, flood-producing rainfall events is expected to increase with climate change, although the magnitude of the change cannot be confidently projected.[75] Rainfall extremes in the near future (to 2030) for NSW are not expected to be significant, because the changes fall within the range of inter-annual rainfall variability recorded in the past.[72]

Flood-management structures such as levees and banks have been constructed to mitigate the impacts of floods on life and property in the NSW Murray region. In doing so, they have disconnected and reduced the ability of the floodplains to attenuate floods and protect downstream communities, and have impacted the ecosystems of the floodplain and river. In response to such issues, a floodplain management plan was developed by the NSW Government and local stakeholders for the NSW Murray and Edward rivers floodplain in 2010, so that floodplain management activities would minimise risks to human life and property. For more information, refer to (Section 2.3.4).

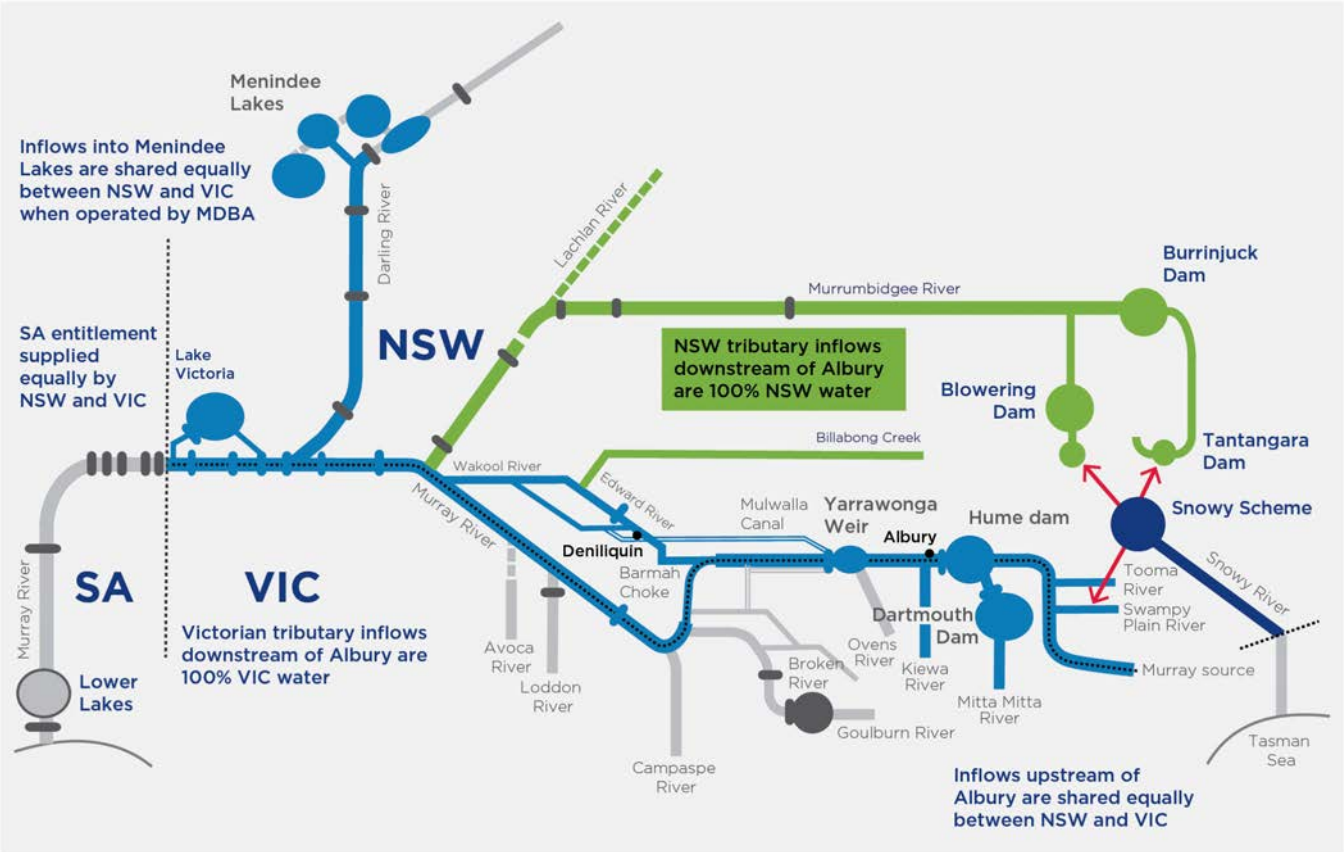
73. Murray–Darling Basin Authority 2021, *The River Murray system*. Retrieved from riverdata.mdba.gov.au/system-view
74. Murray–Darling Basin Authority 2020, *Managing floods at Hume Dam*. Retrieved from www.mdba.gov.au/water-management/infrastructure/hume-dam/managing-floods
75. Adapt NSW 2021, *Floods and Storms*. Retrieved from www.climatechange.environment.nsw.gov.au/Impacts-of-climate-change/Floods-and-storms

2.3 Managing water in the NSW Murray region

Water management in the NSW Murray region is highly complex. Interstate agreements and rules govern how water in the Murray River catchment is shared between NSW, Victoria and South Australia, including water released from the Snowy Scheme. Within the NSW Murray region and in other regions across NSW water is managed and shared under the *Water Management Act 2000* (NSW), with specific rules set out in respective surface water and groundwater water sharing plans.[76]

2.3.1 Sharing the Murray and Snowy rivers with Victoria and South Australia

Figure 21. Surface water resources of the southern Murray–Darling Basin; resources for the NSW Murray region are shown in lighter blue[77]



The Murray River

Figure 21 depicts the broader southern connected Basin rivers—including the Darling, Murrumbidgee, upper Murray and Victorian tributaries flowing into the regulated NSW Murray on its way into South Australia and eventually the Southern Ocean.

Apart from being hydrologically connected water sources, the Murray and Murrumbidgee rivers share many other interlinkages. Both rivers have headwaters in the Snowy Scheme, and the Snowy Water Licence requires sharing inflows to both rivers each year.

76. More information about water policy and planning is provided in the *Regional Water Strategies Guide*.
77. Options for the Menindee Lakes and Lower Darling River are discussed in the Draft Western Regional Water Strategy.

The *Water Sharing Plan for the Murrumbidgee Regulated River Water Source 2016* specifies end-of-system minimum flows for the Murrumbidgee River and Billabong Creek to meet low-flow connectivity requirements. Flows that exceed these are rainfall-driven higher flows as well as bulk inter-valley water transfers usually associated with the trade of water on the market (Section 2.3.6 gives more information on water trade).

In recent years, environmental flow delivery between the two systems has become more coordinated through a broader initiative to synchronise and optimise delivery from the key Murray River tributaries. In particular, return flows from upstream Murrumbidgee environmental watering actions are now able to be re-delivered in the Murray system to achieve environmental outcomes.

Similarly, the Murray River has strong interlinkages with the Lower Darling River; the two rivers join at Wentworth and are managed under the *Water Sharing Plan for the New South Wales Murray and Lower Darling Regulated Rivers Water Sources 2016*. Menindee Lakes, on the Darling River, is one of the shared water storages for NSW, Victoria and South Australia when the water storage level is above specified thresholds. As such, any changes to the operation of Menindee Lakes could also impact water availability in the Murray River. The Lower Darling River is covered by the Draft Western Regional Water Strategy.

The water resources of the Murray River system are shared between NSW, Victoria and South Australia in accordance with the Murray-Darling Basin Agreement. Overseen by the Murray-Darling Basin Ministerial Council[78] with the advice of the Basin Officials Committee,[79] the Agreement's purpose is to 'promote and co-ordinate effective planning and management for the equitable, efficient and sustainable use of the water and other natural resources of the Murray–Darling Basin, including by implementing arrangements agreed between the Contracting Governments to give effect to the Basin Plan, the *Commonwealth Water Act 2007* and state water entitlements.'

In collaboration with a range of other agencies, the Murray–Darling Basin Authority is responsible for managing the jointly owned assets of the Murray River system according to the Agreement, and the objectives and outcomes set by the Basin Officials Committee.[80] The Basin Plan also places obligations on the Murray–Darling Basin Authority in relation to river management. Combined, the Murray–Darling Basin Authority's role in managing the Murray River system includes:[81]

- sharing Murray River water between the three states (NSW, Victoria and South Australia)
- managing and operating infrastructure such as dams, weirs and locks
- overseeing construction and maintenance of water resource infrastructure.

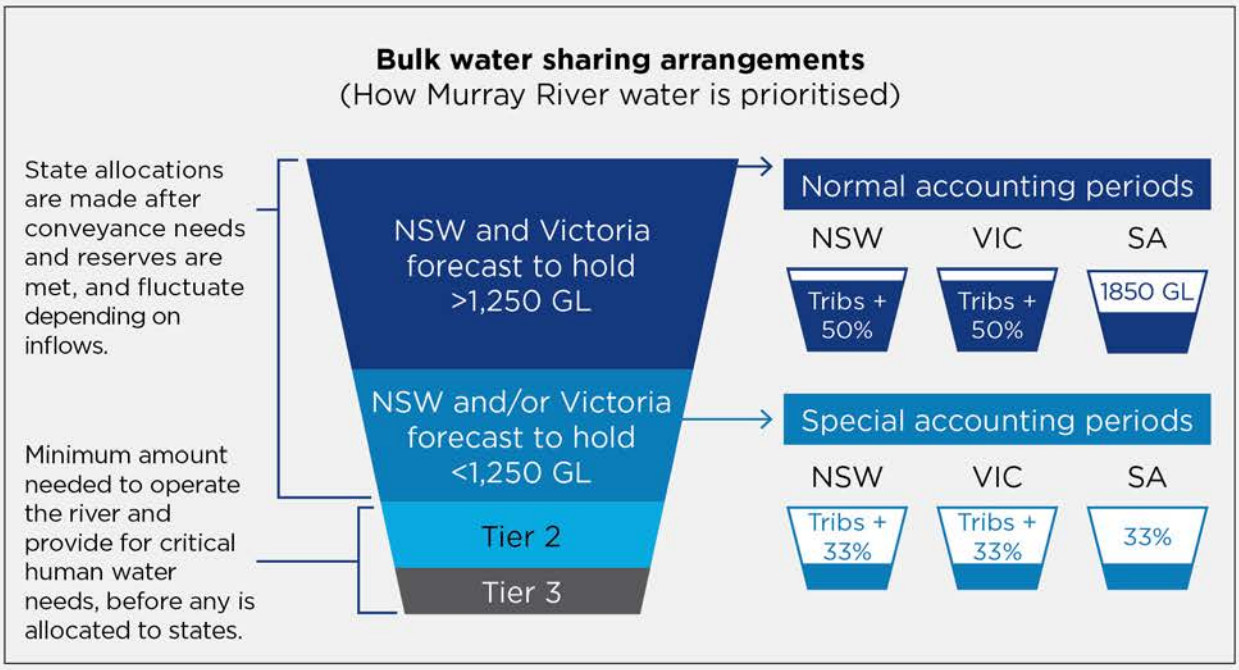
78. The Ministerial Council is a group of water ministers from the state and territory governments (Murray–Darling Basin only) and the Australian Government. Key functions and powers: consideration and determination of policy outcomes and objectives; determination on matters specified in the Murray–Darling Basin Agreement; approval of the annual corporate plan, budget and asset management plan prepared by the Murray–Darling Basin Authority; agree to amendments to the Murray–Darling Basin Agreement.
79. The Basin Officials Committee is a group of senior water managers from the state and territory government (Murray–Darling Basin only) and Australian Government agencies. They are responsible for providing advice to the Ministerial Council, and for implementing policy and decisions of the Ministerial Council on matters such as state water shares and the funding and delivery of natural resource management programs.
80. Murray–Darling Basin Authority 2021, *Objectives and outcomes for river operations in the River Murray System*. See www.mdba.gov.au/publications/mdba-reports/objectives-outcomes-river-operations-river-murray-system
81. Murray–Darling Basin Authority 2020, *Who manages the Murray–Darling Basin?* Retrieved from www.mdba.gov.au/water-management/allocations-states-mdba/managing-murray-river

High-level water sharing arrangements under the Murray–Darling Basin Agreement

The Murray–Darling Basin Agreement is a legal instrument that embodies the long-standing agreement between NSW, Victoria and South Australia to share the water of the Murray River and many of the rivers that flow into it. Schedule 1 of the *Water Act 2007* sets out rules and provides a framework of powers and responsibilities (Figure 22):

- Critical human water needs and conveyance water for NSW, Victoria and South Australia are prioritised to ensure basic human water needs along the river can be met, and to cover in-stream losses along the river when delivering water for entitlement holders.
- NSW and Victoria equally share all inflows into Dartmouth and Hume dams and from the Kiewa River. This is essentially all inflows upstream of Albury, and includes releases from the Snowy Scheme's southern Snowy-Murray Development.
- Inflows to the Menindee Lakes are also shared equally between NSW and Victoria, except when NSW needs to manage water for local supplies. This occurs when the volume of water in the lakes drops below 480 GL. They do not become available to the Murray–Darling Basin Authority again until volumes exceed 640 GL.
- Murrumbidgee River and Billabong Creek inflows belong to NSW, while inflows from the Ovens, Goulburn, Campaspe and Loddon rivers belong to Victoria.
- The South Australian entitlement volume (1,850 GL/year) is supplied equally by Victoria and NSW from their share of Murray water.

Figure 22. Sharing Murray system water between the states



As shown in Figure 22, special accounting arrangements are enacted during periods of low water availability, when NSW and Victoria are expected to hold less than 1,250 GL. This is essentially a period of 'water restrictions' at the state level, meaning that each state receives an equal one-third share of the limited, shared supply.

During extreme dry periods, further restrictions are enacted when Tier 2 ('insufficient conveyance water available to operate the river') and Tier 3 ('insufficient water available for critical human needs') are put into place by the Murray–Darling Basin Authority.

The Agreement also provides requirements for implementing the ***Basin Salinity Management 2030*** strategy—including end-of-valley salinity targets for each valley in the southern connected system.

There is a long history of collaboration between state and Australian Government agencies to manage the southern connected basin. However, cross-border water management at such a large scale can be challenging at times, and particularly because changes to the Agreement must be agreed (by consensus) by the Murray–Darling Basin Ministerial Council.

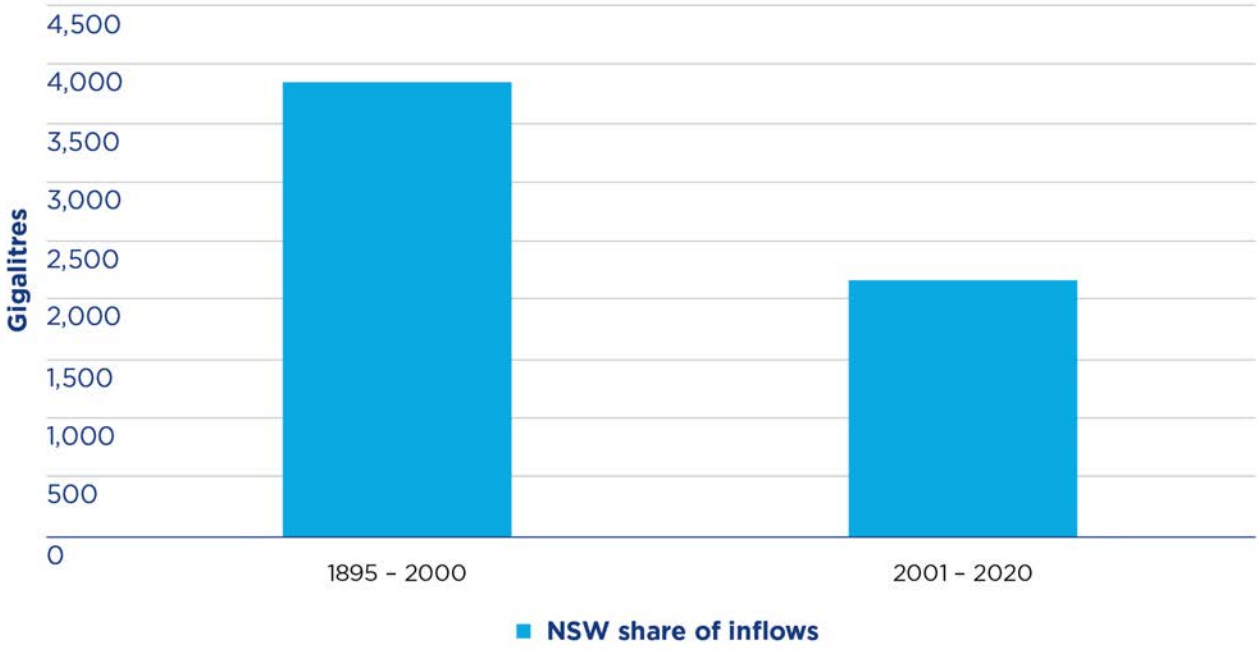
The broad water sharing arrangements of the Agreement have remained the same since the original agreement was established in 1914. Apart from changes made in 2011—to address issues identified during the Millennium Drought—the last substantive change occurred in 1970 after 10 years of negotiations, and led to the construction of Dartmouth Dam and an increase to South Australia's entitlement.

The impacts of a drier climate and lower inflows into the Murray and Murrumbidgee systems are already evident. Since 2000, NSW's share of Murray inflows has declined by 44% compared to the period 1895–2000 (Figure 23). Given the observed decline in inflows over the last two decades (Section 2.2.1) and future climate change projections (Section 2.1.2), the pressures on water users and the environment is likely to increase.

With a potential further decline in water availability, the ability to meet the ever-changing water needs of NSW communities, Aboriginal people, industries and the environment will become increasingly challenging, especially in the context of future growth aspirations in the region.

Considering such aspirations and risks, there is a need for inter-jurisdictional discussion about the current settings of the Agreement, and how current river operations can be improved or optimised to ensure that our river systems can be adaptively managed.

Figure 23. Change in NSW share of Murray River system inflows



Source: Murray–Darling Basin Authority

Recovery of 660 GL (NSW Murray component) of held environmental water

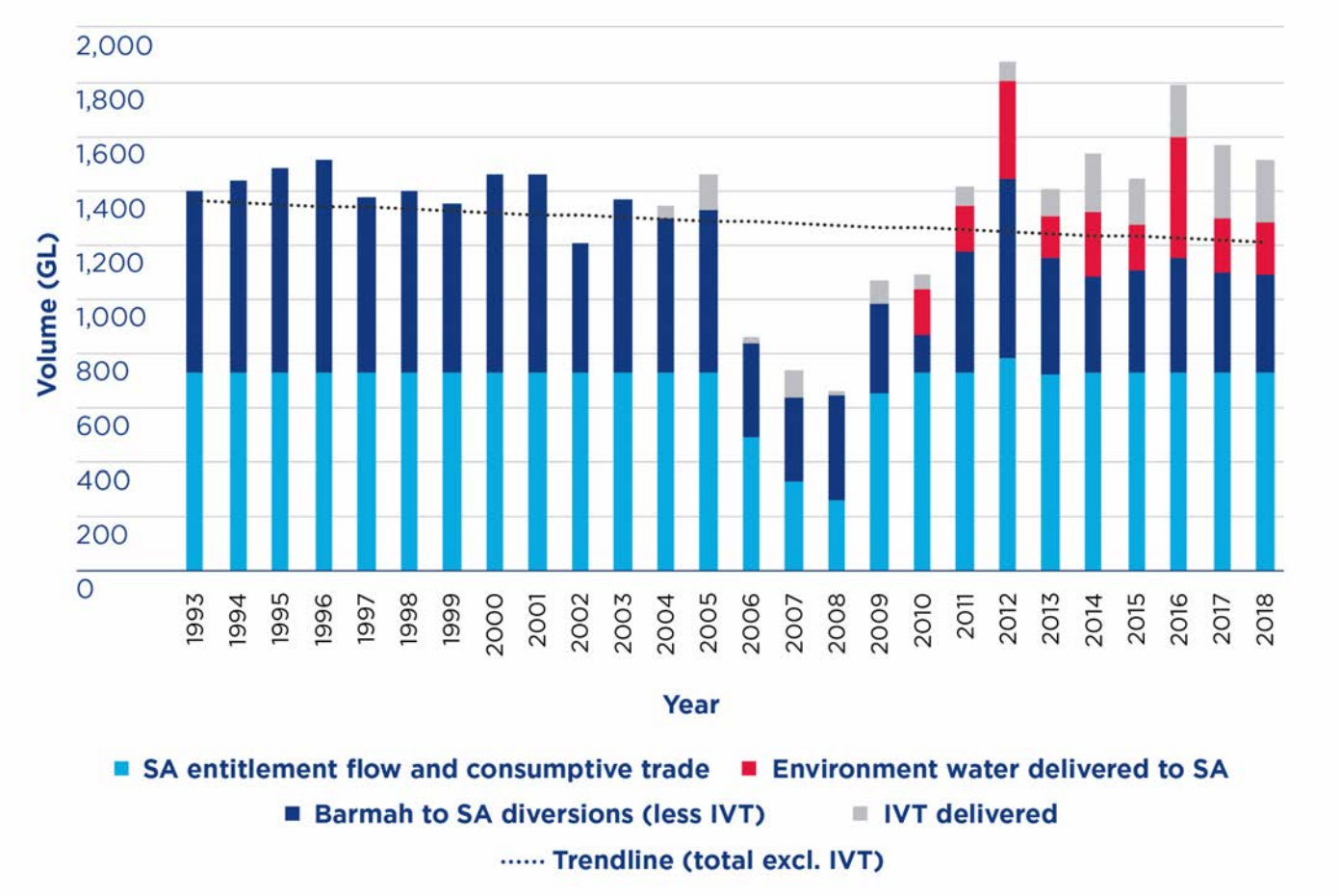
In order for this water to be efficiently used to achieve environmental outcomes, it needs to be delivered in a different way to water for consumptive use. This involves delivering it at higher flow rates to achieve the required inundations of wetlands and desired flow rates for aquatic species.

Refer to Section 3.2 for more information about challenges and opportunities in effectively delivering environmental water.

Continued growth and concentration of permanent plantings in the Lower Murray River, enabled by trade of water from other valleys

Recent permanent plantings have offset the expected reductions for irrigation water demand in the lower Murray River from the recovery of environmental water under the Basin Plan. Now, more water needs to be delivered to the lower Murray to meet peak demands of both irrigation and the environment. Figure 24 highlights a decrease in the total volume of water sourced from the Murray system that is used consumptively below the Barmah Choke in Victoria and NSW during the peak irrigation season (January–April). Consumptive demands in this part of the Murray River have been sustained by increased deliveries from the tributaries, which is shown as inter-valley trade delivered (IVT in the graph).

Figure 24. Deliveries of water to the Murray River downstream of the Barmah Choke



Source: MDBA 2020[82]

The capacity of the Barmah Choke has fallen progressively over the past three decades, from 11,500 ML/day in the 1980s to 9,200 ML/day in 2019—which means around 20% less water can flow through the Barmah Choke channel in summer.[83] With high demands for water in the Lower Murray River driving a need to send water through the Barmah Choke at maximum capacity, or higher, we have seen degradation of river banks and damaging, unseasonal inundation in the Barmah–Millewa Forest. In addition, there is now the risk that water cannot be delivered to users when and where it is needed, thus increasing the risk of a shortfall.

There are considered to be two types of shortfalls:[84]

- **Delivery shortfalls—**these occur when actual water use is higher than was forecast when river water was released weeks earlier (from the Hume and Dartmouth storages) to meet the forecast needs for irrigation and water for the environment.
- **System shortfalls—**in these shortfalls, the combined capacity of the system is unable to supply all downstream requirements over the full season.

82. Murray–Darling Basin Authority 2020, *Managing Delivery Risks in the River Murray System*. Retrieved from www.mdba.gov.au/sites/default/files/pubs/managing-delivery-risks-in-the-river-murray-system.pdf
83. Murray–Darling Basin Authority 2021, *The Barmah Choke*. Retrieved from www.mdba.gov.au/water-management/water-markets-trade/barmah-choke
84. Murray–Darling Basin Authority 2021, *Water demand (shortfalls)*. Retrieved from www.mdba.gov.au/water-management/river-operations/water-demand-shortfalls

If such shortfalls were to occur, they could cause significant economic and environmental impacts including loss of crops or inability to satisfy necessary environmental water requirements.

This risk will likely increase in the future if the capacity of the Barmah Choke declines further, as:

- permanent crops reach maturity and more areas requiring irrigation are planted
- projected climate change results in reduced water availability from Menindee Lakes
- more frequent and hotter heatwaves occur (resulting in spikes in water demand that cannot be met from dam releases, due to the time it takes for water to travel from the dam to where the water will be used).

As such, the NSW Government is working with other Basin governments to explore long-term options for managing delivery capacity to the Lower Murray system, including:

- better understanding the tolerable ecological limits of the Barmah Choke and Edward/Kolety–Wakool system
- building on current practices to formalise a shortfall response plan
- communicating risks to water users and market participants
- restoring delivery capacities
- assessing, reporting and reviewing cumulative changes in water demand.

An important next step will be a feasibility study that explores options to reinstate the delivery capacity of water across the Barmah Choke, and other alternatives to support future system capacity and reduce the risk of shortfalls in water delivery. Ongoing refinement of river operations and delivery of the Reconnecting River Country Program will also be important in avoiding water delivery shortfalls.

The Snowy Scheme

The water released from the Snowy Scheme to the Murray and Murrumbidgee rivers increases water availability in the Murray–Darling Basin. Releases to the Murray River are shared in accordance with the Murray–Darling Basin Agreement, and secure the reliability of allocations against water licences issued by NSW, Victoria and South Australia in the Murray system for both consumptive and environmental purposes.[49] The Snowy Water Licence and Murray–Darling Basin Agreement also allows NSW, Victoria and South Australia to store and call on drought reserves at their discretion under certain circumstances.

Under the SDLAM (Section 2.3.3), there is a proposed project to revise the strategy for release of River Murray Increased Flows to allow greater flexibility in the timing of environmental water deliveries, aiming for better environmental outcomes downstream of Hume Dam.

2.3.2 Water extraction limits

The *Basin Plan 2012* sets the limit on the amount of water that can be extracted (on average) from the region's water sources located in the Murray River catchment. Current estimates of the annual Sustainable Diversion Limits for sources located in the Murray and Lower Darling catchments are 1,522.9 GL for surface water and 192.4 GL for alluvial groundwater.[85] There are also limited volumes, in terms of quantity and quality, available in the Lachlan Fold Belt MDB and Western Murray Porous Rock groundwater sources.[86] These limits are currently implemented through the following water sharing plans:

- *Water Sharing Plan for the Lower Murray–Darling Unregulated River Water Source 2011 (NSW)*
- *Water Sharing Plan for the Murray Alluvial Groundwater Sources Order 2020 (NSW)*
- *Water Sharing Plan for the Murray Unregulated River Water Sources 2011 (NSW)*
- *Water Sharing Plan for the New South Wales Murray and Lower Darling Regulated Rivers Water Sources 2016 (NSW)*
- *Water Sharing Plan for the NSW Murray–Darling Basin Fractured Rock Groundwater Sources Order 2020 (NSW)*
- *Water Sharing Plan for the NSW Murray–Darling Basin Porous Rock Groundwater Sources Order 2020 (NSW).*

Extraction limits in the Snowy River catchment are defined and implemented through the Snowy Water Licence and the following water sharing plans:

- *Water Sharing Plan for the Snowy Genoa Unregulated and Alluvial Water Sources 2016 (NSW)*
- *Water Sharing Plan for the South Coast Groundwater Sources 2016 (NSW).*

Annual diversions from the Snowy River to the Murray River under the Snowy Water Licence averaged around 930 GL/year from 2011 to 2020. Compared to other water sources, this volume is not established in a water sharing plan. The water sharing plans for the Snowy River catchment reflect the sum of licensed volumes and estimated basic landholder rights at the time the water sharing plans were made, and are considerably less than Snowy Scheme diversions and the volume of total annual flows.

85. Murray–Darling Basin Authority 2019, *Appendix A: Murray Alluvium Water Resource Plan Groundwater resource description*. Retrieved from www.industry.nsw.gov.au/__data/assets/pdf_file/0004/230674/appendix-a-murray-alluvium-wrp-groundwater-resource-description.pdf
86. Murray–Darling Basin Authority 2012, *Groundwater Sustainable Diversion Limit Resource Unit Summary Report Cards*. Retrieved from www.mdba.gov.au/sites/default/files/archived/proposed/GW-reportcards-SA.pdf

2.3.3 Environmental water recovery in the NSW Murray region

The Living Murray Program and the Snowy Water Initiative were the first water recovery programs set up between the states and the Australian Government to begin the process of providing the environment with a sufficient share of water to return key environmental assets to a healthy state. Following on from these programs, there was a much larger program by the Australian Government to recover water to meet the targets under the sustainable diversion limits required by the Basin Plan.

Under these programs, water was recovered from consumptive uses through direct market purchases, or investment in improvements to on- and off-farm water efficiency measures—with generated water savings returned to the environment or shared with irrigators.

Sustainable Diversion Limit Adjustment Mechanism

The Basin Plan includes the Sustainable Diversion Limit Adjustment Mechanism (SDLAM) that allows the Sustainable Diversion Limits to be adjusted by a maximum of 5% by implementing a suite of supply or efficiency measures.[87]

Supply measures are projects that improve how the Basin's rivers are managed to more efficiently deliver water for the environment. Projects include environmental works, such as building or improving river or water management structures, and changes to river operating rules that achieve environmental outcomes with less water.

Included with supply measures is the Reconnecting River Country Program—formally known as Constraints Measures Program—that aims to achieve a balance of economic, social, cultural and environmental outcomes across southern NSW by improving wetland and floodplain connectivity.

There are a range of constraints or barriers limiting flows along our river systems, including physical structures (e.g. low-lying bridges and roads), river management practices and operational flow limits. Removing or 'relaxing' constraints by addressing issues in collaboration with affected landholders will allow water for the environment to be delivered at higher levels and at more appropriate times. This will improve the outcomes achievable with water for the environment.

Efficiency measures are activities that change water use practices and save water for the environment. Projects can include upgrading irrigation systems, lining water delivery channels, installing water meters, improving water productivity in manufacturing or irrigated agriculture, or changing urban water management practices to reduce water use. It should be noted that NSW has not nominated any efficiency measures for inclusion in the SDLAM program.

87. The SDLAM assumes that Prerequisite Policy Measures are implemented in the southern NSW regions. These measures ensure more flexible water management arrangements to maximise the beneficial outcomes of proposed supply measure projects for the SDLAM.

In 2017, the Basin states and the Commonwealth agreed on a package of 36 SDLAM projects across the southern connected Murray-Darling Basin, with NSW leading or partnering in 21 projects. The SDLAM projects within the NSW Murray region include:

- Sustainable Diversion Limit Offsets in the Lower Murray (Locks 8 and 9 Project)
- Murray and Murrumbidgee National Park Project (Yanga and Millewa)
- Yarrawonga to Wakool Junction component of the Reconnecting River Country Program
- Hume to Yarrawonga component of the Reconnecting River Country Program
- 2011 Snowy Water Licence Schedule 4 Amendments to River Murray Increased Flows
- operating rule change to the use of the Barmah–Millewa Forest Environmental Water Allocation
- flexible rates of fall in river levels downstream of Hume Dam
- operating rule change to Hume Dam airspace management and pre-releases
- enhanced environmental water delivery
- the six Living Murray Environmental Works and Measures Projects: Koondrook-Perricoota Forest, Lindsay-Wallpolla Islands (including Mulcra Island), Hattah Lakes, Gunbower Forest and Chowilla Floodplain.

To date, 12 of the NSW Government's 21 SDLAM projects across the southern connected Murray-Darling Basin, are complete or nearly complete, and are delivering Basin Plan outcomes. The water recovered through these projects is already bringing positive impacts to Basin environments and communities.

Building on this progress, the NSW Government is bringing forward $320 million of its remaining project funding through the NSW SDLAM Acceleration Program. This program will remove barriers and streamline construction funding to allow the delivery of five projects (three full projects and components of two more projects), and up to 45 GL of Sustainable Diversion Limits offset by 30 June 2024, which is the legislated date by which SDLAM projects are required to enter into operation.[88]

88. More details of SDLAM projects across the southern connected Basin, including the NSW Murray region, are provided at www.dpie.nsw.gov.au/water/water-infrastructure-nsw/sdlam

2.3.4 Managing floods

In NSW, a risk management approach is taken to reduce the impact of flooding on flood-prone land and reduce private and public losses resulting from floods. For inland regulated river systems such as the Murray, a range of other agencies have a role in active flood management.

Floodplain risk management

The *NSW Flood Prone Land Policy* outlines the government partnerships for flood risk management in NSW. It identifies that local councils are primarily responsible for managing urban flood risk in their communities, while the Department of Planning and Environment is primarily responsible for rural floodplain management in the Basin.

The *Floodplain Development Manual* outlines the roles and responsibilities of local councils, which include:

- developing and implementing floodplain risk management plans to better understand and manage flood risk to the community
- providing information to, and improving the awareness of flooding in, the community
- operating and maintaining their flood mitigation assets (e.g. drainage and levees)
- considering flooding in development and infrastructure decisions
- supporting the NSW State Emergency Service in emergency management and associated planning.

The Environment and Heritage Division of the Department of Planning and Environment leads the implementation of the *NSW Flood Prone Land Policy* and provides support to councils through the *Floodplain Development Manual* and associated policies, guidelines and tools. The division is currently reviewing the manual and its associated guidance. They also influence the planning and management of flood prone land through State Environmental Planning Policies, and regional strategies and plans.

Councils also receive specialist technical support from the division's flood risk management experts and financial assistance through the NSW Floodplain Management Program. This program supports the development and implementation of floodplain risk management plans consistent with the manual. The program provides funding to local government authorities to manage flood risk at a general rate of $2 for every $1 provided by the council.

The *Floodplain Development Manual* and *NSW Flood Prone Land Policy* guides councils to prepare flood studies, and floodplain risk management studies and plans to reduce the impact of flooding on their communities. These studies and management plans characterise flood behaviour in local sections of the floodplain and identify a preferred mix of local options—typically including property modification measures, response measures and flood modification measures such as levees and bypass channels.

The NSW State Emergency Service leads flood emergency management, planning and response. The Bureau of Meteorology provides essential flood forecasting to the State Emergency Service to inform flood warnings and flood response operations. The State Emergency Service and councils are responsible for developing local flood plans for flood-affected communities across the state; establishing flood warning systems; and coordinating evacuation and initial recovery from flooding.

Rural floodplain management plans

The Department of Planning and Environment—Water prepares rural floodplain management plans under the *Water Management Act 2000*. These plans coordinate flood work on a valley-wide basis to maintain the natural pattern of flood flows, and protect ecological and cultural floodplain assets.

WaterNSW is responsible for implementing floodplain management plans by assessing, granting or refusing and conditioning flood work approvals. The NSW Natural Resources Access Regulator is responsible for the compliance and enforcement around flood work approvals and unauthorised flood works.

New, integrated, valley-wide rural floodplain management plans[89] have recently been developed for the five valleys of the northern NSW Murray–Darling Basin, in combination with work to license the take of floodplain harvesting water, as part of implementing the NSW Healthy Floodplains Project.[90] In contrast, there has been limited reform around the 10 existing and fragmented local floodplain management plans in southern NSW. The Murray Long Term Water Plan identified that the lack of integrated floodplain management plans in the region poses potential risks to the effective delivery of environmental water. There is growing support for similar reform in the southern Basin.

The Natural Resources Commission recently audited the implementation of existing rural floodplain management plans[91] for key floodplain areas in the Lachlan, the NSW Murray and Murrumbidgee. This included floodplains in the mid-Murray and the Edward/Kolety–Wakool areas in the NSW Murray region. The audit found that the provisions of the floodplain management plans have not been given full effect in accordance with the *Water Act 1912* (NSW).

Key findings included: inadequate systems for managing approvals and enforcing required modifications, a lack of environmental and flood monitoring to inform the plans and reviews, and five-year reviews that were not undertaken. There are a range of other actions that the department is progressing in response to the audit.[92]

Similarly, a review under Section 43[93] of the *Water Management Act 2000* found that the floodplain management plans:

- are not adequate and appropriate to effectively implement the water management principles under the Act
- should be replaced with valley-based plans
- should be expanded so their boundaries include the local ecosystems, flood fringe areas and upstream extents to be consistent with the Act.

The regional water strategies provide an opportunity to progress this evolution in NSW floodplain management planning (see Option 16: Enhance southern inland floodplain management plans).

89. New floodplain management plans are in response to the Department of Planning and Environment transitioning from the floodplain management plan and controlled works provisions of Part 8 of the Water Act 1912 to the equivalent provisions under the *Water Management Act 2000*.
90. See www.industry.nsw.gov.au/water/plans-programs/healthy-floodplains-project/about
91. At the time of drafting, these plans were still in effect.
92. See details in the department's response to the audit findings at www.nrc.nsw.gov.au/WMP%20audits-%20Final%20Report%20-%20DPIE%20response.pdf?downloadable=1
93. Section 43 review undertaken by the Department of Planning and Environment

Flood operations

The Murray–Darling Basin Authority manages the key headwater storages of the Murray River system, including Hume and Dartmouth dams, which are operated by WaterNSW and Goulburn–Murray Water respectively. Hume Dam's primary purpose is for water regulation and conservation, but it also provides additional benefits including flood mitigation, particularly when storage levels are low. For example, since the commissioning of Dartmouth Dam in 1979, about 70% of flood events in the upstream catchment have been completely captured and stored in Hume Reservoir, with no flooding immediately downstream.[94]

Better data and information on floods in the NSW Murray region is critical to understand how floodplains are connected, how groundwater reserves are replenished and how much flooding risks towns and villages.

Flood studies that analyse the characteristics and movements of floods will help to protect rural properties and vital infrastructure, while ensuring that environmental and cultural assets are not negatively affected.

Rebuilding NSW—State Infrastructure Strategy 2014 identified flood management risk as a key issue, based on the limited capacity of major dams to provide flood mitigation. To date, no flood mitigation options for Hume Dam have been identified.

Some of the actions arising from the 10-year review of the Snowy Water Licence that are being investigated aim to improve the effectiveness of flood management (Section 2.3.4).

94. Murray–Darling Basin Authority 2020, *Managing Floods at Hume Dam*. Retrieved from www.mdba.gov.au/water-management/infrastructure/hume-dam/managing-floods

Photography
Image courtesy of iStock.
Murray River, Albury.

2.3.5 Managing water quality

Water quality is managed through several legislative and regulatory instruments and agencies. The NSW Government adopted the National Water Quality Management Strategy[95] as its policy to manage the quality of waterways in NSW and protect water resources. It includes guidelines to support state and local governments, water authorities and industry to maintain and improve water quality according to local community's environmental values and uses as outlined in the NSW Water Quality and River Flow Objectives.[96]

The NSW Environment Protection Agency is responsible for managing water pollution (diffuse and point-source) in NSW under the *Protection of the Environment Operations Act 1997* and the *Protection of the Environment Operations (General) Regulation 2009*.

The NSW Government has developed the *Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land use Planning Decisions*[97] to provide an evidence-based decision-making framework to assist regional planners to integrate water quality into strategic land use planning decisions, and assist councils to reduce the impacts of land use developments on waterways.

For all inland NSW regions, water quality management plans have been developed to support the development of the water resource plans and meet the relevant requirements of the Basin Plan.

The plans provide a framework to protect, improve and restore NSW surface water and groundwater quality to:

- provide essential and recreational amenity for rural communities
- protect and improve ecological processes and healthy aquatic ecosystems
- support Aboriginal peoples' spiritual, cultural, customary and economic values
- assist industry to be productive and profitable.

The water quality management plans are supplemented by NSW's incident response guides.[98] The guides outline management responses, in accordance with provisions of the *Water Management Act 2000*, for water use during 'extreme water quality events'. Extreme water quality events include the occurrence of hypoxic blackwater, low dissolved oxygen, salinity or blue-green algae outbreaks. Under an extreme water quality event,[99] water quality may be insufficient to meet critical human needs or may reduce aquatic ecosystem health. Potential management responses in the NSW Murray region include temporarily restricting take, reviewing release of operational water, or using environmental water for critical ecological needs such as maintaining fish refuges.

95. Water Quality Australia 2020, *Guidelines for Water Quality Management*. Retrieved from www.waterquality.gov.au/guidelines
96. Department of Environment, Climate Change and Water 2006, *NSW Water Quality and River Flow Objectives*. Retrieved from www.environment.nsw.gov.au/ieo/index.htm
97. Dela-Cruz J., Pik A. and Wearne P. 2017, *Risk-based framework for considering waterway health outcomes in strategic land use planning decisions*. Office of Environment and Heritage and Environment Protection Authority. See www.environment.nsw.gov.au/research-and-publications/publications-search/risk-based-framework-for-considering-waterway-health-outcomes-in-strategic-land-use-planning
98. Department of Industry 2019, *Draft Incident Response Guide for the Murray Surface Water Resource Plan Area*. See www.industry.nsw.gov.au/__data/assets/pdf_file/0008/230678/schedule-e-draft-incident-response-guide-murray-alluvium-wrpa.pdf
99. An extreme event is defined in the NSW Extreme Events Policy and in section 10.51 of the *Basin Plan 2012.*

NSW water sharing plans do not contain rules directly concerning water quality; however, they provide a number of mechanisms and tools (including extraction limits, cease-to-pump rules, supplementary access rules and strategic environmental watering) to help ensure sufficient flow is available to meet water quality objectives and targets (Section 3.2).

The Murray–Darling Basin Agreement and the Basin Plan 2012 collectively outline the salinity management obligations for Basin states that are party to the Murray–Darling Basin Agreement. The Basin Plan includes a water quality and salinity management plan, which includes end-of-valley salinity targets for various locations in the southern connected basin.[100] These salinity targets provide guidance for operational decisions that will assist in maintaining salinity at acceptable levels in the Murray River. The *Basin Salinity Management 2030 BSM2030* builds on over 30 years of salinity management in the Basin and provides a framework for governments to work individually and collectively to meet the Basin Plan obligations. The strategy includes maintaining a salinity register, responsibly managing salt interception schemes, knowledge building and guiding flow management.

The NSW Government has recently embarked on a process to investigate options on how to better manage the impacts from new irrigation development in areas of high-salinity-discharge risk. The work will seek to address identified information gaps and build awareness of high-impact salinity areas to support sustainable irrigation development into the future.

The quality of water resources is also affected by land use activities (Section 2.2.4), many of which are outside the influence of flow management and therefore cannot be addressed through NSW water planning alone.

The process used to assess and manage the impacts of land use activities and water extraction on water quality is outlined in the *Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land use Planning Decisions*.[101] This framework helps local councils to support healthy waterways through regional and local planning instruments, environmental regulation, integrated water cycle management plans, or other catchment management plans for restoring and protecting the health of waterways.

Managing catchment water quality also helps local water utilities meet drinking-water quality standards set out in the Australian Drinking Water Guidelines.[102] The guidelines detail a preventative management approach that manages and monitors water quality from the catchment to the consumer. They are used by NSW Health, the Department of Planning and Environment and local water utilities to assure safe, good-quality drinking water for NSW communities.

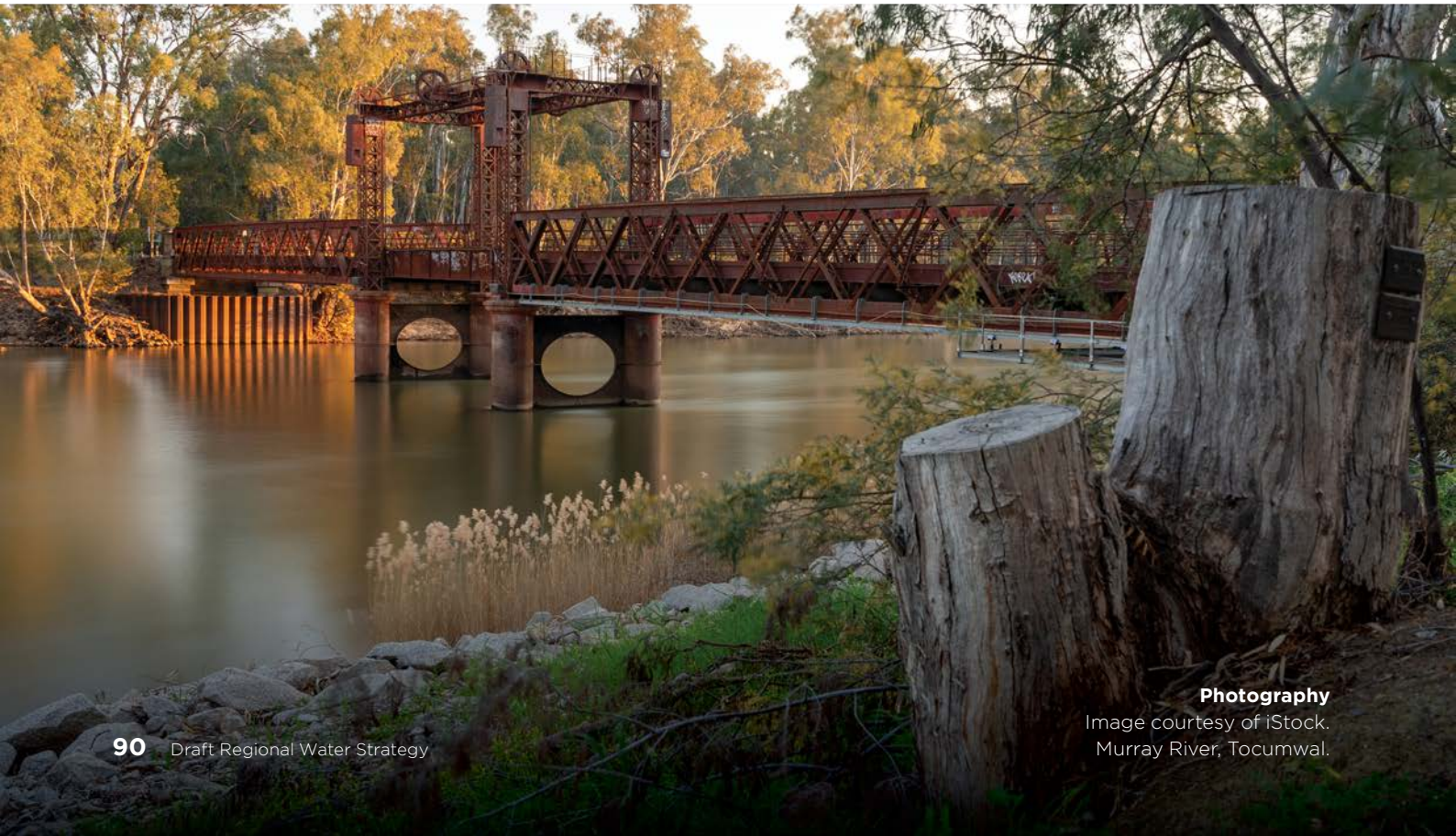
Water supplies in regional NSW are monitored for microbiological and chemical quality through NSW Health's Drinking Water Monitoring Program. NSW Health also publicly reports water quality incidents. The Department of Planning and Environment—Water division monitors the performance of local water utilities in providing drinking water.

100. The Basin is required to include a Water Quality and Salinity Management Plan under the *Commonwealth Water Act 2007.*
101. Dela-Cruz J., Pik A. and Wearne P. 2017, *Risk-based framework for considering waterway health outcomes in strategic land use planning decisions*. Office of Environment and Heritage and Environment Protection Authority. See www.environment.nsw.gov.au/research-and-publications/publications-search/risk-based-framework-for-considering-waterway-health-outcomes-in-strategic-land-use-planning
102. National Health and Medical Research Council, National Resource Management Ministerial Council 2018, *Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy*. See www.nhmrc.gov.au/about-us/publications/australian-drinking-water-guidelines

Additional measures that aim to address water quality issues affecting specific water users, including the environment, are discussed in Chapter 3.

The Murray Regional Water Strategy is an opportunity to consider which additional actions are needed to better manage water quality in the NSW Murray, including:

- Option 8: Review drought rules for the NSW Murray region: review the adequacy and effectiveness of the incident response guides applicable in the NSW Murray region by testing them against the new climate data and updated modelling now available for the Murray Regional Water Strategy
- Option 17: Investigate water quality improvement measures to avoid and mitigate water quality issues such as hypoxic blackwater and blue-green algae events and their severe social, environmental, economic and cultural impacts for the NSW Murray region, as well as other issues such as persistent turbidity (muddiness)
- Option 18: Manage groundwater salinity: such that we can avoid changes in groundwater flows that result in contamination of ground or surface water supplies from other saline groundwater sources
- Option 31: Develop river and catchment recovery program for the NSW Murray region: to improve catchment health and resilience
- Option 44: Consider Hydrologic processes in bushfire management



Photography
Image courtesy of iStock.
Murray River, Tocumwal.

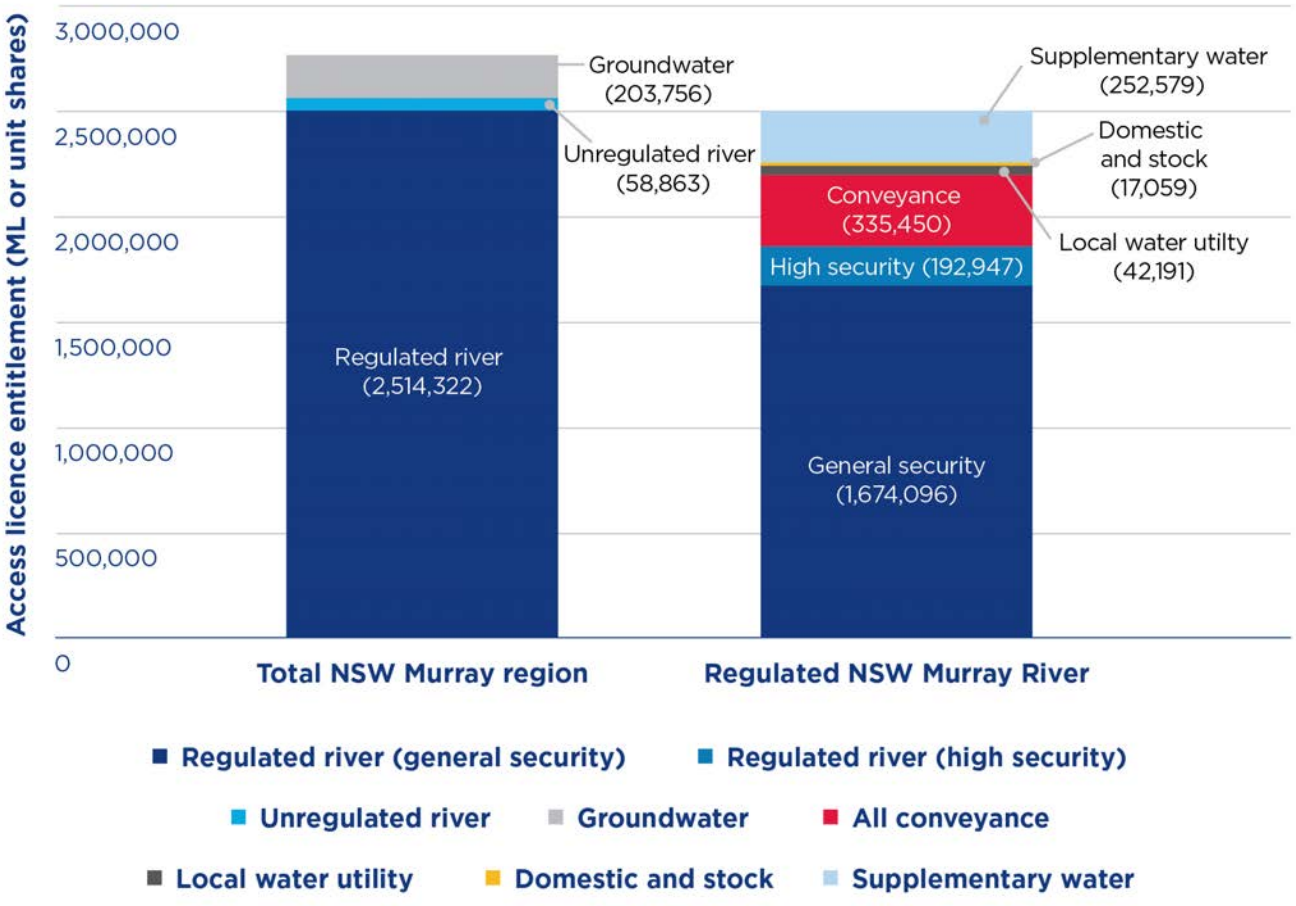
2.3.6 Entitlements to water in the region

Most water access licences in the NSW Murray region have been issued for the NSW Murray regulated river Source and alluvial groundwater sources in the Murray catchment.

In the NSW Murray Regulated Water Source, there are around 2,505,000 ML of water access licence shares. Only a small portion of NSW water licences are for stock and domestic use, and town water supplies (Figure 25). The Murray River supplies many NSW towns with water, including Albury, Corowa, Tocumwal and Euston, to name a few.

Most NSW entitlements (1,674,000 ML) are for general security licences, which are mainly used for irrigation and environmental purposes. High security licences (193,465 ML) exist to provide holders with a more reliable supply of water for purposes such as permanent planting irrigation, high priority environmental use and urban supplies. Another major component is supplementary access (252,579 ML), where water is only permitted to be taken when flows in the river are declared to be greater than water orders. In addition, there is 38,217 ML allocated to NSW local water utilities, and another 42,446 ML and 6,687 ML in the unregulated water sources of the NSW Murray and Snowy Genoa valleys, respectively.

Figure 25. NSW Murray region water access licence shares*



* Note: This does not include shares within cross-regional porous and fractured rock groundwater systems, or extraction of water from alluvial aquifers in the Snowy–Genoa catchments, because this is a very small amount from 17 licenced bores.

2.3.7 Setting priorities for water sharing

The *Water Management Act 2000* sets out how we prioritise water sharing of NSW's water resources during normal operations; the highest priority is reserved for the environment, followed by basic landholder rights (Table 3). In the case of the Murray River, the Murray–Darling Basin Agreement sets out how the water of the Murray River is shared (Figure 22).

During extreme events, such as prolonged droughts or severe water shortages,[103] the priority changes. Critical human water needs become the highest priority, followed by the environment.[104]

This change in priorities is triggered when a NSW water sharing plan (or part of a plan) is suspended. The aim is to operate within the plan rules for as long as possible, to provide certainty for all users of these water sources. The Murray Regional Water Strategy is an opportunity to consider whether the trigger should be reviewed (see Option 8: Review drought rules for the NSW Murray region).

Table 3. Priorities for water sharing

Priority	Extreme events	Normal circumstances
Highest	• Critical human water needs	• Needs of the environment
High	• Needs of the environment	• Basic landholder rights
	• Stock • High security licences • Commercial and industrial activities authorised by local water utility • Water for electricity generation on a major utility licence • Conveyance in supplying water for any priority 3 take	• Local water utility access licences • Major utility access licences • Stock and domestic access licences
	• General security licences	• Regulated river (high security) access licences
Low	• Supplementary licences	• All other forms of access licences • Supplementary access licences

Source: s 60(3A) NSW *Water Management Act 2000* and NSW Murray and Lower Darling Surface Water Resource Plan: Schedule G—Incident Response Guide

103. *Water Management Act 2000*, Section 60(3)
104. Note that for extreme droughts, under the Murray–Darling Basin Agreement, high-level water sharing arrangements include provisions to alter the water sharing arrangements between states during extreme drought conditions. Further information on the Murray–Darling Basin Agreement is provided in Section 2.3.1.

Sharing and allocating water in the Regulated Murray River

In the Regulated Murray River, the processes for determining water resource availability and announcing available water determinations (typically referred to as 'allocations') involves regular resource assessments of water availability.

The Murray–Darling Basin Authority performs water resource assessments, based upon the actual water available in the system, minimum inflows, minimum required annual releases from the Snowy Scheme, water needed to offset delivery losses, and South Australia's entitlement. The results are used to allocate water to each state's share.

At the beginning of the water year (a water year runs from 1 July to 30 June), NSW first reserves the necessary volumes for future years from its share before making water available to licence holders under the first allocation announcement of the year. The opening allocation will represent a volume that can be confidently made available and delivered across the entire year to all NSW licenced users as per the *Water Management Act 2000* priorities for water sharing (Table 3).

In doing so, NSW takes a risk-based approach, and provides allocations based on existing water in storage and a minimum natural inflow into storages expected during the year that can be allocated for regulated use; for example, minimum inflow sequence assumptions prescribed in the water sharing plans.[105]

Due to these conditions, NSW water allocations at the beginning of the water year (1 July) are generally low; however, additional allocation announcements are often made throughout the water year depending on ongoing resource assessments. If there are drier conditions than expected or the system losses exceed historical amounts, there is a residual risk of insufficient water available to meet all water needs for the year.

When these unexpected conditions occur, it is important that adequate NSW drought management actions are enacted to ensure critical needs[106] can be protected as efficiently as possible.

Making NSW allocation announcements is a careful balancing act between making water available for the different priorities shown in Table 3. The more conservatively NSW chooses to allocate water, the less water is available for lower priority needs like NSW general security entitlements. Conversely, the less conservative NSW allocates water, the greater the risk that insufficient water will be available to meet NSW high-priority needs like critical human water needs and town water supplies, particularly if conditions are drier than expected.

The new climate datasets and updated modelling for the Draft Murray Regional Water Strategy will provide an opportunity to review the current assumptions and processes that are used to make NSW allocation announcements. In particular, we now have much more comprehensive datasets that enable us to test the existing NSW water allocation framework, and analyse the merits and risks of changing it (see Option 9: Review of water allocation and accounting framework in the NSW Murray region regulated system).

To help NSW entitlement holders manage variability in annual water availability, the *Water Sharing Plan for the New South Wales Murray and Lower Darling Regulated Rivers Water Sources 2016* allows the unused NSW general security water allocation to be carried over from one year to the next, up to a maximum of 50% of the year's allocation. Water trading also facilitates managing the variability of water availability by enabling water users to buy unused allocations from others who do not require it. Refer to 'Water Trade' in this section for further information.

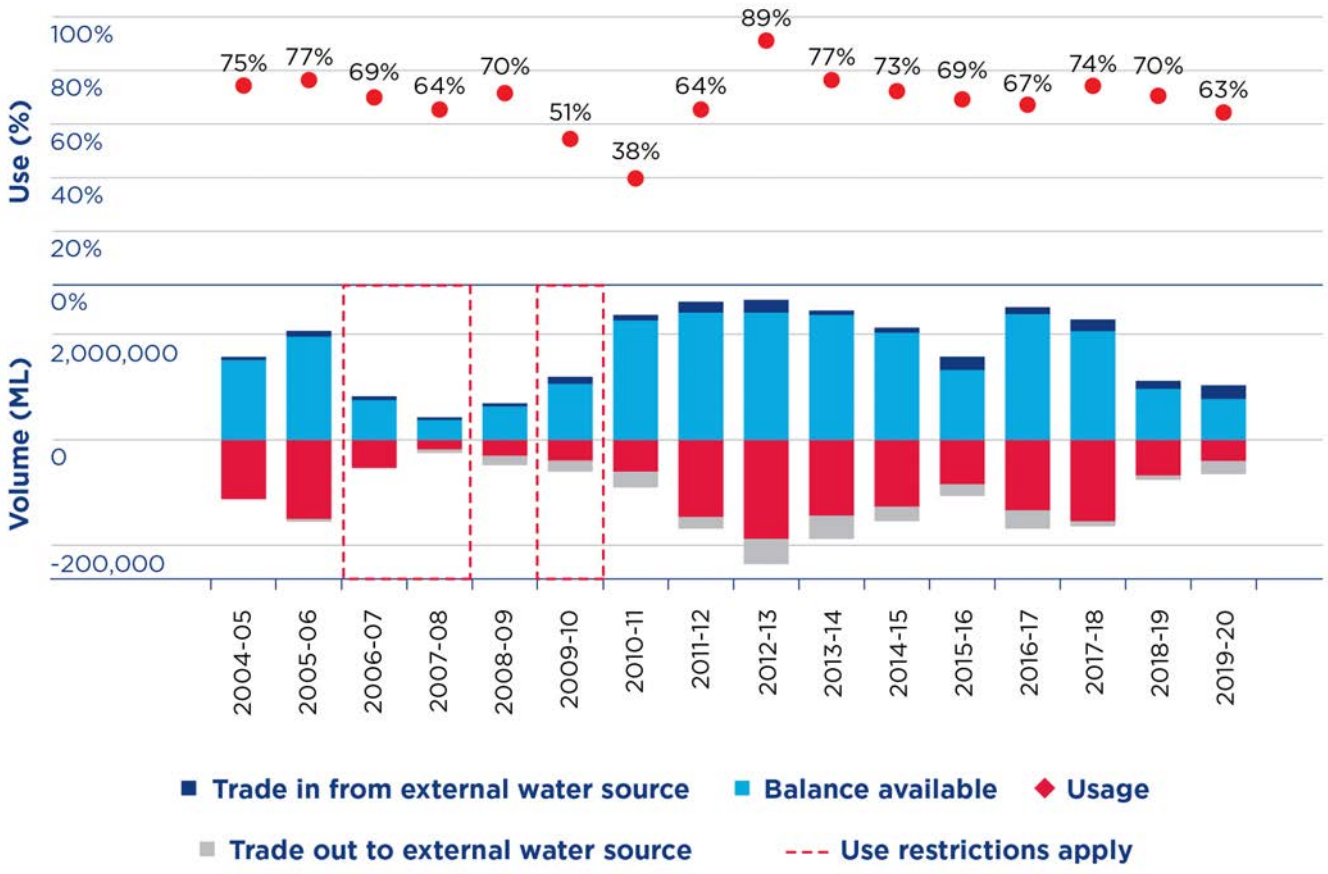
Nonetheless, the variability and declining water availability of the past 20 years has presented challenges for water users.

105. A more complete summary of the process to determine allocations each year in the Regulated Murray River can be found at www.industry.nsw.gov.au/__data/assets/pdf_file/0008/166283/How-water-is-shared-in-the-regulated-nsw-murray-valley.pdf
106. A discussion paper on critical needs is currently in development

Reduced NSW allocation and comparative use levels

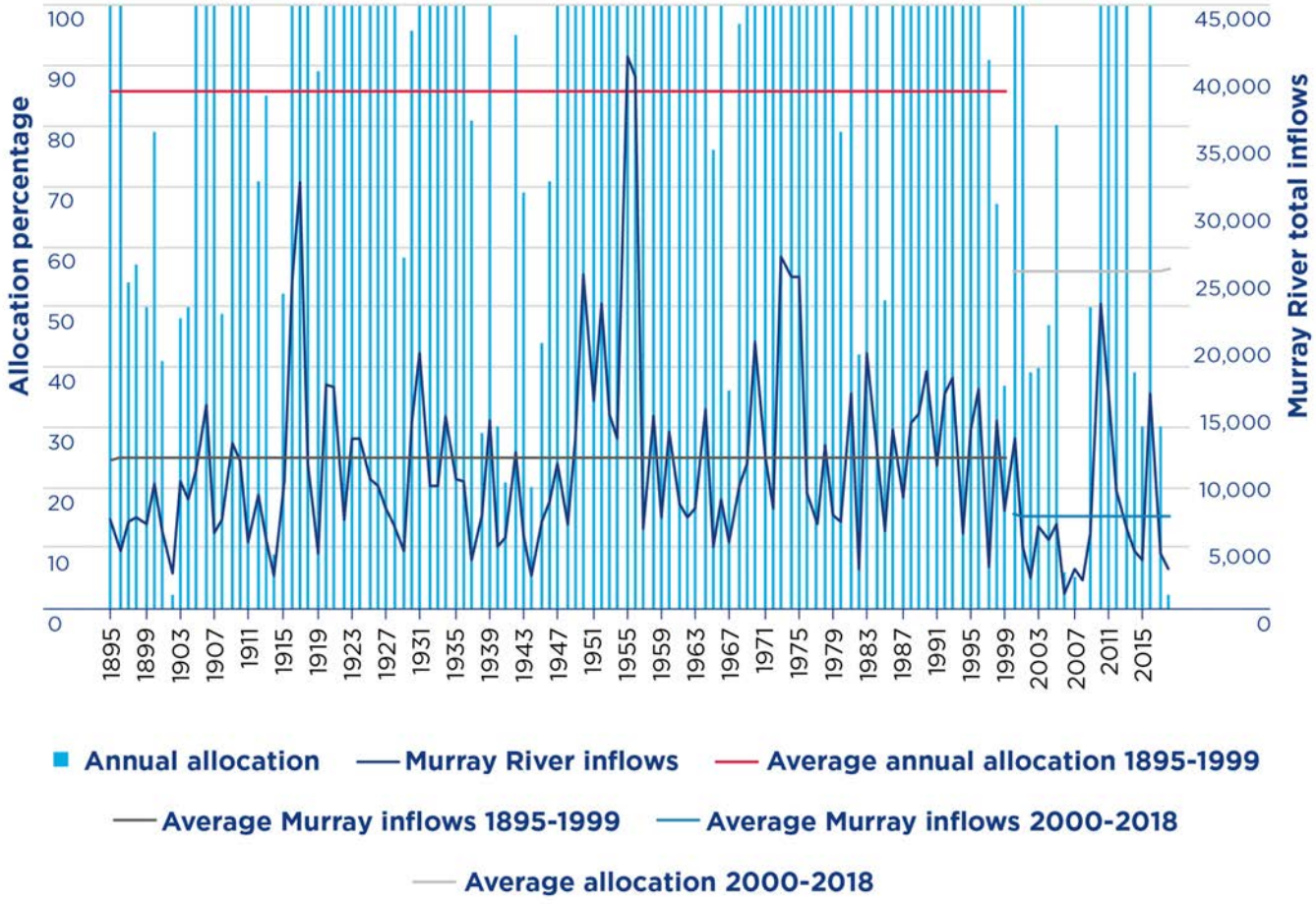
The vast majority of NSW Murray River irrigators hold NSW general security entitlements. Due to the highly variable climate, the amount of water allocated each year to NSW general security entitlements has varied widely. There have been consecutive years (2006/07 and 2007/08) of low allocations, and water use restrictions have applied in several years. This is why many agricultural producers hold a diversified portfolio of water entitlements, and apply a conservative water use approach to mitigate their water supply risks. Figure 26 shows that NSW water use rates are lower than available water in a given year.

Figure 26. Access licence account use for regulated supplies (except supplementary) in the NSW Murray River



With the decline in inflows experienced in the past 20 years (Section 2.2.1), there has also been a reduction in the availability of NSW Murray general security allocations (Figure 27). This shows that—using present day rules and infrastructure applied retrospectively over the model simulation period of 1895–2018 (not actual observed allocation levels)—average NSW annual allocations have declined from 86% during 1895–1999 to 56% during 2000–18. The plot also shows the same large reduction in Murray River inflows that is driving the reduction in allocations.

Figure 27. Modelled NSW general security allocations and total Murray River inflows (1895–2018)



Source: Murray–Darling Basin Authority (taken from Source Murray Model and includes present day rules and infrastructure applied retrospectively over the model simulation period and, thus, does not reflect actual observed allocations).

Given potential reductions in precipitation and potential increases in evaporation in the headwater catchments (Sections 2.1.2 and 2.2.1), as well as altered run-off relationships from catchment-based challenges such as intense bushfires (Section 2.2.1), this pattern of reliability may decline even further.

Reduced water availability will have an impact on all water users in the NSW Murray region; however, given the priority of how water is allocated in NSW, the risks lie disproportionately with NSW general security licence holders.

The post-2000 declines in water availability have also led to reduced patterns of water use relative to Sustainable Diversion Limits in the NSW Murray region and in the broader southern connected Basin. For example, during the Basin Plan Sustainable Diversion Limits transition period from 2012/13 to 2018/19, the NSW Regulated Murray River experienced an average 'credit' accumulation of 71 GL against the transitional diversion limit (5% of the total).[107]

The conservative behaviour of water users is considered to be a driver of reduced usage compared to the diversion limits, as they now reduce the current year's extraction and instead carry over 18–27% of their water to shore up next year's supply.[103] Going forward, we need to better understand how usage tracks against the new Sustainable Diversion Limits. Refer to Option 39: Investigate of water availability in the NSW Murray region.

The NSW Government has recently introduced a new provision into regulated river water sharing plans: to review and address significant future underuse against water sharing plan or Sustainable Diversion Limits. Key requirements of the provision require gaining a sound understanding of the drivers of underuse, and that any amendments to management arrangements would need to be within the requirements of the Basin Plan. Option 39: Investigate underuse in the NSW Murray region, builds on this.

Furthermore, the Murray–Darling Basin Authority has committed to work with the states to monitor and report on trends in use relative to Sustainable Diversion Limits, and continue to improve Sustainable Diversion Limit accounting and communicate about how the accounting operates.

The NSW Government is committed to continue working closely with the Murray–Darling Basin Authority on these matters, as well as continuing to provide and improve information available for water users about how water is managed in NSW—including available water determination arrangements. Currently information is available through the Department of Planning and Environment website, the WaterNSW Water Insights Portal and the Bureau of Meteorology's Murray–Darling Basin water information portal. In addition, Option 38: Develop targeted education and capacity building programs, has been developed to assist water users to make informed decisions about their water supply security, providing greater transparency about NSW water management and water modelling.

Through this regional water strategy, the NSW Government proposes a review (Option 9. Review the allocation and accounting framework in the NSW Murray (regulated system)) into the NSW surface water available water determination and accounting processes to help balance regional economic outcomes against water supply security. Any potential changes arising need to be carefully analysed, and both technical and policy aspects considered. This will need to be a detailed, nuanced and transparent discussion with potentially affected stakeholders and the broader community. Complex issues of risk appetite and risk sharing need to be explored.

107. Murray–Darling Basin Authority 2020, *Trends in water use relative to the sustainable diversion limit in the southern Murray–Darling Basin*. See www.mdba.gov.au/publications/mdba-reports/analysing-trends-water-use-relative-sustainable-diversion-limits-southern

Groundwater licences

NSW groundwater extraction limits represent the volume of water that can be sustainably extracted each year from the groundwater source. NSW groundwater sources with low connectivity to surface water like the Lachlan Fold Belt and Western Murray Porous Rock generally have extraction limits calculated based on a percentage of rainfall as recharge. Whereas the extraction limit for the upper Murray Alluvium is based on the level of extraction when the NSW water sharing plans were introduced, with the assumption that the level of impact from this extraction was deemed acceptable. Option 12: Provide increased clarity about sustainable groundwater management, will establish a systematic, statewide process to ensure groundwater access to water users, and review existing NSW groundwater resource extraction limits to incorporate up-to-date information.

The NSW extraction limit is divided into unit shares and a volume is set aside for basic landholder rights. The unit shares, also known as entitlements, are held by water users through NSW water access licences. For most of the groundwater sources in the NSW Murray region, the number of entitlements plus basic landholder rights is equal to the extraction limit. However, the upper Murray Alluvium has more than double the number of entitlements compared to the extraction limit. This can be a challenge, because it increases the likelihood of the amount of groundwater extracted exceeding the extraction limit. Option 12: Provide increased clarity about sustainable groundwater management, will investigate ways to better manage these NSW groundwater sources, and give clarity to water users about how these groundwater systems will be managed as activation and use increases over the next 30 years.

When the five-year average extraction exceeds the extraction limit compliance trigger, the NSW available water determination process can be used to reduce the volume of water available in the following year. The number of NSW entitlements remains the same, but the volume of water allocated to each entitlement changes. 'Maximum water account debit limit' (which is specified in the NSW water sharing plan) is another potential method to return average extraction to the extraction limit, by capping the total amount of water that can be taken, regardless of how much water is held in access licence accounts. The five-year NSW average extraction limit in the upper Murray Alluvium exceeded the extraction limit in 2018/19 and 2019/20. Option 12: Provide increased clarity about sustainable groundwater management, will develop and publish a decision framework for how available water determinations are calculated to make assessment processes more transparent.

For some groundwater sources like the Lachlan Fold Belt MDB Groundwater Source and Western Murray Porous Rock Groundwater Source, the number of NSW entitlements plus basic landholder rights is less than the extraction limit. This means there is opportunity for the NSW Government to grant more entitlements through a process called 'controlled allocations'. Controlled allocations provide an opportunity for further developing a groundwater source like the Western Murray Porous Rock; however, more information about the groundwater source is required to target areas that produce sufficient yield and water quality (Option 42: Undertake joint exploration for groundwater with the NSW Geological Survey).

Water trade

Both NSW water access licence entitlements and water allocations can be traded between water access licence holders, subject to specific legislated rules and licence conditions. Many different water holders participate in the water market, including irrigators, irrigation infrastructure operators, local water utilities, environmental water managers, water brokers and exchanges, investors, Aboriginal people and others.

Of these groups, Aboriginal people hold the least volume and number of water access licence entitlements, and are largely absent from the water market. However, Aboriginal people have expressed an aspiration to increase their access to water to allow them to generate cultural, environmental and economic benefits for their communities. Some have noted that treating water as a property right can be at odds with many traditional beliefs, however water markets are considered a potential pathway to increase access to water for Aboriginal people.[108]

For businesses, environmental water managers and local water utilities, water markets are an important tool to manage their water needs and access water in systems that are fully allocated. For example, water markets allow businesses to supplement their water supply to expand production, free up capital that can be invested elsewhere, or access carryover opportunities to shore up water supplies for the next season. NSW water access licence entitlements are also a significant asset for many businesses, often equating to or exceeding the value of land assets.[102]

Since mid-2012, water market participants traded a total value of approximately $12.7 billion (2019/20, value) in water access licence entitlements across the Murray–Darling Basin water markets. In contrast, the total value of water allocation trades equated to around $2.7 billion (in 2019/20, constant terms).[102] Most trading activities in the Murray–Darling Basin occurred in surface water systems across the southern connected basin.

The volume of surface water allocation trade strongly correlates to climate conditions and water availability. However, there are indications that the volume traded relative to the total water allocated to water access licence entitlements has grown over the years.[102] This indicates that water markets are developing, and more water holders are using the market to meet their needs. Groundwater markets are also developing, with increased trading activities in some groundwater systems. In the context of a variable and changing climate, groundwater markets are likely to become more important.

Significant regulatory, policy, investment, water use and climatic changes have occurred in the southern connected basin over the last two decades, which has led water markets to continue to evolve; and increase in size, value and complexity. In recent years, changes in land use and the expansion of permanent horticulture in the region below the Barmah Choke have influenced water markets and trading across the southern connected basin. This has resulted in several investigations and inquiries, including the Australian Competition and Consumer Commission's water markets inquiry and the Murray–Darling Basin Authority independent expert panel's work to understand and manage shortfall risk for the River Murray system.[109]

Future changes in the region's climate, together with ongoing changes in land use and population growth are likely to influence surface water and groundwater markets and trading activities in the southern connected basin over the next few decades.

108. Australian Competition and Consumer Commission 2021, *Murray–Darling Basin water market inquiry—Final report*. Retrieved from www.accc.gov.au/focus-areas/inquiries-finalised/murray-darling-basin-water-markets-inquiry/final-report
109. Communique: Murray–Darling Basin Ministerial Council, 27 November 2020. See www.mdba.gov.au/media/mr/Murray-Darling-basin-ministerial-council-27-nov-2020

Australian Competition and Consumer Commission water markets inquiry

Recently, the Australian Competition and Consumer Commission undertook an inquiry into water markets in the Murray–Darling Basin. The review highlighted that Basin water markets are critical to the efficiency and productivity of Australian agriculture, and that water trading delivers substantial benefits to both water users and the economy. However, it also highlighted significant deficiencies, and recommended major reforms across four key areas:

- market governance needs comprehensive reform
- stronger market integrity and conduct regulations are needed
- trade processes and information need to improve
- market architecture (trade rules and system design) needs to better reflect the physical river system.

Full details can be found in the final report from the inquiry.[110]

In May 2021, the Australian Government committed $3.5 million to establish an expert panel to address the four recommendations.[111] A principal advisor was appointed and work is underway to find actions that can be agreed by Basin states. The draft implementation roadmap is expected to be released in June 2022.[112]

The NSW Government is currently considering further reforms to the water market following the release of the Australian Competition and Consumer Commission's final report, including the opportunities to introduce 'unique common identifiers' for each market participant. These unique common identifiers would enable trades to be traced and the conduct of traders to be more easily scrutinised across regions and multiple accounts, to strengthen the transparency of water markets in NSW.

Transparency in how water markets operate is critical to ensure trust and accountability for all market participants. To improve transparency in water markets, the NSW Government has already:

- published a trade price dashboard
- collected new information on NSW trade in relation to dates, and the purpose and price of the trade
- identified broker and environmental trades
- increased the scrutiny of $0 trade price reporting
- added an environmental water portal to the public water register.

In late 2020, the NSW Government also invited community feedback on all of NSW's water market information platforms to understand what information should be shared, and how the various platforms could be improved. Submissions on the *Transparency in the NSW water markets (Discussion paper)* will feed into future considerations around water market reforms in NSW.[113]

110. Australian Competition and Consumer Commission 2021, *Murray–Darling Basin water market inquiry—Final report*. Retrieved from www.accc.gov.au/focus-areas/inquiries-finalised/murray-darling-basin-water-markets-inquiry/final-report
111. The Hon Keith Pitt MP, *Budget beginnings process of water market reform*. See www.minister.awe.gov.au/pitt/media-releases/budget-water-market-reform
112. Australian Government 2021, *Water market reform roadmap*. Retrieved from www.awe.gov.au/water/policy/markets/reform
113. The NSW Government will consider the potential socioeconomic impacts of future water market reforms.

Inter-valley and interstate water trade in the southern connected basin

There are 15 unique trading zones where water allocations can be traded in the Murrumbidgee, NSW Murray, Lower Darling, Victorian and South Australian regulated river water sources. Trade between zones is subject to inter-zone trading rules, sometimes also referred to as 'inter-valley trading rules' or 'interstate trading rules', which impose restrictions on trade.[114]

The four major allocation trade restrictions in the southern connected basin are:

- Murrumbidgee Inter-Valley Trade (Murrumbidgee IVT) limit
- Goulburn to Murray Trade (Goulburn IVT) limit
- NSW to Victoria Trade Limit[115]
- Barmah Choke trade restriction.

The Murrumbidgee IVT operates between the Murrumbidgee and NSW Murray regulated river water sources. It reflects the net balance of surface water volume that has been traded out of the Murrumbidgee regulated river water source to the Murray system at any point in time, and that is therefore still 'owed' to the Murray in a physical sense as a result of those trades.[116]

The Murrumbidgee IVT is an important mechanism to partially overcome constraints in the mid-Murray, including the Barmah Choke. Since 2011/12, the Murrumbidgee IVT has switched regularly between being opened and closed; however, during 2016/17 and 2018/19, there have been regular and extensive closure periods of the Murrumbidgee IVT.

WaterNSW is responsible for administering and managing the trade processes that facilitate the Murrumbidgee IVT. Due to changes in water use patterns and trading behaviours, WaterNSW is conducting a review of the current arrangements for receiving and processing trade applications for access to the Murrumbidgee IVT capacity.[117]

The Goulburn IVT is operated by the Victorian Government. This IVT does not allow trade from the Goulburn, Campaspe, Broken and Loddon systems to the Murray if more than 200 GL of water is 'owed' to the Murray at any one time.[118] Since 2012/13, there have been extended periods when the Goulburn IVT has been closed, including most of the 2019/2020 water year.

The Victorian Government has consulted on changes to the Goulburn IVT to address impacts on the environment and other water access entitlement holders. Should trades via the Goulburn IVT be further restricted, this will likely place increased pressure on the Murrumbidgee IVT.

Murray–Darling Basin Authority's River Murray Operations use the Goulburn IVT and Murrumbidgee IVT accounts to meet Murray River system demands efficiently when needed. This occurs when the Murray–Darling Basin Authority calls on the operators of these two systems to release water to the Murray in a bulk delivery, and essentially 'pays back' an amount owing to the Murray.

114. Australian Competition and Consumer Commission 2021, *Murray–Darling Basin water market inquiry—Final report*. Retrieved from www.accc.gov.au/publications/murray-darling-basin-water-markets-inquiry-final-report
115. The NSW to Victoria spill risk trade limit is implemented by the Victorian Government. It limits allocation trade from NSW to Victoria to the lesser of a net annual volume of 200 GL or a volume that keeps the risk of spill in Victoria's share in the Murray system below 50%. Since 2012, this trade limit mostly did not apply, except during late 2015/16 and 2016/17.
116. The Murrumbidgee IVT account is operated between a lower limit of 0 GL and an upper limit of 100 GL. If the balance reaches 0 GL, trade into the Murrumbidgee is closed, while if the balance reaches 100 GL, trade out of the Murrumbidgee is closed. These volumetric limits are in place to address physical system constraints and to minimise impacts on the water available to other water users.
117. WaterNSW 2021, *Review of the Murrumbidgee inter-valley transfer (IVT) application and assessment approach*. Retrieved from www.waternsw.com.au/__data/assets/pdf_file/0009/168669/Murrumbidgee-IVT-review-issues-and-options-paper.pdf
118. If the 200 GL is exceeded, trade out of the Goulburn system is closed and cannot open again until the Goulburn IVT account balance falls below 200 GL.

The Barmah Choke trade restriction is implemented by the Murray–Darling Basin Authority, and reflects the physical constraint on the Murray River running through the Barmah–Millewa Forest. The Barmah Choke restricts the flow of the Murray River to 9,200 ML/day.

The Barmah Choke trade restriction ensures that water allocation trade downstream through the Barmah Choke can only occur when there is sufficient matching prior trade upstream. Since 2014/15, the Barmah Choke trade balance has varied; however, during recent years, the balance has generally been 0 GL, with only small periods when water allocation trade downstream could occur.

Due to the increasing demand in downstream regions and other factors, inter-regional and inter-valley trade restrictions are becoming more binding and we will likely see continuous price differentials between regions, especially during dry periods. It may also increase the risks of supply shortfalls within a year, particularly under a drier future climate or if trade constraints are further tightened.

The climate datasets and updated modelling developed for the regional water strategies will provide further important information to analyse the potential impacts of climate variability and climate change on water markets and trading activities.

Photography
Image courtesy of Destination NSW.
Murray River, Barmah National Park.

Compliance

An effective compliance regime is important to ensure that:

- our water resources are effectively managed
- water users and communities can have confidence that everyone 'plays by the rules' and if they do not, then they are held to account.

Following the 2017 *Independent investigation into NSW water management and compliance—final report* (the Matthews Report),[119] the NSW Government established and is building an effective, efficient, transparent and accountable compliance and enforcement framework, supported by fair and consistent procedures to manage the state's water resources. Leading this work is the independent Natural Resources Access Regulator, established in 2017.

The Natural Resources Access Regulator is moving from reactive to proactive and preventative compliance work to get ahead of emerging issues, better understand the regulated environment and support the rollout of new initiatives such as the new non-urban water metering policy.

This policy, announced by the NSW Government as part of the 2017 Water Reform Action Plan, will significantly improve water management and compliance in the state. Under the framework, large surface water pumps (500 mm and above) were required to be fitted with compliant metering and telemetry equipment by 1 December 2020. All remaining NSW inland surface and groundwater works covered by the rules need to be fitted with compliant metering equipment by December 2022.

In June 2021, the NSW Government announced $23.6 million of new funding to assist water users transition to telemetry-based metering—of which $9 million will fund rebates for water users switching to telemetry, and $14.6 million will support upgrading government-owned meters.[120, 121]

119. Matthews, K. 2017, *Independent investigation into NSW water management and compliance*. Advice on implementation. Retrieved from www.industry.nsw.gov.au/__data/assets/pdf_file/0019/131905/Matthews-final-report-NSW-water-management-and-compliance.pdf
120. Department of Planning, Industry and Environment 2021, *$23.6m to support modernisation of non-urban water meters in NSW*. Retrieved from www.dpie.nsw.gov.au/news-and-events/articles/2021/$23.6m-to-support-modernisation-of-non-urban-water-meters-in-nsw
121. In Murray and Murrumbidgee regions, around 1,900 works captured by the new metering rules are fitted with meters owned by WaterNSW, as a legacy of previous Commonwealth funded programs, www.dpie.nsw.gov.au/news-and-events/articles/2021/$23.6m-to-support-modernisation-of-non-urban-water-meters-in-nsw

Knowledge and information are essential to manage water resources

To efficiently and effectively manage NSW surface water and groundwater resources and protect them into the future, we need to continuously improve our understanding of the resources and how they are used across the NSW Murray region.

Gathering and analysing data about how water is used in the catchment and how changes in population and land uses may affect water resources, water demands and usage behaviours will help:

- inform NSW water management decisions
- better protect the region's water resources
- address water-related risks earlier and thereby support our local communities, industries and the environment.

As a highly regulated system, there is a range of information available about storage levels, regulated river heights and flow rates in the Murray River. In addition, the southern NSW valleys were part of an early Southern Valley Metering Project which commenced in 2015 and aimed to ensure 95% of total extraction in the regulated, unregulated and groundwater systems in the region were metered. Through the new Non-Urban Water Metering Policy announced by the NSW Government as part of the 2017 Water Reform Action Plan, remaining gaps in metering will be addressed[122] (see section on 'Compliance' above).

The regional water strategies provide an opportunity to undertake further work to better understand water user behaviour in the southern NSW regions—in particular, industry water use to determine whether extractions track at, equal or below the Sustainable Diversion Limits (see Option 35: Better understand water use with data and analytics). In addition, we need to better understand growth in NSW town water needs over the next 20 years, including the proportion of non-residential water users reliant on town water supplies.

Data and information is also important to help communities, industries and the environment to better manage their water needs and any water-related risks. We acknowledge that a lot of information is already available, but it is often dispersed and not easily accessible. The regional water strategies provide an opportunity to consider how we best share the data we have across water users in the NSW Murray, and how we tailor our data analytics and information products to meet the needs of different water users. Option 38: Develop targeted education and capacity building programs, has been informed by our past conversations with communities in the NSW Murray, and suggests several areas where we could target our initial efforts and build on past initiatives.

Given the continuing demands on groundwater, increasing our understanding of the interaction between surface water and groundwater resources in the NSW Murray will help us improve our management of these resources. We need to understand how a change in groundwater use can influence flows to rivers and vice versa. We also need to understand how a changing climate is impacting the replenishment of groundwater resources.

122. As of 1 December 2021, 83% of pumps 500 mm or greater in the Murrumbidgee and 75% of pumps 500 mm or greater in the Murray were fully compliant with the new metering rules.

More broadly, we need to ensure ongoing investment in the groundwater monitoring network so we have the water level and quality information we need to manage the resource into the future (see Option 19: Monitor sediment compaction over the long term). Additionally, we need to investigate how the new climate datasets and improved representation of surface water–groundwater interaction can be integrated into the NSW groundwater models (see Option 36: Improve the understanding of groundwater sources and processes, risks and impacts).

The economic value of ecosystem services and their financial contribution to economic output is not well understood, nor is economic loss due to negative development impacts on ecological function. As a result, our ability to determine what the least-cost policy and infrastructure options are is limited in this regard. As such, there is a need to recognise, describe, support and improve the economic value of waterways and ecological assets and processes by:

- establishing the value of those assets and services, and their contribution to economic output
- using those values in investment decision-making.

Refer to Option 34: Better understand economic value of ecosystem services of riverine environment assets.

To build community confidence in water management, there is a need for government to provide more transparent and accessible information. The NSW Government has released the NSW Water Strategy, which includes a key action to increase the amount and quality of publicly available information about water in NSW. The department has also recently released a range of videos that explain how water is managed in NSW.[123]

Within NSW, there have been several improvements in communicating water information to stakeholders:

- The **NSW Water Register** provides a central point of public access to information about water licences, approvals, water trading, water dealings, environmental water and other matters related to water entitlements in NSW.
- The **WaterInsights Portal** provides meaningful information and real-time data to support WaterNSW customers and communities.
- The NSW **Allocations Dashboard** brings greater transparency to water users and market participants via water availability announcements.
- The **Trade Dashboard** brings greater transparency to water users and market participants via information on dealings in the water markets.
- The **Environmental Water Hub** collates relevant data and information about environmental watering activities in NSW.
- The Natural Resource Access Regulator's **Public Register** lets the public find out about convictions under water legislation in NSW.

In addition, the Bureau of Meteorology has recently released the Murray–Darling Basin water information portal (online) for access to storage levels, water allocations and trading information across the Basin.

These information tools are expected to lead to improvements in water market participation, in the ability for water users to make business plans and decisions, and in the level of engagement in NSW water resource management planning initiatives and reforms.

123. Department of Planning and Environment—Water, *Resource assessment process*. Retrieved from www.industry.nsw.gov.au/water/allocations-availability/allocations/how-water-is-allocated/resource-assessment-process

Enhanced Drought Information System web portal

As a result of a national review of drought policy and state review of seasonal condition reporting, the NSW Government initiated the Enhanced Drought Information System Project to track all phases of drought onset and recovery. The project aims to enable more proactive drought management by building drought risk awareness, emphasising drought preparedness and improving confidence in drought monitoring and early warnings.

A key feature of the portal is the Department of Primary Industries Combined Drought Indicator, which provides complex data in a format that is useful for decision-makers. The indicator integrates meteorological, hydrologic, agronomic and drought direction indexes—combined to indicate the five phases of drought (non drought, recovering, drought affected, drought and intense drought).

The Future Ready Regions Strategy includes a commitment to upgrade the portal to provide farms with world-leading weather and climate data so they can make better business decisions.

The Enhanced Drought Information System web portal is located at edis.dpi.nsw.gov.au

Photography
Image courtesy of iStock.
Hume Lake, Albury.

Chapter 3

More resilient water resources for the NSW Murray region

Photography
Image courtesy of iStock.
Murray River, NSW.

Snapshot

Water is essential for Aboriginal people's health, wellbeing and connection to Country.

- The current provisions in the *Water Management Act 2000* are not meeting the spiritual, cultural, social and economic needs of Aboriginal people.
- In our conversations with Aboriginal people, there was a strong sentiment that Aboriginal people want to be represented in the decision-making process, and have a say in how water is managed in their region.
- Two sites have been assessed as part of the Aboriginal Waterways Assessment program in the NSW Murray region, including the Werai Forest and the Millewa Forest, and a range of values were identified—including heritage sites and key wetlands.
- The government recognises there are systemic issues that need to be addressed at a statewide and regional level to better enable Aboriginal people to exercise their rights and to access water.

There are challenges in meeting environmental needs and sustaining the long-term health of floodplain forests and woodlands, wetlands, riparian zones, and plants and animals.

- The natural flow regime of many rivers has been significantly altered due to water extraction, dam and weir construction, and regulation of flows. There has also been a large reduction in the natural winter/spring pulse flows, and sustained unseasonal flows during the warmer months when river levels would typically be lower. To address this, the state and federal governments have embarked upon a long-term reform process to restore a more natural flow regime in the Snowy and Murray rivers.
- Large floods, combined with stressed floodplains, can impact water quality and heighten the risk of extensive hypoxic blackwater events, which pose serious risks for aquatic wildlife, water-based recreational activities and consumptive water users.
- Water infrastructure prevents wildlife from completing their life cycles. Dams and weirs create an impenetrable barrier to aquatic organisms moving, such as our native fish species. In-stream water storages also create barriers that reduce the amount of flowing habitat needed by many native fish species such as Murray and trout cod, and golden and silver perch. There are opportunities for increasing areas of fast-flowing habitat such as those being considered under the SDLAM Project for Locks 8 and 9.
- Thermal stratification of dams and weirs can cause a variety of impacts. The Murray River from Hume Dam to Yarrawonga Weir is impacted by cold-water pollution with an almost complete loss of historic populations of Murray cod, trout cod, Macquarie perch and catfish. Stratification can lead to potentially toxic algal blooms. Blooms occurred in 2009, 2010 and 2016 in the Murray and Edward/Kolety–Wakool river systems and a 'Red Alert' warning level was issued for the southern Basin in 2021. Thermal stratification is addressed in the *Cold Water Pollution Strategy 2004*; however, a lack of funding has led to significant delays in trials and assessments.

- Introduced animals such as carp, redfin perch, trout, feral pigs and horses, and plants such as the water weeds Elodea and Egeria continue to impact native species and the landscape. Management actions to improve riverine environments require coordination with appropriate agencies. To ensure that invasive species cannot negate any potential benefits of management actions or receive a greater share of benefit compared to native species, this aspect has been built into considerations for numerous options.

Regional town water supplies are under increasing pressure.

- The region's local water utilities hold approximately 50 GL of regulated and unregulated surface water access licences to supply towns and villages. This equates to less than 2% of all licensed water entitlement in the region. Water availability within the region is finite and fully allocated.

- The expected future population growth and urban development in the region, coupled with the ongoing pressures of drought and climate change, mean that integrating long-term planning for water resources and other planning is critical. Several local water utilities are already implementing water conservation and demand management measures; however, many are yet to start, or are in the early stages of developing an integrated water cycle management strategy.

- The region's economy and population are expected to grow over the next 15 years, with employment opportunities expected to grow around 6%. Economic growth in the region will be stimulated by increasing global and domestic demands for food and fibre, existing high-growth service industries such as health, education and tourism, and infrastructure spend (such as the Inland Rail Project and the Snowy Mountains Special Activation Precinct).

- Poor water quality in some areas of the NSW Murray region can render water unsafe for recreation or be prohibitively expensive to treat. For example, blue-green algae blooms impact waterway users and the tourism industry that is reliant on the Murray River for waterskiing, boating, swimming and fishing. Furthermore, towns like Bombala experience persistent issues with turbidity affecting potable water treatment.

Water security and reliability are essential for industry and economic development.

- Agriculture is the largest industry in the NSW Murray region that directly uses water, producing much of the economic output and being a major employer, particularly in secondary agribusiness industries. In 2017, agriculture in the Murray–Riverina area was worth $1.4 billion, and is one of the most productive and diverse agricultural areas in Australia, giving rise to its claim as the 'food bowl of Australia'. However, during the 2017-2020 drought, reduced water availability and increased water costs drove declines in irrigation activities.

- In 2019, there were 2.8 million visitors across the NSW Murray region, who spent approximately $1.4 billion on tourism. Central to this tourism is a healthy river system with attractions such as food, produce, wineries, natural attractions, fishing, houseboats, and snow and water sports. The newly created Snowy Mountains Special Activation Precinct aims to transform the area into a successful four-season tourism destination by leveraging natural assets and unique climate to stimulate economic development and investment. Ensuring that water resources, including riverine environments, are managed sustainably will be critical to encourage further growth in tourism.

3.1 Recognise and protect Aboriginal water rights, interests and access to water

3.1.1 Water, culture and Country

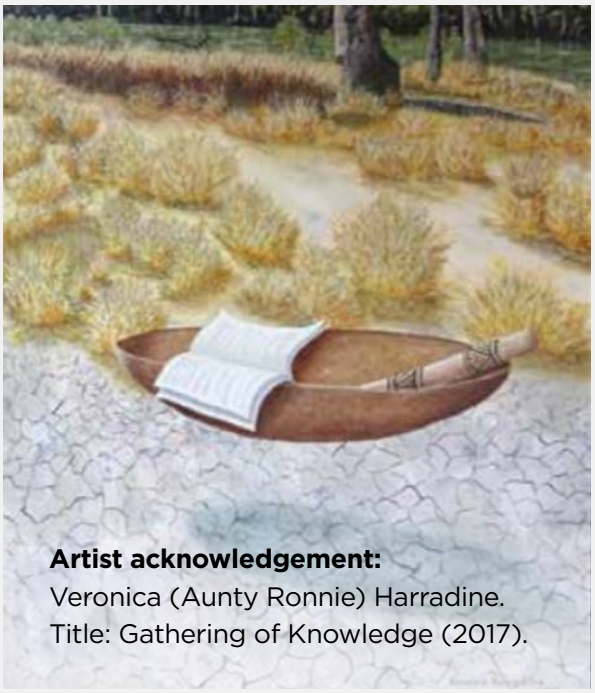
Aboriginal people have lived in the NSW Murray region for over 45,000 years and have experienced major climate, environmental and land use changes. The NSW Murray region lies within the lands of 17 First Nations:

Bangerang	Mutthi Mutthi	Wadi Wadi	Ngarigu
Barkandji	Ngiyampaa	Wemba Wemba	Walgalu
Barapa Barapa	Nyeri Nyeri	Weki Weki	Bidhawal
Maljangapa	Tati Tati	Wiradjuri	Yorta Yorta
Maraura			

Water is deeply entwined with Aboriginal culture and Aboriginal peoples' connection to Country. As the first managers and carers of this natural resource, Aboriginal people have rights and a moral obligation to care for water under their law and customs. These obligations connect communities and encompass connected surface water and groundwater systems.

Similar to the veins in a human body, waterways are often likened to the 'veins of the country',[124] carrying water to sustain people and all parts of the landscape. Wetlands are often compared to human 'kidneys', filtering the water as it passes through the land. This understanding of water as a life source shows the deep connection Aboriginal people have to Country and shows their sense of cultural responsibility to look after all water sources so that, in turn, the water will look after people and all living beings.

124. Murray–Darling Basin Authority 2021, *Rivers—the veins of our Country*. Retrieved from www.mdba.gov.au/sites/default/files/pubs/rivers-the-veins-of-our-country-2019-20.pdf



Artist acknowledgement:
Veronica (Aunty Ronnie) Harradine.
Title: Gathering of Knowledge (2017).

This artwork symbolises the coming together of two cultures for the protection of Country and to preserve Aboriginal sites, lands, waterways, flora and fauna.

Respect and acknowledgement of the expertise which comes from both Indigenous cultural practices and western knowledge are represented.

This artwork celebrates the importance of healing, preserving and caring for Country, to maintain cultural knowledge. The Coolamon, an Aboriginal gathering tool, sustains life; hence, the title of the painting, Gathering of Knowledge.

(Image provided by the Mallee Catchment Management Authority).

The region contains places of deep significance to these First Nations which are central to their spiritual and religious belief system; and are often celebrated in ritual, ceremony, story, dance and artwork. Water supports kinship, connection, stories, songlines and healing through medicine and food. Healthy waterways and groundwater systems are critical to sustaining these aspects of Aboriginal life and to ensure the wellbeing of Aboriginal people.

The *Murray–Lower Darling Long-Term Water Plan* also recognises Aboriginal peoples' connection to Country and their aim to protect Country by maintaining the health of rivers and wetlands, and water dependent plants and animals. Through the Aboriginal Waterways Assessment Program,[125] two sites have been assessed in the NSW Murray catchment—the Werai Forest by the Wemba Wemba and Barapa Barapa Nations and the Millewa Forest by the Bangerang and Yorta Yorta Nations. The *Murray–Lower Darling Long-Term Water Plan* identifies water management strategies that aim to maintain and improve the long-term health of the Werai Forest and other sites in the NSW Murray region. However, to nourish these important sites, it is acknowledged that genuine and ongoing consultation with Aboriginal people is vital.

125. Murray Lower Darling Rivers Indigenous Nations. *Un-dated. Using the Aboriginal Waterways Assessment tool: A handbook for practitioners*. See www.mldrin.org.au/what-we-do/aboriginal-waterways-assessment/

Working together on the Millewa Aboriginal Waterways Assessment

The Barmah–Millewa Forest is the largest river red gum forest in Australia and listed as an internationally significant wetland (Ramsar site).[126] The forest spans the NSW and Victorian border and includes 66,000 ha of wetlands. The area is abundant in native plants, fish, reptiles, birds and mammals; and is an important spiritual and cultural place for Yorta Yorta and Bangerang people.

In November 2018, around 18 Aboriginal community representatives completed an assessment at Millewa Forest—the first formal Aboriginal Waterway Assessment undertaken in NSW.[127]

The assessment identified a number of values within the forest, including contemporary stories associated with the use of areas and resources, as well as significant Aboriginal heritage sites around key wetlands. This input continues to inform targeted environmental water delivery to sites which are of cultural and ecological value.

Improving the health of the Millewa Forest environment using Aboriginal knowledge would increase biodiversity, and provide opportunities for sustainable use of cultural resources by Aboriginal people. It would also contribute to the management of the Millewa Forest, and provide opportunities for Aboriginal people to connect to Country and culture. Recent activities included attaching GPS data loggers to eastern long-necked turtles for a Yorta Yorta Nation Aboriginal Corporation turtle-tracking project[128] and fuelling reduction burns to observe how carex (a sedge important for weaving) responds to fire.

126. Department of Sustainability, Environment, Water, Population and Communities 2011, *Barmah Forest Ramsar site Ecological Character Description*. Retrieved from www.environment.gov.au/water/wetlands/publications/barmah-forest-ramsar-site-ecological-character-description
127. Australian River Restoration Centre 2018, *Working together on the Millewa Aboriginal Waterways Assessment*. Retrieved from arrc.com.au/rivers-the-veins-of-our-country/working-together-on-the-millewa-aboriginal-waterways-assessment-nsw/
128. Department of Environment, Land, Water and Planning, *Cultural conservation of freshwater turtles*. Retrieved from www.ari.vic.gov.au/research/wetlands-and-floodplains/cultural-conservation-of-freshwater-turtles

Photography
Image courtesy of iStock.
Wonga Wetlands, Albury.

Water for Aboriginal people

Aboriginal peoples' legal rights as they apply to water management have been recognised in international human rights treaties and conventions, in Australian and NSW Native Title and land rights laws, and in national and state-based water plans. These instruments recognise the importance of maintaining the knowledge and practices of Aboriginal people, promoting their full participation in decisions about water resources, and acknowledging Aboriginal cultural values and uses in water planning.

In addition, First Nations prepared the 2007 Echuca Declaration which defines cultural flows as 'water entitlements that are legally and beneficially owned by the Nations of a sufficient and adequate quantity and quality to improve the spiritual, cultural, natural, environmental, social and economic conditions of those Nations'.[129]

While there are some ways of accessing water for cultural purposes, we heard from Aboriginal people in inland regions across the State that the current provisions in the *Water Management Act 2000* are not meeting their spiritual, cultural, social and economic needs. We are committed to having an ongoing dialogue with Aboriginal people to find ways to improve this.

Native Title claims

Australia's Native Title laws recognise the traditional rights and interests to land and water of Aboriginal people, established by the *Native Title Act 1993*. The NSW *Water Management Act 2000* specifically recognises Native Title water rights, stating that 'a Native Title holder is entitled, without the need for an access licence, water supply works approval or water use approval, to take and use water in the exercise of Native Title rights' (section 55). Anyone who holds Native Title with respect to water can take and use water in accordance with the laws and customs by which the title is held. As stated in section 211(2) of the *Native Title Act 1993*, 'the law does not prohibit or restrict the Native Title holders from carrying on the class of activity, or from gaining access to the land or waters for the purpose of carrying on the class of activity, where they do so for a) the purpose of satisfying their personal, domestic or non-commercial communal needs; and b) in exercise or enjoyment of their Native Title rights and interest'.[130] Native title holders and Traditional Owners often have water-related aspirations—from protecting water to giving advice on water management practices within a determinations area and seeking water allocations.

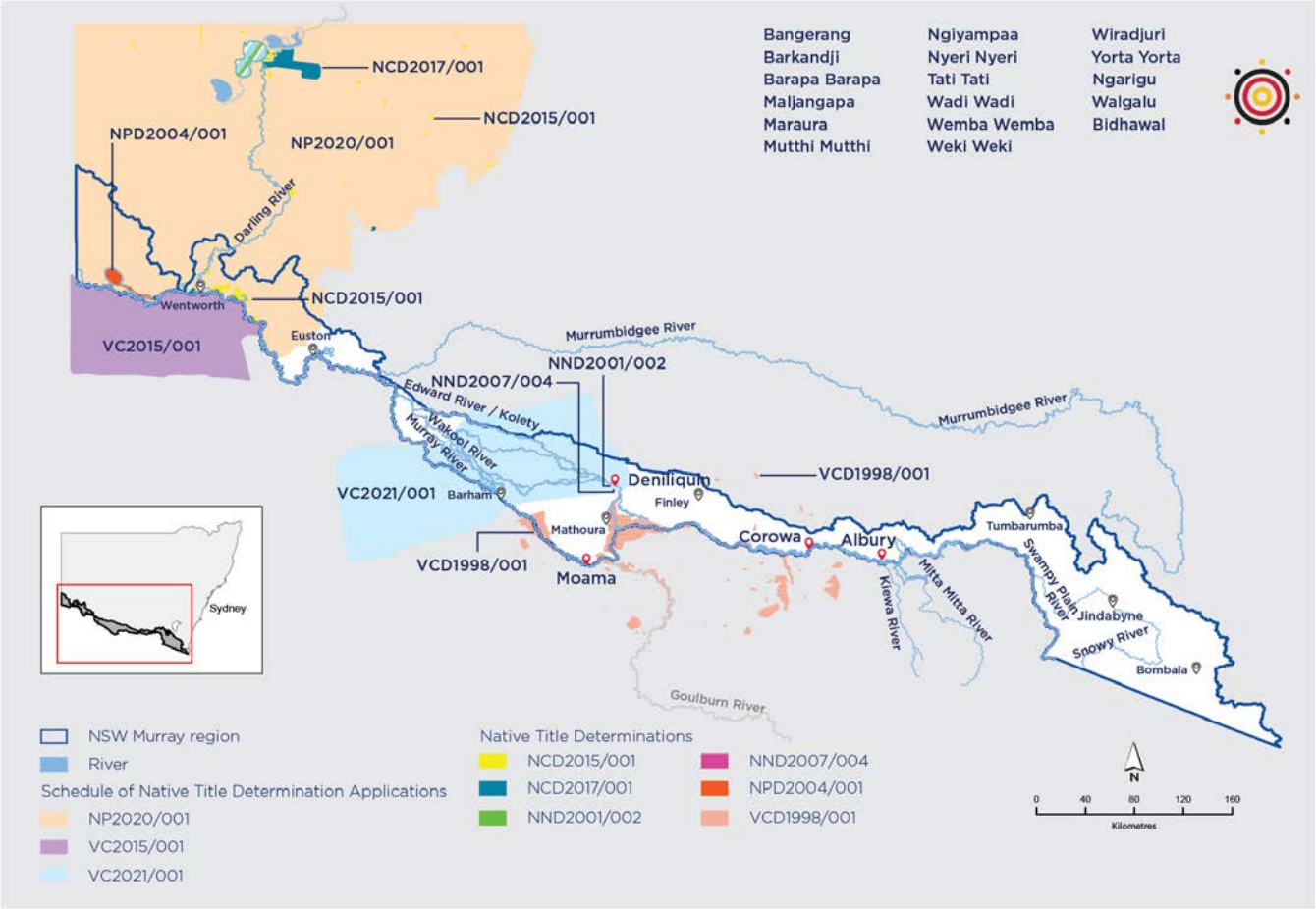
There have been several Native Title applications made in the NSW Murray region.[131] In three cases, it has been determined that Native Title exists (Table 4 and Figure 28).[132]

129. Murray Lower Darling Rivers Indigenous Nations (MLDRN) 2007, *Echuca Declaration*. See www.mldrin.org.au/echuca-declaration-final-pdf/
130. This subsection applies if section 211(1) of the *Native Title Act 1993* is met.
131. Native Title Tribunal. n.d. *About native title applications or native title determination applications*. Retrieved from www.nntt.gov.au/nativetitleapplications/Pages/default.aspx
132. All water planning processes should engage with Native Title holders or registered claimants, and account for the possible existence of Native Title rights to water in any given area.

Table 4. Native Title applications in the NSW Murray region

Application name	Tribunal file number	Status	Native Title claim overview
Barkandji Maljangapa People	NP2020/001	Pre-notification	The claim is located in the far west of NSW and includes the Murray River north to Wanaaring, and west to the South Australian border. It includes towns such as Broken Hill, Wilcannia and Pooncarie.
First Peoples of the Millewa-Mallee Claim	VC2015/001	Registered	The claim is located in north-west Victoria and includes the Murray River west of and including the greater Mildura area.
Barkandji Traditional Owners #8 (Part A)	NCD2015/001	Determined	Native Title exists in parts of the determination area.
Barkandji Traditional Owners #8 (Part B)	NCD2017/001	Determined	Native Title exists in parts of the determination area.
Deniliquin Local Aboriginal Land Council	NND2001/002	Determined	Native Title does not exist.
Deniliquin Local Aboriginal Land Council	NND2007/004	Determined	Native Title does not exist.
Barkandji (Paakantyi) People #11	NPD2004/001	Determined	Native Title does not exist.
Yorta Yorta	VCD1998/001	Determined	Native Title does not exist.
Wemba Wemba	VC2021/001	Pre-notification	The claim is located at Lake Tyrrell and Birchip, Victoria, extending to Deniliquin, NSW.

Figure 28. NSW Murray region Native Title applications and determinations



3.1.2 Water issues raised by Aboriginal people in the region

Aboriginal people can apply for individual Aboriginal cultural water access licences.[133] If granted, this licence can provide up to 10 ML/year for cultural purposes such as cultural teaching or ceremonial purposes. During our conversations with Aboriginal people, we heard that the process to apply for this licence is complicated and often associated with significant costs. We will address opportunities to simplify the application process, and provide clearer and targeted information material on how Aboriginal people can apply, as part of the broader statewide process.

In addition, we heard that licences and water entitlements owned by Aboriginal people should allow for economic benefits and enable employment opportunities to be created. While some groups and Aboriginal Land Councils own water licences, the licensing framework and costs of purchasing water on the market create significant barriers for Aboriginal people to buy and own water entitlements and allocations.

In our conversation with Aboriginal people, we heard concerns about the state of the river and about governments not listening to First Nations. There was a strong sentiment that Aboriginal people want to be represented in the decision-making process and have a say in how water is managed in their region. We also heard that there are concerns about access to water and Country, which often rely on existing relationships with resident landholders. In cases where these relationships are not established, Aboriginal people felt shut out of places that are of deep cultural significance to them. Land clearing and disturbance of important sites is another major concern, which has resulted in loss of native plants and other resources used for food and medicine.

Collectively, these constraints prevent Aboriginal people from adequate access to water and Country, to fulfil their rights and moral obligations under their law and customs, and to protect their important cultural sites.

133. In NSW, the *Water Management (General) Regulation 2018* also allows for applications to be made for any category of specific purpose access licence, subcategory Aboriginal Cultural, for Aboriginal cultural purposes. This ensures that applications can be made for an Aboriginal Cultural licence throughout NSW, in both surface water and groundwater. These licences allow the take of water independent of Native Title rights.

3.1.3 Opportunities and potential options

The NSW Government recognises there are systemic issues that need to be addressed at a statewide and regional level to better enable Aboriginal people to exercise their rights and access to water. These issues include:

- access to cultural flows
- self-determination and decision-making regarding water policy
- increased understanding (for Aboriginal people) of the water management framework
- incorporation of Aboriginal people's knowledge and science about water systems into water planning, management and policy development.

The strategy will also consider how water-related solutions can help to deliver NSW's commitments under the National Agreement on Closing the Gap.[134]

Taking statewide action

The NSW Government recognises Aboriginal people's rights to water and we aim to secure a future where water for Aboriginal people is embedded within the water planning and management regime in NSW and delivering cultural, spiritual, social, environmental and economic benefits to communities.

Actions are proposed in the NSW Water Strategy to:

- strengthen the role of First Nations in water planning and management
- develop a statewide Aboriginal Water Strategy
- provide Aboriginal ownership of and access to water for cultural and economic purposes
- work with First Nations to improve our shared water knowledge
- work with Aboriginal people to maintain and preserve water-related cultural sites and landscapes.

134. Australian Government 2020, *National Agreement on Closing the Gap*. Retrieved from www.closingthegap.gov.au

There are also opportunities to advance the rights, interests and aspirations of Aboriginal people in the region. These include improving the individual 10 ML Aboriginal Cultural Licence application process, enabling better access to water and Country, and simplifying cultural fishing rules and processes. There are also several other options on the long list, including environmental restoration works, and options related to groundwater that may advance the rights, interests and aspirations of Aboriginal people in the NSW Murray region.

There may also be opportunities to build on recent funding commitments by the Australian Government to establish river ranger positions across the Basin to help improve waterway health, manage Country and ensure more Aboriginal people are involved in managing water.

Due to the COVID-19 pandemic, our engagement with Aboriginal people was significantly hindered. Accordingly, the options presented in this draft strategy to recognise and protect Aboriginal rights, interests and access to water are limited. Based on the lessons from our limited engagement, the following options have been included for the Draft Murray Regional Water Strategy—and we are interested in feedback from Aboriginal people on these draft options:

- Option 1: Improve access to culturally significant areas and waterways for Aboriginal people
- Option 2: Review the Aboriginal Cultural Water Access Licence framework
- Option 3: Support long-term participation of local Aboriginal people in water-related matters
- Option 4: Fund water entitlements for Aboriginal communities
- Option 5: Secure flows for water dependent cultural sites
- Option 6: Shared benefit project (environment and cultural outcomes)
- Option 7: Incorporate Aboriginal history of water and culture in the southern Basin into water data.

We are committed to continuing our conversation with Aboriginal people on how to develop the Murray Regional Water Strategy to ensure that their rights, interests and concerns related to water are heard and included in the final strategy. We will continue this dialogue into the future to keep the Murray Regional Water Strategy up to date with the needs and aspirations of Aboriginal people.[135]

135. More information about our First Nations engagement approach is in the *Regional Water Strategies Guide*.

3.2 Protect and enhance the environment

The NSW Murray region is renowned for its natural riverine features and assets—including a range of upland and lowland rivers, nationally and internationally recognised wetlands, lakes, extensive river red gum forests, and a diverse range of native and threatened plants and animals. These riverine features exist across the entire length of the region and are critical to sustain the health of the river system for the benefit of communities, the tourist industry and industries alike.

Key water dependent environmental assets in the NSW Murray region include:

- the iconic Snowy and Murray rivers that have sustained Aboriginal people for thousands of years and helped build and feed a prosperous, modern-day Australia
- alpine Glacial lakes including Lakes Albina, Cootapatamba, Club, and the Ramsar-listed Blue Lake and Hedley Tarn (which are rare near-natural alpine wetlands in Kosciuszko National Park)
- Koondrook–Perricoota, Werai and Millewa forests that are part of the NSW Central Murray Forests Ramsar site
- many wetlands located on private land that contain critical habitats for threatened species such as the southern bell frog
- large lake systems on the Murray River floodplain including Poon Boon, Euston lakes, Tooim, Gol Gol and Lake Victoria
- threatened and iconic species, including a diverse range of native fish such as the Murray cod, Australian bass, river blackfish, trout cod, golden perch and Macquarie perch; vegetation communities of black box, river red gum, Moira grass and spike rush; waterbirds such as the Australasian bittern and Australian painted snipe; and threatened and vulnerable species of frogs such as the endangered southern bell frog and corroboree frog.

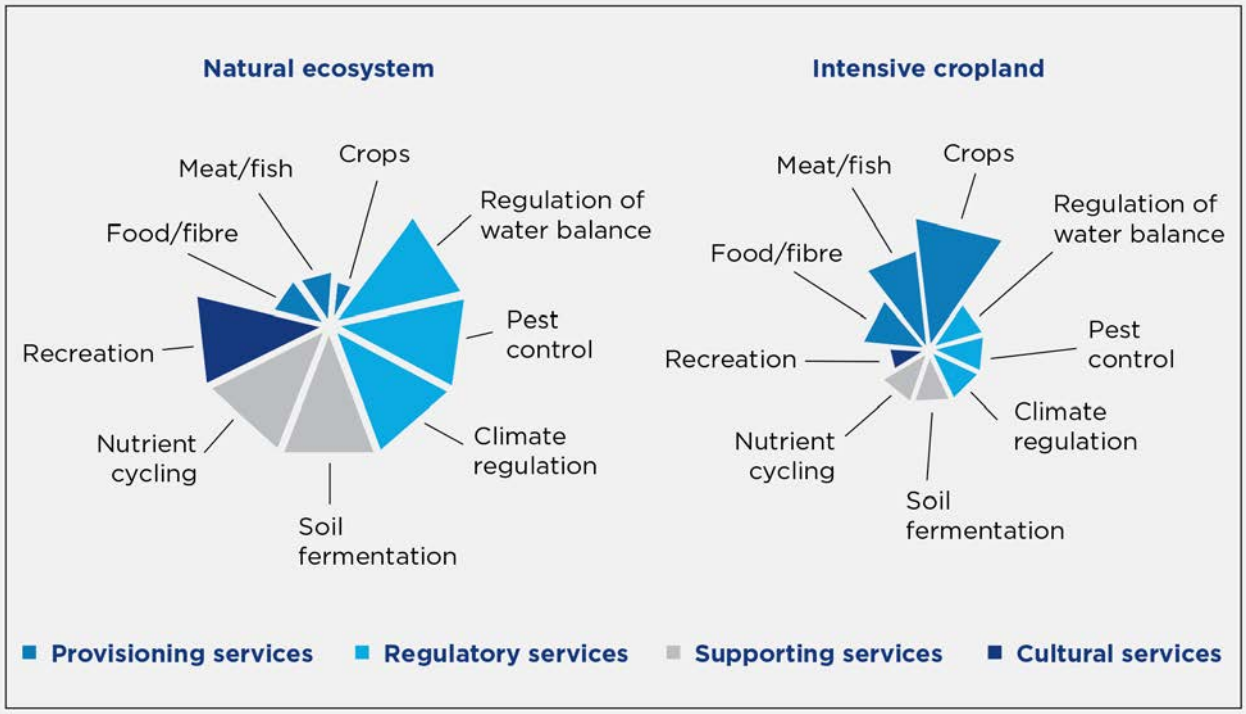
Resilient water resources are essential to support these environmental assets and species, and a healthy environment in turn supports improved liveability of the region, community health and wellbeing, and industries like agriculture and tourism.

Understanding and balancing agricultural and ecosystem services

The Riverina–Murray area is one of the most productive and diverse agricultural regions in Australia, giving rise to its claim as the 'food bowl of Australia'.[136] The riverine landscapes in the Riverina–Murray area not only support agriculture, but also provide a range of services to local communities and other industries. Figure 29 conceptualises the different types of services provided by natural ecosystems and by intensive croplands for areas like the Riverina–Murray:

- Ecosystems are important for sustaining Aboriginal cultural practices; removing pollutants; regulating local climate; providing recreational opportunities such as waterskiing, fishing and nature-based pursuits; and so on.
- Croplands primarily underpin production of food and fibre.

Figure 29. Contrasting services provided by natural ecosystems and agricultural services for a conceptual river valley



Source: adapted from Boelee, 2011;[137] Gordon et al, 2010[138]

136. Department of Planning and Environment 2017, *Riverina Murray Regional Plan 2036*. Retrieved from www.planning.nsw.gov.au/-/media/Files/DPE/Plans-and-policies/riverina-murray-regional-plan-2017.pdf
137. International Water Management Institute 2011, *Ecosystems for water and food security*. Retrieved from www.iwmi.cgiar.org/Issues/Ecosystems/PDF/Background_Document-Ecosystems_for_Water_and_Food_Security_2011_UNEP-IWMI.pdf
138. Gordon LJ, Finlayson cm, Falkenmark m. 2010, *Managing water in agriculture for food production and other ecosystem services*. Agricultural Water Management 97(4), p512-519. See www.sciencedirect.com/science/article/abs/pii/S0378377409000924.

From the start of the twentieth century until the 1980s, development of water resources in the NSW Murray region underwent significant expansion with the construction of dams, weirs, offtakes; and issuing of water licences.[139] This included constructing major dams such as those in the Snowy Scheme, Hume and Dartmouth dams, and Murray River weirs.

These initiatives were part of 'nation-building' programs that focused on economic development without adequate regard to managing the impacts on the environment. As a result, these policy settings have seen priority given to 'provisioning services' over the range of services provided by natural ecosystems (Figure 24) that are also important to healthy, functioning landscapes and prosperous communities.

The decline in river health has been progressively recognised since the 1980s with a series of reforms and actions to restore the health of riverine environments.

Through this regional water strategy, we need to continue working to sustain both productive agricultural industries and healthy rivers—and the services they provide. This includes a range of options to improve environmental health, but to also better understand the value that natural ecosystems provide (see Option 34: Better understand economic value of ecosystem services of riverine environment assets).

The water dependent native plants and animals in the NSW Murray region have evolved to function in the extremes that characterise the Australian climate.[140]

Patterns of flooding and drying are dictated by annual pulses of higher natural river flows in winter and spring in response to rainfall and snowmelt. These flows rise in the headwater streams and make their way downstream into the lowland rivers—temporarily raising water levels; inundating surrounding flood runners, floodplains, wetlands and forests; and causing an important exchange of food and nutrients with the river. River flow patterns trigger fish spawning and migration as well as waterbird breeding. Natural patterns of seasonal drying are also important for plant growth and reproduction, and maintaining habitat and foraging opportunities for animals.

Climate conditions and surface water flows are not the only determinant of the health of the environment in the NSW Murray region. Groundwater in the alluvial sediments of the Murray River plays an important role in supporting water dependent ecosystems. The groundwater dependent ecosystems[141] occur along rivers where there is greater connectivity between surface water and groundwater, and where groundwater provides critical baseflow to the river during dry periods to help sustain drought refuges for wildlife, trees and shrubs.

The following section explores the range of challenges, current actions and future opportunities to restore and maintain a healthy riverine environment for the benefit of not just the plants and animals they support, but also the range of industries, communities and cultural practices that they support.

139. National Water Commission 2011, *Water markets in Australia: a short history*. See apo.org.au/sites/default/files/resource-files/2011-12/apo-nid27438.pdf
140. Murray–Darling Basin Authority 2021, *Bioregions*. Retrieved from www.mdba.gov.au/importance-murray-darling-basin/environment/bioregions
141. Groundwater dependent ecosystems are 'ecosystems that require access to groundwater to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services'. Kuginis L, Dabovic, J, Byrne, G, Raine, A and Hemakumara, H. 2016, *Methods for the identification of high probability groundwater dependent vegetation ecosystems*. See www.industry.nsw.gov.au/__data/assets/pdf_file/0010/151894/High-Probability-GDE-method-report.pdf

Environmental status and issues

Development and river regulation in the region has negatively impacted environmental assets, ecosystems and their functions since the nineteenth century. These impacts are discussed below in more detail and include:

- Changes in flow patterns mean that some rivers can no longer sustain certain ecosystems.
- Large floods, combined with stressed floodplains, can reduce water quality and heighten the risk of extensive hypoxic blackwater events.
- Water infrastructure prevents wildlife from completing life cycles.
- Thermal stratification of ponded water bodies can cause a variety of impacts.
- Climate change is impacting the environment and is expected to worsen.
- Introduced species compete with native species and degrade ecosystems and habitats.

Changes in flow patterns mean that some rivers can no longer sustain certain ecosystems

Due to water extraction, dam and weir construction, and regulation of flows, the natural flow regime of many rivers has been significantly altered, with a large reduction in the natural winter/spring pulse flows and sustained unseasonal flows during warmer months when river levels would typically be lower. This has resulted in numerous impacts including, but not limited to:

- less diverse and smaller populations of wildlife including waterbirds, amphibians, crustaceans, reptiles and mammals
- fewer native fish in our rivers than there used to be, with some species being lost from certain areas entirely
- less riparian and floodplain vegetation, including forests and woodlands
- loss of the natural geomorphic character of our rivers and the dynamic habitat it provides to maintain biodiversity
- reduced quality of the water in terms of salinity, blue-green algae blooms, hypoxic blackwater, reduced oxygen and altered temperatures
- improved habitat conditions for invasive species such as carp.

To address this issue, the state and federal governments have embarked upon a long-term reform process to restore a more natural flow regime in the Snowy and Murray rivers. As such, a range of actions are being and have been undertaken. Notable ones include:

- establishing water sharing plans and rules to ensure a minimum amount of water and flow in our river systems for the environment. There are two types of environmental water[142] in the NSW Murray region:
    - planned environmental water is water committed for ecosystem health or other environmental purposes and managed through provisions in water sharing plans. This water can be rules based (such as transparent and translucent flows, end of system flows) or 'discretionary' in the form of environmental water allowances (volume of water set aside for environmental purposes and ordered by water managers)
    - held environmental water relates to water allocated to water access licences held by environmental managers for discretionary environmental use.
- recovering held environmental water under the Snowy Water Initiative and The Living Murray Initiative and, more recently, the Murray–Darling Basin Plan. Refer to the 'Water extraction limits' (Section 2.2.3) for further information
- adaptively delivering held environmental water (Figure 30) in the Murray River each year, guided by long-term and operational planning, commensurate with prevailing conditions
- delivering river flows that optimise environmental, social and economic outcomes with the combined efforts of river operators and environmental water managers working together
- constructing a range of floodplain environmental watering works across the Murray River downstream of Hume Dam, to achieve better environmental outcomes with less water
- changing management and operating rules and policies to enable efficient delivery of environmental water (e.g. the prerequisite policy measures)[143]
- upgrading infrastructure, such as increasing the release capacity of Jindabyne Dam.

142. NSW Government, *What is water for the environment?* Retrieved from www.industry.nsw.gov.au/water/environmental-water-hub/water-for-the-environment
143. Department of Planning and Environment, *Prerequisite Policy Measures*. Retrieved from www.industry.nsw.gov.au/water/environmental-water-hub/working-on/prerequisite-policy-measures

However, only part of this long-term restoration process has been completed due to multifaceted challenges that often require inter-regional and inter-jurisdictional collaboration:

- Overcoming the challenges posed by flow constraints associated with the Barmah Choke, which currently place significant limitations on the delivery of regulated consumptive and environmental flows (Section 2.3.1).
- Restoring more frequent connection of flows from the northern Murray–Darling Basin to the Lower Darling and Murray rivers to enable fish migration from nursery grounds in the Darling River catchment, which is important for the long-term survival of native fish species. In doing so, there would also be significant local social, economic, cultural and environmental benefits with the more frequent flows in the Lower Darling River en route. The Western Regional Water Strategy is considering options around flow connectivity across the northern Basin.

Figure 30. Volumes of held environmental water in the NSW Murray Regulated River Water Source[144]

144. Note: This only shows the entitlement volumes of held environmental water in the NSW Murray Regulated River Water Source. There are other entitlements held in other valleys and states, and allocations under those can move according to the rules of the water market. As such, those allocations can be used in the NSW Murray, and NSW Murray allocations can be used in other systems as well.

Snowy River environmental flows

With the construction of the Snowy Scheme completed in 1974, waters of the Snowy Mountains that once maintained a healthy Snowy River system all the way to the sea were henceforth stored within the scheme for electricity generation, and diverted west to the Murray–Darling Basin.

With the absence of these flows, the health of the Snowy River declined significantly for decades. In response, the Snowy Water Inquiry was held in 1998 to examine these issues. The *Snowy Water Inquiry Outcomes Implementation Deed* was released shortly after, stating environmental flow rules that would see more water and higher flows delivered to the Snowy River from Jindabyne Dam.

Because Jindabyne Dam was not originally built with the capacity to cater for this new flow regime, new outlet works were constructed in 2005 to enable flows of up to 5,000 ML/day to be delivered.

Due to the need to generate electricity and divert water westwards, it is not possible to restore the Snowy River to its former, natural self. Instead the focus of the rules and environmental managers is to deliver flows that will support a smaller, but healthy Snowy River with:

- diverse habitats and improved biological production and
- improved breeding, recruitment and migration opportunities for aquatic life.

Before each year, environmental managers plan what the flows will be, with the assistance of a technique called 'flow scaling'. Flow scaling, in this case, involves using historical flow data from the undammed, free-flowing Thredbo River to generate a 'natural' flow sequence from Jindabyne Dam that reflects the volume of water available to be delivered in the coming year. The approach also recognises the current needs of the environment; for example, a flow pattern for 2020/21 was targeted to help scour significant quantities of sediment and ash from the river after the 2019/20 bushfires.

Environmental flows have improved the health and condition of the Snowy River by removing fine sediment and restoring pools and riffles—providing essential habitat for water dependent animals including native fish, platypus and macroinvertebrates. In some river reaches, the low-flow river channel has become wider, providing more habitat for aquatic organisms and, over time, the environmental flows have improved the aquatic insect (indicators of river health) community composition and food web.[145, 146]

145. Department of Planning, Industry and Environment 2020, *Assessing changes to the Snowy River channel and vegetation 2010/19*. See www.water.nsw.gov.au/__data/assets/pdf_file/0004/309685/mer-report-snowy-environmental-flows-march-2020.pdf
146. Department of Planning, Industry and Environment 2020, *Recovery of macroinvertebrate communities after environmental flows to the Snowy River below Jindabyne Dam, Snowy river increased flows 2010-2016*. See www.industry.nsw.gov.au/__data/assets/pdf_file/0004/341383/recovery-of-macroinvertebrate-communities-after-environmental-flows.pdf

In addition to the state and federal government long-term reform process for the Murray and Snowy rivers, there are further opportunities that we could pursue to restore a more natural flow regime and better support the riverine environment in the NSW Murray region, including:

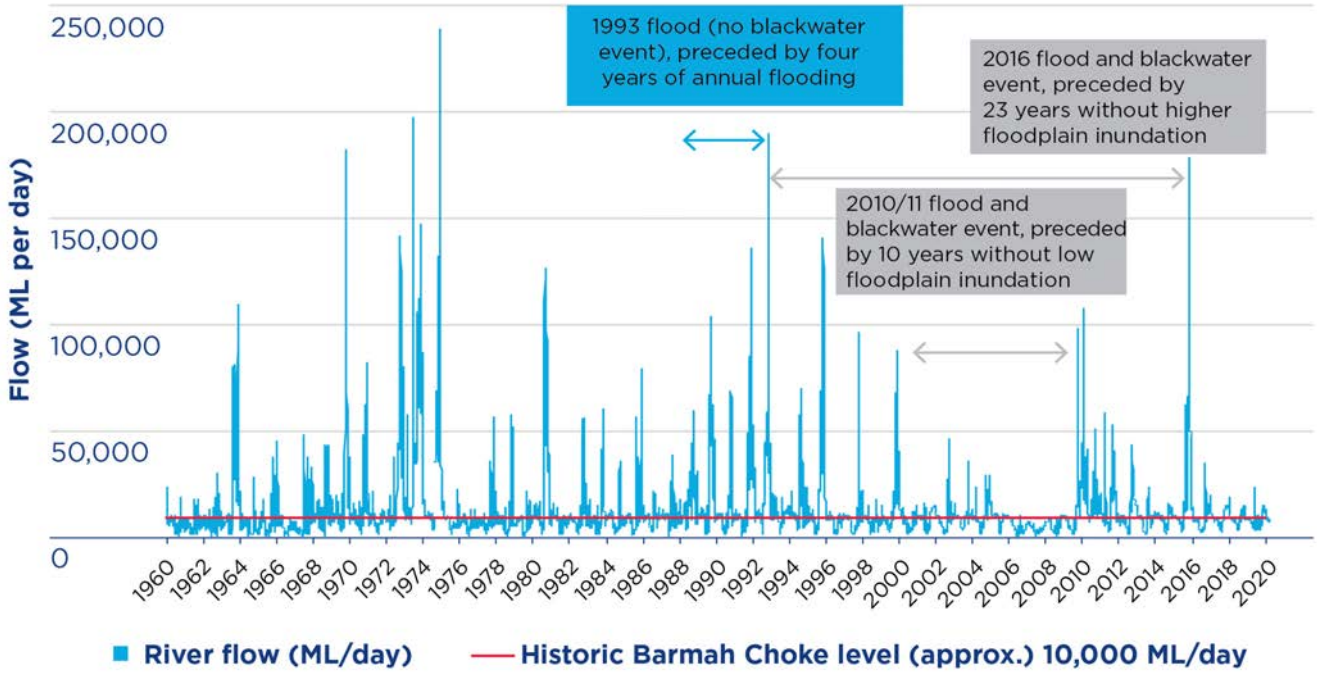
- improving the protection of water for the environment from extraction. Refer to Option 32: Review environmental water arrangements
- upgrading existing and developing further environmental watering works along the Murray and Edward/Kolety–Wakool river systems to identify further environmental sites that could benefit from efficient and flexible environmental water supply. Refer to Option 30: Improve flows to important ecological sites
- improving the efficiency in providing environmental flows to achieve better environmental outcomes within and from the Snowy Scheme. Refer to Option 15: Develop climate risk evidence base to inform the next Snowy Water Licence Review
- gaining a better understanding about the role of groundwater in maintaining the health of important wetlands. Refer to Option 26: Improved protection of groundwater dependent ecosystems
- gaining a better understanding of the impact of catchment management and land use on landscape function and water resources. Refer to Option 31: Develop river and catchment recovery program for the NSW Murray region
- understanding the implications of the impacts of climate change on availability of water allocations under held environmental water entitlements. Refer to Option 32: Review environmental water arrangements.

Large floods, combined with stressed floodplains, can reduce water quality and heighten the risk of extensive hypoxic blackwater events

This can pose serious risks for aquatic wildlife, water-based recreational activities and consumptive water users. Major hypoxic blackwater events occurred in 2010 and 2016 after floodwaters reached areas that had not been inundated for decades, and flushed very large amounts of plant material and nutrients from areas of natural forest and farmland. This material and nutrients then fed a boom of bacterial growth in the river, which consumed most if not all of the available oxygen and resulted in widespread asphyxiation deaths of fish and other aquatic animals.[147] These events occurred following significant periods without floods, and are in contrast to the 1993 flood event where no large-scale hypoxic blackwater event occurred due to previous years of floods (Figure 31).

147. Howitt, J., and Watts, R. 2016, *Answers to some questions about the 2016 hypoxic blackwater event in the southern Murray–Darling Basin*. Institute for Land, Water and Society. Retrieved from www.csu.edu.au/research/ilws/research/environmental-water/edward-wakool-research-project/Blackwater-event-in-the-Murray-in-2016.pdf

Figure 31. Recent hypoxic blackwater events relative to flooding events



Source: Murray–Darling Basin Authority Murray River data and Department of Primary Industries[148]

Large flood-driven hypoxic blackwater events cannot be prevented entirely, but their impacts can be minimised by restoring a more frequent inundation regime of low-lying forested floodplains and wetlands; or by restoring environmental flows into areas where it has not been possible to do so (refer to Option 30: Improve flows to important ecological sites). This will keep vegetation healthy and regularly flush small, manageable amounts of carbon to the river during the cooler months, that provides food for our native fish such as golden perch and Murray cod.

During large-scale hypoxic blackwater events, management actions need to focus on mitigating ecological harm by the event. Key actions we can take to minimise the impacts of large-scale hypoxic blackwater events are:

- delivering water with high dissolved oxygen levels from irrigation canals or from headwater storages to create localised pockets of oxygen refuge
- promoting re-aeration of hypoxic water in rivers by running weirs as 'overshot' (i.e. cascading the water), or diverting water into shallow lakes for a period and returning it to the river
- providing escape options for large-bodied fish into large lakes or other places with higher oxygen levels
- appropriate monitoring to provide real-time information to support operational decision-making
- factoring in the annual risk and potential response strategies in river operations and environmental water annual plans, to facilitate swifter, better responses
- targeting research and development towards continually improving our hypoxic blackwater management approaches, with community input.

148. Murray–Darling Basin Authority. n.d. *The River Murray system*. Retrieved from riverdata.mdba.gov.au/system-view

Water infrastructure prevents wildlife from completing life cycles

Our water infrastructure, which provides many valuable social and economic benefits, also creates a number of challenges for our riverine ecosystems and valued plants and animals, aside from the impacts on flow patterns described above.

Dams and weirs create barriers to upstream and downstream movements of aquatic organisms such as our native fish species. This inability to freely migrate interrupts their spawning, restricts access to preferred habitat and food resources, increases the chance of predation and disease, and reduces genetic flow between populations through population fragmentation. Consequently, species and populations are less resilient to shocks like large hypoxic blackwater events. It is possible to partially overcome this problem by constructing fishways on weirs. Significant investment has gone into this in the Murray over the past 20 years through the 'Sea to Hume Dam' Program of fishways. However, there are further opportunities to be realised to enable further passage (refer to Option 28: Remediate fish passage).

In-stream water storages also create large areas of deeper, slow-flowing or still water that reduce the amount of flowing habitat that is required for many native fish species such as Murray and trout cod, and golden and silver perch. These species require faster flowing water that suits their feeding techniques. As such, there are opportunities to increase areas of fast-flowing habitat such as those being considered under the SDLAM Project for Locks 8 and 9. Conversely, any future projects to create further water storage in the mid to lower Murray River should be considered in off-river locations.

Thermal stratification of ponded water bodies can cause a variety of impacts

Dams such as Hume and Dartmouth were constructed at a time before the impacts of cold water pollution were well known. We now know that these pieces of infrastructure have dramatically changed the river water temperatures in the reaches downstream—particularly during the warmer months, when reservoir stratification is more prevalent. Cold-water pollution impacts on native fish include reduced body growth and condition, changed range and distribution of species, and reduced opportunities for effective reproduction and recruitment. Cold-water pollution limits other biochemical processes that are necessary for aquatic plants, animals and ecosystems to remain healthy and viable.

The Murray River from Hume Dam to Yarrawonga Weir is particularly impacted, with an almost complete loss of historic populations of Murray cod, trout cod, Macquarie perch and catfish.[149] Releases from Khancoban Dam also cause cold-water pollution impacts for around 130 km downstream, but these mostly occur when large releases of cold water are made through the Murray 2 Power Station.[150]

In 2004 the government adopted the *NSW Cold Water Pollution Strategy* to reduce the significant effect of cold-water pollution below the state's major storages. The strategy was designed to progress in five-year stages of planning, implementation and evaluation of outcomes. However, one of the constraints to the success of the strategy has been a lack of funding to trial and assess the suitability of various alternate technologies and operational protocols to mitigate cold-water pollution from storages with problematic algal blooms.

149. Department of Primary Industries—Office of Water 2012, *NSW Cold Water Pollution Strategy—Report on the implementation of stage one*. Retrieved from water.dpie.nsw.gov.au/__data/assets/pdf_file/0009/456912/NSW-Cold-water-pollution-strategy-stage-one.pdf
150. Pope E. and Nolan, A. 2018, *Data versus Desktop: An assessment of the severity of Cold-water pollution in the Swampy Plains and Murray Rivers below Khancoban Dam*. See asnevents.s3.amazonaws.com/Abstrakt-FullPaper/51600/9ASM+Full-Paper-LizziePope-Final+Paper.pdf

Stratification of water in Hume Dam can also provide ideal conditions for potentially toxic blue-green algae (cyanobacteria) to multiply and, via water releases from the dam, can impact up to thousands of kilometres downstream in the Murray—particularly during warmer months. Such events occurred in 2009, 2010 and 2016 in the Murray and Edward/Kolety–Wakool river systems,[151] posing serious health risks to water and waterway users and wildlife. In 2021 significant blooms and 'Red Alert' warnings were issued across the southern Basin. As blooms subside, the dead algae present a further risk to wildlife as they decay—which consumes oxygen in the water, causing stress or death to aquatic animals.[152]

Stratification of reservoirs can also lead to significant fish kills if the stratification breaks down suddenly, say, in response to a sudden change in air pressure or arrival of increased flows, lowering the oxygen levels throughout the water to levels that cannot support fish.[153] Such events have occurred in the Lower Darling and Murrumbidgee in recent years, and it is also conceivable that it can occur in the Murray and Edward/Kolety–Wakool river systems.

Several technologies are available to reduce reservoir stratification, reduce cold water pollution and minimise blue-green algae blooms. These include artificial destratification, installation of multi-level offtakes or structures at inflow sites, or chemical amelioration to lock nutrients (particularly phosphorus) in the sediments. All these technologies require a detailed understanding of the lake limnology to ensure implementation will be effective. Investing in the development of detailed three-dimensional hydrodynamic models of the storages will help to better understand the consequences of thermal stratification and how to manage it. Refer to Option 17: Investigate water quality improvement measures and Option 27: Address cold water pollution in Hume Dam.

Climate change is impacting the environment and is expected to worsen

Higher temperatures, increased evapotranspiration, changes to rainfall patterns and associated flows, more intense dry and wet periods, and adverse bushfire regimes have the potential to significantly impact ecosystems. These climate changes will exacerbate existing threats to ecological health caused by developing water resources.

Updated hydrologic modelling is being undertaken that will analyse the hydrologic impacts of climate change on the riverine environment. The results will be made available in the near future. Importantly, these climatic changes will not occur in isolation, but will coincide with potential increases in demand for water resources, land and agriculture. The current flow management arrangements may not be as effective under a hotter and drier climate with more frequent drought periods. Further, the release of environmental water that is tied to flow thresholds may not be possible with prolonged periods of low or no inflow.

This presents a long-term risk to river, wetland and floodplain health, making it more difficult to manage our landscapes and ecosystems—and the human activities that depend on and benefit from them. A more variable climate means that concerted and coordinated efforts will be required to protect and improve the region's vital environmental, economic, social and cultural assets into the future.

As such, the options being considered for the final Murray Regional Water Strategy will require a coordinated assessment to optimise achievement of resilient water resources for towns and communities, Aboriginal communities, industry and the environment.

151. Bowling L, Baldwin D, Merrick C, Brayan J, Panther J. 2018, *Possible drivers of a Chrysosporum ovalisporum bloom in the Murray River, Australia, in 2016*. Marine and Freshwater Research, 2018, 69, p1649–1662. See researchoutput.csu.edu.au/en/publications/possible-drivers-of-a-chrysosporum-ovalisporum-bloom-in-the-murra
152. Australian Government Environmental Water Office. n.d. *Blue-green algae and Commonwealth Environmental Water.* Retrieved from www.awe.gov.au/water/cewo/blue-green-algae-cew
153. D.S. Baldwin 2020, *Water quality in the Murray–Darling Basin: The potential impacts of climate change In Ecohydrology from catchment to coast Murray–Darling Basin, Australia: Its Future Management*. p137–62. See www.elsevier.com/books/murray-darling-basin-australia/hart/978-0-12-818152-2

Many of the options presented in this Draft Murray Regional Water Strategy focus on improving the health of the natural systems that underpin the resilience of water resources from the top of the headwaters to the South Australian border. This includes options to:

- improve catchment health (Options 31: Develop river and catchment recovery program for the NSW Murray region, Option 33: Re-establish threatened fish species through habitat restoration and conservation restocking

- improve river, wetland, floodplain, plant, wildlife and ecosystem health (Option 26: Improve protection of groundwater dependant ecosystems, Option 27: Address cold water pollution in Hume Dam, Option 28: Remediate fish passage, Option 29: Implement fish-friendly water extraction, and Option 30: Improve flows to important ecological sites)

- incorporate the use of new and emerging climate and eco-hydrologic data and assessment tools/models to better understand and address risks to the environment (Refer to Option 32: Review environmental water arrangements).

Introduced species

There are a number of introduced species that impact the landscapes and in turn the waterways of the NSW Murray region. Introduced aquatic species such as fish and plants can directly affect waterways whilst other introduced species, particularly mammals such as feral pigs and horses can destroy native vegetation, reducing groundcover and causing large scale degradation to areas such as wetlands and stream banks.

Carp, redfin perch and trout continue to impact native fauna species through competition, predation and altering habitats,[154, 155, 156] limiting restoration of native flora and fauna communities. Water weeds such as the introduced Elodea and Egeria species form dense clumps that smother large areas of waterways, which can affect recreational and tourism activities, town water supplies, fishway operation, hydro-electric operations in the mid-Murray, ecosystems and irrigation canals.

Invasive species are currently managed under the NSW Invasive Species Plan 2018–2021 which helps to prevent new incursions, eliminate or contain existing populations, and effectively manage already-widespread invasive species. Its scope includes weeds; and vertebrate and invertebrate pests in terrestrial, freshwater and marine environments.

Given the presence of invasive species, any management actions to improve management of the riverine environment require careful and coordinated consideration of invasive species, to ensure that invasive species cannot significantly negate any potential benefits of the action or receive a greater share of benefit compared to native species. This aspect has been built into considerations for numerous options.

Also included are a number of options to improve populations of native species including Option 33: Re-establish threatened fish species through habitat restoration and conservation restocking.

154. National Carp Control Plan. n.d. *The carp problem*. Retrieved from www.carp.gov.au/the-carp-problem
155. Cadwallader, P.L. 1996, *Overview of the Impacts of Introduced Salmonids on Australian Native Fauna. Prepared for the Australian Nature Conservation Agency*. Retrieved from www.awe.gov.au/sites/default/files/documents/salmonids.pdf
156. Murray–Darling Basin Commission 2007, *Factsheet alien brown trout*. Retrieved from www.mdba.gov.au/sites/default/files/archived/mdbc-NFS-reports/2201_factsheet_alien_brown_trout.pdf

3.3 Deliver and manage water for local communities

3.3.1 People and towns in the NSW Murray region

The NSW Murray region is home to around 110,000 people and includes the regional centres of Albury (51,100), Deniliquin (6,800), Moama (5,600), Corowa (5,300) and Jindabyne (1,770).[157] The rest of the population lives in small towns or rural areas, located close to productive agricultural lands, transport routes and tourist attractions such as the alpine resorts in the Snowy Mountains.

The regional centres are cultural hubs, hosting several festivals and events throughout the year—such as the Snowies Mountain Bike Festival, the Southern 80 waterski race and the Deniliquin 'Deni' Ute Muster—that attract tens of thousands of visitors each year. On average, around 50% of the central Murray region's visitors are from Victoria, due to the close proximity to metropolitan Melbourne.[158] There are around 718,000 annual visitors to the Snowy Mountains and most travel from the ACT, Greater Sydney and regional NSW.[159]

The region's economy and population are expected to grow by 5,200–19,000 between 2016 and 2036, with employment opportunities expected to grow by around 6%. Most of this growth is likely to be concentrated in the larger centres like Albury, Corowa and Moama, which will continue to provide jobs and services for surrounding towns. Ongoing work is required to refine these population projections and understand the potential impact the COVID-19 pandemic could have on future population distributions across NSW, including the NSW Murray region.

Economic development in the region is guided by NSW's strategic planning framework for regional NSW. The South East and Tablelands and Riverina–Murray regional plans set out planning directions for the state government, councils and other organisations to realise the potential for growth across the NSW Murray region. The Regional Economic Development Strategies provide the blueprints for harnessing the opportunities provided by the region's key endowments (Section 3.4).[160]

Economic growth in the region will be stimulated by increasing global and domestic demands for food and fibre; existing high-growth service industries such as health, education and tourism; infrastructure spend such as the Inland Rail Project and the Snowy Mountains Special Activation Precinct. Special activation precincts are a new way of planning and delivering infrastructure projects in specific regional locations in NSW to attract businesses, stimulate the local economy and provide more local employment opportunities. As the region grows, so will the need for town-based services such as water and wastewater, health care, transport, digital connectivity, construction and retail, all of which the NSW Government is investing in.

157. Australian Bureau of Statistics 2016, *Australian Census of Population and Housing, via TableBuilder Pro.* Note: Town population figures are based on urban centre and localities measures from the Australian Bureau of Statistics and are not based on total local government area population.
158. Ruzzene, m., and Funtera, C. n.d. *Murray Region Destination Management Plan. Report prepared for Murray Regional Tourism*. Retrieved from www.murrayregionaltourism.com.au/wp-content/uploads/sites/2/Murray-Region-DMP-Final.pdf
159. Stafford Strategy 2021, *Snowy Mountains South Australia Tourism development study*. See www.dsnsw.com.au/download/snowy-mountains-sap-tourism-development-study/
160. www.nsw.gov.au/regional-nsw/regional-economic-development-strategies

The NSW Government is investing heavily in transport, education, health, community and digital connectivity infrastructure to cater for the future population, and to improve liveability and amenity for regional towns and communities, including:

- Snowy Mountains Special Activation Precinct
- Albury Regional Jobs Precinct
- $400 million of funding to improve digital connectivity across regional NSW
- $68 million Restart NSW Fund commitments in 2021/22 (as part of a $193 million Restart NSW Fund package) allocated directly to Riverina–Murray local authorities and organisations for infrastructure building, renewal and upgrade
- $8.8 million in 2021/22 to continue construction of the new Murray River Bridge between Echuca in Victoria and Moama. Works include the intersection upgrade of the Cobb Highway and Link Road
- $5.1 million in 2021/22 (as part of a $17.2 million project) to continue improvements to the Snowies Iconic Walk.

Future population growth and urban development in the region, coupled with the ongoing pressures of drought and climate change, mean that integration of long-term planning for water resources and other planning is critical. Water availability within the region is finite and fully allocated. Consequently, the regional water strategies will inform growth and investment decisions by government and the private sector based on the constraints associated with water availability and reliability, and seek opportunities to more effectively share available water and secure water for growing towns, including through the water market.

Water for people and towns

Providing secure water supplies to regional towns is vital to ensure the long-term prosperity of the NSW Murray region and its regional planning goals, particularly in the context of a changing, more variable climate.

Secure water supplies support a growing population and tourism; and contribute to the liveability, amenity and wellbeing of residents and visitors. In our conversations with local councils, we heard that rivers, creeks, town lakes, open spaces and parks offer opportunities which are important for social and mental wellbeing, a sense of community, culture, recreation and tourism. We need to find new and better ways to keep regional towns 'green' during dry periods, including through alternative water sources (see Option 23: Maintain water-related amenity in the NSW Murray region during droughts).

In regional NSW, town water supply systems are designed on a consistent basis using the NSW Government's *Guidelines on Assuring Future Urban Water Security*.[161] Systems are developed to balance costs with the community's expected levels of service. As such, all town water supplies have an inherent water security risk and are designed to accommodate moderate levels of restrictions. In regional NSW, these supply systems are planned and sized by considering the historical and future consumptive needs and climate projections, in consultation with communities. It is the responsibility of local water utilities to plan and provide water and sewerage services to each of their respective communities in a way that balances costs and community expectations. This responsibility extends to planning and delivering secure water supplies.

161. Office of Water 2013, *Assuring future urban water security: Assessment and adaption guidelines for NSW local water utilities*.

Current and emerging risks to water utility services in the NSW Murray region include the following (Table 5 gives individual risk ratings):

- population growth increasing the demand for water and wastewater services compared to limited volumes under held water entitlements
- water treatment plants, wastewater treatment plants, reservoirs and pipelines requiring upgrades to increase capacity to meet existing or near-future high demands
- extreme dry events (such as a repeat of the Millennium Drought) placing restrictions on use. Climate change, and the expected increases in the severity and duration of droughts would exacerbate this risk further
- blue-green algal blooms that are now a regular problem in the Murray River downstream of Hume Dam, which would be expected to increase in a warmer future with lower flows. When blooms occur, direct contact with the water can be unsafe, resulting in significant impacts for waterway users and the tourism industry. Blue-green algal blooms create challenges for water treatment plants due to the associated toxins that need to be removed before water can be supplied for potable use. The added organic matter can slow the production of treated water through clogging, and treatment of toxins is expensive
- peak holiday periods overloading wastewater treatment plants
- inadequate yields from unregulated watercourses during times of drought, which may worsen under projected climate change or under post-bushfire forest regrowth scenarios
- heavy rain on degraded landscapes or following intense bushfires in water supply catchments washing significant amounts of ash, debris and soil into waterways causing major water quality issues for water treatment plants (e.g. the town of Bombala experiencing persistent issues with turbidity).

Several local water utilities provide water and sewerage services in the region. Most utilities receive bulk water from the Regulated Murray River system, but are responsible for reticulating supply within towns, as well as sewerage services and billing. Snowy Valleys Council and Snowy Monaro Regional Council provide both bulk water and reticulated water supply and sewerage services across their local government areas. Both rely primarily on unregulated surface water sources for their water supplies, except for the town of Jindabyne that is supplied from Lake Jindabyne.

The region's local water utilities hold approximately 50 GL of regulated and unregulated surface water access licences to supply their towns and villages (Figure 32). This equates to less than 2% of all licensed water entitlement in the region. Table 5 and Figure 33 show the population and primary water source for each town.

Figure 32. Town water supply entitlements in the NSW Murray region

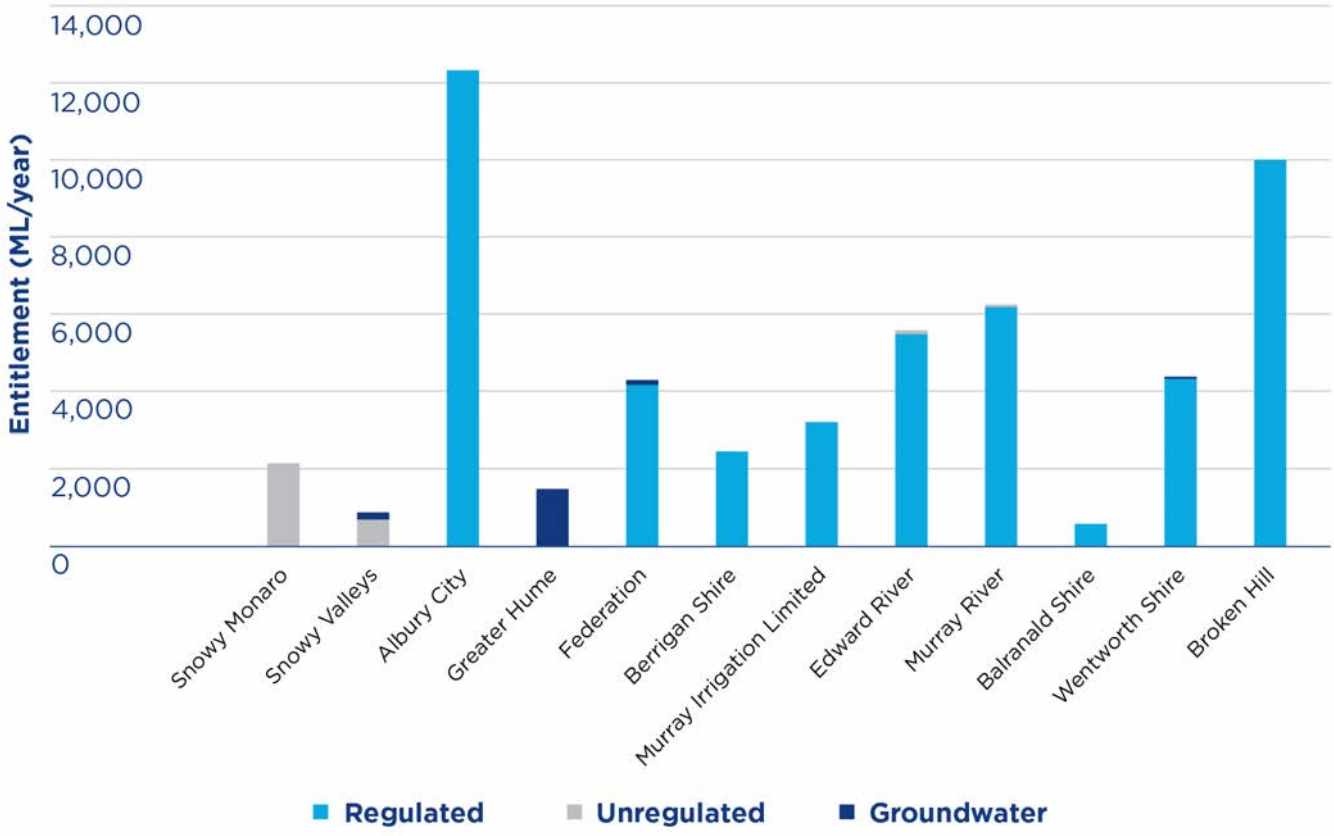


Table 5. Primary water sources of towns in the NSW Murray region

Town	Local water utility	2016 population[162]	Town water risk rating* **	Primary water source
NSW Murray				
Albury	Albury City Council	51,076	High	Murray Regulated River
Finley	Berrigan Shire Council	1,888	High to Very High	Murray Regulated River—via Mulwala Canal (MIL)
Berrigan		934		Murray Regulated River—via Mulwala Canal (MIL)
Barooga		1,654		Murray Regulated River
Tocumwal		2,352		Murray Regulated River
Deniliquin	Edward River Council	6,833		Murray Regulated River—Edward River

162. ABS 2 for Urban Centre/Locality or Significant Urban areas only

Table 5. Primary water sources of towns in the NSW Murray region (continued)

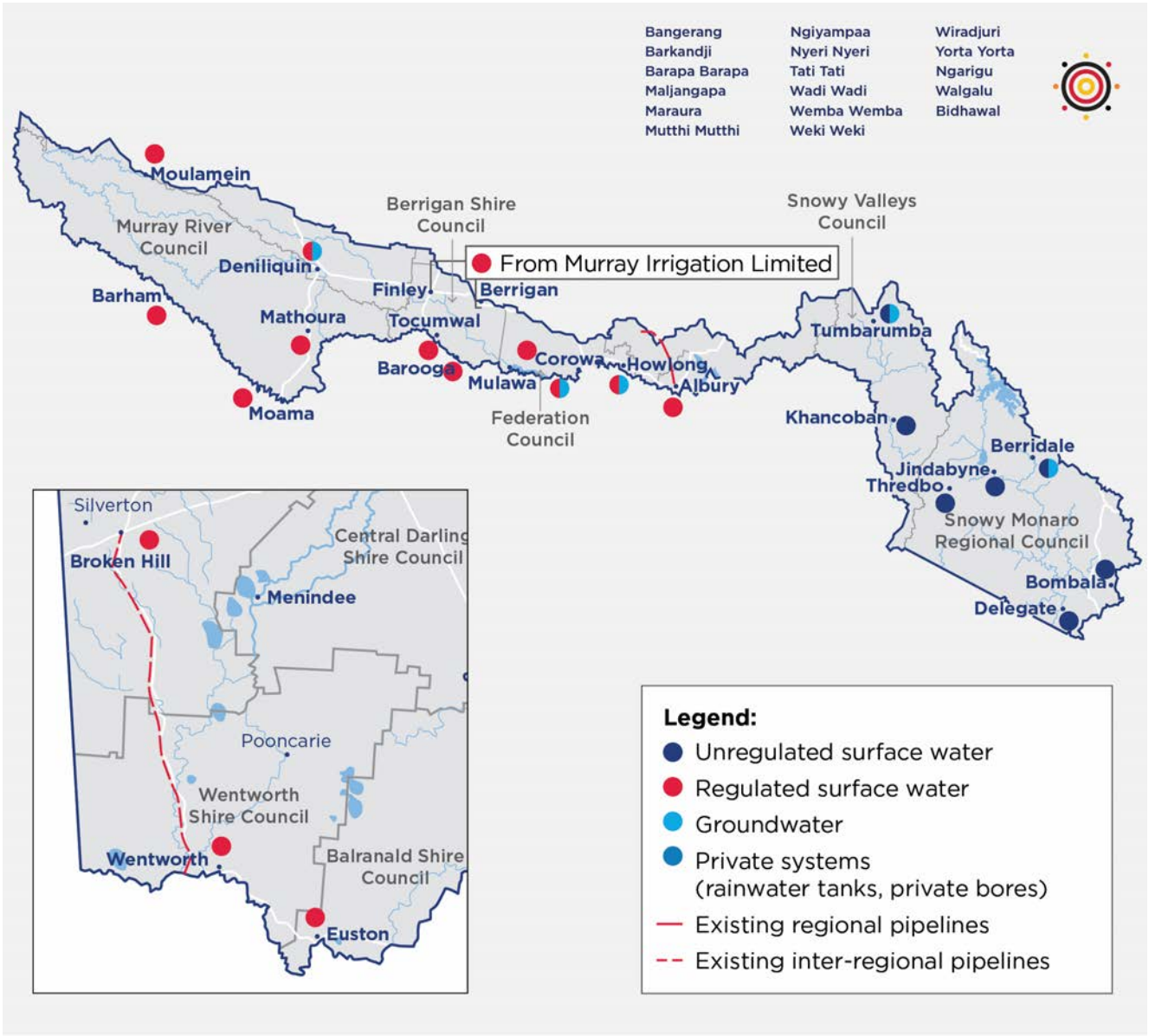
Town	Local water utility	2016 population	Town water risk rating* **	Primary water source
Mulwala	Federation Shire Council	1,962	High	Murray Regulated River
Howlong		2,406		Murray Regulated River
Corowa		5,337		Murray Regulated River
Moama	Murray River Council	5,620	Medium to Very High	Murray Regulated River
Barham		1,159		Murray Regulated River
Mathoura		663		Murray Regulated River—Gulpa Creek
Moulamein		305		Murray Regulated River—Edward River
Euston	Balranald Shire Council	510	Medium	Murray Regulated River
Buronga/Gol Gol	Wentworth Shire Council	2,154	Very High	Murray Regulated River
Dareton		501		Murray Regulated River
Wentworth		1,221		Murray Regulated River
Broken Hill	Essential Water	18,517	Medium	Murray Regulated River
Tumbarumba	Snowy Valleys Council	1,484	Medium to Very High	Murray Unregulated—Tumbarumba Water Source, Burra Creek
Khancoban		233		Murray Unregulated—Swampy Plain Water Source, Khancoban Creek
TOTAL		**88,292**		
Snowy–Genoa region				
Bombala	Snowy–Monaro Regional Council	1,200	Very Low to Very High	Snowy Genoa Unregulated and Alluvial
Jindabyne		1,770		
Berridale and East Jindabyne		1,560		
Delegate		277		
TOTAL		**4,807**		

Source: Population data from ABS 2016 Census QuickStats—Urban Centres (UCL) or Significant urban areas (SUA). Retrieved from www.abs.gov.au/websitedbs/D3310114.nsf/Home/2016%20QuickStats

Note:

* Water security risk represents the preliminary risk as assessed by the Safe and Secure Water Program as of April 2020 and is subject to change over time based on further investigation, new information from councils and/or delivery of projects/solutions addressing these risks.
* The regional water strategies focus on modelled risk to local water utility surface water entitlement reliability and will not review nor has adopted the preliminary water security risk assessed by the Safe and Secure Water Program outlined in this table. The water security access risk assessment undertaken by the Safe and Secure Program considers: headworks arrangement and capacities; the physical delivery and operational rules under water sharing plans; local operating protocol; and past experiences in delivering water in drought conditions. This results in a water security access risk specific to each local water utility's town water supply system that is different to the modelled surface water entitlement reliability.

Figure 33. Town water supply sources for the NSW Murray region



Climate modelling, for town water supplies that draw from the regulated Murray River, is under development and will be released in the future as we progress the development of Murray Regional Water Strategy to its finalisation.

Local water utilities are encouraged to prepare and implement a water conservation and demand management plan as part of their integrated water cycle management strategy. Local water utilities undertake risk analyses of water security access as part of planning their integrated water cycle management. These analyses take into account:

- headworks (water storage and treatment) arrangement and capacities
- physical water delivery system and operational rules under water sharing plans
- operating protocols and past experiences in delivering water in drought conditions
- current and emerging hazards to water services.

Several local water utilities are already implementing water conservation and demand management measures—including water efficient devices, leakage reduction, restrictions and water re-use. However, many local water utilities in the region are yet to start or are in the early stages of developing an integrated water cycle management strategy.

The regional water strategies provide an opportunity to support initiatives already being pursued by councils, and may provide avenues to identify new initiatives that can be aligned with work undertaken as part of integrated water cycle management strategies or by Department of Planning and Environment—Water Utilities. These initiatives can contribute to reduced consumption of non-revenue water and residential water, which is generally, and in some cases significantly, higher across the NSW Murray region than the NSW regional median of 159.6 kL/household connection/year.

The Safe and Secure Water Program includes several projects in the region aimed at improving town water access security, improving the quality of treated effluent discharged to the river system and improving raw-water treatment facilities to ensure town supplies are more resilient to fluctuations in water availability and quality. The regional water strategy will provide an opportunity to assess towns' water entitlement reliability at a regional scale, and consider any broader or subregional-scale options to improve water security and reliability. This will include exploring new and better ways for towns to improve water efficiency, conserve water and keep regional towns 'green' during dry periods, including alternative water sources.

Integrated water cycle management

A 30-year integrated water cycle management strategy addresses the complex linkages between elements of the urban water cycle (water supply, wastewater and stormwater) and community expectations. This is done within the urban area and between its water-related physical and legislative operating environment. This multi-level approach enables cost-effective integration of these urban water systems in consultation with the local community.

Integrated systems often rely less on limited natural water sources, and reduce pollutant loads to the environment. They encourage water conservation and efficient water use, enable the implementation of cost-effective recycling of treated wastewater and urban stormwater–use options, and satisfy water-sensitive urban design and 'liveable cities and towns' objectives.

The 30-year strategy ensures that any necessary capital works projects are appropriately sized; and is essential to provide appropriate, affordable, cost-effective urban water services that meet community needs, and protect public health and the environment.

Town Water Risk Reduction Program

The Town Water Risk Reduction Program is a two-year program supporting local water utilities to manage safe, secure and sustainable water supply and sewerage services to regional communities across NSW. The program is taking a collaborative approach to improve the regulatory framework, including integrated water cycle management strategies, as well as addressing critical skill shortages, encouraging collaboration between utilities, facilitating greater NSW Government support and considering alternative funding models.

Every local water utility faces unique challenges and risks. The Town Water Risk Reduction Program team works in partnership with councils, local water utilities, government agencies and the broader sector to design and implement long-term solutions that suit their circumstances and address the specific challenges faced by their communities.

While the Safe and Secure Water Program will continue to provide funding to Local Water Utilities to address specific risks in their systems, the Town Water Risk Reduction Program looks at broader improvements in the system—both at a state and in local government level– that enables Local Water Utilities to manage risks more effectively and efficiently.

Beneficial use of wastewater and stormwater

Wastewater and stormwater are common features of urban water systems that present both challenges and opportunities for local councils to beneficially manage them within an integrated water cycle.

Each local council area and community has different water needs that are shaped by supply and demand, availability of alternative water sources, vulnerability to drought, growth of population, tolerance to water restrictions, capacity to pay, potential use(s) for wastewater and stormwater, and social and cultural water-based values. As such, decisions about investment in wastewater and stormwater management focus on communities finding the most beneficial use for the water, which may be different for every community.

The new climate datasets provide an opportunity to better assess future risks for each community in the NSW Murray region.

Social values are increasingly being recognised through water-sensitive urban design. Albury City Council placed a high value on returning local wetlands to more natural wetting and drying cycles by building Wonga Wetlands, which is a popular attraction for the community.

Others use wastewater to support local initiatives, such as agriculture or irrigating parks, garden, ovals and golf courses. Others still may find the most benefit in simply treating the water and returning it to rivers to sustain baseflows that can help maintain the local riverine environment and amenity.

As part of the planning process, there are also a range of human health and environmental risks that require careful consideration. The *Australian Guidelines for Water Recycling*[163] provide an authoritative reference to support local councils considering different uses for these resources.

163. Water Quality Australia. n.d. Australian guidelines for water recycling. Retrieved from www.waterquality.gov.au/guidelines/recycled-water#managed-aquifer-recharge-phase-2

Wonga Wetlands

Wonga Wetlands in Albury is a great example of the community, environmental and economic benefits that can be achieved by using treated wastewater in alternative ways.

The wetlands were constructed in the late 1990s by Albury City Council as a beneficial way to use large volumes of treated wastewater from the nearby treatment plants instead of returning the water directly back to the Murray River. In 2018/19, 1,841 ML of wastewater was treated and delivered to the wetlands.[164]

With the delivery of treated wastewater each winter and deliberate drying over summer, a natural wetting and drying pattern has been instated and the wetlands have developed into a healthy ecosystem.

The site is now a home for over 350 varieties of birds, mammals, reptiles and fish. In summer, the treated wastewater is supplied to irrigate 150 ha of pine and hardwood plantations.

When it was first developed, the wetland system was not intended as a tourist attraction. It was intended to be a way to make use of the wastewater for local environmental benefit. However, with the development of a healthy ecosystem, the wetlands are now a popular destination for locals and tourists with around 8,000 visitors each year who come for bushwalking, picnics and barbecues, visiting the Aquatic Environment Education Centre, birdwatching, Aboriginal cultural experiences and weddings.

Source: Albury City Council.

Opportunities and potential options

The draft strategy includes a number of different opportunities to help local water utilities address these challenges, including investigating:

- how to mitigate the risk of large-scale blue-green algal blooms, particularly those originating in Lake Hume and that can spread long distances down the Murray River (Refer to Option 17: Investigate water quality improvement measures)
- the feasibility of accessing deeper and more saline groundwater sources, with appropriate treatment for supply during major droughts (see Option 25: Investigate groundwater desalination for industry and towns and Option 42: Undertake joint exploration for groundwater with the NSW Geological Survey)
- potential for managed aquifer recharge (see Option 21: Managed aquifer recharge investigations and policy)
- the potential of regional water supply schemes to link towns, agriculture and industries with pipelines (see Option 24: Investigate inter-regional connections)
- how to remove impediments to water recycling (see Option 20: Review impediments to water recycling projects)
- water efficiency programs (see Option 40: Investigate non-residential water efficiency in towns and industries).

164. Department of Planning and Environment. n.d. LWU performance monitoring data and reports. Retrieved from www.industry.nsw.gov.au/water/water-utilities/lwu-performance-monitoring-data

3.4 Enable economic prosperity

3.4.1 Jobs and industries in the NSW Murray region

The NSW Murray region has a diverse economy, reflecting its varied landscape and climate. The region is acknowledged as one of Australia's premium agricultural areas. The wider Riverina–Murray area is renowned as Australia's 'food bowl', and makes the largest regional contribution to agricultural production in NSW.[165]

In 2016, over 65,000 people were employed across the NSW Murray region.[166] Economic output for the NSW Murray region was over $9.6 billion[167] in 2018/19 and accounted for 1.7% of NSW's economic output (measured by Gross Value Added).[168, 169] Agriculture is a key contributor to economic output across the NSW Murray region (Figure 34).

There are differences between the economies of the western Murray local government areas[170] and the central Murray[171] and eastern Murray.[172] In 2018/19, the western Murray economy's Gross Value Added was $586 million; agriculture accounted for the largest proportion of total for the region (27%), followed by rental, hiring and real estate services (12%).[173] In 2018/19, central Murray economy's Gross Value Added was $6.6 billion and more diverse—rental, hiring and real estate services accounted for the largest proportion of total Gross Value Added (14%); followed by agriculture, forestry and fishing (10%); health care and social assistance (9%); manufacturing (8%) and construction (8%). In 2018/19, eastern Murray economy's Gross Value Added was $2.4 billion—agriculture, forestry and fishing accounted for the largest proportion of total Gross Value Added (16%); followed by rental, hiring and real estate services (15%).

The primary employment sector in the NSW Murray region is health care and social assistance (Figure 35), followed by agriculture and manufacturing. Tourism is also a major employing sector; over 6,600 workers worked in 2016 across the accommodation and food services and retail trade sectors.[174] The tourism sector is the largest employer in the eastern Murray local government areas, employing 17% of the region's workforce. In both the central and western Murray areas, tourism employs 8% of the region's workforce.

165. Department of Planning and Environment 2017, *Riverina Murray Regional Plan 2036*.
166. REMPLAN 2019, *REMPLAN Economy: Custom data*. See www.remplan.com.au/economy. Note: Due to the regional boundaries under which industry information is collected and reported, it is not possible to present specific information relevant to the NSW Murray region as defined by this Murray Regional Water Strategy. However, relevant information that covers different local government areas located or partially located within the boundaries of defined by the Murray Regional Water Strategy is presented. Given some of these local government areas cross over into other regional water strategy regions, there will be overlapping figures presented in the Murray Regional Water Strategy and in other strategies such as the Murrumbidgee Regional Water Strategy and Western Regional Water Strategy. 'East' refers to the Snowy Valley and Snowy Monaro local government areas, which are partially in the Murray Regional Water Strategy region; 'Central' refers to the Albury, Berrigan, Edward River, Federation, Greater Hume and Murray River local government areas'; and 'West' refers to the Balranald and Wentworth local government areas.
167. Economic output is based on local government area boundaries as of 2018/19. Several local government areas overlap the Murray and Murrumbidgee regional water strategies' area.
168. REMPLAN 2019, *REMPLAN Economy: Custom data.* See www.remplan.com.au/economy
169. Due to misalignment between regional water strategy and local government area boundaries, economic data from the following local government areas are also counted in the Murrumbidgee Regional Water Strategy area: Snowy Monaro Regional Council, Snowy Valleys Council and Balranald Shire Council.
170. Wentworth and Balranald local government areas
171. Albury, Berrigan, Edward River, Federation, Greater Hume and Murray River local government areas
172. Snowy Valleys and Snowy–Monaro local government areas
173. REMPLAN 2019, *REMPLAN Economy: Custom data.* See www.remplan.com.au/economy
174. REMPLAN 2019, *REMPLAN Economy: Custom data.* See www.remplan.com.au/economy

Figure 34. Gross Value Added for key sectors of local government areas in the NSW Murray region[175]

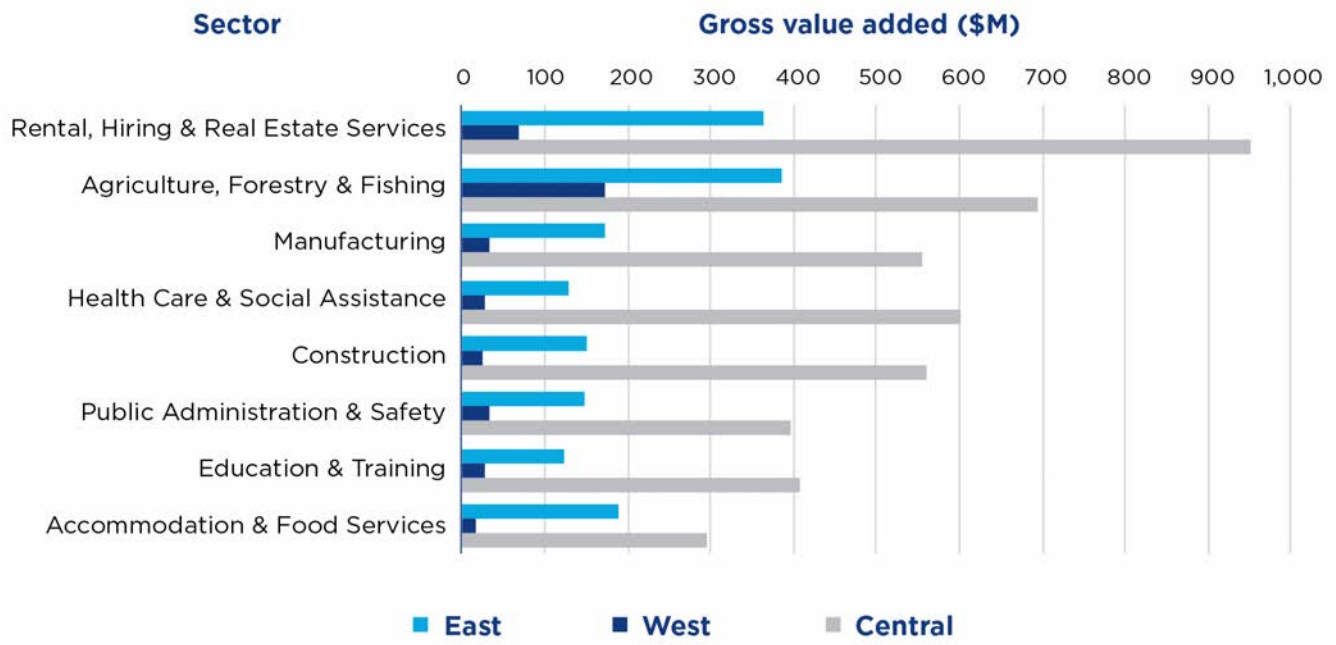


Figure 35. Employment for key sectors of local government areas in the NSW Murray region [175]

175. Note: Figures are based on 10 main local government areas within the region with the main regional centres located within the Murray region. Several other local government areas span across two or more regions and are not included in these figures. GVA figures are categorised using ANZSIC industry classifications. As tourism is not a defined ANZSIC industry category (tourism is an amalgam of activities across various industry sectors such as retail, accommodation and food services, and arts and recreation services) it has been derived by REMPLAN. Source: REMPLAN Economy: custom data 2019.

The estimated total regional exports for the NSW Murray region was over $8.7 billion in 2016, of which manufacturing (includes value-added food or fibre processing) accounted for approximately 34%.[176] Agriculture, forestry and fisheries accounted for approximately 23%.[177]

Water is a critical enabler of many businesses in the region, especially agriculture and hydro-electricity. The region's water resources also support indirect water users, including the tourism and manufacturing. Equitably and sustainably providing secure and reliable water supplies for multiple water users in a changing climate is a key priority for this strategy.

Economic growth and employment are expected to be stimulated by the Snowy Mountains Special Activation Precinct and by the Albury Regional Job Precinct.[178, 179] These precincts are a new way of planning and delivering infrastructure projects in specific regional locations in NSW to attract businesses, stimulate the local economy and provide more local employment opportunities. The Snowy Mountains Special Activation Precinct will focus on increasing year-round tourism for the region.

As captured in both the South East and Tablelands and Riverina–Murray Regional Plans, the NSW Government's vision for the Murrumbidgee–Murray region is for a borderless region of Australia's most geographically diverse natural environment and for a diversified economy. The vision is anchored by the region's engine industries, iconic waterways and a network of vibrant, connected communities.[180] The broader Murrumbidgee–Murray regions are expected to grow in several key industries—including agribusiness and advanced value-added manufacturing, health care and social assistance, freight and logistics, tourism and renewable energy. Industrial and commercial growth in strategically located regional centres is expected to be driven by the increases in agricultural outputs, diversification of agribusiness and new value-added processing and manufacturing opportunities.

The NSW Government is focusing on continued growth in the region by leveraging the region's location and natural assets, and by specialisation of industry and business.[181] Regional economic development strategies recently developed in consultation with local councils identified several key specialisations of the region including agriculture (particularly dairy cattle farming), food processing, manufacturing, health care and tourism.[182]

Attracting new, high-value industries and supporting economic diversification is a strong focus for the region. Access to reliable water is important to realising this vision. The Inland Rail Project, upgrades to the Newell Highway and other initiatives will enable the region to leverage its position along nationally significant rail and road corridors, encouraging further industry development and job growth. The Snowy Mountains Special Activation Precinct will help stimulate economic growth and investments made by the NSW Government, while the Albury Regional Jobs Precinct will leverage the region's established industries to grow existing businesses and attract new businesses.

The regional water strategies will factor in these developments to better understand how they can encourage future population and industry changes, broaden regional growth opportunities and help meet the region's water needs over the next 20–40 years.

176. REMPLAN 2019, *REMPLAN Economy: Custom data*. See www.remplan.com.au/economy
177. REMPLAN 2019, *REMPLAN Economy: Custom data*. See www.remplan.com.au/economy
178. Department of Planning, Industry and Environment. n.d. *Snowy Mountain Special Activation Precinct*. Retrieved from www.planning.nsw.gov.au/Plans-for-your-area/Special-Activation-Precincts/Snowy-Mountains-Special-Activation-Precinct
179. Government. n.d. *Albury Regional Job Precinct*. Retrieved from www.nsw.gov.au/snowy-hydro-legacy-fund/special-activation-precincts/regional-job-precincts/albury-regional-job-precinct
180. Department of Planning and Environment 2017, *Riverina Murray Regional Plan 2036*. Retrieved from www.planning.nsw.gov.au/-/media/Files/DPE/Plans-and-policies/riverina-murray-regional-plan-2017.pdf
Department of Planning and Environment 2017, *South East and Tablelands Regional Plan 2036*. Retrieved from www.planning.nsw.gov.au/-/media/Files/DPE/Plans-and-policies/south-east-and-tableland-regional-plan-2017-07.pdf
181. This focus is also reiterated in the Regional Economic Development Strategies across the broader Riverina-Murray region.
182. Regional Economic Development Strategies relevant to the NSW Murray region: including Murray, Western Murray, Albury-Wodonga, Snowy Valleys and Snowy Monaro.

Inland Rail: creating new regional opportunities

The Inland Rail Project is a once-in-a-generation project that will become the backbone of freight and supply chain networks connecting regional NSW with Victoria and Queensland. Opportunities for regional NSW include:

- more jobs, with the project expected to create 16,000 new jobs during construction and an additional 700 ongoing jobs across the network
- better connections within the national freight network
- better transit time, reliability and cost-savings—perishable goods can access markets faster
- transport cost-savings, with horticulture and post-processed food supply chains estimated to save on average $76/t when travelling via Inland Rail (compared to road trips).[183]

The Inland Rail route passes through an area covered by seven regional water strategies (Murray, Murrumbidgee, Lachlan, Macquarie-Castlereagh, Namoi, Gwydir and Border Rivers). The final regional water strategies will factor in anticipated demographic and industry developments associated with the Inland Rail to better understand how it may change future water demands over the next 20–40 years.

183. Australian Government, Department of Infrastructure, Transport, Regional Development and Communications 2019, *CSIRO Supply Chain Mapping-Pilot Study*. Retrieved from www.inlandrail.gov.au/understanding-inland-rail/publications-and-reports/inland-rail-supply-chain-mapping-pilot-study

Photography
Image courtesy of Destination NSW.
Cobar Highway, Deniliquin.

Agriculture

Agriculture is the largest industry in the NSW Murray region with a direct demand for water, producing much of the economic output and being a major employer, particularly in secondary agribusiness industries.[184] In 2018/19, the agricultural sector contributed over $1.2 billion to regional output in terms of Gross Value Added; and in 2016 directly employed over 7,900 people, which is approximately 10% of total employment across the NSW Murray region.[185, 186]

The diverse landscape, climate and transport links in the region support a wide range of agricultural industries that directly (and indirectly) rely on the region's water resources.

Major agricultural enterprises include mixed farms growing rice, winter crops and pastures for livestock production and dairying in the mid-Murray region (Finley, Deniliquin, Wakool), citrus in the south-west (Barham) and other horticultural crops including grapes, fruit and nuts in the Mid- to Lower Murray. Cattle and sheep grazing occurs across the Snowy Genoa area. Other agricultural industries throughout the region are grains, table grapes and viticulture. Cotton has historically not been a major crop within the region; however, production in recent years has increased, and there is growing interest given the potential higher returns compared to more traditional seasonal crops (such as rice).

184. Department of Planning and Environment 2016, *Riverina-Murray Economy—Fact Sheet #1*. Retrieved from www.planning.nsw.gov.au/-/media/Files/DPE/Factsheets-and-faqs/faqs-riverina-murray-fact-sheet-no-1-economy-2016-04.pdf?la=en
185. REMPLAN 2019, *REMPLAN Economy: Custom data*. See www.remplan.com.au/economy Based on local government areas of Wentworth, Balranald, Albury, Berrigan, Edward River, Federation, Murray River, Greater Hume, Snowy Valleys and Snowy–Monaro.
186. Due to misalignment between regional water strategy and local government area boundaries, economic data from the following local government areas are also counted in the Murrumbidgee Regional Water Strategy area: Snowy–Monaro Regional Council, Snowy Valleys Council and Balranald Shire Council.

Photography
Image courtesy of Department of Primary Industries.

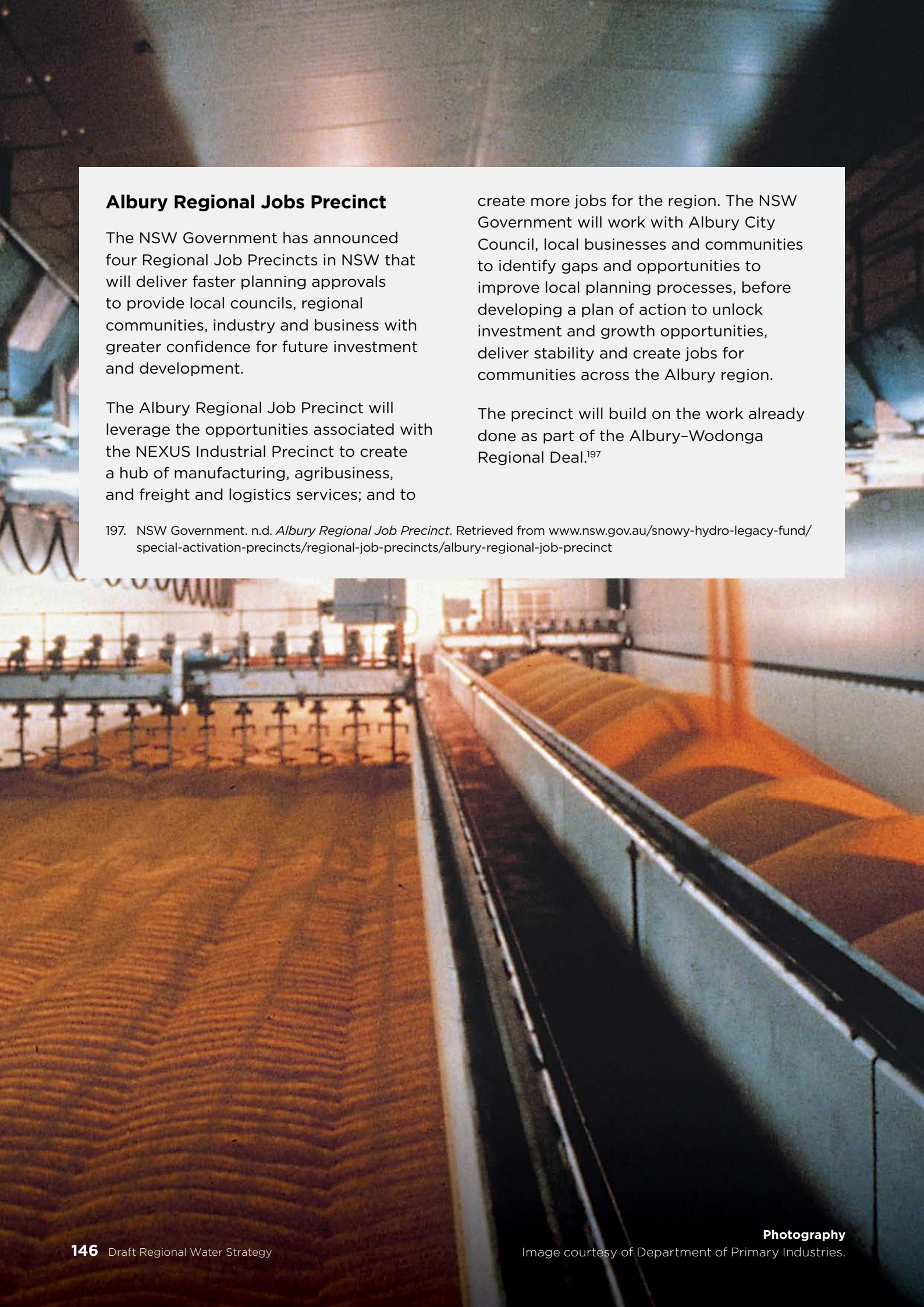
Manufacturing

The NSW Murray region has a large manufacturing sector, which in 2018/19 contributed $763 million to regional output in terms of Gross Value Added, and directly employed over 5,100 people (approximately 8% of total employment in the NSW Murray region) in 2016.[187]

The Murray region's proximity to highly productive agricultural areas and its strategic location along major freight corridors between Adelaide, Melbourne, Canberra, Sydney and Brisbane supports the continued development of value-added manufacturing enterprises in food and fibre sourced from the Murray and nearby regions.[188] Value-added manufacturing and food-processing areas established throughout the wider NSW Murray region include rice and grain milling; oil-seed processing; animal produce and fibre processing; animal feed manufacturing; fruit, nut, vegetable and meat packing; and dairy, wine and food product processing.[189]

There is a large manufacturing sector in Albury with manufacturing capabilities in automation, steel fabrication, recycled plastics, defence products, geosynthetics and more.[190] From the Albury region, 75% of Australia's population can be accessed within 24 hours, which acts as an enabler for the manufacturing sector.[191] Major manufacturing businesses currently located in the Albury region include Asahi Beverages, who are also currently building Australia's largest PET-recycling plant in the region,[192] Seeley International[193] and Geofabrics Australasia.[194] Manufacturing also occurs in other areas across the NSW Murray region—including the largest rice mill in the southern hemisphere in Deniliquin,[195] and a timber mill in Deniliquin that is the largest softwood processing plant in Australia and employs around 200 people.[196] Reliable water supplies support the manufacturing (and secondary) industries that are necessary for the NSW Murray region to grow and thrive.

187. REMPLAN 2019, *REMPLAN Economy: Custom data*. See www.remplan.com.au/economy
188. Department of Planning and Environment 2017, *Riverina Murray Regional Plan 2036*. Retrieved from www.planning.nsw.gov.au/-/media/Files/DPE/Plans-and-policies/riverina-murray-regional-plan-2017.pdf
189. Department of Primary Industries 2020, *Agricultural Industry Snapshot for Planning: Murray Sub Region*. Retrieved from www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/1260492/Murray-Snapshot.pdf
190. Invest Albury Wodonga 2020, *Exploring the manufacturing landscape*. Retrieved from www.investalburywodonga.com.au/news/2020/feb/exploring-the-manufacturing-landscape
191. Invest Albury Wodonga. n.d. *Manufacturing*. Retrieved from www.investalburywodonga.com.au/opportunities/manufacturing?gclid=EAIaIQobChMIyZaG2I_h8AIVl6yWCh0L0A2rEAAYASouth AustraliaAEgKc3_D_BwE
192. Asahi Beverages 2021, *Australia's largest PET recycling plant now under construction in Albury–Wodonga*. Retrieved from www.asahi.com.au/images/media/Albury_recycling_plant_-_5_Feb_2021.pdf
193. Seeley International. n.d. *About Us*. Retrieved from www.seeleyinternational.com/corporate/about/
194. Geofabrics Australasia. n.d. *Contact*. Retrieved from www.geofabrics.co/contact
195. Ricegrowers' Association of Australia. n.d. *Rice Regions*. Retrieved from www.rga.org.au/Public/The_Rice_Industry/Rice_Regions/Public/Content/The_Rice_Industry/The_Rice_Regions.aspx?hkey=c103ced1-f22c-4e3b-97fb-089449ff2c80
196. Regional NSW. n.d. *Success Story Riverina-Murray—Forestry—Hyne Timber*. Retrieved from www.investregional.nsw.gov.au/success-stories/hyne-timber/



Albury Regional Jobs Precinct

The NSW Government has announced four Regional Job Precincts in NSW that will deliver faster planning approvals to provide local councils, regional communities, industry and business with greater confidence for future investment and development.

The Albury Regional Job Precinct will leverage the opportunities associated with the NEXUS Industrial Precinct to create a hub of manufacturing, agribusiness, and freight and logistics services; and to create more jobs for the region. The NSW Government will work with Albury City Council, local businesses and communities to identify gaps and opportunities to improve local planning processes, before developing a plan of action to unlock investment and growth opportunities, deliver stability and create jobs for communities across the Albury region.

The precinct will build on the work already done as part of the Albury–Wodonga Regional Deal.[197]

197. NSW Government. n.d. *Albury Regional Job Precinct*. Retrieved from www.nsw.gov.au/snowy-hydro-legacy-fund/special-activation-precincts/regional-job-precincts/albury-regional-job-precinct

Photography
Image courtesy of Department of Primary Industries.

Tourism

Another industry that is directly and indirectly reliant on the region's water resources and a healthy environment is tourism. The region is a popular tourism destination, given its close proximity to the large metropolitan areas of Melbourne, Canberra and Greater Sydney. Currently, the Snowy Mountains provides popular year-round attractions with snow sports in winter, and mountain biking, bush walking, fishing, horse riding, boating and music festivals in the warmer months. It is also well serviced by an array of accommodation and food options suited to a diverse clientele. In 2019, there were 2.8 million visitors (international, domestic overnight and domestic daytrip) across the NSW Murray region,[198] with 1.7 million visitors to the Snowy Mountains region alone.[199]

Along the Murray River, there are numerous tourist attractions that are intricately linked to the river's natural assets that are popular with locals and interstate visitors alike. Key attractions include water sports; food; wine; produce; fishing; houseboats; river cruises; local heritage; and emerging attractions including arts, culture and adventure. Its proximity to the Melbourne metropolitan area provides it with a unique opportunity for further growth that will help to diversify local economies.

Tourism provides jobs for over 3,900 workers in central and western parts of the region along the Murray River, which represents approximately 8% of the region's total employment. In the Snowy Mountains region, tourism provides jobs for over 2,700 workers, which represents 17% of the region's total employment. In 2019, tourism expenditure amounted to approximately $778 million across the central and western regions' local economies and approximately $659 million for the Snowy Mountains local economy.[200]

The NSW Government's current plan is to support tourism growth by improving visitor access to and experiences at major rivers and lakes (to increase water-based activities), and leveraging the region's agricultural produce abundance to foster contemporary food and wine experiences.[201] Ensuring water resources, including the riverine environments, are managed sustainably will be critical to encourage further growth in tourism.

198. Destination NSW 2019, *The Murray visitor profile Year ending December 2019*. Retrieved from www.destinationnsw.com.au/wp-content/uploads/2020/04/the-murray-fact-sheet-ye-dec-19.pdf Note: Due to the regional boundaries under which industry information is collected and reported, it is not possible to present specific information relevant to the NSW Murray region as defined by this Murray Regional Water Strategy. As such, these visitor figures are based on those from the Murray regional tourism region, which is similar.
199. Destination NSW 2019, *Snowy Mountains visitor profile Year ending December 2019*. Retrieved from www.destinationnsw.com.au/wp-content/uploads/2020/04/snowy-mountains-fact-sheet-ye-dec-19.pdf Note: The Snowy Mountains tourism region is shared with the Murrumbidgee Region.
200. REMPLAN 2019, *REMPLAN Economy: Custom data*. See www.remplan.com.au/economy
201. Destination Riverina Murray NSW 2018, *Riverina Murray Destination Management Plan 2018*. Retrieved from www.riverinamurray.com.au/app/uploads/2019/06/Riverina_Murray_DMP_April_2018_DigitalLQ.2.pdf

Tourism in the region, like the rest of Australia, has been impacted by the COVID-19 pandemic. However, there is potential for a domestic-led recovery. This is positive for tourism across the NSW Murray region, which already relies heavily on domestic travel. Funding assistance is available from the NSW Government through the Regional Events Acceleration Fund to help organisations attract new major international and domestic events to regional areas and supports existing regional events to grow even bigger and better.[202]

Against the backdrop of COVID-19, the NSW Visitor Economy Strategy 2030[203] has been developed to help drive growth and investment in the tourism sector, so that NSW can become the premier visitor economy in the Asia–Pacific.

The newly created Snowy Mountains Special Activation Precinct aims to transform the area into a successful four-season tourism destination by leveraging natural assets and unique climate to stimulate economic development and investment. The Murray Regional Water Strategy presents an opportunity to help ensure this growth is sustainable, with a secure water supply and best-practice water-sensitive design to make efficient use of limited supplies and minimise pollution on downstream receiving waters.

Snowy Mountains Special Activation Precinct

Building on work already undertaken as part of the Go Jindabyne Master Plan, there is an opportunity to grow Jindabyne and the Snowy Mountains region into Australia's alpine capital, benefiting industries including tourism, hospitality, sport and recreation.

Tourism is already a growth engine for the Snowy Mountains; however, the precinct master plan will identify opportunities to:

- develop year-round attractions and improve amenity
- improve regional access to enable more visitors to get to the area
- remove capacity constraints to enable growth in winter tourism
- grow the region into the national training base for Australian Olympic and Paralympic athletes, building on the NSW Government's $5 million commitment to a new National Snowsport Training Centre in Jindabyne.

202. This funding was awarded through the NSW Government's $1 million 2020 Regional Events Acceleration Fund. See www.nsw.gov.au/regional-growth-fund/regional-events-acceleration-fund

203. Destination NSW. n.d. *NSW Visitor Economy Strategy 2030*. Retrieved from www.destinationnsw.com.au/wp-content/uploads/2020/12/nsw-ves-2030.pdf

Hydro-electricity

The Snowy Scheme, which was commissioned in 1972, is the largest hydro-electric scheme on mainland Australia, producing around 4,500 GWh each year. The scheme operates a series of dams, intakes, pipelines and power stations that use the water resources of the Snowy Mountains.

There are also smaller hydro-electric power stations on the Murray River, such as at Hume Dam and Yarrawonga Weir, which make use of the large volumes of water delivered from lakes Hume and Mulwala for downstream consumptive uses.

There is an opportunity to use the new climate data sets and models developed for the regional water strategies, to support strategic decision-making for hydro-electric plants. Such new information will provide a clearer picture of the future climate risks to water availability and, in turn, energy security.

Agricultural water use

Water is an important input to many production processes across the NSW Murray region. In terms of overall volumes, irrigated agriculture is the largest and primary consumptive water user in the region. The main irrigated crops are rice, cotton, lucerne, maize, soybeans and oats. Winter cereals are often grown in rotation with irrigated summer crops to use the subsoil moisture stored from irrigation and as a break crop.

All water dependent industries in the Murray are required to hold a water access licence to take water for any commercial production purposes.[204] In the central and western local government areas, many industries hold a portfolio of water access licences in both surface (high security or general security) and groundwater, and trade water allocations or entitlements to meet their water needs. In the eastern part of the NSW Murray region, farmers use small farm dams across their properties to capture local run-off for watering their sheep and cattle. Sometimes they may hold unregulated surface water or groundwater licences to supplement their supplies.

Depending on the type of water access licence held (or the water access arrangements) by the individual business, water availability can vary significantly between years. In particular, industries that predominantly rely on general security and supplementary access licences are more exposed to the region's climate variability, because water under these licences will only be allocated if other high-priority needs and commitments have been met and sufficient water is available. Similarly, unregulated river licences may only be activated when there is sufficient water at the point of extraction.

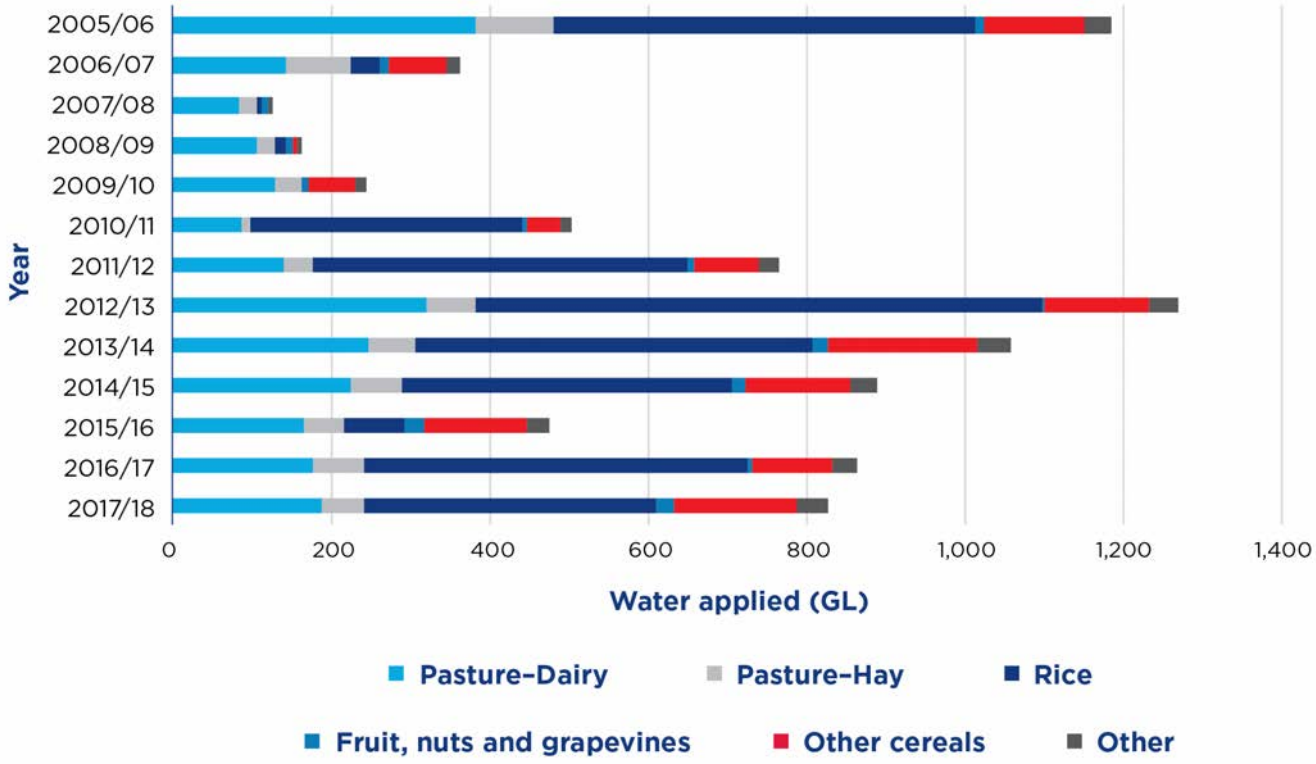
In the past, the expansion and contraction of annual crops have generally been driven by water availability. When water availability is high, and there is high or full allocation to general security entitlement holders, annual crop production has flexibly expanded. Conversely, production of annual crops contracted significantly during the Millennium Drought due to consecutive years of low general security allocations. The flow-on effects of this contraction on regional communities was significant, with closure of related processing facilities.

Extensive irrigation occurs in the central and western local government areas within three private irrigation areas—Murray Irrigation Limited, Western Irrigation and other private diverters from the Murray, Edward/Kolety–Wakool rivers.

As seen in Figure 36, water use by annual crops (such as rice) in central and eastern Murray local government areas varies significantly between wet and dry years. Comparatively, water use by permanent plantings (fruit, nuts and grapevines) has remained relatively constant from 2005/06 to 2017/18.

204. Unless these industries have alternative contractual arrangements through existing town water supply systems.

Figure 36. Water applied in the upper Murray region from 2005/06 to 2017/18[205]



Source: NRAR Water Market Intelligence. 2019. Retrieved from www.nrar.nsw.gov.au/progress-and-outcomes/compliance-and-enforcement-reports-and-tools

However, as reflected in the most recent drought, reduced water availability and increased water costs have driven declines in irrigation activities in 2019/20. As highlighted by the Australian Bureau of Statistics, the total area of irrigated crops reduced. Fruit and nuts were the only crops that saw an increase in irrigation area and volume from 2018 to 2019.[206]

With the change in industry profile to a larger proportion of permanent plantings, water use and demand pattern will likely change further in the region. Although total water use for industries is bound by the Sustainable Diversion Limits (for surface water and groundwater systems), changes within and between industries—including the growth of permanent plantings in the western parts of the NSW Murray region—is altering the geographical use of water in the catchment, trade patterns and seasonal water demand in the regions.

The impacts on conveyance and transmission requirements, channel capacity constraints and evaporation losses will need to be investigated and considered in future water management arrangements in the area.

205. The 'Upper Murray' region in the NRAR Water Market Intelligence Report (2019) uses data from Snowy Valleys, Albury, Greater Hume, Federation, Berrigan and Murray River council areas.
206. ABS. *Water use on Australian Farms*. See www.abs.gov.au/statistics/industry/agriculture/water-use-australian-farms/latest-release

Agricultural water use in a more variable and changing climate

Irrigated agriculture (including post-farm processing of irrigated agriculture produce) is a major economic driver within the region, and a key cornerstone of communities like Deniliquin, Finley and Wakool.[207] In addition, investing in upgrading water infrastructure is also a significant economic driver and employer.

Improving agricultural water efficiency still represents an important opportunity for the region despite large-scale investment through Australian Government water recovery programs over the past decade or so. There are irrigation networks that have not taken part in these initiatives, and many that have only seen partial upgrades and improvements. Therefore, more work is needed to make more efficient use of limited water supplies across the region.

The $1 billion Farm Innovation Fund also helps farmers by providing low-interest loans for investing in permanent farm infrastructure such as: improving water efficiencies with irrigation systems, capping and piping bores, building new dams, installing water tanks and de-silting ground tanks. These measures all help farmers mitigate the risks of reduced water availability and high water prices.

Further diversification of agricultural production and other industries presents an opportunity to buffer against an increasingly variable climate, reduced water availability, high water prices and fluctuating commodity prices. In many places across the NSW Murray region, diversification of industries and production methods is already occurring, with growth in a variety of irrigated, dryland and animal products.[208] Many irrigators are now managing their irrigation layouts in a way that provides the flexibility to opt in or out of different production methods that can include a variety of dryland or irrigated crops. This gives them more options to capitalise on variable seasonal conditions and prices.

The NSW Government is also undertaking a vulnerability assessment of the impact of climate change on the state's agricultural industries, and the potential opportunities for these industries to adapt. These findings will be available in mid-2022 and will be a key input to future water policy and initiatives.

The NSW Agriculture Commissioner was appointed to lead the next phase of the NSW Government's Right to Farm reforms, with a focus on agricultural land use planning. The Murray Regional Water Strategy provides an opportunity to build on this work, and look at options that would support the region's industries to build resilience and mitigate the impacts of these climate risks.

The Department of Regional NSW has recently released its Future Ready Regions Strategy which outlines 14 commitments to achieve sustainable, secure and healthy waterways, build stronger primary industries prepared for drought, and support stronger communities and diverse regional economies. The key actions listed in the Future Ready Regions Strategy align with the NSW Water Strategy and the Murray Regional Water Strategy, and aim to build resilience and better prepare us for future droughts in the regions.

New climate risk modelling will give us a better understanding of the risks to future water availability and enables us to test how different infrastructure, operational and policy options will perform under a more variable and changing climate. The new modelling is under development and will be released in the near future as we progress the strategy.

207. Several communities in the Murray have a high dependency on irrigated agriculture. See www.mdba.gov.au/sites/default/files/archived/guide_pbp/AppendixC_NSW_Central_Murray_community_profile.pdf
208. Department of Primary Industries 2018, *Discussion paper: R&D to increase the flexibility, productivity and profitability of Riverina farming systems*. Unpublished.

3.4.2 Opportunities and potential options

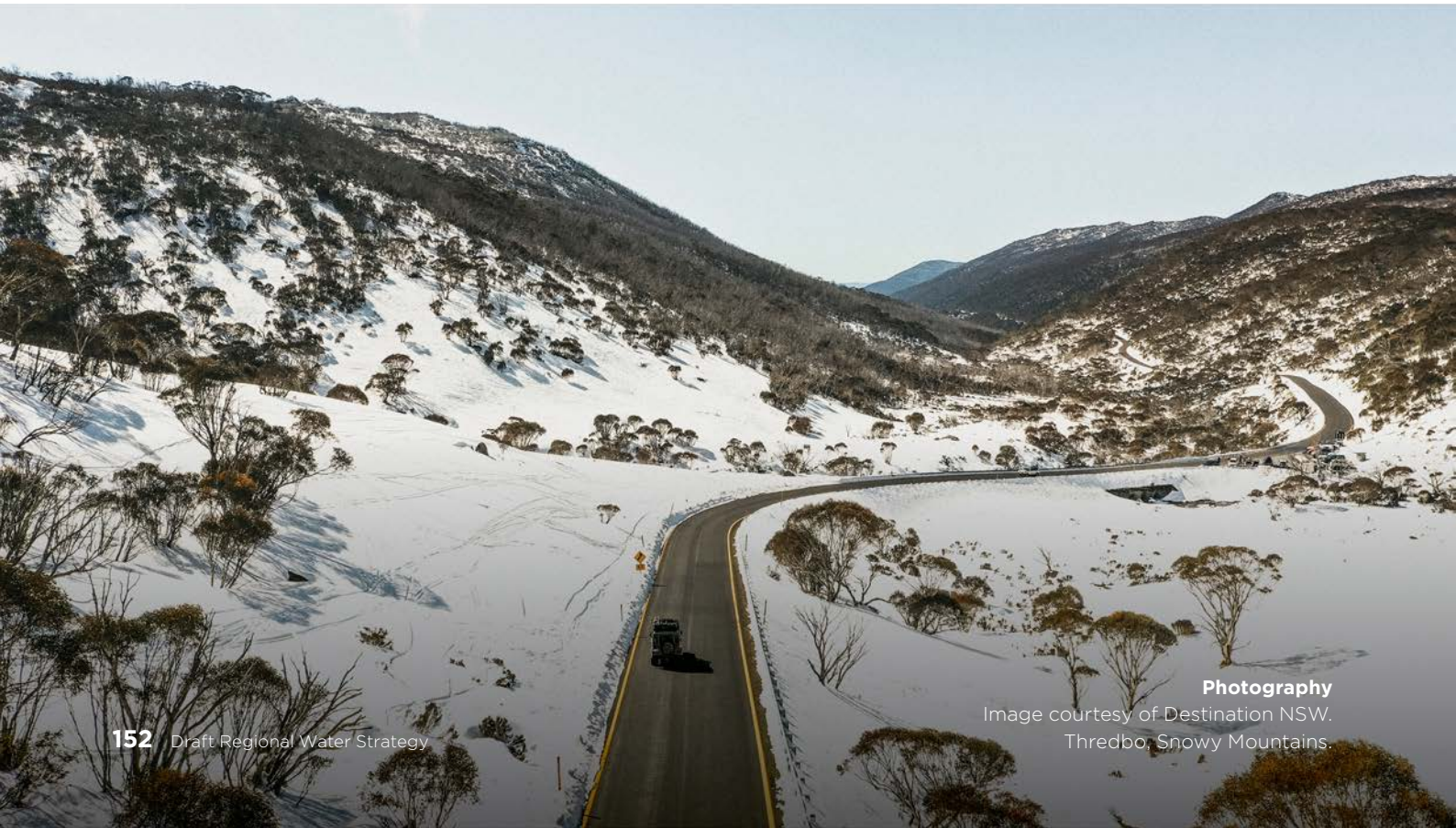
To support economic prosperity in the NSW Murray region, new initiatives will be needed to keep pace with changing climate, industry profiles and water needs; and to make sure that industries across the region have access to reliable water supplies.

The Murray Regional Water Strategy is an opportunity to better understand these industry changes, usage patterns and access risks; and the possible impacts these have on river operations, environmental and cultural impacts. It also provides opportunities to look at options that support regional industries and businesses to effectively and efficiently use all available water resources up to their allowable limit.

Using the recently updated climate risk modelling will give us a better understanding of the risks to future water availability; and enable us to test how different infrastructure, operational and policy options will perform under a more variable and changing climate.

However, there are also options directly focussed on producers and secondary industries, including:

- Option 40: Investigate non-residential water efficiency in towns and industries
- Option 37: Undertake a water dependent industry resilience study
- Option 14: Investigate land use change and population growth impacts on water resources
- Option 35: Better understand water use with data collection and analytics
- Option 25: Investigate groundwater desalination for industry and towns
- Option 42: Undertake joint exploration for groundwater with the NSW Geological Survey.

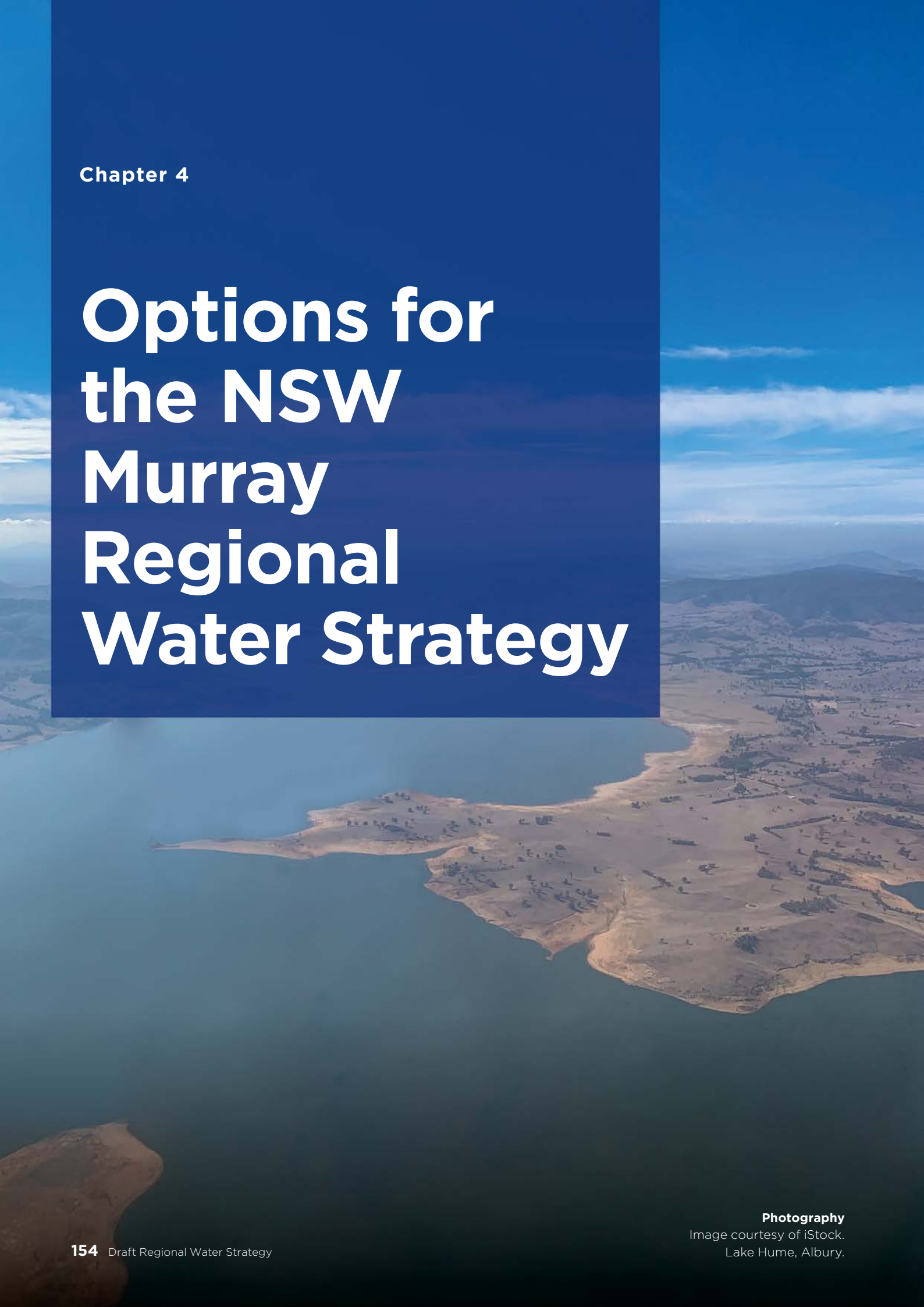


Photography
Image courtesy of Destination NSW.
Thredbo, Snowy Mountains.

Photography
Image courtesy of iStock.
Murray River, Albury.

Chapter 4

Options for the NSW Murray Regional Water Strategy



Photography
Image courtesy of iStock.
Lake Hume, Albury.

Snapshot

We have developed a long list of options that could be included in the final Murray Regional Water Strategy.

- To identify these options, we have drawn ideas from previous studies; experiences of past droughts; consultation with local councils, local water utilities and joint organisations; and government reforms and programs.
- Each option is expected to address at least one of the objectives set for the regional water strategies.
- The options aim to contribute to achieving our vision of having healthy and resilient water resources for a liveable and prosperous NSW Murray region.
- The options have been developed with regard to legislative frameworks and inter-jurisdictional Acts and Agreements that NSW is party to.
- The options are not listed in a particular order, nor prioritised.

The options aim to tackle the challenges facing the NSW Murray region, and maximise opportunities arising from regional growth and investment.

Options in the current long list focus on addressing some of the key challenges in the NSW Murray region including:

- an inadequate water management framework to meet the needs and aspirations of Aboriginal people
- current water sharing arrangements based on 125 years of data
- insufficiently integrated land and water planning and management
- vulnerability of town water supplies and amenity
- degradation of riverine and floodplain ecosystems
- limits to water availability in times of a changing climate.

In each of these areas, we are open to exploring fresh ideas and innovative solutions that will add value to regional industries; leverage new investments; and support new economic, employment and environmental opportunities.

Not all options will be progressed in the final strategy.

- Inevitably, these options will involve trade-offs and choices. To fully understand the impacts, trade-offs and synergies, we will seek feedback on these options before undertaking a formal assessment process.
- The assessment process will look at the positive and negative effects of the option, its cost efficiency, how widely its benefits are likely to be distributed and its feasibility. Not all the regional water strategies' objectives can be quantified. When the outcome is difficult to assess in a financial context, options will be assessed on how effective they are at achieving objectives, rather than on a cost basis.
- Options that are common between the Murray and Murrumbidgee regions will be assessed together to ensure efficiencies in the assessment process and in the development of the final strategies.
- Preferred options and packages of options delivered together will be informed by a range of evidence including new climate modelling, expert judgement and community input. These will form the final, comprehensive Murray Regional Water Strategy.

4.1 Our vision for the Murray Regional Water Strategy

The current challenges in the NSW Murray region stem from the highly variable climate, the length of the rivers, ongoing competition for water resources across the region, physical constraints and the broader complexities prevalent in the southern connected basin. Future climate conditions—changing rainfall and snowfall patterns, increased evapotranspiration, potentially longer dry periods and storms that are more intense—are likely to further exacerbate these challenges.

Although we cannot change the region's climate or the basic hydrology of our river and groundwater systems, we can deliver better outcomes for the region by changing how we:

- operate the water system; such as water sharing arrangements, water delivery, allocations, environmental flow management, water trade, compliance and flood management
- design and operate infrastructure in the region; such as water storages, pumps, pipes and channels
- gather, analyse and report data and information about water resources
- use water and how water users behave, including demand management measures
- communicate, engage and collaborate with water users and communities
- or any combination of the above.

We have identified policy, planning, regulatory, educational, technology and infrastructure options that address the challenges the region may face; and maximise opportunities arising from growing regional centres, emerging and expanding industries, and new investments in transport and developments such as the Snowy Mountains Special Activation Precinct.

The options included in the long list also align with the actions in the NSW Water Strategy and complement these initiatives on a regional level.

Our vision for the strategy

Our vision for the strategy is to support the delivery of healthy, reliable and resilient water resources for a liveable and prosperous NSW Murray region. To achieve this, we need to position the region so there is the right amount of water of the right quality delivered in the right way for people, Aboriginal communities, towns, industries and the environment.

4.2 Identifying and developing the options

We have developed a long list of options that could be included in the final Murray Regional Water Strategy. In preparing this list, we recognise and acknowledge the large amount of work that has been done over the last decades to identify initiatives that could improve water management and water security in the region. We have collated these initiatives and supplemented them with further actions based on feedback from local councils, local water utilities, joint organisations, Aboriginal communities and government agencies. The public consultation process and further engagement with Aboriginal people will provide another opportunity to identify additional options and seek feedback on the long list of options.

Bringing all of the options together will help us to align and better sequence the various water reform processes as we develop the strategy.

In developing the list of options for the NSW Murray region, we have specifically considered the following:

- Each option is expected to address at least one of the regional water strategy objectives (Section 1.2). Some options will support multiple objectives. Other options may have positive benefits for one objective while having negative impacts for another objective. We do not currently have all the information needed to understand these impacts. We will do further work to understand these impacts and seek your views on how each option may impact you and your values.
- While considering a range of options to maintain and improve the resilience of the region's water resources in the face of a variable and changing climate, we have also included options that take the next step in identifying innovative water solutions that will add value to existing industries, create opportunities for new industries and generate greater benefits that extend across the community.
- As discussed in Section 1.3.1, the NSW Government is invested in new climate datasets and improved modelling that give us a more accurate understanding of future climatic conditions in the NSW Murray region. Options in the long list propose reviews of existing policy settings, operational rules and management plans considering this new data.
- As discussed in Sections 1.3.2 and 1.3.3, we have drawn on a range of sources to develop the options, including existing studies; inquiries and reviews; past experiences of droughts; engagement with local councils, local water utilities and joint organisations; and current NSW Government initiatives and programs. This process acknowledges the significant amount of thought and work already directed towards addressing the region's water-related challenges. More information about these sources is in the Regional Water Strategies Guide and the NSW Water Strategy.[209]
- We have had conversations with local councils, local water utilities and joint organisations to understand their views about water-related challenges and opportunities in the region for potential options that would improve water security and quality for towns and communities (Section 1.3.2).

209. Department of Planning and Environment 2021, *NSW Water Strategy*. Retrieved from www.dpie.nsw.gov.au/water/plans-and-programs/nsw-water-strategy

- We have aligned the Draft Murray Regional Water Strategy with the NSW Water Strategy and the Riverina–Murray and South East Tablelands Regional Plans,[210] and sought expert advice from government agencies and independent regulators.
- Parallel work on the Draft Murrumbidgee Regional Water Strategy has informed the development of the Draft Murray Regional Water Strategy. Synergies between both regions made it imperative that options being developed for the Murray Regional Water Strategy considered the potential impacts on the wider southern connected basin.

As discussed in Section 1.3.2, face-to-face engagement with Aboriginal communities in the NSW Murray region was delayed due to the COVID-19 pandemic. As such, we expect further options will be identified when consultation with Aboriginal communities is progressed.

We have not ordered or prioritised the options identified for the NSW Murray region and many options on the list have not been costed.

210. Department of Planning, Industry and Environment 2021, *Regional Plans*. Retrieved from www.planning.nsw.gov.au/Plans-for-your-area/Regional-Plans

Photography
Image courtesy of iStock.
Deniliquin, NSW.

4.3 Which options will be progressed?

Not all options in the long list will be progressed through to the final strategy. Only feasible options will be progressed following an assessment process.

Inevitably, these options—and their priority in the Murray Regional Water Strategy—will involve trade-offs and choices. To understand the impacts and trade-offs we will first seek your feedback on these options, and then use a formal options assessment process which will look at:

- **Effect**
  To what extent are the options expected to contribute to or otherwise impact on the objectives over the planning horizon and/or during extreme events?

- **Impacts and magnitudes of impacts**
  A risk assessment of the positive or negative impact of the option on the objectives, and the magnitude and frequency of these impacts.

- **Cost efficiency**
  To what extent are the options likely to deliver cost-effective outcomes?

- **Distribution of benefit**
  Is there likely to be a broader public or regional benefit from the option, or is the benefit concentrated to a small number of users?

- **Feasibility**
  To what extent is the option likely to be feasible (including regulatory/policy change, stakeholder acceptance, time to implement, cost, alignment with government policy (national and international) and technical)?

Further information on this process is in the Regional Water Strategies Guide.

It is unlikely that a single option will be capable of addressing all the identified risks across the objectives we have set for the strategy. The greatest benefits are likely to be realised by combining options (or packaging them) so that they complement each other to improve the efficiency of the system, offset impacts or unlock greater benefits by using the different levers that are available—such as policy and infrastructure levers. Other opportunities may be unlocked through the NSW Water Strategy or the Murrumbidgee Regional Water Strategy.

For example, infrastructure options may improve water reliability for industries and water security for towns, but could have negative environmental impacts. To mitigate these impacts and increase the benefit of the projects, infrastructure projects could be combined with:

- environmental options that could mitigate the impacts of the infrastructure on native fish species and environmental assets, such as wetlands and estuaries

- demand management measures to make sure industries are operating as efficiently as possible

- policy and regulatory options that review whether the water sharing arrangements under altered conditions are appropriate.

Combining some of the options might mean that other options cannot be pursued. At present, we do not have enough information to understand the trade-offs between options or combinations of options that are described in Table 6.

As development of the strategy progresses, preferred options and combinations of options—and their trade-offs—will be informed by multiple lines of evidence, including new climate modelling, expert judgement and community input. In particular, the NSW Government has invested in new modelling to gain a more accurate understanding of future climatic conditions in the NSW Murray region (Section 1.3.1). This new data, along with economic analysis, will be used to help assess the pros and cons of each option and the impact of various combinations of options in addressing the key challenges facing the region.

It is important to remember that the way we progress options will need to take account of the *Water Management Act 2000* and NSW commitments under the Murray–Darling Basin Plan—for example, the Sustainable Diversion Limits set in the Basin Plan for each valley and each water source.[211]

211. Murray–Darling Basin Authority 2019, *Sustainable diversion limits*. www.mdba.gov.au/basin-plan-roll-out/sustainable-diversion-limits

Photography
Image courtesy of iStock.
River Red Gum, Corowa.

4.4 Murray: Long list of options and government commitments

Table 6 summarises the long list of options we have identified for the Draft Murray Regional Water Strategy. Detailed information about each option, the challenges it will address, its potential combination with other options and further work required to progress the option is set out in the *Murray: Long list of options*. In addition, we have highlighted options which are common with the Murrumbidgee or another regional water strategy.

The current long list of options focuses on addressing some of the key challenges in the NSW Murray region:

- inadequate water management framework to meet the needs and aspirations of Aboriginal people
- current water sharing arrangements based on 125 years of data
- insufficiently integrated land and water planning and management
- vulnerability of town water supplies and amenity
- degradation of riverine and floodplain ecosystems
- limits to water availability in times of a changing climate.

Concentrating on the six key challenges will enable us to address the challenges facing water users in the NSW Murray region, while maximising opportunities for regional communities and industries, and supporting their aspirations.

We heard from communities that the regional water strategies should not just focus on the risks and challenges of today. This is why our current long list of options not only focuses on the issues identified in Chapters 2 and 3, but also includes a number of options that may become important in future decades.

These options need to be supported by comprehensive and robust data and information, and the right tools and infrastructure to implement change in the future.

However, this means that some of our draft long list options are still in a conceptual state. We need to continually work with communities, environmental managers, Aboriginal peak bodies, Aboriginal people, and industries to develop and refine these ideas.

Regional water strategy: objectives

Deliver and manage water for local communities
Improve water security, water quality and flood management for regional towns and communities.

Enable economic prosperity
Improve water access reliability for regional industries.

Recognise and protect Aboriginal water rights, interests and access to water
Including Aboriginal heritage assets.

Protect and enhance the environment
Improve the health and integrity of environmental systems and assets, including by improving water quality.

Affordability
Identify least cost policy and infrastructure options.

Table 6. Long List of options and government commitments

Option	Description	Objective
Existing government commitments		
• **Sustainable Diversion Limit Adjustment Mechanism**	In 2017, the Basin States and the Australian Government agreed on a package of 36 Sustainable Diversion Limit Adjustment Mechanism (SDLAM) projects across the southern connected Murray–Darling Basin.	
Inadequate water management framework to meet the needs and aspiration of Aboriginal people— *Opportunities to protect and strengthen cultural landscapes, practices, knowledge and traditions. Supporting empowerment, self-determination and economic advancement of Aboriginal people, as well as strengthening community wellbeing.*		
1. **Improve access to culturally significant areas and waterways for Aboriginal people**	This option would investigate the benefits and constraints of developing formal access arrangements between Aboriginal people and landholders in the NSW Murray region.	
2. **Review Aboriginal Cultural Water Access Licence framework**	This option would undertake a review of water access licences for Aboriginal cultural uses to determine their effectiveness and identify opportunities for improvement.	
3. **Support long-term participation of local Aboriginal people in water-related matters**	This option would provide support for local Aboriginal groups to be involved in water management processes.	
4. **Fund water entitlements for Aboriginal communities**	This option would provide funding to support Aboriginal people to purchase water entitlements and water infrastructure—such as pumps—that can be used to improve economic and cultural outcomes across the southern connected basin.	
5. **Secure flows for water dependent cultural sites**	This option would investigate opportunities to improve the timing, rate and consistency of flows to places of cultural significance. The places would be identified by Aboriginal community members.	
6. **Shared benefit project (environment and cultural outcomes)**	This option would investigate opportunities to work more closely with environmental water holders for shared benefits from using water for the environment that would also achieve cultural environmental outcomes, recognising it does not replace the provision of cultural flows.	

Option	Description	Objective
7. Incorporate Aboriginal history of water and culture in the southern Basin into water data	This option aims to document and integrate Aboriginal science and culture into government processes to help better manage the river systems.	
Current water sharing arrangements based on 125 years of data—*Opportunities to consider the adequacies of existing water sharing and management arrangements in the region under a more variable and changing climate.*		
8. Review drought rules for the NSW Murray region	This option would review the adequacy and effectiveness of the *Murray Incident Response Guides* by testing them against the new climate data and updated modelling being developed for the Murray Regional Water Strategy.	
9. Review the allocation and accounting framework in the NSW Murray (regulated system)	This option would review several settings of the current water accounting and allocation process in the NSW Murray regulated river system, and consider whether and how the climate data should be used when making allocation decisions.	
10. Investigate Murray River system water sharing, delivery and accounting arrangements under the Murray-Darling Basin Agreement	This option would review current water management arrangements under the Murray-Darling Basin Agreement in the context of a changing climate and reduced water availability.	
11. Review groundwater extraction limits	This option would review the existing NSW groundwater extraction limits to incorporate up-to-date information, including scientific studies that incorporate the new climate change datasets to give an improved understanding of groundwater processes.	
12. Provide increased clarity about sustainable groundwater management	This option would review, revise and develop policies to give water users greater clarity and certainty in how groundwater is managed in NSW.	
13. Investigate Water Access Licence conversion	This option would test the potential risk and benefits of allowing voluntary conversion from general security to high security, and high security to town water supply water access licences in the NSW Murray Regulated River Water Source.	

Option	Description	Objective
Insufficiently integrated land and water planning and management—*Opportunities to better integrate water resource management into other processes including assessing current land uses and land-use trends in the Murray, to better understand spatial changes in the region's water uses and emerging pollution and flooding risks.*		
14. Investigate land use change and population growth impacts on water resources	This option would investigate opportunities to better integrate the NSW land use planning and water resource management frameworks.	
15. Develop climate risk evidence base to inform the next Snowy Water Licence Review	This option would seek to gather information and evidence to inform the next Snowy Licence Review in 2027.	
16. Enhance southern inland floodplain management plans	This option would develop valley-wide, connected floodplain management plans using the northern NSW Murray–Darling Basin floodplain management plan (NSW Healthy Floodplains Project) template.	
17. Investigate water quality improvement measures	This option would conduct a gap analysis of water quality information to identify opportunities to support water quality management plans in the NSW Murray region.	
18. Manage groundwater salinity	This option would explore a range of related actions to address groundwater salinity challenges in the NSW Murray region.	
19. Monitor sediment compaction over the long term	This option would develop a long-term monitoring program for the NSW Murray region to ensure sediment compaction does not occur in the future, reducing risks to groundwater storage and long-term bore yields.	
Vulnerability of town water supplies and amenity—*Opportunities to improve policy and planning around water re-use and recycling, and strengthen water security for local communities and important water-related amenity in the region.*		
20. Review impediments to water recycling projects	This option would review impediments (such as cost, pricing, regulatory or engineering constraints, and community acceptance) to water recycling projects in the NSW Murray region.	

Option	Description	Objective
21. Managed aquifer recharge investigations and policy	This option would investigate opportunities to undertake managed aquifer recharge in the NSW Murray region, including investigating the recharge capacity of sites for temporary storage of stormwater, river flow or purified recycled water in aquifers.	
22. Secure and reliable access to groundwater for towns	This option would undertake a strategic review of groundwater use by towns across the NSW Murray region to improve understanding of the regional need, challenges and opportunities for towns to access groundwater.	
23. Maintain water-related amenity in the Murray during droughts	This option would investigate opportunities to maintain water-related amenity, including town water lakes, local parks and recreational areas, in and around towns in the NSW Murray region during droughts or extended dry periods.	
24. Investigate inter-regional connections	This option would investigate the construction of inter-regional town water supply pipeline connections within and between the NSW Murray region and neighbouring regions.	
25. Investigate groundwater desalination for industry and towns	This option would investigate the opportunities associated with desalination of groundwater to make it suitable for industrial and town uses.	
Degradation of riverine and floodplain ecosystems—*Opportunities to address the risk to the environment, the ecology and groundwater dependent ecosystems and improve the health of the region's rivers and groundwater sources.*		
26. Improve protection of groundwater dependent ecosystems	This option aims to advance our knowledge and management of groundwater dependent ecosystems in the NSW Murray region, such as the Walla Walla swamp.	
27. Address cold water pollution in the Hume Dam	This option would involve a program of work with the Australian Government including the Murray–Darling Basin Authority, and with other states through the Complementary Measures Program to address cold water pollution in Hume Dam.	
28. Remediate fish passage	This option would address barriers to fish passage that disrupt native lifecycles and inhibit migration.	
29. Implement fish-friendly water extraction	This option would investigate the installation of screens on pumps and gravity diversions, considering the optimal approach velocity for improved juvenile fish survival.	

Option	Description	Objective
30. Improve flows to important ecological sites	This option would consist of several projects that aim to restore important ecological flows and connectivity between floodplains and the Murray, Edward Kolety and Wakool rivers.	
31. Develop a river and catchment recovery program for the NSW Murray region	This option would consist of a program aimed at better managing catchment hydrology, addressing erosion issues and restoring riparian and river habitats at priority locations within the catchment. This program would also include a component that undertakes long-term analysis of the impact of climate variability and climate change on future water availability for the catchment with focus on floodplains and river environments.	
32. Review environmental water arrangements	This option would use the new climate datasets and updated hydrologic models (once completed) to review the effectiveness of existing NSW water sharing plan rules to meet the environmental watering requirements as outlined in the *Murray-Lower Darling Long Term Water Plan* under long-term climate change projections.	
33. Re-establish threatened fish species through habitat restoration and conservation restocking	This option would aim to improve the condition, connectivity, and resilience of native fish by restoring habitat through protection and rehabilitation of priority areas using best practice management, while building the skills and sharing the knowledge of local landholders, community groups, and Aboriginal people.	
34. Better understand the economic value of ecosystem services of riverine environmental assets	This option would seek to improve the valuation of ecosystem services in the NSW Murray River to provide a more coherent, consistent and comparable set of information regarding the environmental, social and economic benefits provided by ecosystem services of riverine environmental assets.	
Limits to water availability in times of a changing climate—*Opportunities to better understand water use behaviour, and to develop strategies and information to build greater resilience.*		
35. Better understand water use with data collection and analytics	This option would undertake a research project to better understand water use and water user behaviour in the NSW Murray region.	
36. Improve the understanding of groundwater sources and processes, risks and impacts	This option will combine desktop studies, field studies and numerical models—delivered in collaboration with consultancies and research centres—to give water users and towns access to data and information about groundwater resources.	

Option	Description	Objective
37. Undertake a water dependent industry resilience study	This option would include a comprehensive long-term study on the impacts of climate variability and climate change on future water availability to determine the impacts on water dependent industries in the NSW Murray region, including those reliant on town water supply systems.	
38. Develop targeted education and capacity building programs	This option would develop targeted education and capacity building programs to build community confidence in NSW water management, with a focus on the NSW Murray region, and help communities, industries and the environment to better manage their water needs and water-related risks.	
39. Investigate water availability in the NSW Murray region	This option would consider whether there is systemic reduction in available water in the NSW Murray region and investigate possible causes and potential responses.	
40. Investigate non-residential water efficiency (towns and industries)	This option would investigate opportunities to improve the efficiency of non-residential water use of both raw and town water supplies such as by agriculture, schools, hospitals, industrial uses (e.g. food processing) and recreational and amenity uses (water parks, sports ovals, town water lakes).	
41. Investigate the expansion of cloud seeding in key water supply catchments	This option would investigate potential additional benefits from expanding current cloud seeding activities into the upper Murray River catchment.	
42. Undertake joint exploration for groundwater with the NSW Geological Survey	This option would use regional and locally targeted geophysics to identify potential resources (fractured and porous rock systems like the Lachlan Fold Belt and Western Murray Porous Rock) followed by drilling, testing and water quality analysis to assess the resource's suitability for supply.	
43. Review water markets and trade	This option would progress the implementation of water market reforms, based on the recommendations of the Australian Competition and Consumer Commission's *Murray–Darling Basin water markets inquiry*.	
44. Consider hydrological processes in bushfire management	This option would investigate how bushfire management could be strengthened in priority watersheds by including protection of rainfall run-off processes as a key bushfire management priority in national parks and reserves.	

Chapter 5

Where to from here?

We have developed this draft strategy based on the new evidence base we have, the latest policies and programs for the region and feedback from government agencies, local councils and peak Aboriginal groups.

The outcomes, challenges, opportunities and options we have identified in this strategy will be tested, evaluated and refined based on your input.

Ongoing analysis, using the new climate datasets and integrated hydrologic models will provide an updated understanding of risks to water security and availability in the NSW Murray region, which will be released following the draft strategies. This will inform the development of the final Murray Regional Water Strategy and provide a more robust tool for assessing the benefits and impacts of our long list of options, across the southern regions.

Photography
Image courtesy of Destination NSW.
Edward River, Deniliquin.

5.1 Finalising the strategy

Our next steps are to use the feedback you provide to analyse, screen and assess the long list of options, put together a portfolio of options to be progressed and develop a final strategy for release in 2022. We will also be prioritising face-to-face engagement with Aboriginal communities to develop additional options for the final strategy.

We recognise that in getting to the final strategy there may be hard trade-offs, but the only way we can make the best decisions possible is to deal with issues proactively and realistically. This will give us the most likely chance of long-term success.

The final Murray Regional Water Strategy will have the flexibility to adapt over time and to new situations and circumstances. It will incorporate regular review processes to ensure the region has an effective strategy in place that remains relevant for future water management.

Following completion, each regional water strategy will be reviewed when the equivalent water sharing plans are reviewed.

Photography
Image courtesy of Destination NSW.
Township, Deniliquin.

5.2 Implementing the strategy

Community engagement does not end with consultation but is a vital part of implementation. The final Murray Regional Water Strategy will map out our approach to implementation and include an implementation plan. This plan will set out how NSW Government agencies and other organisations with a role in NSW water management will deliver key actions and strategies for maximising water security and availability for all users and the environment. This implementation plan will be clear about timeframes and responsibilities for delivery.

We want to be clear about how we work with communities and regions to ensure:

- we are accountable for what we promise our regions
- we have the right partnerships in place to drive forward action
- we are transparent in how we go about those actions
- we seek feedback from those with on-the-ground and lived experience that the directions and actions we pursue continue to be the right ones for each region.

When the actions will be implemented

Not all actions will be implemented in the short term. Following public consultation, we will prioritise when to progress or implement each action as part of the implementation plan.

Some actions will need to be implemented in collaboration with a range of partners, including local councils and cross-government agencies. Actions will be implemented as funding becomes available over the next 20 years, and we will use the regional water strategies to assist us in making the case when we seek funding. The final regional water strategy will identify the priority for each action—immediate, mid- or longer term.

We want your feedback on which actions should be prioritised for implementation over the next three to five years, and which ones should be implemented in the mid- or longer term.

Your voice is important

We have prepared this draft strategy to continue our discussions with you about the future management of water in your community. It has been prepared in consultation with local councils, local water utilities, joint organisations and Aboriginal people.

We would like to hear your views of the draft strategy and whether you have any further information that could help us to assess the benefits or disadvantages of any of the options. This may include:

- how your household, business, industry or community currently manages the impacts of a highly variable climate
- the current and future challenges you see in the NSW Murray region and how you think these should be addressed
- how the management of water resources can be improved or leveraged to create and take up new opportunities in the region
- the option presented in the draft strategy
- how we can achieve our aims for accountability and transparency
- the best ways of partnering with communities and regions to implement the strategy.

Your views on the strategy's vision and objectives are also important. This Draft Murray Regional Water Strategy is on public exhibition from 11 April to 22 May 2022 for a six-week period. A range of supporting information is available at www.dpie.nsw.gov.au/murray-regional-water-strategy

You can have your say on the draft strategy by providing written feedback to the Department of Planning and Environment by midnight 22 May 2022 via:

Web: www.dpie.nsw.gov.au/murray-regional-water-strategy

Email:
regionalwater.strategies@dpie.nsw.gov.au

Please note that all submissions will be published on the department's website unless you let us know in your submission that you do not wish the content to be released.

We will be holding online sessions on the draft strategy during the public exhibition period to help shape the final strategy. These sessions will give participants an understanding of the context for the strategy, introduce the new climate modelling and what the options for better managing water in the NSW Murray region could mean. Times and locations for these sessions can be found at www.industry.nsw.gov.au/water/plansprograms/regional-water-strategies/murray

We will also continue to meet with local councils, local water utilities, Aboriginal communities and other stakeholders. Talking with these groups is critical for designing a strategy that builds on their knowledge and capacity, is feasible in terms of implementation and links to their relevant initiatives, plans and strategies.

Attachments

Photography
Image courtesy of iStock.
River Red Gum, Deniliquin.

Attachment 1

Targeted stakeholder engagement

Overview

A thorough engagement program supports the development of the regional water strategies. The purpose of the engagement is to inform, obtain information and feedback and collaborate with stakeholders on the development of the regional water strategy.

Given the inter-connectedness of the Murray and Murrumbidgee regions, and the significant overlap in stakeholder groups, engagement outcomes have been consolidated in this report.

The development of the Murray and Murrumbidgee regional water strategies will be supported by five engagement phases:

1. Targeted engagement with councils, local water utilities, Joint Organisations, Aboriginal people on the development of the draft regional water strategies.
2. Public exhibition of the draft regional water strategies and targeted engagement with State and regional peak bodies.
3. Further targeted engagement with councils, local water utilities and Joint Organisations in each region, as well as Aboriginal people.
4. Public exhibition of the updated draft regional water strategies and the shortlisted actions.
5. Public release of final regional water strategy.

An internal working group and an interagency panel was formed to assist in the development of the Draft Murrumbidgee and Murray regional water strategies. The working group and interagency panel, chaired by the Department of Planning and Environment—Water, included representatives from across the Department of Planning and Environment—Water divisions and also from:

- Department of Planning and Environment—Planning
- Department of Planning and Environment—Environment and Heritage
- Department of Primary Industries—Agriculture
- Department of Primary Industries—Fisheries
- Local Land Services
- WaterNSW
- NSW Health
- The Office of Local Government
- The Natural Resources Access Regulator
- Department of Regional NSW.

This report documents targeted stakeholder feedback obtained during Phase 1 of the development of the Draft Murrumbidgee and Murray regional water strategies.

Engagement

Discussions were held with the following councils, local water utilities, Joint Organisations and Aboriginal communities between August 2020 and March 2022:

Local councils*/local water utilities/joint organisations of councils
Albury City Council
Balranald Shire Council
Berrigan Shire Council
Bland Shire Council
Canberra Region Joint Organisation
Carrathool Shire Council
Coolamon Shire Council
Cootamundra-Gundagai Regional Council
Edward River Council
Federation Council
Goldenfields Water County Council
Greater Hume Shire Council
Griffith City Council
Hay Shire Council
Hilltops Council
Icon Water
Junee Shire Council
Leeton Shire Council
Lockhart Shire Council
Murray Darling Association
Murray River Council
Murrumbidgee Council
Narrandera Shire Council
Queanbeyan Palerang Regional Council
Riverina and Murray Joint Organisation

Local councils*/local water utilities/joint organisations of councils
Riverina Joint Organisation
Riverina Water County Council
Snowy Monaro Regional Council
Snowy Valleys Council
Temora Shire Council
Wagga Wagga City Council
Wentworth Shire Council
Yass Valley Council

Aboriginal community
Murray Lower Darling Rivers Indigenous Nations
The Riverina Murray Regional Alliance
In addition, meetings were held in the following towns however not all were attended: • Euston • Queanbeyan • Yass • Tumut • Wagga Wagga • Barham • Moulamein • Balranald.

* The regional water strategy team did not have the opportunity to meet with every council individually. Joint briefings organised through the Joint Organisations of councils facilitated conversations with a diverse set of representatives from member councils. For this reason, Bega Valley Shire Council and Goulburn Mulwaree Council were present at some meetings but have limited jurisdictional overlap with the Murray or Murrumbidgee regional water strategy areas.

The purpose of discussions was to establish a collaborative relationship with local councils, local water utilities, Joint Organisations of councils and Aboriginal people as well as to gain an understanding of key water-related challenges and risks in the Murrumbidgee and Murray regions.

Discussions with Aboriginal people focused on water-related challenges to Aboriginal people in the regions. Due to the COVID-19 pandemic, our face-to-face engagement with Aboriginal communities in the Murray and Murrumbidgee regions was significantly hindered, however we are committed to having ongoing conversations with Aboriginal people to ensure their views are reflected in the final Murray and Murrumbidgee regional water strategies.

What we heard

Quick stats, recurring themes and hot topics

A total of 29 meetings were held with over 136 people from August 2020 to March 2022. A summary of participants and recurring themes and hot topics raised by them are outlined below.

Councils/local water utilities/ other organisations	Aboriginal community
Quick Stats	**Quick Stats**
19 targeted meetings, including four round tables	10 targeted meetings**
152 participants	10 participants
Face to face and online meetings	Face to face and online meetings
Over 63 ideas, opportunities and challenges and suggestions identified	Over 41 ideas, opportunities and challenges and suggestions identified

**Some meetings had no attendance by Aboriginal people.

Recurring themes	Recurring themes
Collaboration and an ongoing partnership approach are highly valued	Water is culturally significant to Aboriginal people and should be protected
Water security is important for regional growth and community wellbeing	River health and long-term sustainable management of water resources is a priority
The inter-connectedness of water in the Murray and Murrumbidgee regions is central to water management	The need for ongoing and improved consultation with Aboriginal people is required throughout the development of the regional water strategies
A consistent and whole-of-government approach to water policy, planning and regulation is needed	Access to water and water entitlements needs to be improved for Aboriginal people
Groundwater is an essential water source for the region that must be protected and managed sustainably	Aboriginal people should be given an opportunity to play a more active role in water management

Councils/local water utilities/ other organisations	Aboriginal community
Hot topics	**Hot topics**
Water access and water availability, including water trading and licensing	Need for Aboriginal people to have a voice in water management, be compensated to attend consultation sessions, and incorporate Aboriginal people' knowledge (including traditional ecological science) into water resource management and planning
Interaction between regional water strategies, existing government commitments, current policies and regulation (including water sharing plans and water resource plans)	Need for a pathway to greater water entitlement holdings by Aboriginal people for economic and cultural purposes and improvements to the application process for Aboriginal Cultural Water Access Licences
Town water security in the context of future population and industry growth	Perceived government inaction following ongoing consultations leading to a breakdown in trust
Contamination risks and responsible management of groundwater sources	Education and employment opportunities in the water sector would help advance Aboriginal involvement, especially for youth
New water storage facilities and the ability to achieve water deliver efficiencies throughout the system	Poor water management has led to environmental issues including erosion and loss of habitat/breeding grounds for plants and animals
Management of water for the environment could be improved and requires greater transparency	Concern that access to water by industry and landowners is prioritised over Aboriginal peoples access

Detailed feedback

The following is a summary of the feedback from the first round of targeted engagement in the Murray and Murrumbidgee regional water strategy areas.

Council engagement

Topic	Comment
New climate datasets and updated hydrological modelling	Attendees expressed an interest in the new regional water strategy climate datasets and updated hydrological modelling. A number of questions and concerns were raised, including: • how the new climate datasets and modelling could be shared and used by local councils and water utilities to inform future water management and planning decisions, including councils' future integrated water cycle management strategies • how the new climate datasets and modelling could provide insight into the vulnerability of groundwater sources to climate change, which was identified as a potential data gap • how the new climate datasets and modelling may help to analyse and mitigate future water security risks • clarity on the differences between the Department's new climate datasets and modelling and the climate change research conducted by other agencies, organisations, and government departments • whether the hydrological models have considered treated effluent return flows to waterways, which are generally minimal during drought but high during wet periods • need to emphasise that there is uncertainty about modelling and climate forecasting for the region • how the new climate datasets and modelling will be kept up-to-date and whether it will also enable an analysis of extreme wet periods, including flooding.
Water management	Attendees sought clarity on the roles and responsibilities of different agencies with responsibility for water management and provided suggestions on how regional water management could be improved, including: • create a better understanding of who is responsible for water management and ensure water is equitably shared in the region • incentivise more efficient water use by industry • consider new/augmented water storages which could address water security issues, improve system efficiencies, and enhance flood mitigation • consider the use of stormwater, especially in light of more severe weather and drought • optimise water allocations to benefit the regional economy more broadly, noting that local industries are heavily dependent on water. There were also concerns that high value crops were being prioritised • ensure that agency roles around Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) management are clear, as raised recently with Town Water Risk Reduction Program • interest in solidifying a broad, integrated catchment management approach • stressed that communities rely on water for recreation and tourism.
Groundwater	Attendees stressed that groundwater is an essential resource for the region and expressed concerns and questions regarding its management. Attendees particularly raised: • the reliability of groundwater needs to be protected given that some towns like Bungendore rely entirely on groundwater for their water supply. It was mentioned that there is a need for alternative water infrastructure to secure town water supply • the importance of mitigating and preventing groundwater contamination • the need for clarity on how new groundwater licences are granted • questions on whether new groundwater sources could be identified • questions on how appropriate the existing groundwater sustainable diversion limits are.

Topic	Comment
Water allocations, trading, pricing and licensing	Attendees expressed a strong interest in NSW's water allocation process, water trading, and licensing. They shared a range of questions and suggestions including: • the regional water strategies and the NSW Government need to be clear and transparent about how water is allocated • the regional water strategies need to provide clear information on what avenues are available to access additional water to support future population growth in the region • it should be easier for councils to trade water entitlements (such as urban water entitlements, wastewater discharge, and excess bulk water) without penalty • interest in how inter-valley trade operates and if trade can occur from one water source into another. There was also interest in how the regional water strategies will model inter-valley transfers • interest in obtaining greater clarity on proposed increases to bulk water charges for southern NSW water users • the region has reliable water source, although there are some pressure points and residual risks resulting in long water delivery times and channel capacity issues.
Environment and environmental flows	Improving the management of water for the environment was noted as a priority by some participants who shared the following concerns and suggestions: • desire for more information and transparency about expected environmental flows, so that irrigation water demand and environmental water demand could be better balanced • water levels in the rivers can rise and fall very quickly causing issues such as bank erosion and flooding with little warning • changes could be made to the timing of environmental releases to avoid negatively impacting local communities and industry • interest in the environmental impacts of cross-border transfers and treated wastewater.
Water quality	Attendees discussed the importance of water quality across the region and the range of factors that affect it, including: • impacts on water quality are more likely to be experienced during periods of drought or high rainfall • recurring water quality problems include algal blooms in surface waters and increased carbon dioxide levels in aquifers interest in whether the Water Quality Management Plans were developed in consultation with local councils and water utilities • concern regarding ecological risks from Snowy Scheme releases, which could result in wide-spread algal blooms in the catchment • contamination caused by septic systems, mining activities and existing PFAS in groundwater (mid-Murrumbidgee) raised concerns and were seen as a significant threat to water security.
Inter-connected nature of the region and cross-border agreements	Attendees emphasised the interconnectedness of the Murrumbidgee and Murray regions but highlighted that each region was different and had region-specific issues that should be captured in the respective regional water strategy. They shared the following feedback: • concern that a 'region by region' approach to developing the strategies may undermine regional connections between the Murray and Murrumbidgee region. However, attendees also mentioned that it will be important that the strategies pick up on different issues in the upper, mid and lower parts of the catchment • concern that the need for interjurisdictional collaboration was not adequately covered in the draft regional water strategies • the Murray and Murrumbidgee regions border both Victoria and the ACT, and many local and regional water systems are highly interconnected and reliant on cross-border sources • interest in mapping current water resource ownership and transfers across borders • clarity on how the regional water strategies address water management within other states and territories • a desire for border communities in Victoria and the ACT to also be consulted during the regional water strategies process • interest in the potential to increase water supply by accessing inter-state sources.

Topic	Comment
Interaction between regional water strategies and existing policies and plans	Attendees asked how the regional water strategies will take account of and integrate existing government commitments and other water management policies and plans. Attendees offered a range of suggestions including: • clarity on how the regional water strategies will integrate and respond to existing or ongoing water projects and programs as well as past inquiries, reviews and studies • concern regarding delays in implementing recommendations from previously completed studies, inquires and reports • interest in how the regional water strategies will support local councils in a way that existing mechanisms and documents do not • better coordination with councils about local water infrastructure projects could help improve delivery and maximise outcomes • clarity on the operation and licensing of the Snowy Scheme, including whether the regional water strategies will include options that concern the Snowy Scheme • clarity on whether the regional water strategies would influence legislation regarding land use planning, river corridor management or Integrated Water Cycle Management plans • that regional water strategies and any future sub-regional water strategies need to relate to each other • the need for consistent boundaries across all local, regional, state, and national plans and strategies • the need for a transparent link between the NSW Water Strategy and regional water strategies.
Engagement and partnership with communities to develop the regional water strategies	Attendees advocated for a collaborative approach to developing the regional water strategies and stated that: • licence holders and local groups should be engaged early to inform the Murray and Murrumbidgee regional water strategies • engagement with grassroots groups, regulatory industry groups and local Aboriginal groups is important to the development of the strategies • the regional water strategies' options assessment process must be transparent about how shortlisted options were selected • the region is unique due to two existing major water authorities (Riverina Water and Goldenfields Water) which should be accounted for in the Draft Murrumbidgee regional water strategy • collaboration between Department of Planning and Environment—Water and local councils, local water utilities is essential to develop and implement the regional water strategies.
Town water security	Attendees emphasised the importance of securing town water supplies, particularly given the pressures of predicted population growth and changes to industry. There were a number of questions and suggestions including: • taking a more pro-active approach to delivering and maintaining town water infrastructure, especially given the regions' ageing infrastructure • concerns regarding shifting maintenance costs for state and federally-delivered infrastructure and water re-use schemes to local councils • regional population growth and investment including the Wagga Wagga Special Activation Precinct may affect local and regional water demand • interest in whether water availability could inform population growth or influence industry changes • local councils are under increasing pressure to add additional water connections to service new developments • concern that the regional water strategies will rely on NSW Government common planning assumptions (population projections) which may not accurately represent regional population growth • suggestion that water security risk ratings identified in the strategies should be changed or further information provided for context • need to account for changes to industry, such as potential growth of the mining industry.

Aboriginal engagement

Topic	Comment
The cultural significance of water	Attendees emphasised the cultural significance of water to Aboriginal people and shared and shared a range of thoughts, ideas and concerns—in particular, Aboriginal people: • emphasised the significance of traditional medicines and the need to protect native plant species that might be threatened by poor water management • emphasised the cultural significance of water to Aboriginal people and the desire to share stories to help communicate this • shared concerns that while culturally-significant sites have been protected, this can be overridden by large scale projects • shared concerns that landholder and industry access to water is prioritised over cultural water and water for Aboriginal people • concern that the water management framework does not account for the importance of the rivers and the sacred and spiritual connection of Aboriginal people to water.
Aboriginal water entitlements, cultural licences and access	Attendees expressed concern that Aboriginal people are locked out of culturally-significant sites and have limited access to water entitlements. They shared the following thoughts, ideas and concerns: • having greater access to water entitlements would enable Aboriginal peoples and organisations to make better use of their land holdings • concern that Aboriginal people are prevented from accessing certain sections of the river due to private land ownership • Aboriginal Cultural Water Access Licences are difficult to apply for and their acquisition can be associated with additional costs • disappointment that Aboriginal Cultural Water Access Licences cannot be used for economic purposes • frustration about the lack of progress on the Federal Government's $40 million commitment to increase water entitlement ownership for Aboriginal people in the Murray–Darling Basin • emphasised the importance of building awareness in Aboriginal communities about opportunities that exist for Aboriginal people around water • concern about cost of buying water entitlements and the limited capital that Aboriginal people have to buy water entitlements • the Murrumbidgee Cultural Water Licence can only be used in four sites due to high costs and a lack of infrastructure • more transparency is required about water access licences in the region, such as who holds them, how they can be used and how the allocation process works • cultural water allocations are needed and could be supported through partnerships with local water utilities.

Topic	Comment
Sustainable water management and river health	Attendees expressed concern regarding the health of the rivers and waterways in the region and the long-term environmental impacts caused by unsustainable management. They shared the following thoughts, ideas and concerns: • concern regarding river health and that current water management approaches don't value a healthy river system • concerns about expansion of irrigation activities in the lower Murray River • there are no words in any Aboriginal language to describe 'no flow' demonstrating this is a new and concerning challenge for river health • concern around the growth of water-intensive agriculture • concern regarding the health of the river and the need for more sustainable management • emphasised the importance of environmental flows to the health of the rivers • expressed the view that Aboriginal people have sustainably managed water for thousands of years and current approach is impacting Country—and that there is a need to incorporate Aboriginal peoples' knowledge (traditional ecological science) into water resource management and planning to complement and integrate with Western scientific methods • concern that current river management arrangements are causing environmental issues in the upper Murrumbidgee. Fast moving water has caused erosion and removal of vegetation that are important habitats and breeding areas for native species • concern that there was no consultation or forward planning before the banks were artificially stabilised in the upper Murrumbidgee, resulting in negative environmental impacts • rehabilitation work could 'offset' environmental/cultural damage from past council work • concerns that there are conflicting views between the Department of Primary Industries—Fisheries and the Aboriginal community regarding cultural fishing and fish management.
Aboriginal engagement and involvement in development of regional water strategies	Attendees stressed the importance of meaningful consultation with Aboriginal people when developing the regional water strategies, including promoting engagement activities to ensure greater participation. They shared the following thoughts, ideas and concerns: • frustration about ongoing consultations with Aboriginal people regarding water and perceived government inaction • Aboriginal people should be paid to attend engagement sessions given the time commitment, similarly to the approach in Victoria and South Australia • consultation times could be changed (i.e. outside of business hours) and transport could be provided to make it easier for Aboriginal people to attend • government could develop policies to enable all Aboriginal people to attend consultation activities, regardless of their employment status • the need for consultation to be followed through with action, and that Aboriginal people had lost trust in the process • concern that the NSW Government departments wouldn't give community members an opportunity to review the meeting minutes.

Topic	Comment
Water management	Attendees expressed an interest in current water management approaches including how Aboriginal people could play a more active role. They shared the following thoughts, ideas and concerns: • there is a limited relationship between the Department of Planning and Environment and local Aboriginal communities, inhibiting good water management • there isn't enough focus on water management in the Murrumbidgee region, compared to engagements in the Darling and Murray regions • education and employment opportunities in the water sector would help advance Aboriginal people involvement in water, especially providing a career pathways for young people. There was support for the establishment of a River Ranger Program • Aboriginal youth can play an important role in water management and there is a need to build capacity of youth through knowledge transfer and learning from elders • Aboriginal people should be involved in decision making around water and play an active role in water management • sought clarity on the roles and responsibilities in water management including which entities will hear out Aboriginal people concerns and issues • suggested that Aboriginal Waterway Assessment Program should be done in other parts of the Murray and Murrumbidgee regions • concern about water reforms which led to the separation of land and water entitlements.

Next steps

The Draft Murrumbidgee and Murray regional water strategies will be placed on public exhibition for six weeks from 11 April 2022. Additional public engagement will take place during this time and written submissions will be accepted. Further engagement will be conducted once outcomes and submissions from the public exhibition period have been reviewed and before the regional water strategies are finalised.

Attachment 2

Glossary

Term	Definition
Access licence	An access licence entitles its holder to take water from a water source in accordance with the licence conditions. Key elements of an access licence are defined in section 56(1) of the NSW *Water Management Act 2000* as: *(a) specified shares in the available water within a specified water management area or from a specified water source (the share component), and* *(b) authorisation to take water:* *(i) at specified times, at specified rates or in specified circumstances, or in any combination of these* *(ii) in specified areas or from specified locations (the extraction component).* An access licence may also be referred to as a water access licence or a WAL.
Allocation	The specific volume of water licence holders can access. The amount of water allocated to licence holders varies from year to year based on the type of licence, size of their individual entitlement, dam storage levels, river flows and catchment conditions.
Alluvium, alluvial	Loose unconsolidated soil or sediment that has been deposited by surface water such as rivers and floods.
Anabranch	A stream/channel that branches off from a river and re-joins it further downstream.
Aquifer	Geological structure or formation, or landfill that can hold water.
Basic landholder rights	Where landholders can take water without a water licence or approval under section 52, 53 and 55 of the NSW *Water Management Act 2000*. There are three types of basic landholder rights under the NSW *Water Management Act 2000*: • domestic and stock rights—where water can be taken for domestic consumption or stock watering if the landholder's land has river frontage or is overlying an aquifer • harvestable rights—where landholders can store some water from rainfall runoff in dams • Native Title Rights—anyone with a Native Title right to water, determined under the *Australian Native Title Act 1993.*
Basin Plan	As a requirement of the *Water Act 2007*, the Murray–Darling Basin Authority was required to develop the Murray–Darling Basin Plan (Basin Plan) to manage the Basin as a whole connected system. The Basin Plan 2012 provides a coordinated approach to water use across the Murray–Darling Basin's four states and the ACT, balancing environmental, social and economic considerations by setting water use to an environmentally sustainable level.
Biota	The total collection of animal and plant life of a geographic region or habitat.

Term	Definition
Blackwater event	An event that occurs when flooding washes organic material into waterways where it is decomposed by bacteria, releasing carbon, depleting oxygen levels and giving water a black or tea-coloured appearance. The sudden decrease in oxygen can result in the death of fish and other organisms.
Catchment	A natural drainage area, bounded by sloping ground, hills or mountains from which water flows to a low point. Flows within the catchment contribute to surface water sources as well as to groundwater sources.
Cease-to-take rule	A requirement in water sharing plans that licence holders stop pumping when the river flow falls below a certain level.
Climate-independent water source	A source of water that does not depend on rainfall or streamflows for replenishment. Includes seawater desalination and recycled water.
Climate variability	Describes the way key climatic elements, such as temperature, rainfall, evaporation and humidity, depart from the average over time. Variability can be caused by natural or man-made processes.
Cold water pollution	An artificial decrease in the temperature of water in a river. It is usually caused by cold water being released into rivers from large dams during warmer months.
Constraints	Under the Murray Darling Basin Plan, a constraint is a rule or structure which limits the volume and/or timing of the delivery of environmental water. Constraints can include physical structures (e.g. low-lying bridges), river management practices, and operational limits for river heights.
Constraints Management Strategy	The Murray–Darling Basin Authority's Constraints Management Strategy investigates more efficient ways to deliver water to where it's needed, when it's needed; while avoiding or mitigating impacts to riparian landholders, communities and industries. It focuses on seven key areas in the Basin, proposing projects for addressing constraints. The constraints projects (excluding those in the Gwydir) are part of the package of projects submitted by states through the Sustainable Diversion Limit Adjustment Mechanism process.
County Council	County Councils are regional utilities, constituted under the provisions of the *Local Government Act 1993*, that operate across multiple local government areas in NSW. County Council functions may include bulk water supply, water and sewerage services, floodplain management and weed biosecurity. There are 10 County Councils in NSW, four of which have bulk water supply functions.
Cultural flows	While the *NSW Water Management Act 2000* does not define cultural flows, the Murray Lower Darling River Indigenous Nations Echuca Declaration, 2007, defines cultural flows as: 'water entitlements that are legally and beneficially owned by the Nations of a sufficient and adequate quantity and quality to improve the spiritual, cultural, natural, environmental, social and economic conditions of those Nations.'
Direct employment	Refers to employment directly arising from the demand for a specific product or service.
Effluent	Flow leaving a place or process. Sewage effluent refers to the flow leaving a sewage treatment plant. An effluent stream is one that leaves the main river and does not return.
Endangered ecological community	Ecological communities as listed in 'Schedule I' of the *Threatened Species Conservation Act 1995* or Schedule 4 of the *Fisheries Management Act 1994*.
End of system	The last defined point in a catchment where water information can be measured and/or reported.

Term	Definition
Entitlement	The exclusive share of the available water that a licence holder can take, subject to allocations.
Environmental asset	Natural features that contribute to the ecosystem of a region.
Environmental water	Water allocated to support environmental outcomes and other public benefits. Environmental water provisions recognise the environmental water requirements and are based on environmental, social and economic considerations, including existing user rights.
Eutrophication	Eutrophication is the process by which a body of water becomes saturated with minerals and nutrients, leading to excessive plant and algal growth. Algal blooms and low-oxygen waters can kill fish and aquatic flora and reduce fish habitats.
Evapotranspiration	The combined effect of evaporation and transpiration.
Evaporation	The process by which water or another liquid becomes a gas. Water from land areas, bodies of water and all other moist surfaces is absorbed into the atmosphere as a vapour.
Extraction limit	A limit on the long-term average volume of water that can be extracted from a source.
Fish passage	The free movement of fish up and down rivers and streams.
Floodplain	Flat land bordering a river or stream that is naturally subject to flooding and is made up of alluvium (sand, silt and clay) deposited during floods. Floodplain harvesting is the collection or capture of water flowing across floodplains.
Freshes	Freshes are where the surface water flow is of sufficient size and duration to 'reset' river reaches. Resetting includes improving water quality, clearing sediment build-up to enhance instream habitat, redistributing sediment to enable normal geomorphic processes, redistributing nutrients to enable normal levels of instream productivity and encouraging instream biota to disperse and/or breed.
General security licence	A category of water access licence under the NSW *Water Management Act 2000*. This category of licence forms the bulk of the water access licence entitlement volume in NSW regulated rivers and is a low priority entitlement—that is, receives water once essential and high security entitlements are met.
Gross Regional Product	A measure of the market value of all goods and services produced in a region within a period of time. Gross regional product is a similar measure to gross state product and gross domestic product.
Gross value added	A measure of the value of goods and services produced in an area, industry or sector of an economy. Gross value added is a similar measure to gross regional product.
Groundwater	Water located beneath the ground in the spaces between sediments and in the fractures of rock formations.
Groundwater-dependent ecosystem	Ecosystems that require access to groundwater to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services.
High flows	Also called bankfull events, these flows reshape the channel, creating habitats such as pools, bars and benches.

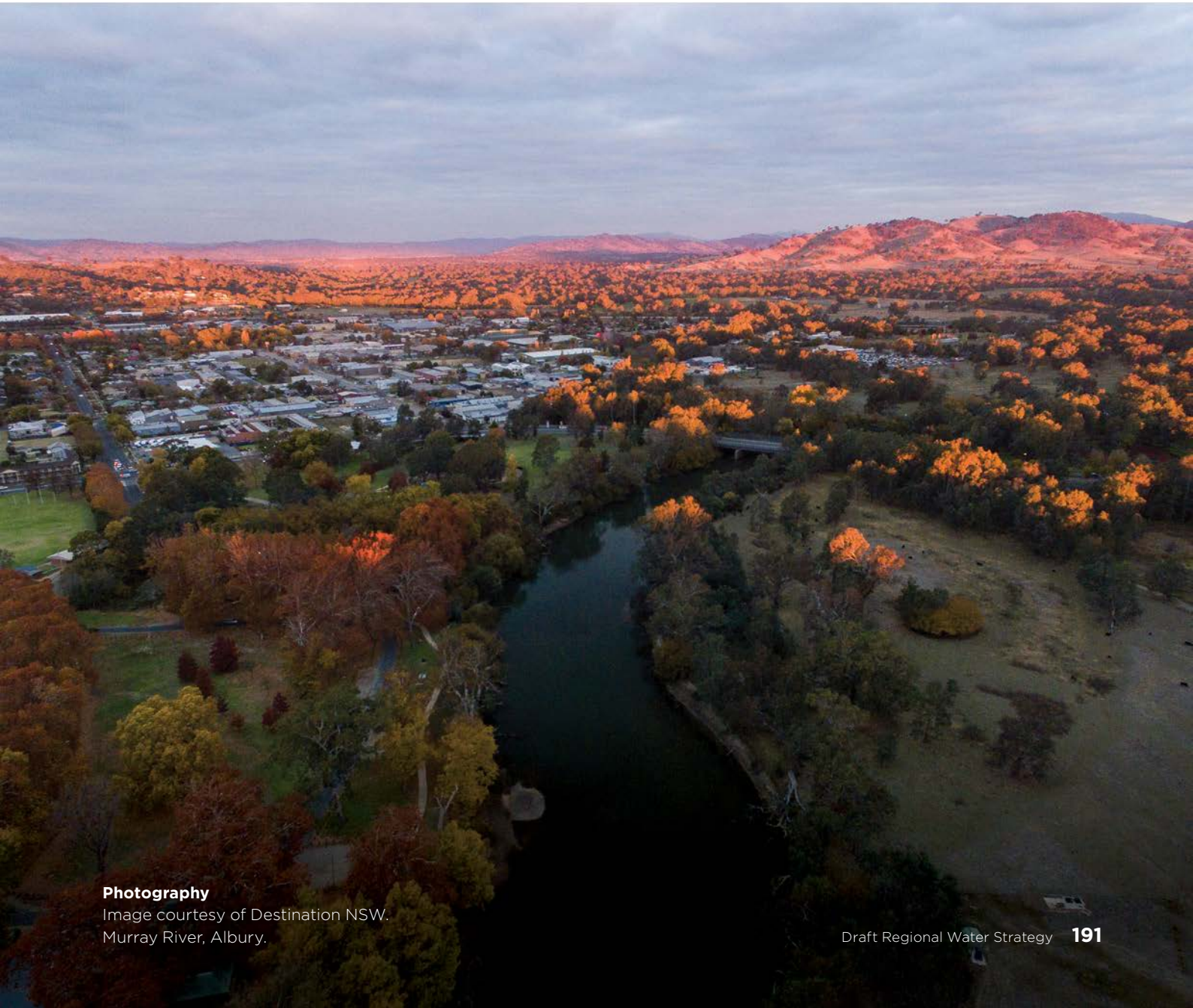
Term	Definition
High security licence	A category of water access licence in regulated rivers implemented under the NSW *Water Management Act 2000*. Receives a higher priority than general security licences but less priority than essential requirements in the available water determination process. Many high security licences are held by water users that have inflexible water demands, such as those growing permanent plantings and mining companies.
Hydrologic stress	Refers to the level of extraction in a river system. In NSW, 'high hydrologic stress' is defined as 70–100% average annual river flow extracted; and 'medium hydrologic stress' as 40–60% flow extracted.
Hypoxic Blackwater	Hypoxic blackwater events refer to occasions when dissolved oxygen concentrations in water are very low. These events occur when floodwaters leach organic matter from leaf litter, plants and soil resulting in water that is very high in dissolved organic matter (blackwater). This organic matter is consumed rapidly by microbes resulting in oxygen being used faster than it can be replenished. Hypoxic conditions place high stress on aquatic biota and can lead to fish kills.
Indirect employment	Jobs that are created by other businesses to support the primary employment sector.
Irrigation Corporation	Irrigation corporations are private companies that hold water licences and approvals on behalf of their shareholders. They are authorised to supply water under an operating licence granted under the *Water Management Act 2000*.
Inflows	The amount of water coming into a surface water source or groundwater source.
Joint organisation	An entity formed under the NSW *Local Government Act 1993* to perform three principal functions in a region: strategic planning and priority setting, intergovernmental collaboration and shared leadership and advocacy. Each joint organisation comprises at least three member councils and aligns with one of the State's strategic growth planning regions.
Local water utilities	Generally, these are council owned and operated utilities that provide water supply and sewerage services to local communities.
Managed aquifer recharge	Intentional recharge of water to aquifers through infiltration or injection for subsequent use or environmental benefit.
Non-revenue water	Water that has been produced and is 'lost' before it reaches the customer. Losses can be real losses (through leaks, sometimes also referred to as physical losses) or apparent losses (for example through theft or metering inaccuracies).
Non-stationarity	A data sample, which shows upwards and downwards trends but does not have a long-term trend is a stationary series. For climate data, the datasets need to extend beyond the limited observational records to assess stationarity. Stationarity is a property of an underlying stochastic process, and not of observed data. All natural systems are non-stationary, but when the non-stationarity is not substantial and the process can be accurately represented by a comparatively simple stationary stochastic model then it is considered to be stationary. In contrast, non-stationarity can simply be defined as processes that are not stationary and that have statistical properties that are deterministic functions of time.
Operational rules	The procedures for managing releases and extractions of water (surface and groundwater) to meet the rules of relevant legislation and policy, for example water sharing plans and long-term water plans.

Term	Definition
Paleoclimate data	Refers to climate records prior to instrumental records. Various environmental indicators can be used to reconstruct paleoclimate variability extending back hundreds of thousands of years in time. These indicators include marine and terrestrial deposits, tree rings and ice cores.
Permanent plantings	Crops that are not replanted after a growing season. These crops generally require more than one growing season to be productive. Examples include grapes, citrus fruits and almond trees. These are different from annual (or broadacre) crops, which are harvested within 12 months of planting and require replanting to produce a new crop.
Per- and polyfluoroalkyl substances (PFAS)	PFAS are manufactured chemicals used in products that resist heat, oil, stains and water. PFAS are contained in many common household products, such as paints and pesticides, and in legacy firefighting foams. The use of PFAS by Australia's Defence Force was phased out in 2004, however, the release of PFAS into the environment has become a concern as these chemicals can persist in humans, animals and the environment.
Ramsar Convention	The Convention on Wetlands of International Importance (Ramsar Convention) is an international treaty to halt the worldwide loss of wetlands and conserve those that remain. Australia has 66 Wetlands of International Significance listed under the convention.
Recharge	Groundwater recharge is a hydrologic process where water drains downward from surface water to groundwater. Groundwater is recharged naturally by rain, floods and snow melt and to a smaller extent by drainage directly from surface water (such as rivers and lakes).
Recycled water	Water that has been treated to a 'fit for purpose' standard for a specific application as per the Australian Guidelines for Water Recycling.
Refugia	Ecological refuges (or refugia) are places that naturally provide protection for plants and animals from threats, such as drought, fire, diseases and invasive species.
Regional Plan	The Department of Planning and Environment has developed regional plans for nine regions across NSW to help support future community needs. They set regional planning priorities and provide a framework for regional and local planning decisions. Regional plans include plans for housing, jobs, community infrastructure and a healthy environment.
Regulated river	A river system where flow is controlled via one or more major man-made structures (e.g. dams and weirs). For the purposes of the NSW *Water Management Act 2000*, a regulated river is one that is declared by the Minister to be a regulated river. Within a regulated river system, licence holders can order water which is released from the dam and then taken from the river under their water access licence.
Resilience	Resilient water resources as those that can withstand extreme events, such as drought and flood, and/or adapt and respond to changes caused by extreme events.
Riparian	The part of the landscape adjoining rivers and streams that has a direct influence on the water and aquatic ecosystems within them.
Salinity	The concentration of sodium chloride or other dissolved minerals in water.
Snowy Scheme	The Snowy Mountains Hydro-electric Scheme (Snowy Scheme) is one of the most complex integrated water and hydroelectric power schemes in the world. The Snowy Scheme is operated and maintained by Snowy Hydro Limited, a company owned by the Australian Government.

Term	Definition
Snowy Water Licence	The Snowy Water Licence (the licence) defines Snowy Hydro Limited's rights and obligations in relation to water in the Snowy Scheme. The licence allows Snowy Hydro Limited to collect, divert, store, and release water by and from the works of the Snowy Scheme for the 75-year term of the licence. The licence also defines the rules for releases into the Murray and Murrumbidgee rivers and imposes environmental flow release obligations on Snowy Hydro Limited for the benefit of the Snowy River and other montane rivers (the rivers of the Snowy Mountains).
Special activation precinct	A dedicated area in a regional location identified by NSW Government to become a thriving business hub.
Stochastic climate datasets	Stochastic climate datasets are extended climate sequences that are synthesised using statistical methods applied to observed data of rainfall and evapotranspiration and can include paleoclimatic data. These extended sequences include a more complete sample of climate variability, part of which describes more severe drought sequences.
Storage	A state-owned dam, weir or other structure which is used to regulate and manage river flows in the catchment. There are also a range of storages owned by local water utilities. Also refers to the water bodies impounded by these structures.
Stormwater	The runoff of water generated from rainfall, from land to natural waterbodies, such as creeks, rivers and the sea. It includes surface flow and flow within conduits.
Supplementary flow	Where a surplus flow from rain events cannot be captured in storages, such as dams and weirs, and this water is not needed to meet current demands or commitments, then it is considered surplus to requirements. Reaches or zones of regulated rivers are typically unregulated for a short period of time.
Supplementary licence	When supplementary flow conditions are identified for a particular river zone, a period of Supplementary Access is announced. Supplementary Water Access Licence holders can only pump water against these licences during these announced periods. General Security licence holders may also be permitted to pump water during these periods.
Surface water	All water that occurs naturally above ground including rivers, lakes, reservoirs, creeks, wetlands and estuaries.
Sustainable diversion limit	Sustainable diversion limits apply to defined resource units, which are specified in the Basin Plan. They specify how much surface water or groundwater, on average, can be used in the Murray–Darling Basin by towns, communities, industry and farmers. These limits are written into law in NSW through water sharing plans.
Sustainable Diversion Limit Adjustment Mechanism	A mechanism included in the Basin Plan to adjust sustainable diversion limits in the southern Basin. The mechanism is a way to achieve similar or better environmental outcomes for rivers, wetlands and wildlife using less water. The adjustment mechanism can be achieved through supply, including constraints, or efficiency measures. Supply projects aim to improve water infrastructure and operating rules and efficiency projects improve water delivery systems.
Synthetic datasets	Data that is artificially created using algorithms and not obtained by direct measurement or generated by actual events.
Transmission losses	Water, from an accounting perspective, that is considered lost. This water has been lost through surface water seeping into the ground or through evaporation.
Transpiration	The process where plants absorb liquid water through their roots and then lose water vapour (gas) through pores in their leaves.

Term	Definition
Tributary	A smaller river or stream that flows into a larger river or stream. Usually, a number of smaller tributaries merge to form a river.
Unregulated river	Rivers or streams that are not fully controlled by releases from a dam or through the use of weirs and gated structures. However, in some catchments there are town water supply dams that control flows downstream. Water users on unregulated rivers are reliant on climatic conditions and rainfall. For the purpose of the NSW *Water Management Act 2000*, an unregulated river is one that has not been declared by the Minister to be a regulated river.
Wastewater	Water that is an output of or discharged from a particular activity; for example, from domestic, commercial, industrial or agricultural activities. The chemical composition of the wastewater (compared to the source) will be contaminated.
Water accounting	The systematic process of identifying, recognising, quantifying, reporting, assuring and publishing information about water, the rights or other claims to that water, and the obligations against that water.
Water reliability	Refers to how often an outcome is achieved. It is often considered to be the likelihood, in percentage of years, of receiving full water allocations by the end of a water year for a licence category. For example, a 60% reliability means that in 60% of years a licence holder can expect to receive 100% of their licensed entitlement by the end of the water year. Other measures of volumetric reliability could also be used; for example, the percentage allocation a licence holder could expect to receive at a particular time of the year as a long-term average. Reliability may also refer to how often an acceptable water quality is available. A reliable water supply gives some clarity to water users and helps them plan to meet their water needs.
Water resource plan	A plan made under the Australian *Water Act 2007* that outlines how a particular area of the Murray–Darling Basin's water resources will be managed to be consistent with the Murray–Darling Basin Plan 2012. These plans set out the water sharing rules and arrangements relating to issues such as annual limits on water take, environmental water, managing water during extreme events and strategies to achieve water quality standards and manage risks.
Water rights	The legal right of a person to take water from a water source such as a river, stream or groundwater source.
Water security	Water security in the context of regional water strategies refers to the acceptable chance of not having town water supplies fail. This requires community and government to have a shared understanding of what is a 'fail event' (for example, no drinking water, or water use restrictions for longer than a defined period, or unacceptable water quality) and the level of acceptability they will pay for. The NSW Government's guidance around an appropriate level of security for town water supply is the 5/10/10 rule. Under this approach, the total time spent in drought restrictions should be no more than 5% of the time, restrictions should not need to be applied in more than 10% of years and when they are applied there should be an average reduction of 10% in water use. This allows full demand to be met in most years and allows for water restrictions to be implemented infrequently to conserve supplies.
Water sharing plan	A plan made under the NSW *Water Management Act 2000* which sets out the rules for sharing water between the environment and water users, and between different water users, within whole or part of a water management area or water source.

Term	Definition
Water source	Defined under the NSW *Water Management Act 2000* as 'The whole or any part of one or more rivers, lakes or estuaries, or one or more places where water occurs naturally on or below the surface of the ground and includes the coastal waters of the State.' Individual water sources are more specifically defined in water sharing plans.
Water trade	The process of buying and selling water entitlements and water allocations.
Water year	In NSW, the water year runs from 1 July to 30 June.
Wetland	Wetlands are areas of land where water covers the soil—for all or part of the year. They include swamps, marshes, billabongs, lakes, and lagoons. Wetlands may be natural or artificial and the water within a wetland may be static or flowing, fresh, brackish or saline.



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Murray River, Albury.

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