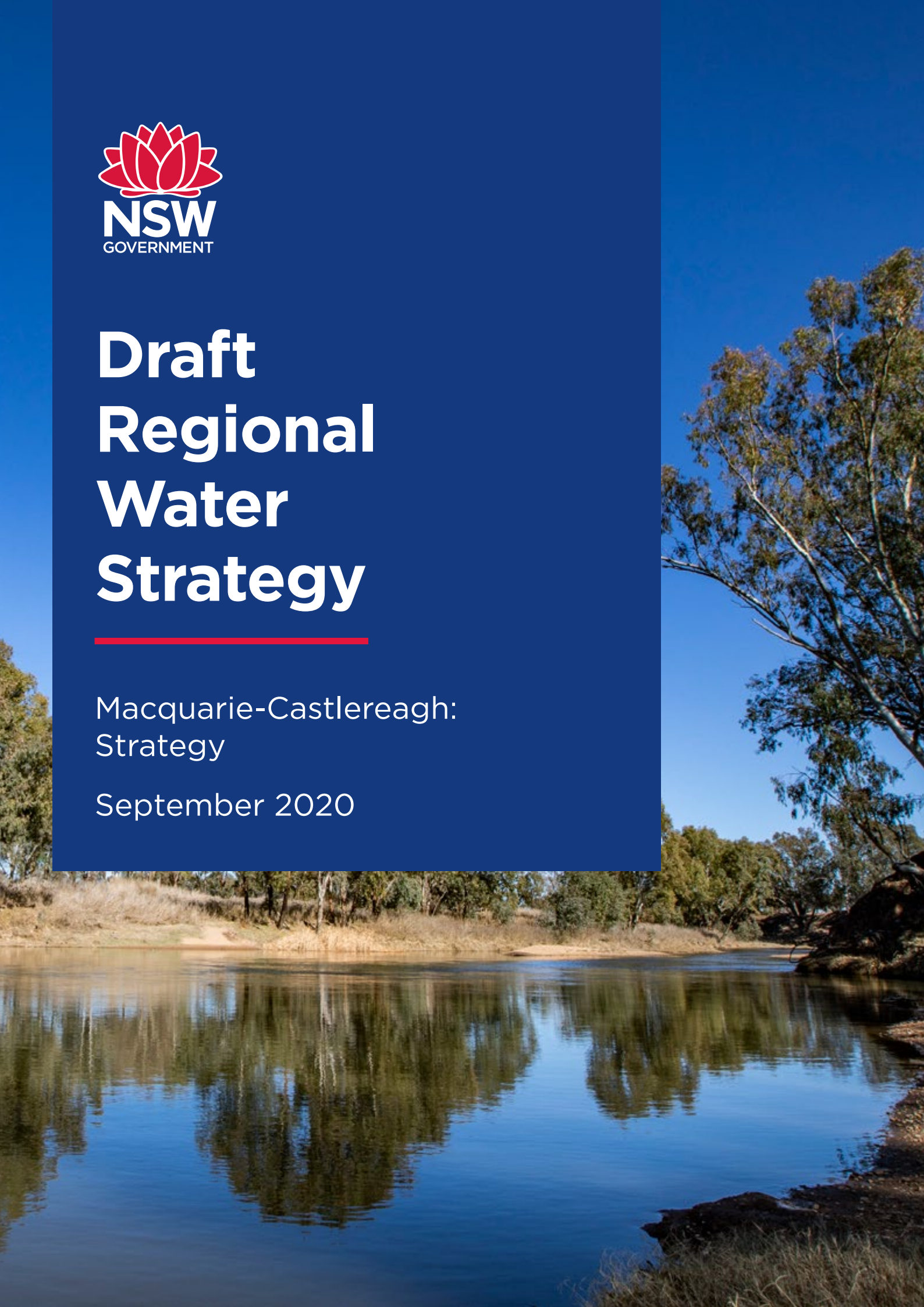
NSW GOVERNMENT

Draft Regional Water Strategy

Macquarie-Castlereagh: Strategy

September 2020



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The NSW Government acknowledges Aboriginal people as Australia's first people practicing the oldest living culture on earth and as the Traditional Owners and Custodians of the lands and waters.

We acknowledge that the people of the Gomeroi/Kamilaroi/Gamilaroi/Gamilaraay, Ngemba, Ngiyampaa, Wailwan and Wiradjuri Nations hold a significant connection to the lands in which the Macquarie–Castlereagh Regional Water Strategy falls upon.

The Macquarie–Castlereagh region holds areas of great spiritual, cultural and economic importance to the Aboriginal people and NSW recognises the connection of the water to the people of these nations.

We recognise the intrinsic connection of Traditional Owners to Country and acknowledge their contribution to the management of the Macquarie–Castlereagh Regional Water Strategy area landscape and natural resources.

NSW Department of Planning, Industry and Environment understands the need for consultation and inclusion of Traditional Owner knowledge, values and uses in water quality planning to ensure we are working towards equality in objectives and outcomes.

The Department of Planning, Industry and Environment is committed to continue future relationships and building strong partnerships with Aboriginal people. We thank the Elders, representatives of the Gomeroi/Kamilaroi/Gamilaroi/Gamilaraay, Ngemba, Ngiyampaa, Wailwan and Wiradjuri Nations and Aboriginal community who provided their knowledge throughout the regional water strategy development process.

Cover image and image to right courtesy of Destination NSW.

Minister's foreword

The NSW Government made a commitment before the last election to undertake comprehensive modelling that would enhance the management of water, to improve water security and better prepare our communities for future droughts.

Water is our most precious resource—for our towns, industries and maintaining our natural and cultural assets.

Our water management and understanding has improved considerably in recent times—if you can't measure it you can't manage it.

Communities have participated in tough decisions that have returned just over 1000 gigalitres to natural river flows in the past decade through the Murray-Darling Basin.

The knowledge we have garnered in the development of these strategies will underpin future investments through a better understanding of optimum water management.

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

I appreciate the engagement by local government in the development of the draft strategies. Their continued partnership is very important to ensure the strategies respond to the needs of catchments and which may include many local government boundaries.

Australia is no stranger to extremes, we have always had to manage our water resources through floods and prolonged droughts.

In preparing these strategies, we've engaged leading academics at a number of universities. The Paleoclimate informed rainfall and evaporation modelling was largely undertaken by the University of Newcastle and Adelaide University to help understand and mitigate risk in the most extreme circumstances.

The climate modelling in this draft strategy is based on a deliberately conservative scenario which is intended to pressure test the effectiveness of these strategies in a worst-case scenario. They also do not account for changes in how we operate the system moving forward, where in reality we will respond actively to ongoing drought conditions to prolong the availability of water for critical human needs.

These climate scenarios will not necessarily eventuate, but they give us an idea of the possible climate risks and allow us to begin planning to mitigate these risks if they arise.

The recent drought has 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.

In short, the better 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, and I encourage all stakeholders to take part in giving us your views on how to improve these draft strategies to ensure our water management policies support the future of NSW.

Melinda Pavey
Minister for Water,
Property and Housing

Image courtesy of Amber Hooper.

Contents

Snapshot

The Macquarie-Castlereagh region

212,000
population

92,000 km²
area

Gomeroi, Ngemba, Ngiyampaa, Wailwan and **Wiradjuri Nations**

Key regional centres include:
Dubbo, Orange, Bathurst

Smaller towns include:
Cobar, Mudgee, Wellington, Narromine, Nyngan, Warren, Oberon, Gilgandra, Coonabarabran and Coonamble

Major rivers:
Macquarie, Cudgegong, Bogan, Castlereagh, Campbell and Fish

Major water storages:

Burrendong Dam on the Macquarie River, with a storage capacity of 1,678 GL

Windamere Dam on the Cudgegong River, with a storage capacity of 368 GL

Key environmental assets:

The internationally recognised Macquarie Marshes and eight other nationally significant wetlands

Habitat for hundreds of species of plants and animals

Significant wetland vegetation and native fish

Gross Regional Product: **$13.5 billion**

Image courtesy of Destination NSW.

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.

The NSW Government is preparing comprehensive regional water strategies that 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 strategies also aim to generate greater community benefits and create new economic opportunities across NSW from improving how we manage, share and use water.

The Macquarie-Castlereagh Regional Water Strategy is one of 13 strategies (12 regional water strategies and a Greater Sydney Water Strategy) the Department of Planning, Industry and Environment is developing in partnership with water service providers, local councils, Aboriginal peak bodies, communities and other stakeholders across NSW.

Image courtesy of Destination NSW.

The Macquarie-Castlereagh region

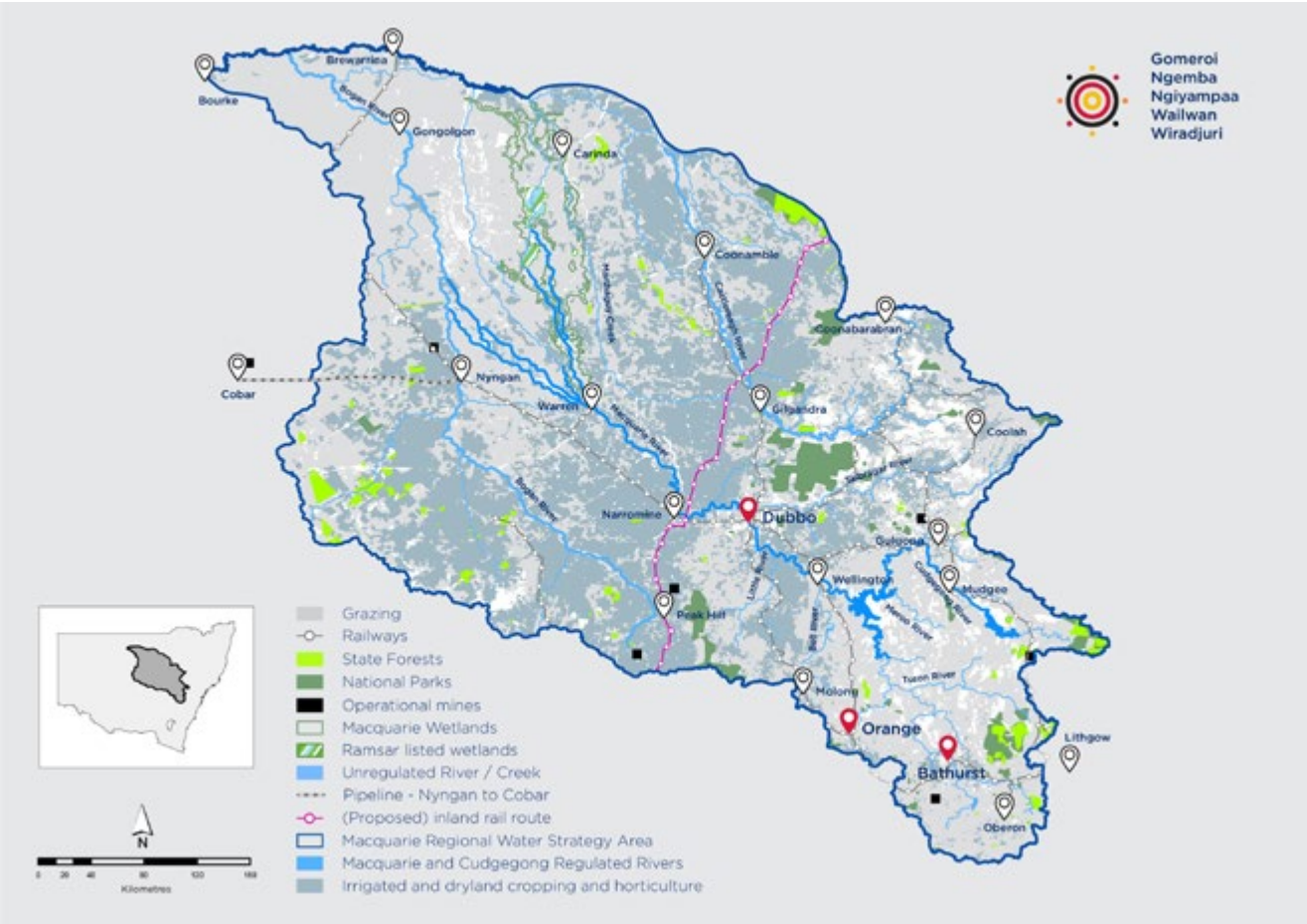
The Macquarie-Castlereagh region (Figure 1) lies west of the Great Dividing Range in central NSW. Covering an area of around 92,000 km^2, the region's landscape varies from steep terrain in the east to open plains in the west. The region is located within the traditional lands of the Gomeroi, Ngemba, Ngiyampaa, Wailwan and Wiradjuri Nations. It is home to over 200,000 people, with more than half of the population living in the centres of Dubbo, Bathurst, Orange, Mudgee and Wellington.

Agriculture (including cotton, grains and horticulture), food processing and mining are major contributors to the region's economy, along with tourism, health and education services, and the transport, freight and logistics industry.

The Macquarie-Castlereagh region is changing and growing. Over the next 20 years, the region's population is expected to increase by about 10%. Dubbo, Orange and Bathurst will continue to grow, providing jobs and services for nearby towns.

The region's industry mix is diversifying—tourism is increasing, the education sector continues to expand, and food processing and specialised agriculture are also expected to grow. The Inland Rail Project, a new regional rail maintenance facility in Dubbo and other transport investments will enable the region to leverage its position along nationally significant rail and road corridors, encouraging further industry development and jobs growth.

Figure 1. Map of the Macquarie-Castlereagh region



Water in the Macquarie-Castlereagh region

The region is supported by multiple sources of water, including the Macquarie, Castlereagh, Cudgegong, Bogan, Campbell, Talbragar and Fish rivers, unregulated creeks, floodplain harvesting, groundwater, recycled water from local water utilities and runoff from rainfall captured in farm dams. The region is also home to the Macquarie Marshes—an internationally significant wetlands listed under the Ramsar Convention on Wetland and of significant Aboriginal cultural importance.

The Macquarie-Castlereagh region has always had a highly variable climate. Over the last 125 years, severe droughts have occurred on average every 20 years, although usually of relatively short duration.

Since 2017, the region has been experiencing widespread drought conditions: by early 2020, below average rainfall conditions had persisted for nearly three years. Very low inflows to Burrendong Dam were just one-third of the previous lowest inflows on record. These conditions have placed the region's water resources—and the communities, industries and ecosystems that rely on them—under considerable stress.

Over the years, the region's industries have adapted to the highly variable climate by obtaining water entitlements from a range of water sources to meet their water needs and mitigate supply side risks. The regional water strategy aims to provide more certainty and assists water users in business planning through a greater understanding of levels of risk.

While industry and the environment generally can adapt to annual and seasonal variations in water availability, most regional towns do not have the same flexibility. Currently, very few cities and towns in the Macquarie-Castlereagh region have adequate water security. This includes larger centres like Dubbo, Bathurst and Orange and smaller towns serviced by the regulated system like Nyngan and Cobar (which is outside of the Macquarie-Castlereagh region, but is supplied from the Macquarie regulated river at Nyngan). Some towns, including Dubbo, are at significant risk of water shortages during increasingly severe droughts.

The Macquarie River system is more than 960 km long, which can make it challenging to deliver water to towns, industries and environmental assets along the full length of the river during extreme drought. Drought risks are also emerging for water users in the upper Macquarie catchment, particularly for Bathurst, Orange and Oberon that are dependent on the unregulated Campbell River, Summerhill Creek and Fish River respectively. Lithgow (outside the region) is also supplied from the unregulated Fish River scheme. These councils (above Burrendong and Windamere dams) are fully responsible for managing their own town water supplies and ensuring water security. Despite multiple water supply sources—such as dams, bores, stormwater harvesting, interconnecting pipelines and access to surface water—record low inflows have highlighted the vulnerability of these town water supplies.

Similarly, the towns of Coonabarabran, Binnaway, Mendooran and Gilgandra on the unregulated Castlereagh river have been experiencing record low inflows, affecting their surface water availability. Across the region, securing water of a suitable quality for smaller towns that rely mainly on unregulated rivers and creeks for their water is becoming increasingly challenging in the context of a more variable climate.

In addition, increased groundwater demand, particularly during drought periods, in some areas within the Macquarie-Castlereagh region is causing a decline in groundwater levels.

Aboriginal people in the region rely on water for their health, wellbeing and connection to Country. Aboriginal people consider that

1. Murray Lower Darling Rivers Indigenous Nations 2007, Echuca Declaration, Part 1. The full declaration is available here: www.mdba.gov.au/sites/default/files/pubs/sa-mldrin-echuca-declaration-2009_0.PDF

current 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[1]). Aboriginal people also seek more opportunities to manage water with their cultural knowledge and improved economic opportunities, either as licence holders or as partners in decision-making.

Providing water for a healthy environment can also be difficult at times in the region. Water for environmental assets in the catchment is provided primarily through general security licences, which are the first to be restricted during dry periods. This means that water available for the Macquarie Marshes is subject to the same pressures as those of the general security irrigation industry. Droughts like the 2017-2020 record drought have been particularly damaging to the Macquarie Marshes and native fish populations. Overall, the fish community in the Macquarie-Castlereagh catchment is in poor health, especially in the upper catchment. Many factors have contributed to this, including barriers to fish passage, changes to water flow, loss of lateral connectivity with floodplain habitats, degradation of in-stream habitat and riparian vegetation, the impact of pumps, land management practices and introduced fish species.

Future climate risks

The NSW Government has invested in new climate datasets and improved modelling that provides a more sophisticated understanding of historic climate variability in the Macquarie-Castlereagh region, as well as potential future climate risks over the next 40+ years. This means that we may be able to move from making decisions based on a single 'worst case' recorded drought to a much more comprehensive understanding of natural climate variability and potential extreme events.[2]

We can now better understand and plan for plausible future climate scenarios, better understand the climate risks facing different water users across NSW (such as the likely frequency, duration and severity of droughts and floods) and better manage our water resources over the medium and long-term to mitigate these risks.

Definitions

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

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 unacceptable water quality) and the level of acceptability they will pay for.

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.

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

2. For further information on the climate modelling method, see the *Regional Water Strategies Guide*.

This new information provides the basis for preparing robust new water strategies for our regions and also offers fresh evidence for examining our existing water policies, operational rules and management plans. The new information provides evidence of an emerging need to change and improve our approach to water management and supply.

Hydrological models updated with more sophisticated climate data for this strategy found that the variable climate seen over the last 130 years of historical records has been similar on average to the long-term climate, but there have been more extreme events in the long-term paleo-historical climate record that we haven't seen in the last 130 years. We need to plan and prepare for such events occurring in the future.

The new modelling also suggests that the Macquarie-Castlereagh region will continue to experience significant periods of wet and dry, with the likelihood of longer duration droughts being higher than previously thought. If no action is taken, we could expect to see:

- a 2-3% probability of droughts similar to the 2017-2020 drought in any given year, potentially leading to conditions in which Burrendong Dam could remain below 5% full for extended periods, with sustained pressure on town water supplies
- droughts occurring in closer succession, with less time to recover in between. We may see the frequency of 10-year droughts (similar to the 1932 to 1942 drought) increase by approximately 22%
- significantly greater probability of cease to flow days, particularly in the regulated parts of the system
- reduced frequency of floods, but when they do occur, significantly higher flood flows throughout the entire region, particularly during the summer-autumn period.

These changes will be coupled with higher average temperatures and evapotranspiration, and changes to the seasonality of rainfall in the near and long term. It also means that our rivers and creeks may not flow as regularly as they do now. Droughts that occur in closer succession and hotter, drier conditions may mean catchments require higher rainfall to generate runoff into rivers and creeks.

Making choices for the future

Like most regions across Australia, the Macquarie-Castlereagh region faces difficult choices and challenges in balancing different water uses as climatic conditions change. However, the region's communities and primary producers are used to variable annual rainfall and river flows, and past droughts have led to government and industry investment in private and public water storages and groundwater bores.

This has put the region in a good position to deal with greater climate variability and tackle future challenges, which include:

- providing reliable and safe water supplies to small towns and Aboriginal communities that rely mainly on unregulated rivers and creeks
- maintaining domestic water availability during drought for the portion of the region's population who are not connected to a town water supply and source their water from unregulated rivers, groundwater aquifers, farm dams and rainwater tanks
- improving water security for regional cities and major towns in the region
- sustaining and improving productivity in the region's agricultural industries
- regulating floodplain harvesting and making sure that adequate water reaches downstream users and is available to protect the environment

- improving waterway connectivity with the Barwon-Darling River
- maintaining flows to and reducing adverse impacts on water-dependent ecosystems, including the Macquarie Marshes.

We need to review existing water allocation and river operating rules to meet these challenges and improve water resilience. With strong growth expected in the region's major centres, we need to make decisions now about how, where and when to direct new investment to give these cities and towns adequate water security into the future. We may need to rethink the types of industries suited to different parts of the region and make better use of technology to reduce water demand and use water more efficiently in agriculture and other important industries, while catering to the growth in the region.

We also need to find ways to better manage groundwater and make more use of recycled wastewater, stormwater and other underused water sources.

Improved water security and reliability will also be critical to attracting people, businesses and jobs to the region, supporting the growing tourism industry and taking up new opportunities offered by the Inland Rail Project and other investments. There is the potential for a range of industries (such as manufacturing, services and education) to grow if there is enhanced water security for towns.

A new, comprehensive water strategy for the Macquarie-Castlereagh region

The Macquarie-Castlereagh Regional Water Strategy will guide how we address future water resource challenges, make the right policy and infrastructure choices and open up new opportunities for the region.

The strategy will bring together all the tools we have—policy, planning, regulatory, technology, educational and infrastructure solutions—in an integrated package that is based on the best evidence, responds to the region's water needs, balances different water uses and delivers the right amount of water for the right purpose at the right times.

The strategy will aim to provide choices to better use, share, store and deliver water to avoid having to ride the highs and lows of water availability. It will cover the whole region and all water types, and it will change how we manage water in the future.

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

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

Our vision for the strategy

Our vision for the Macquarie-Castlereagh 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 delivered in the right way for people, Aboriginal communities, towns, industries and the environment.

The final strategy will set out clear and accountable actions for the NSW Government, local councils and industries to tackle the challenges facing the Macquarie-Castlereagh region and maximise opportunities arising from the growing agricultural sector, other emerging and expanding industries, and new investments in digital connectivity and transport, health and community infrastructure.

To reinforce the significant water reform program undertaken by the NSW Government and other Murray-Darling Basin jurisdictions over the last three years, the final strategy will also help to improve the sequencing and integration of these reforms across the Macquarie-Castlereagh region (and the northern Murray-Darling Basin more broadly) to ensure they are implemented effectively.

The Department of Planning, Industry and Environment will develop an implementation plan that identifies actions and timeframes.

The options

A long list of potential options is presented as part of this draft strategy and includes two existing NSW Government commitments, a new mid system re-regulating weir on the Macquarie River and accessing water from Burrendong Dam's deep storage.

These options build on the NSW Government's current and planned investment in water infrastructure in the region and state-wide reforms to improve water metering, transparency and compliance. Infrastructure options identified through the strategy will also benefit from the NSW Government's move to streamline the approvals process for drought-related projects. Other options, such as policy solutions, will be designed in partnership with communities.

To identify and develop options for the draft strategy, we have drawn from a range of sources including previous studies, community engagement, experiences in the Millennium Drought and existing government programs. We have aligned our approach with regional development and land use strategies to ensure that all options can be integrated and sequenced with state-wide and local plans.

The options cover actions, projects, reforms and investments that focus on:

- **maintaining and diversifying water supplies**, such as additional pipeline connections, improved storages, more reliable access to groundwater for towns and reuse, recycle and stormwater projects
- **protecting and enhancing natural systems**, including better protection for native and threatened fish species, better water flows to wetlands and the removal of floodplain structures that impede the delivery of water to priority ecological assets
- **supporting water use efficiency and conservation**, including enterprise-based water efficiency programs and more efficient water delivery measures
- **strengthening community preparedness for climate extremes**, such as reviewing drought operation rules and allocation processes, improving data collection and sharing, and opportunities to maintain amenity in towns during drought
- **improving the recognition of Aboriginal people's water rights, interests and access to water**—such as reviewing cultural water access licences, ensuring greater involvement of Aboriginal people in water management and Aboriginal regional water advisory committees.

This strategy considers how government and local water utilities can adopt a more integrated approach to managing surface water and groundwater. It also acknowledges that connectivity and end of system flows

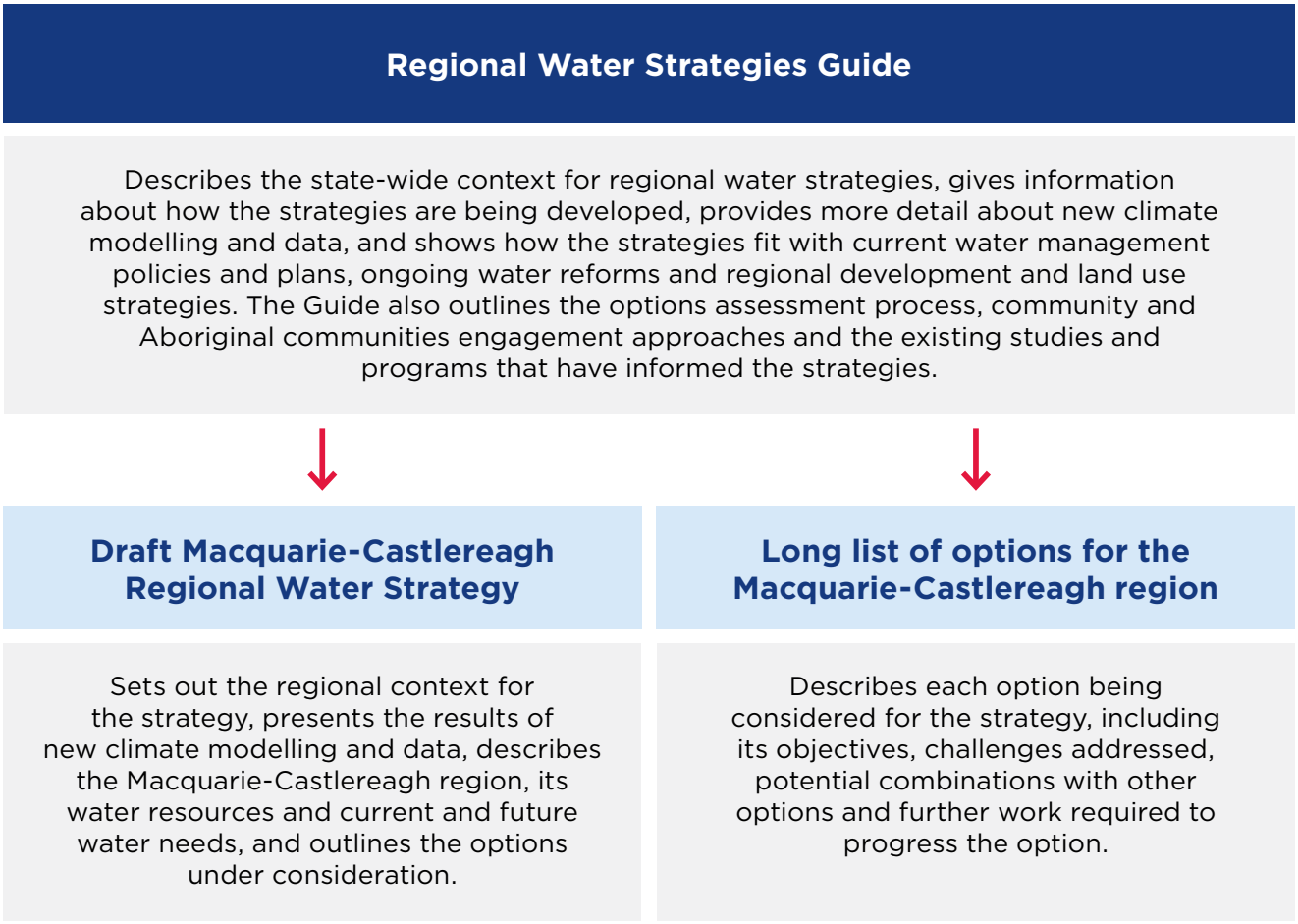
are important for Aboriginal people and the environment, and we received strong feedback from Aboriginal people that we should consider options to enable flows to the end of the system to occur more frequently.

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—they may need to be combined into packages.

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 Macquarie-Castlereagh region. These will form the final, comprehensive Macquarie-Castlereagh Regional Water Strategy.

The Draft Macquarie-Castlereagh 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).

Figure 2. Draft Macquarie-Castlereagh Regional Water Strategy



Chapter 1

Context

Image courtesy of Destination NSW.

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 strategies will aim to understand how much water a region will need to meet future demand, identify the challenges and choices involved in meeting 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 support safe and secure water for towns and communities, support regional industries, boost economic prosperity and safeguard and enhance the environment. The strategies will also recognise and protect Aboriginal rights, interests and access to water.
- The Macquarie-Castlereagh Regional Water Strategy is one of 13 strategies (12 regional water strategies and a Greater Sydney Water Strategy) the Department of Planning, Industry and Environment is developing in partnership with water service providers, local councils, Aboriginal peak bodies. The final strategies will also be informed by communities and other stakeholders across NSW.

New climate data and modelling, plans, studies and investments have also influenced the direction of the Macquarie-Castlereagh Regional Water Strategy.

- A significant amount of work since the Millennium Drought including drought assessment studies and the Macquarie-Castlereagh Incident Response Guide, has improved our understanding of the risks affecting water resource management in the region. Community engagement has also given insights into the best way to prepare for future droughts and floods in the region.
- The NSW Government has invested in new climate datasets and improved modelling to provide a more robust and sophisticated understanding of future risks to water availability in the Macquarie-Castlereagh region.
- 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 and a new streamlined approval process for drought-related projects.
- The strategy also aligns with existing policies and plans that are improving the management of water resources across NSW, as well as being integrated with strategic and local land use planning.

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 a region's medium and long-term water needs.

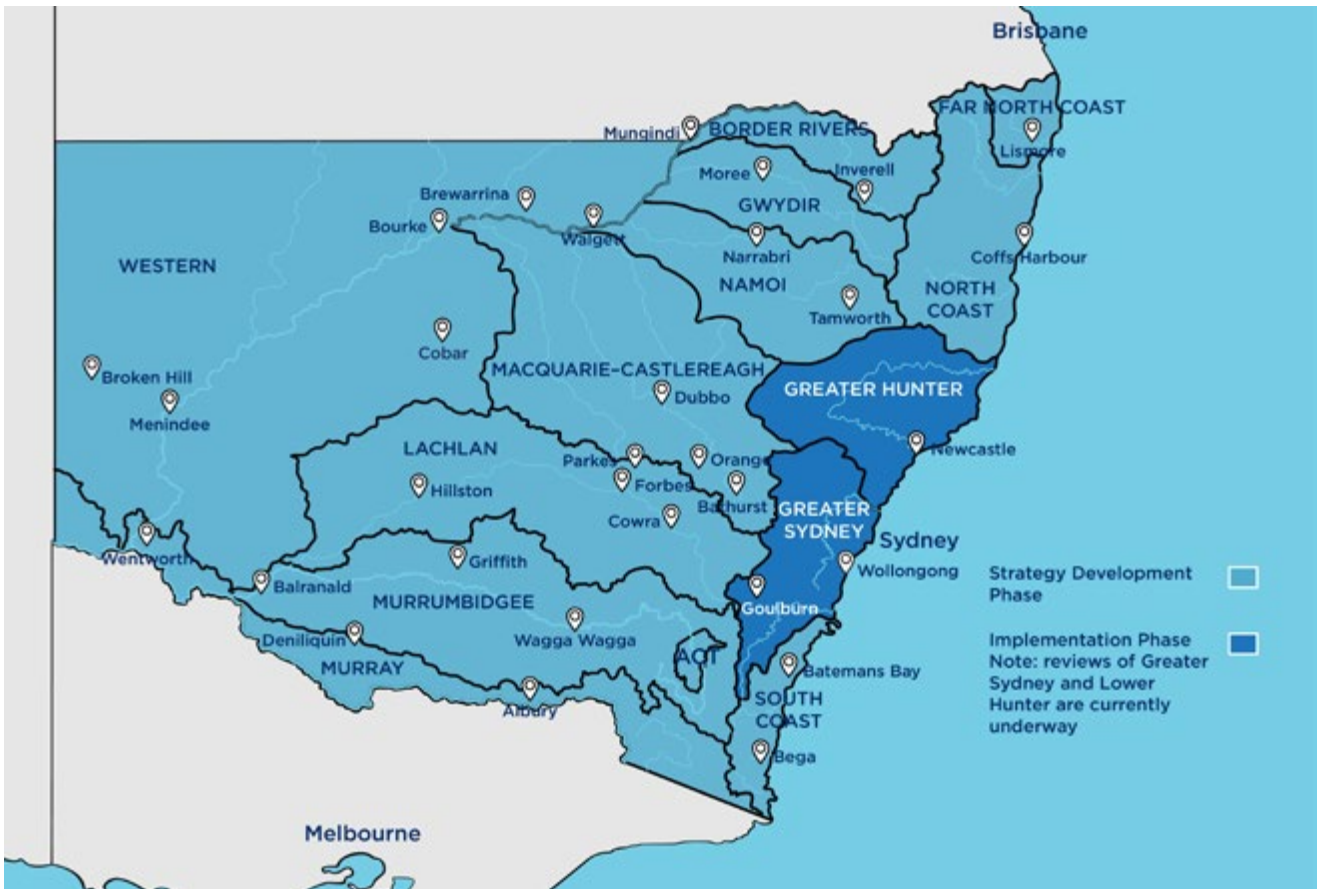
The strategies look out over the next 20 to 40 years and determine the challenges and choices involved in meeting the region's future water needs and the actions we can take to manage risks to water availability and secure healthier, more resilient water sources.

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

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

The Macquarie-Castlereagh Regional Water Strategy is one of 13 strategies (12 regional water strategies and a Greater Sydney Water Strategy) the Department of Planning, Industry and Environment is developing in partnership with water service providers, local councils, Aboriginal peak bodies, 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 'roadmap' of actions to deliver five objectives. 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 (Figure 4).

Figure 4. 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.

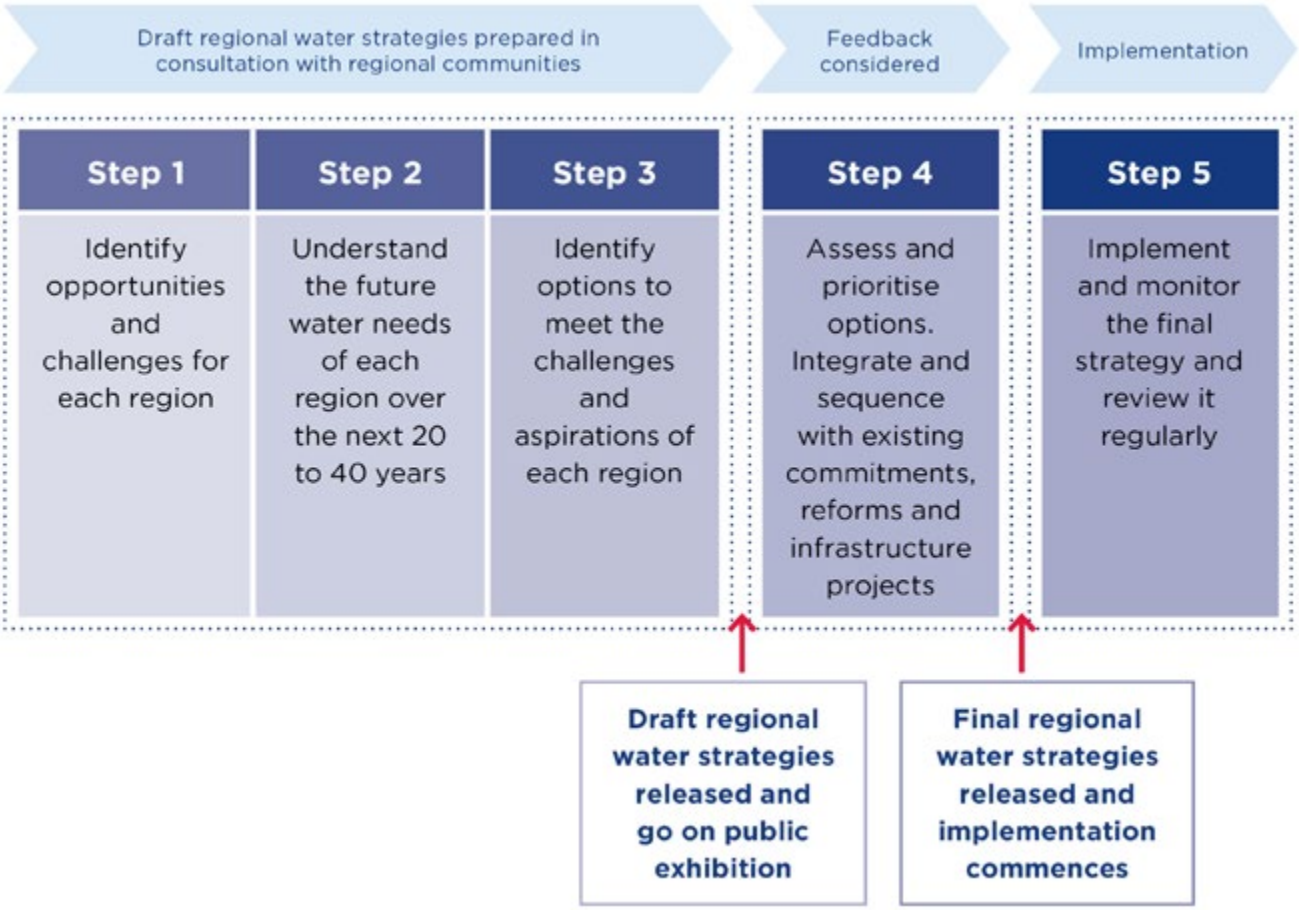
During extreme events, such as the current drought, our focus is on securing basic landholder rights and essential town water supplies. Outside of these extreme events, we have greater flexibility to deliver across all of the objectives, including providing water for the environment.

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.[3]

Through the regional water strategies, we aim to better manage these extreme events for all water users in the future.

The NSW Government is taking a five-step approach to preparing and implementing regional water strategies, as shown in Figure 5 below.

Figure 5. Five step approach to NSW regional water strategies



3. 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 consider ideas and options from each region, we have used a wide range of sources to inform each strategy.

1.3.1 Improved climate modelling and data

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 has invested in new climate datasets and modelling to develop a more sophisticated depiction of long-term streamflow and climatic conditions. This data includes integrating historical data (extending back 130 years) with paleoclimate data (data reconstructed from before observed historical records began, using sources such as tree rings, cave deposits and coral growth) to give a modelling tool that provides 10,000 years of data. When combined with other sources of climate data (such as climate change projections), this has helped us to better understand natural climate variability, including the probability of wet and dry periods in each region, and estimate risks to future water availability.

This improved modelling means that we may be able to move from making decisions based heavily on single 'worst-case' scenarios drawn from a short climatic record to a much more accurate understanding of the length and frequency of past wet and dry periods.

We can now better understand the probability of potential future climate characteristics—such as the frequency, duration and severity of droughts in each region—and also better understand how to mitigate these risks and assess the benefits of medium and long-term solutions.

This new method is an important advance on previous climate datasets and models. Through this work, we can now assess the impact 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.

This updated climate information has been used in developing the draft regional water strategies and will help to assess and compare the effectiveness of the draft options included in each strategy. It will also support all water users in making more informed decisions and better planning and preparing for climate risks.[4]

Chapter 2 sets out the results from the new climate method for the Macquarie-Castlereagh region. We will continue to use the best and latest evidence about the future climate to develop solutions to address the challenges associated with protecting and enhancing environmental assets, regional towns and industries in a more variable climate and during extreme events.

Ongoing analysis will yield more specific and robust results, giving an updated understanding of risks to town water supply, industry and environmental water security in the region. The final Macquarie-Castlereagh Regional Water Strategy will use this new data to identify the best ways to share, manage and use water to manage these risks.

4. More information about this new climate datasets and how they are being used in our river system models is provided in the *Regional Water Strategies Guide*.

1.3.2 Existing studies

A significant amount of work has been undertaken to understand the risks affecting water resource management in regional NSW. Development of the Draft Macquarie-Castlereagh Regional Water Strategy and the long list of options identified for the region was informed by catchment and water security studies, water and drought planning, and regional development, infrastructure and environmental strategies prepared by a range of NSW Government departments and agencies.[5]

This strategy has also been informed by WaterNSW's *Macquarie Priority Catchment Study*, WaterNSW's *20-year Infrastructure Options Study*, the Centroc *2009 Water Security Study* and the *Independent Panel Assessment of the Management of the 2020 Northern Basin First Flush Event*.

We have also taken into account the documentation developed to meet NSW's obligations under the Murray-Darling Basin Plan.

The Australian Government has requested an independent expert panel undertake an assessment of social and economic conditions in communities across the Murray-Darling Basin. The expert panel's draft report was released in March 2020.[6]

In August 2019, the Australian Government also announced that it would direct the Australian Competition and Consumer Commission (ACCC) to conduct an inquiry into markets for tradable water rights in the Murray-Darling Basin. The ACCC was asked to recommend options to enhance markets for tradable water rights, including options to enhance their operations, transparency, regulation, competitiveness and efficiency. An interim report was released in July 2020 and a final report to the Federal Treasurer is due at the end of February 2021.[7]

As there are overlapping objectives with the regional water strategy, the Department of Planning, Industry and Environment is working closely with WaterNSW on the Drought Management Study, which is developing drought relief solutions and optimising drought asset investment for towns in the Macquarie valley. A component of the Drought Relief Strategy is the Nyngan and Cobar Drought Security Project, which is considering options to avoid water supplies for Nyngan, Cobar and the nearby mines failing.

These studies and investigations will be important sources of information as we assess options for the final Macquarie-Castlereagh Regional Water Strategy.

5. More information about this work is in the *Regional Water Strategies Guide.*
6. Murray-Darling Basin Authority 2019, *Independent assessment of social and economic conditions in the Basin*, www.mdba.gov.au/publications/independent-reports/independent-assessment-social-economic-conditions-basin
7. Australian Competition and Consumer Commission 2019, Murray-Darling Basin water markets inquiry, www.accc.gov.au/focus-areas/inquiries-ongoing/murray-darling-basin-water-markets-inquiry

Image courtesy of Destination NSW.

1.3.3 Community engagement

Over the last few years, the NSW Government has been consulting on water sharing plans, water resource plans, metering reforms, floodplain harvesting, environmental water management and drought. Through those processes, we have heard many ideas about how to be better prepared for future droughts and floods and a more variable climate.

We have also been talking with local councils, joint organisations, local water utilities and Aboriginal and community groups about their thoughts on what the Macquarie-Castlereagh Regional Water Strategy could cover. Further information about these initial meetings and discussions is in Attachment 1.

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

- There is support for a long-term strategy for water that aligns with the longer-term vision and needs of the region and links with local planning activities.
- People are seeking meaningful engagement during the development of the strategy.
- There is a need to learn the lessons from this drought and identify the 'warning signs' for future droughts.
- The Macquarie Marshes are vitally important to the region as a culturally, environmentally and economically significant attraction.
- Different challenges in the upper and lower parts of the catchment require different solutions.
- There is a need for water security to provide greater certainty to industries and underpin regional growth.
- We need to consider options such as dedicated drought reserves in storages for town water supply security, as well as to ensure connectivity with the Barwon-Darling system.
- Councils would like more information and data to better understand the capacity, limitations and regulatory arrangements for groundwater supply, as well as a review of current and anticipated demands on groundwater to protect vital supplies for regional towns.
- There are opportunities to progress innovative solutions for stormwater harvesting, water reuse, recycling and groundwater recharge.
- Councils expressed an interest in the new climate data and want more information on how the modelling is being used for decision-making.

What Aboriginal people have told us so far.

- We need to better recognise cultural water access and have dedicated flows to significant areas such as Beemunnel Aboriginal Place.
- More water needs to flow to the Macquarie Marshes, which should be restored to provide connection to Country, cultural benefits for children and also economic benefits.
- It is important to identify cultural sites so they can be protected.
- The strategies could include objectives around maintaining continuous practice and obligations, emphasising the importance of Aboriginal cultural values and rights.
- Access to cultural sites and waterways is important for connection to Country and community wellbeing.
- More culturally appropriate information and education is needed around how governments manage water.
- Aboriginal people want more opportunities to manage land and water utilising their traditional cultural knowledge.

These early insights have been considered in developing this draft strategy.

1.4 Building on existing commitments and reforms

The NSW Government has made significant commitments to improve water resilience and reliability. Much of our current work is to address the risks facing regional NSW and set our regions up for the future. This includes investigating dam upgrades and investing in water saving infrastructure in the current drought and to prepare for the next one.

In the Macquarie-Castlereagh region, projects include:

- Cowra to Central Tablelands Water Emergency connection
- an additional bore and a water treatment facility for Narromine
- Albert Priest Channel maintenance works aimed at reducing losses, and a possible bore supply for Nyngan and Cobar
- the construction of a 5 km pipeline to connect the Spring Creek Dam with a water treatment plant in Orange
- delivery of a replacement pipeline from Winburndale Dam to Bathurst Water Treatment Plant
- duplicating the Blackmans Swamp Creek stormwater harvesting scheme in Orange
- feasibility study and initial detailed planning for the delivery of a pipeline network between Burrendong Dam and Cobar, taking in Narromine, Warren, Nyngan and Dubbo
- construction of a second water storage at Nyngan
- a new ground water supply for Dubbo Regional Council including new bores at Dubbo, Wellington and Geurie, a ground water bore optimisation study, diversification of Dubbo's water supply to include a proposed recycled effluent irrigation scheme and dual cross city pipeline project
- stormwater harvesting scheme at Bathurst
- connection of groundwater to the Warren raw water supply to provide water for firefighting purposes.

Through infrastructure programs such as the Safe and Secure Water Program and Water Security for Regions, the NSW Government is working with local councils to deliver water and sewerage projects across NSW designed to improve public health, water security and environmental outcomes and deliver other social benefits. In the Macquarie-Castlereagh region, the program is providing more than $100 million for water infrastructure, including:

- new pipelines between Orange and Molong, and between Orange, Blayney and Carcoar
- replacing sections of the Nyngan to Cobar pipeline
- bores in Warren, Narromine, Collie, Nevertire, Gilgandra, Coolah, Mendooran and Binnaway.

We are implementing a range of state-wide water reforms, including improving water and sewage services for Aboriginal communities, improving compliance and transparency around water use and access, and introducing robust new metering laws to make sure that most water taken in NSW is accurately measured and monitored.

We are improving how we protect environmental water in the NSW Northern Murray-Darling Basin to maximise environmental outcomes by implementing 'active management' in some unregulated systems (Macquarie Bogan, Lower Gwydir and Lower Darling).

Along with other states, we are implementing the Murray-Darling Basin Plan, which aims to rebalance water sharing between the environment and other water users. We continue to work with communities on the infrastructure and rule changes needed to implement the Basin Plan.

We have also streamlined the approvals process for drought and major dam projects through the *Water Supply (Critical Needs) Bill 2019.*

We continue to work towards a state-wide Aboriginal water policy to better represent the interests of Aboriginal people in water management.

More information about these reforms is in the *Regional Water Strategies Guide.*

The Macquarie-Castlereagh Regional Water Strategy will build on these commitments and reforms, seek to enhance and leverage them where possible, and address any outstanding gaps.

Responding to drought

Up until August 2020, over **$4.5 billion has been committed to the drought response in NSW**. This commitment to drought relief and water security is providing immediate support to farmers, families, towns and businesses impacted by drought:

- More than $2 billion has been provided for a support package for primary producers, businesses and communities.
- With the Commonwealth, the NSW Government will deliver over $1 billion to state significant dam projects, including the upgrade of the Wyangala Dam and Dungowan Dam and pipeline.
- Since 2016, $1.019 billion has been committed to 189 water projects, including building and upgrading water storages, pipelines and bores across regional NSW through programs like the $1 billion Safe and Secure Water Program and the NSW drought response.

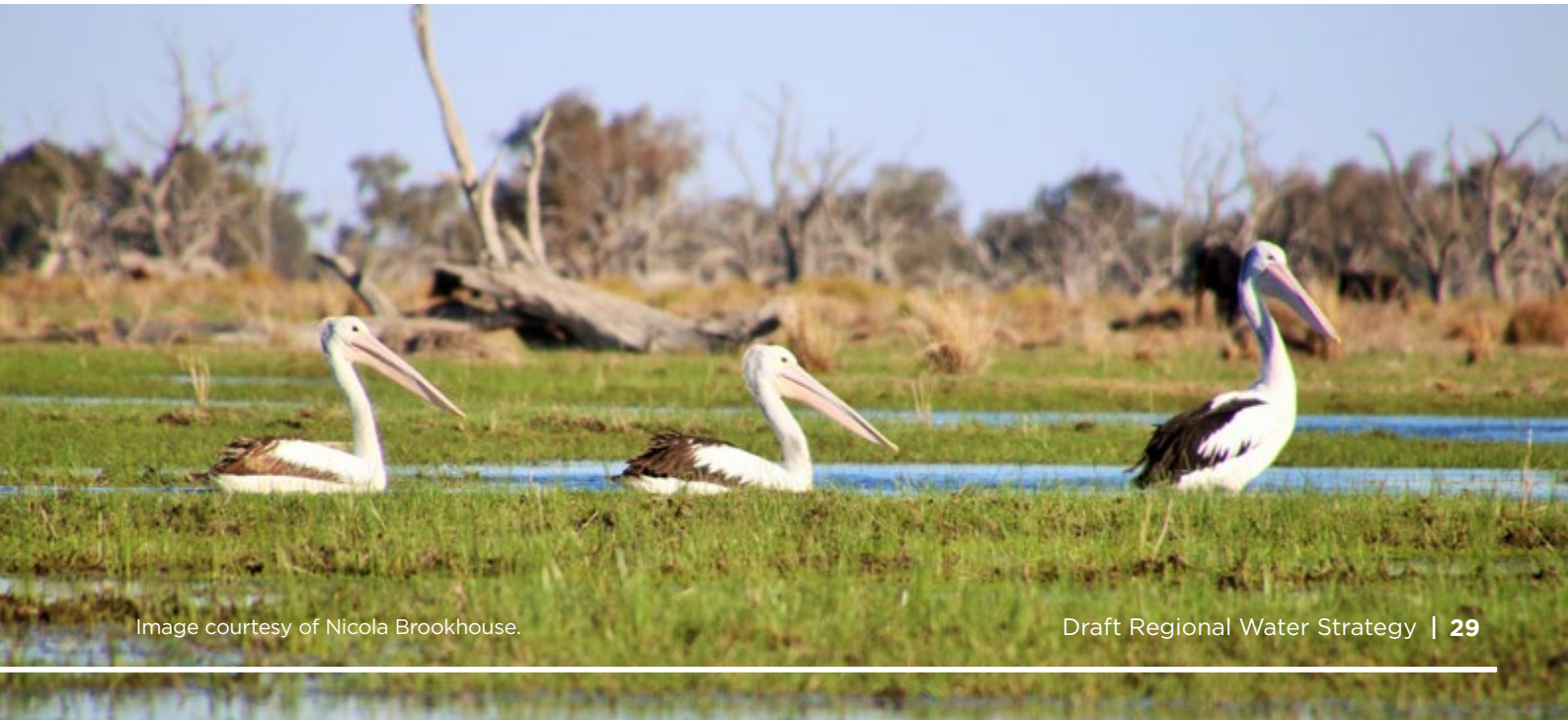


Image courtesy of Nicola Brookhouse.

Image courtesy of Peter Robey.

1.5 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).

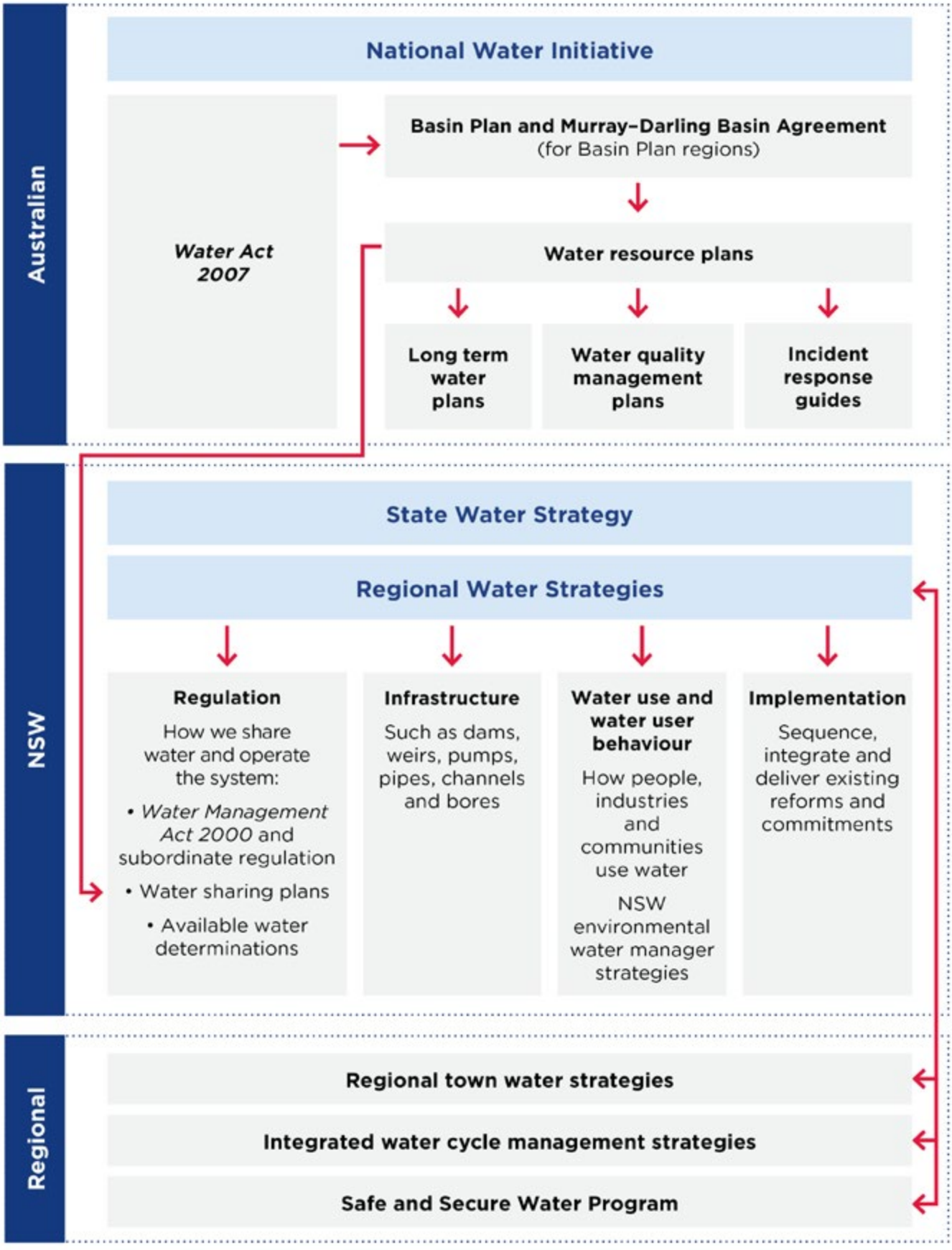
The NSW Government is also developing a 20-year State Water Strategy. This will establish overarching directions for managing water resources and services to ensure future water security, reliability and resilience, and address long-term challenges such as greater climate variability and population changes. The State Water Strategy will set high-level outcomes and actions to achieve these across public and environmental health, service delivery, liveability, economic development and technology, and for Aboriginal people.

Regional water strategies are an opportunity to explore how we can bring together existing commitments and better integrate and shape these plans, policies and investments for improved water outcomes. In particular, the strategies will play a key role in the ordering, sequencing and integration of water reforms in each region.

The strategies also align with the NSW Government's strategic planning hierarchy and will be integrated with current land use and regional plans.[8]

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

Figure 6. NSW water policy and planning context



Chapter 2

The Macquarie-Castlereagh region, its opportunities and challenges

Image courtesy of Destination NSW.

Snapshot

Climate conditions combined with the way the system is currently operated are placing the region's water resources—and the towns, communities, industries and ecosystems that rely on them—under considerable stress.

- The Macquarie-Castlereagh region has a naturally variable climate that includes multiple consecutive years dominated by either wet or dry conditions.
- Hydrological models updated with more sophisticated climate data for this strategy found that the variable climate seen over the last 130 years of historical records has been similar on average to the long-term climate, but there have been more extreme events in the long-term paleo-historical climate record that we haven't seen in the last 130 years, which need to be planned for. However, if our climate change projections eventuate, by 2070 we could see:
  - a significant (up to 50%) decrease in inflows into dams in the region
  - a 2-3% probability of experiencing conditions similar to the current drought (2017-2020), meaning that a drought of this severity and length may go from a 1 in 1000-year event to a 1 in 50-year event
  - increasing potential over the next 40+ years for droughts of 10+ year duration, similar to the 1932 to 1942 drought
  - increasing potential of Burrendong Dam falling below critical levels. Under conservative climate change scenarios, in 40+ years, the dam may be below 10% capacity for half of the time (compared with approximately 20% of the time under historical climatic conditions). This would significantly increase water security risks for water users below Burrendong Dam, particularly Dubbo, Cobar, Wellington and Nyngan
  - drought risks emerging for water users in the upper catchment (above Burrendong Dam) where record low inflows have highlighted the vulnerability of Orange, Bathurst and Oberon water supplies. However, the estimated increase in risk of shortfalls for Lithgow and Oberon under long-term climate change scenarios are not as high as for other regional towns
  - average water availability for water users supplied from Burrendong Dam decreasing, in particular for general security irrigators
  - the potential for some reduction to the size and frequency of smaller floods whereas larger floods may increase in size whilst their frequency is not anticipated to change.
- While our current science indicates that the likelihood of this climate change scenario eventuating is small, it remains a possible and credible future scenario. Assessment of this risk is a robust approach to stress test future water security preparedness for towns in the region.

- The long river system also presents challenges in delivering water to the end of the system. Supplying water over long distances from Burrendong Dam to Nyngan and Cobar, the environment and nearby mines becomes especially difficult under drought conditions.
- In extreme drought conditions, there are no tributary flows to help run the river. Water released from dams to the users at the end of the system seeps into the dry river and surrounding alluvial aquifers and evaporates along the way. This is an economic and social risk for towns, cities, the environment and industries in the region.
- We have an important opportunity to use new climate data and advances in climate modelling to review current water allocations and river operating rules to determine how we can enhance the region's water resilience in the future.

We need to rethink how we manage water in the region.

- We may need to be more conservative in water allocations or create specific reserves within storages to improve water security for towns during extreme events.
- Few cities and towns have adequate water security (including larger centres) and some towns are at significant risk of water shortages during increasingly severe droughts. Water security for these populations is a high priority for the NSW Government.
- We need to be more transparent about water security risks for cities, towns and industries. This will enable them to plan for periods when water is scarce.
- With strong growth expected in the region's major centres, decisions are required on how, where and when to direct new investment and support local councils in ensuring town water supplies are resilient to changing conditions. This could include accessing water from a range of climate-independent sources such as groundwater.
- Floodplain harvesting accounts for nearly 13% of all surface water taken in the region. While the diversion of water from the Macquarie region's floodplain is currently not licensed or measured, processes are currently being put in place to regulate it. The NSW Floodplain Harvesting Policy will help manage growth in this activity to ensure a fair share of water for downstream users and to protect the environment.
- We need to identify and adopt measures to reduce demand and improve water efficiency, while also making more use of recycled wastewater, stormwater harvesting and other underused water sources.
- We may also need to rethink the types of industries suited to different parts of the region and make better use of technology to reduce water demand and use water more efficiently in agriculture, mining and other important industries.

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

- The health of waterways impacts the wellbeing of Aboriginal people in the Macquarie-Castlereagh region.
- While there are some provisions for accessing water for cultural purposes, these do not currently meet the needs and obligations of Aboriginal people to care for Country or achieve the cultural water flows and water management aspirations set out in the 2007 Echuca Declaration. Aboriginal people seek ownership of their water.
- Options to improve Aboriginal people's involvement in water management and recognition of their water rights can protect cultural values and deliver spiritual, cultural, social and economic benefits to Aboriginal communities in the region.

Critical environmental assets need to be protected.

- Healthy water sources support the region's environment, which—in turn—supports liveable communities and thriving industries.
- The ongoing dry decades since 2000 have placed great stress on the river habitats and ecosystems in many parts of the Macquarie-Castlereagh region including native fish populations and the Macquarie Marshes.
- Our new modelling shows that lower inflows and fewer high flow events could place additional stress on aquatic species and the Macquarie Marshes, potentially leading to a decline in the diversity, condition and extent of the wetland vegetation community.
- Coordinated action and planning across the region should support environmental outcomes, including better connectivity with the Barwon-Darling River system, improved movement of native fish species, drought recovery and meeting ecosystem targets for important assets and areas like the Macquarie River and Macquarie Marshes.

Better management of groundwater.

- Groundwater sources are critical for towns, industries and groundwater-dependent ecosystems. However, use of groundwater is increasing and levels are declining in some areas.
- We need to use groundwater more efficiently and make better informed decisions about its management. This includes ensuring equitable and lawful use of groundwater under basic landholder rights.
- Options that increase knowledge about groundwater sources and studies of groundwater recharge rates can help to better manage groundwater resources.
- The opportunity for the next 20 to 40 years is to ensure sustainable access to groundwater resources by all water users.

2.1 What we know about the Macquarie-Castlereagh region's climate

Today's climate

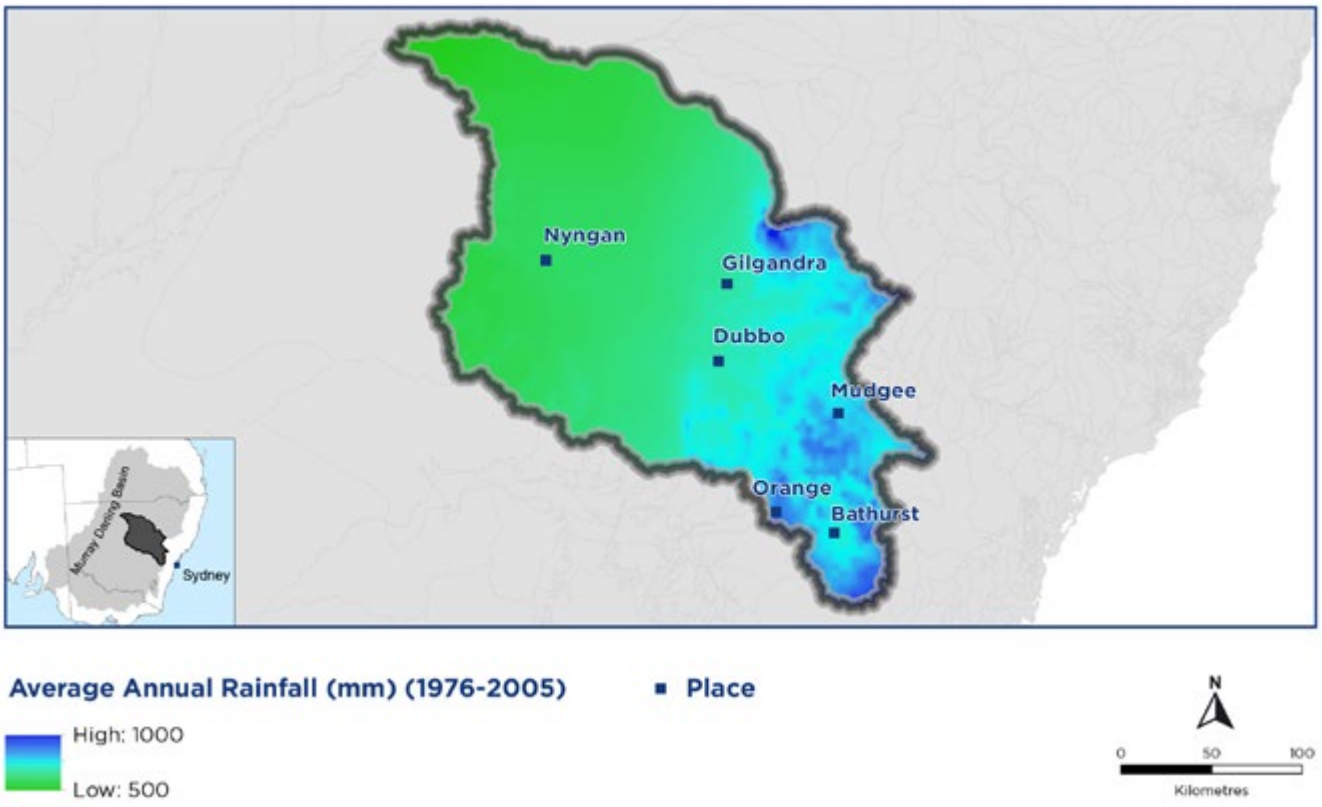
The Macquarie-Castlereagh region, like many valleys in Australia, has a highly variable climate, ranging from temperate conditions around Orange to semi-arid conditions on the alluvial plains north of Warren.

Average, maximum and minimum temperatures in the region have been increasing over the length of the observed historical record[9] and over the last 30 years there have been more hot days and consecutive days above 38°C each year.[10] Since January 2019, the region has experienced its highest record temperatures.[11]

Recorded average annual rainfall in the catchment ranges from over 1,200 mm in the south-eastern catchments to around 300 mm in the north-west plains. Annual evaporation ranges from ~1250 mm to ~1500 mm. Annual rainfall decreases from east to west across the region, while evaporation and temperature increase—meaning there is more evaporation where there is less rain (Figure 7).

Average annual rainfall has been relatively stable in the region, recording an average of around 400 mm in the past 30 years (1989 to 2018). Since 2017, rainfall has been variable across the Macquarie-Castlereagh region, but well below average in parts of the catchment during the last two years.

Figure 7. Observed average annual rainfall in the Macquarie–Castlereagh region



Source: Department of Planning, Industry and Environment, Macquarie-Castlereagh *Surface Water Resource Plan—Surface Water Resource Description—Appendix A 2018*, www.industry.nsw.gov.au/water/plans-programs/water-resource-plans/drafts/macquarie-castlereagh-surface

A better understanding of current climate variability and future climate change

As outlined in section 1.3.1, new studies have been undertaken to better understand the natural variability of the Macquarie-Castlereagh region's climate.

Through this work, we can now apply more extensive and robust climatic/hydrologic datasets to a 'base case' river system model, letting us assess changes to flows and water security over a much wider range of climatic conditions than has been understood from the records of the recent past.

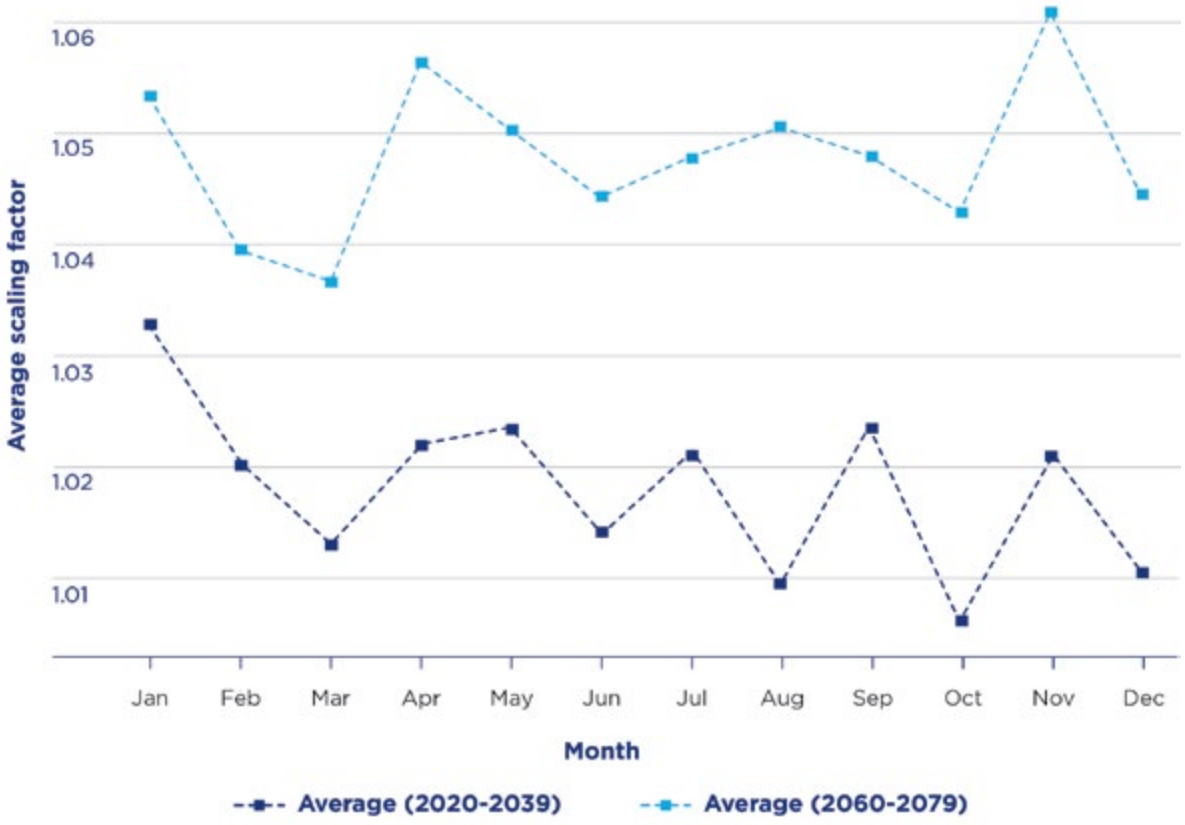
This new modelling gives a more realistic picture of the frequency and severity of past wet and dry periods in the Macquarie-Castlereagh region based on the persistence of climate drivers such as sea-surface temperature and using 1,000 years of climate information before historical records began.

Our new modelling also incorporates recognised climate change forecasts. These climate change forecasts show there could be potential changes to climatic patterns in the future including:[12]

- **higher evapotranspiration**—potential evapotranspiration is expected to increase by up to 5% in autumn and winter (Figure 8a)[13]
- **changing rainfall patterns**—annual average rainfall in the region could decline by up to 12% and heavy rainfall events are likely to be more intense over the long term (2060 to 2079). Shifts in seasonal patterns are expected to cause an overall decrease in spring rainfall across the Central West and Orana over the next 50 years, while autumn rainfall is projected to increase (Figure 8b)[14]
- **higher minimum and maximum temperatures**—maximum temperatures are expected to increase by an average of 0.7°C by 2030 and 2.5°C by 2070. Minimum average temperatures are projected to increase by 0.7°C by 2030 and 2.1°C by 2070[15]
- **more hot days (temperatures over 35°C)**—particularly for the plains north-west of Dubbo, which will likely experience an additional 10 to 20 hot days in the next ten years and 30 to 40 additional hot days by 2070. The east of the region, which includes Orange and Bathurst, will experience around 10 hot days per year.[16]

9. Bureau of Meteorology Australian Climate Change Data Site www.bom.gov.au/cgi-bin/climate/hqsites/site_data cgi?variable=maxT&area= aus&station=065070&dtype=raw&period=monthly&ave_yr=0
10. Regional Weather and Climate Guide 2019, *A climate guide for agriculture—Central West*, NSW
11. Commonwealth Environmental Water: Portfolio Management Plan 2019/20—Macquarie River Valley
12. These results were derived from the driest 130-year period (out of 10,000 years) with the lowest annual average extraction volume by General Security entitlement holders.
13. Department of Planning, Industry and Environment—Water 2020 hydrological modelling
14. Office of Environment and Heritage 2014, Central West and Orana—climate change snapshot drawn from the NSW and ACT Regional Climate Modelling (NARCliM) project
15. Office of Environment and Heritage 2014, Central West and Orana—climate change snapshot drawn from the NSW and ACT Regional Climate Modelling (NARCliM) project, www.climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Climate-projections-for-your-region/Central-West-and-Orana-Climate-Change-Downloads
16. Office of Environment and Heritage 2014, Central West and Orana—climate change snapshot drawn from the NSW and ACT Regional Climate Modelling (NARCliM) project, www.climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Climate-projections-for-your-region/Central-West-and-Orana-Climate-Change-Downloads

Figure 8a. Average monthly change in evapotranspiration for the Macquarie-Castlereagh region for the period 2020 to 2039 and 2060 to 2079 compared to the period 1990 to 2009 from NARCliM projections



Using climate change projections in water modelling

The NSW Government's NARCliM (climate change) datasets include a range of different future climate scenarios. We have used the most conservative result from NARCliM in our modelling—the scenario which represents the greatest reduction in average monthly rainfall.

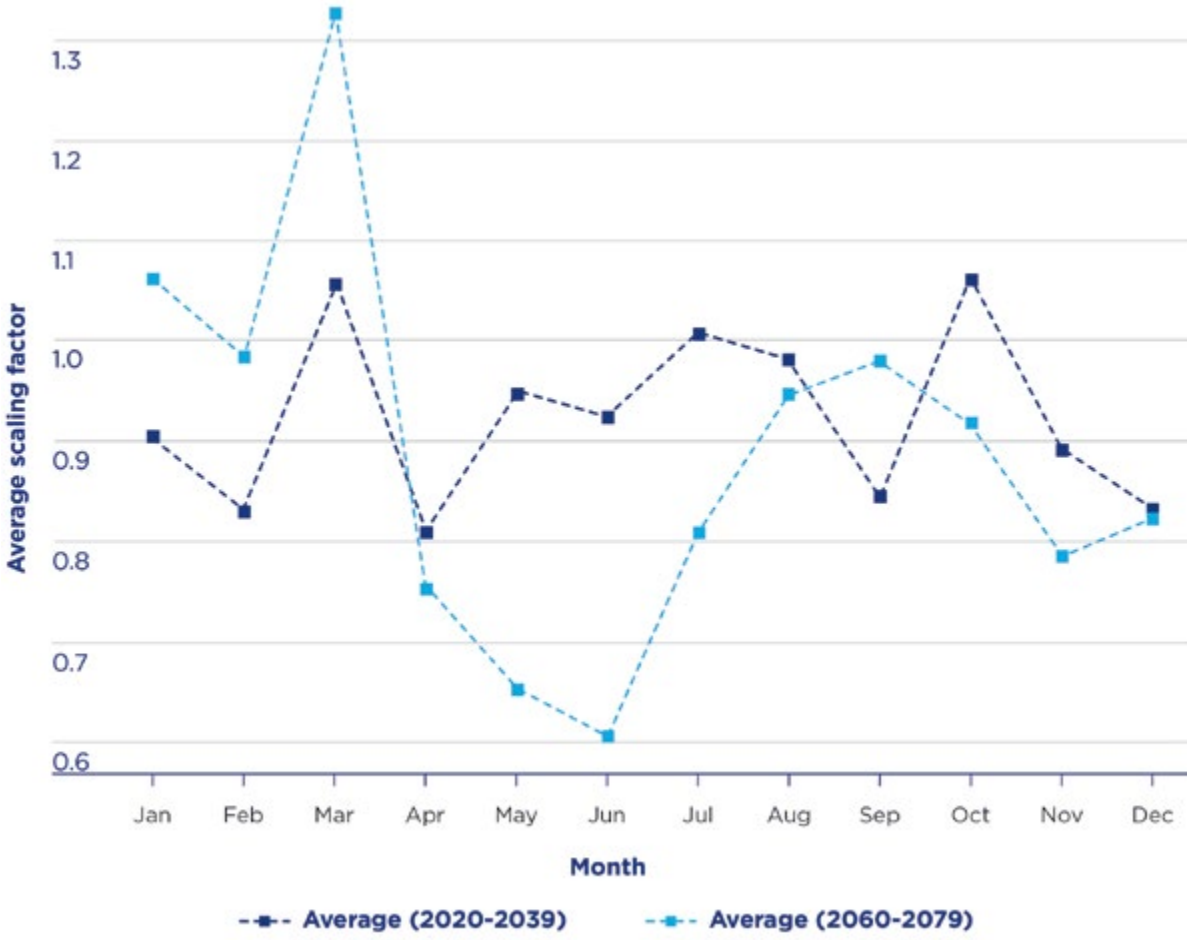
While the results of the other scenarios in the current version of NARCliM are arguably equally appropriate and probable, we intend to stress test the water system and understand the 'worst-case' climate scenario for strategic water planning. This will test the resilience of options proposed in the regional water strategies, particularly options that go towards securing water for critical human needs.

The most recent drought is significantly worse than any previously recorded, and our current science is indicating an increased probability of it reoccurring into the future.

The 2017 to 2020 drought in the Macquarie-Castlereagh region has been significantly worse than any other drought on record since Burrendong Dam was built in 1967.[17] This has been characterised by:

- the lowest recorded inflows into Burrendong Dam (around 88 GL)—which amounts to 36% of the previous record low inflow of around 246 GL for the 21 months ending April 2020. See Figure 9 for average inflows for 2018 and 2019[18]
- critically low dam levels—Burrendong Dam was sitting at less than 3% for 3 months and, after some rain, has risen to 45% full in September 2020

Figure 8b. Average monthly change in rainfall for the Macquarie-Castlereagh region for the period 2020 to 2039 and 2060 to 2079 compared to the period 1990 to 2009 from NARCliM projections



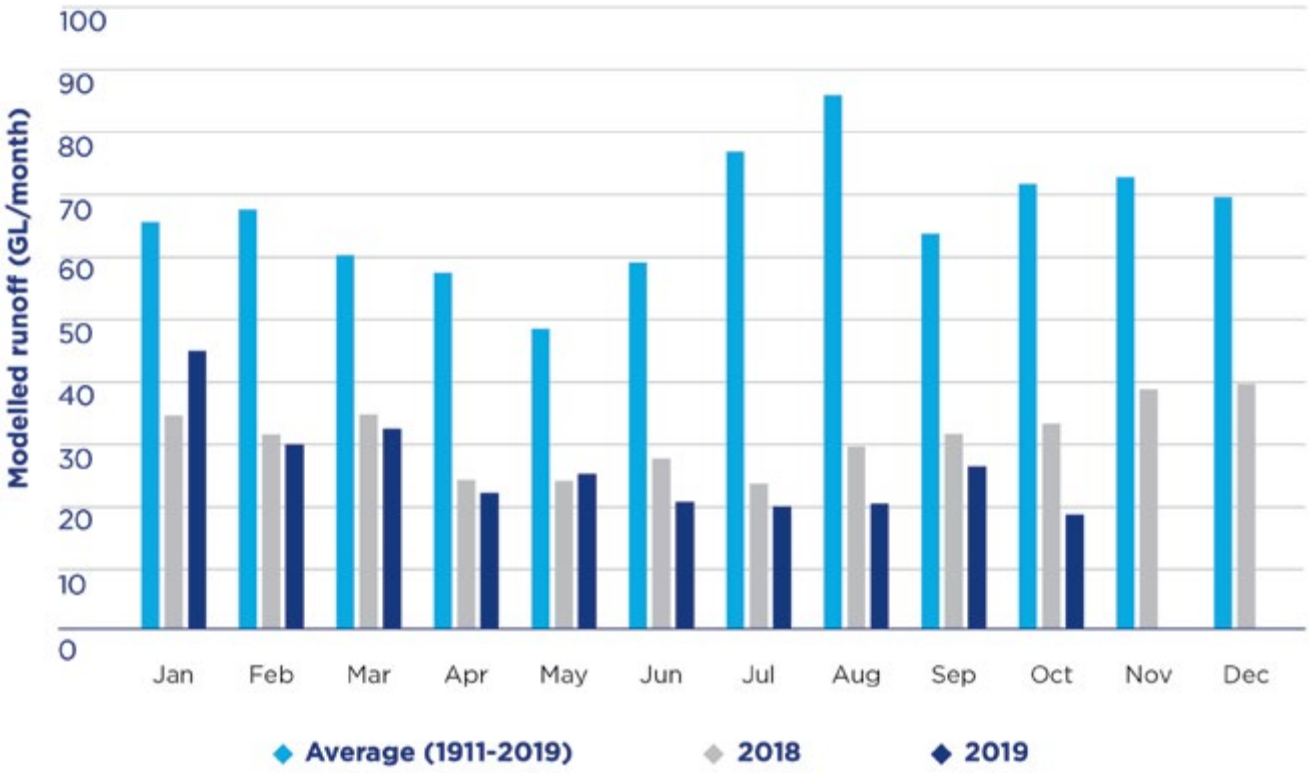
Source: Department of Planning, Industry and Environment—Water 2020, catchment climate data

- general security licence holders in the Macquarie valley—which includes water for the environment and irrigation—not receiving any water allocations for the past two years (2018/19 and 2019/20)[19]
- water for high security licence holders being restricted to a 70% allocation in 2019 and early 2020. Access to planned environmental water allowance was also suspended.

These dry conditions resulted in Burrendong Dam receiving inflows that were well below average during 2018 and 2019 (Figure 9). This caused difficulties for communities throughout the catchment in terms of businesses that rely on water for productive irrigation, towns that require secure and reliable supply and the environment, which relies on flow events of varying frequency, magnitude and duration to remain healthy.

17. Based on the lowest minimum inflows into Burrendong Dam for 24 months
18. Commonwealth Environmental Water: Portfolio Management Plan, 2019/20—Macquarie River Valley available at www.environment.gov.au/water/cewo/publications/portfolio-mgt-plan-macquarie-river-valley-2019-20
19. Department of Planning, Industry and Environment 2019, Macquarie and Cudgegong Valleys Water allocation update 23 August 2019, www.industry.nsw.gov.au/water/allocations-availability/allocations/statements/water-allocation-statements-2019

Figure 9. Burrendong Dam catchment runoff in 2018 and 2019 compared to average runoff



Source: Bureau of Meteorology 2019, Special climate statement 70 update—drought conditions in Australia and impact on water resources in the Murray Darling Basin

Our new modelling shows that the current drought is extremely rare (~0.1% probability of occurrence, or once every 1000 years based on 3-year inflow volume) even when compared to the long-term historical climate. However, under our adopted climate change scenario, the probability of seeing a drought of this severity increases to some 2-3%. While an event with probabilities of 2-3% may seem unlikely, it does represent a step change in the probability of these extreme events occurring. Through the modelling we can use this current drought to 'stress test' options, which will help us to understand how they would perform under a similar drought in the future and steer us towards a more resilient, secure supply system.

Prior to the recorded climate history the region has experienced more extreme dry periods than recorded in the last 130 years, and we have modelled this more comprehensive range of potential climatic conditions to better understand the probability of future droughts.

We have looked at the driest 36-month, 5-year and 10-year periods in the climate record and modelled the probability of droughts similar to these re-occurring. Our new datasets and modelling suggest that the region's extended droughts during the late 1930s are not uncommon; nor are they the worst the region has experienced over the long-term period of record. The region has experienced even drier 10-year periods in the past and it is plausible for those drier conditions to re-occur in the future, potentially in close succession.

The risk of these extended dry periods increases significantly under our projected climate change scenario. We may see the frequency of 10-year droughts (similar to

the 1930s and 1940s drought) increase from approximately 1% under historical climatic conditions up to 20-25% in the lower Macquarie and 10-15% in the upper Macquarie under the projected climate change scenario (Tables 1 and Table 2).

The duration of extended dry periods is just as important to understand as shorter, more intense droughts because the length of a drought will directly impact a system's ability to maintain secure supply for the duration of the event and can also influence how long it may take for water storages to recover once the drought has broken. The size of the dam can also influence which duration drought is most critical. For example, with a drought extending over many years there is an increased probability of small intermittent floods that may refill a small capacity dam.

Table 1. Burrendong Dam minimum inflow sequences and the probability of these sequences occurring again under long-term climate scenarios (stochastic) and a climate change projection (stochastic and NARCliM)

Burrendong Dam minimum inflow sequence	Total inflow volume (ML)	When did it occur in the observed historical record?	Probability of it occurring in the long-term climate scenario (stochastic)	Probability of it occurring in a climate change scenario (stochastic and NARCliM)
36-month	225,316	2017-2020	~0.1%	~2-3%
5-year	1,037,194	1937-1942	~1%	~15-20%
10-year	3,135,971	1932-1942	~1%	~20-25%

Source: Department of Planning, Industry and Environment 2020, hydrological modelling

Table 2. Chifley Dam minimum inflow sequences and the probability of these sequences occurring again under long-term climate scenarios (stochastic) and a climate change projection (stochastic and NARCliM)

Chifley Dam minimum inflow sequence	Total inflow volume (ML)	When did it occur in the observed historical record?	Probability of it occurring in the long-term climate scenario (stochastic)	Probability of it occurring in a climate change scenario (stochastic and NARCliM)
36-month	43,686	1927-1930	~2-3%	~10-15%
5-year	72,349	1937-1942	~0.5-1%	~5-10%
10-year	224,521	1932-1942	~0.5-1%	~10-15%

Source: Department of Planning, Industry and Environment 2020, hydrological modelling

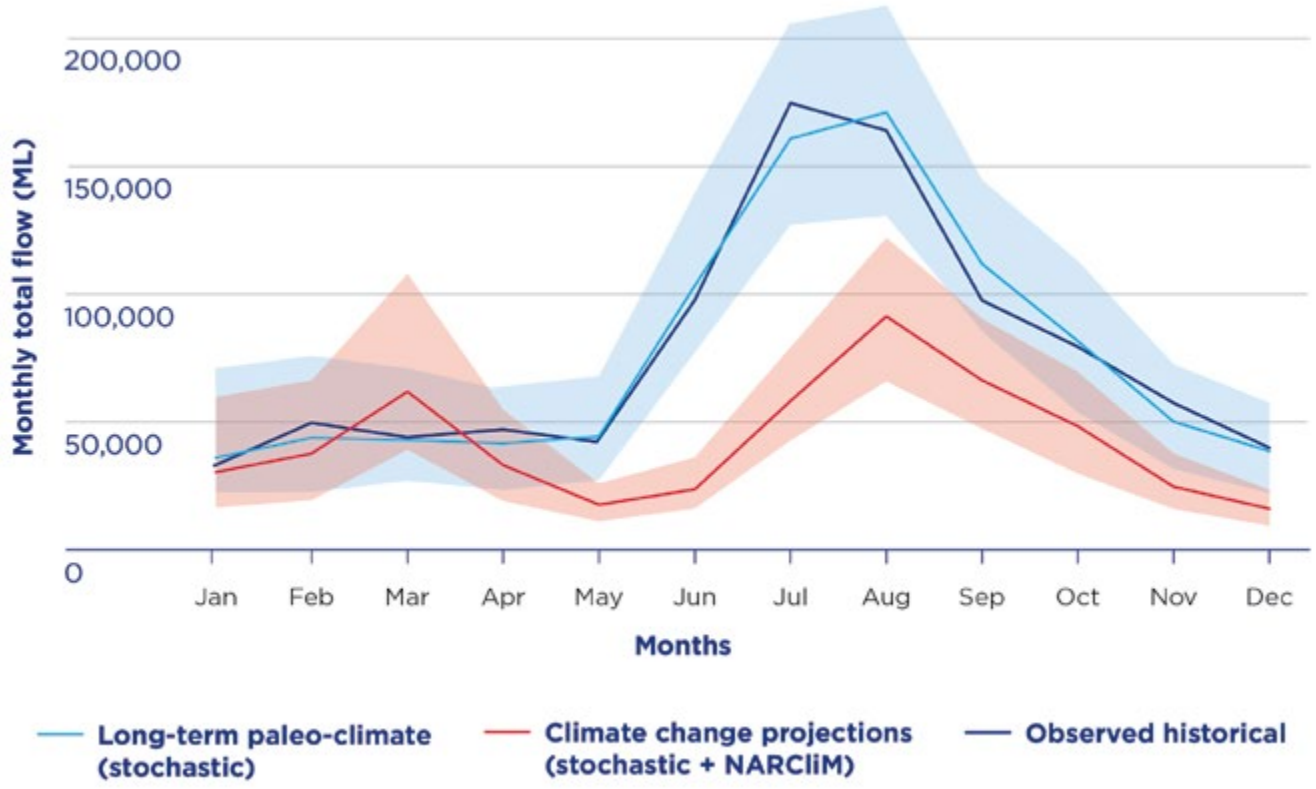
The timing and magnitude of long-term inflows could change

We have modelled the long-term average inflows in Burrendong Dam to understand the behaviour of inflows into the region.

Winter inflows into Burrendong Dam are a key characteristic of the hydrology of the Macquarie River catchment and are critical to managing the region's water needs. The long-term climate change projections suggest the potential for a 'shift' in the seasonal rainfall patterns. As a consequence, these winter inflows could be significantly lower than those occurring in both the observed and long-term historic records. While the modelling indicates we could also see a more modest increase in summer rainfall and associated flow/inflows, the overall impact is one of significant decrease in total dam inflows. (Figure 10).

Under a climate change scenario, the monthly inflow patterns for both Oberon and Chifley dams show a more modest reduction in later winter inflows and little change to the later summer inflow pattern (see Figure 11 for the Chifley Dam monthly inflows, noting that the Oberon Dam monthly inflow pattern is very similar).

Figure 10. Burrendong Dam inflow under different climate scenarios

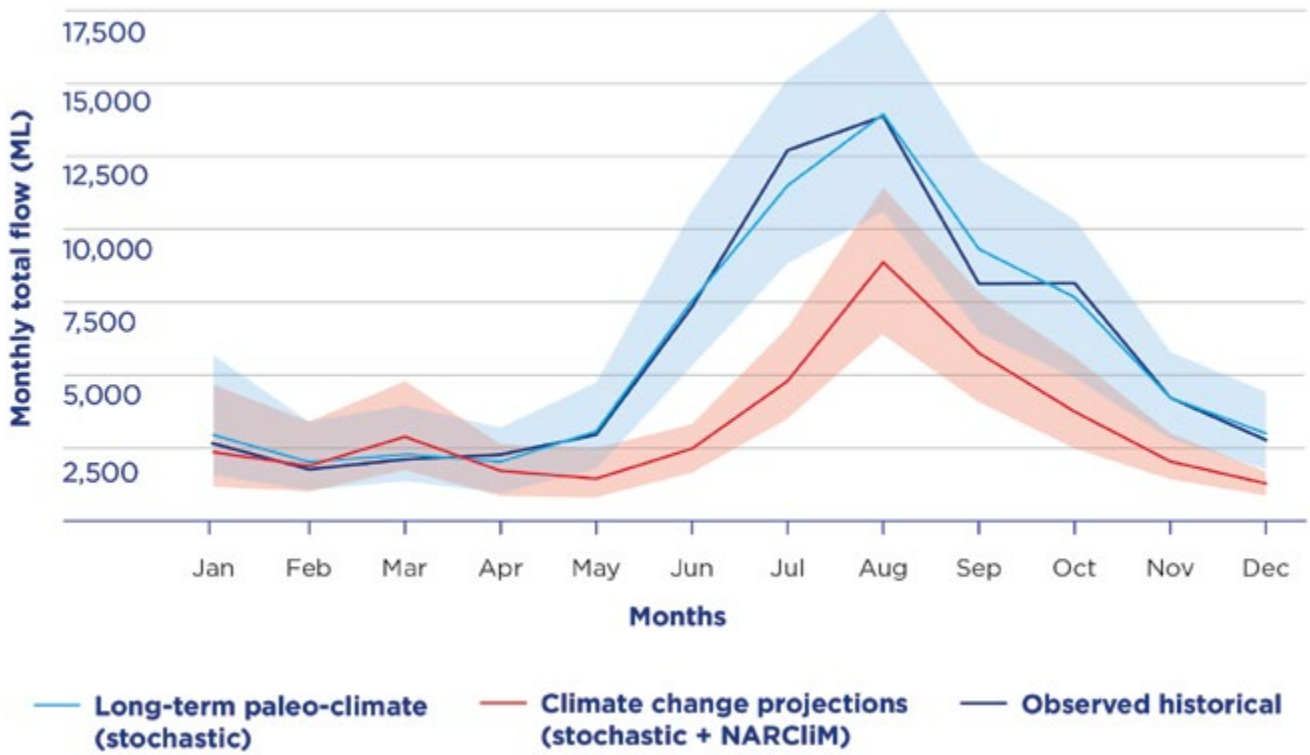


Source: Department of Planning, Industry and Environment—Water 2020, hydrological modelling

Note: The shaded area represents a 95th percentile confidence interval which means a high degree of confidence that values will fall within the shaded range based on the climate projection scenario.

Image courtesy of Destination NSW.

Figure 11. Chifley Dam inflows under different climate scenarios

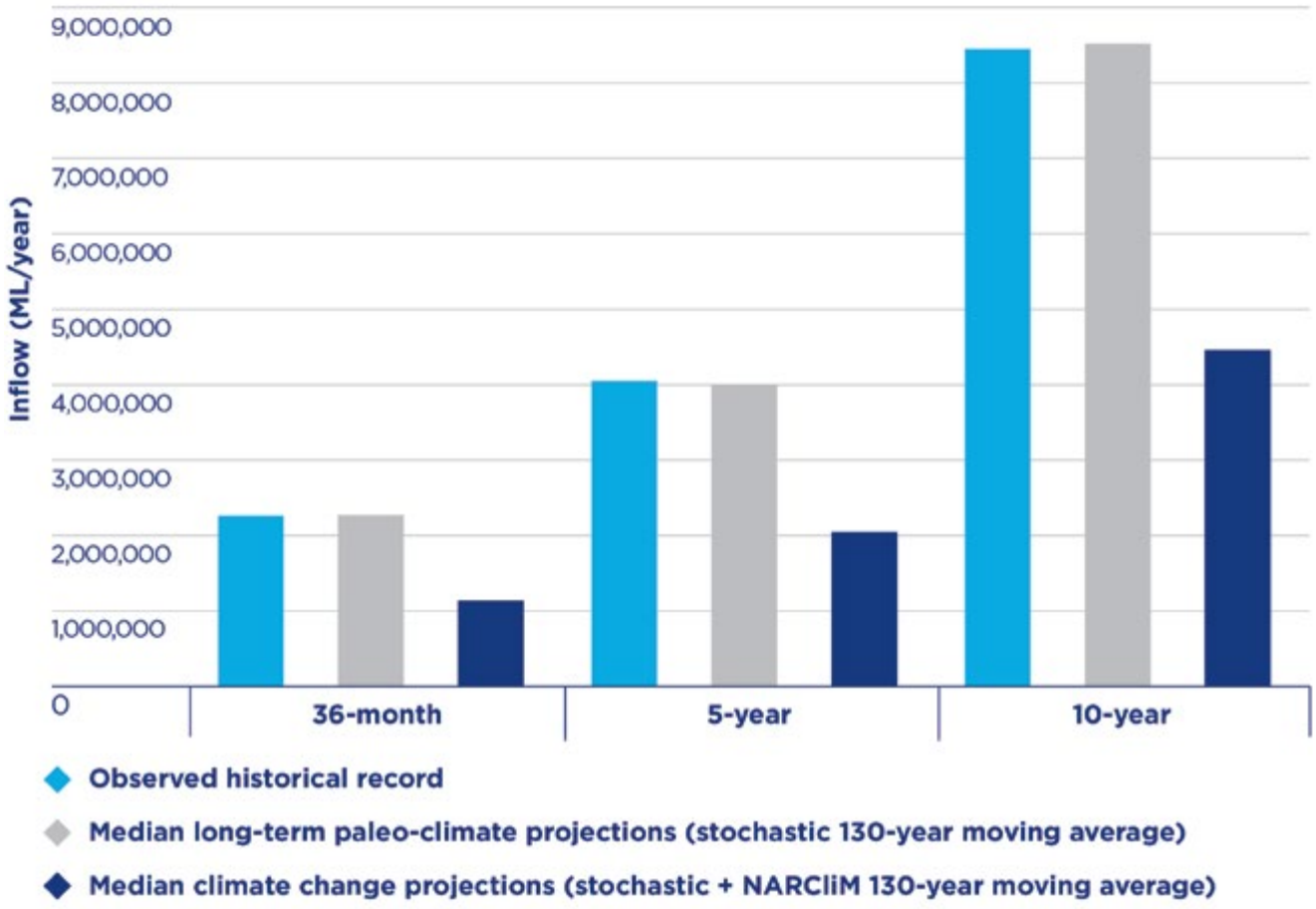


Source: Department of Planning, Industry and Environment—Water 2020, hydrological modelling

Note: The shaded area represents a 95th percentile confidence interval which means a high degree of confidence that values will fall within the shaded range based on the climate projection scenario.

Figure 12 shows the median (50th percentile) annual flow volumes under observed historical record, long-term and climate change projection scenarios. This figure provides an illustration of the potential reduction in projected inflows into Burrendong Dam. As indicated within the figure, modelling under the three climatic datasets estimates that inflows could potentially decline by up to 50% if the adopted climate scenario were to eventuate. We are not expecting to see impacts of these magnitudes in the short-term. However, these results indicate that just relying on our historical data to make water management decisions no longer represents the best course of action and that we have an opportunity to put plans in place to make sure we are prepared and resilient if there are future changes in the climate.

Figure 12. Median annual inflows into Burrendong Dam under three climate scenarios



Source: Department of Planning, Industry and Environment—Water 2020, hydrological modelling

A note of caution: the scenarios in these models will not necessarily eventuate. They are potential scenarios and there is always a level of uncertainty with this type of modelling, which needs to be taken into account as part of any water decision-making and planning.

In some instances, this may mean managing risks to our water security by being prepared and resilient, rather than relying on firm predictions and hard numbers. As the science develops further, we will be able to reduce or quantify some of these uncertainties.

Floods are a feature of the region's past, and its future

The Macquarie-Castlereagh region's long dry periods interspersed with wet years causes significant flood events. The region has experienced significant floods over the past 130 years of record, notably in 1926, 1941, 1950, 1955, 1956, 1971, 1984, 1990 and 2010/11.[20] The most recent major flooding event in the Bogan and Macquarie rivers was during September 2016, where heavy rain, combined with catchments saturated by above-average winter rainfall, resulted in substantial flooding.[21]

The NSW State Infrastructure Strategy 2018 identified the flood management risks for the Macquarie-Castlereagh region to be moderate due to the existing dam's flood mitigation zone; however, floods remain a risk for communities in the floodplains and unregulated reaches.

Large floods can have significant detrimental impacts on people and businesses—damaging infrastructure, creating safety risks and causing financial and economic loss. Floods that occur following extended dry periods can also cause land degradation and soil erosion, damage to river bank vegetation due to rapid wetting of the banks and in some instances flushing of dead organic matter into streams, causing 'blackwater' events that pose a risk to threatened fish species.

But floods are also a vital, natural process that supports the region's ecological productivity and help refill storages.

Floods in 2016 supported a waterbird breeding event in the Macquarie Marshes and provided opportunities for the movement and dispersal of native fish in the lower and mid-Macquarie floodplains and wetlands, which suffered significantly during the Millennium Drought.

Research indicates that the intensity of heavy, flood producing rainfall events is expected to increase with climate change. However, this may not translate into increased runoff and larger floods due to the likelihood of drier soils and catchment conditions. Drier catchments might mean that when we get high intensity rainfall events there may still be a lower likelihood of flood events.

Catchment dams play a large part in the behaviour of downstream flood events, with the potential to capture and store upstream events and therefore reduce the impacts downstream. When considering the potential change in flood behaviour under climate change, the fact that our modelling indicates a general reduction in long-term average inflows and thus generally lower dam storage levels means that even with more intense, large upstream events the net effect downstream could still be one of reduced flood frequency and magnitude. Put simply, while the current climate change science is indicating a general increase in probability of more intense rainfall events and therefore flood events, the presence of significant storages can and will impact on changes to flooding that is experienced downstream.

Preparation of the Macquarie-Castlereagh Regional Water Strategy provides an opportunity to identify how we can harness the benefits of floods while minimising their negative impacts in the region. It also provides the opportunity to assess whether there is any potential ability to improve dam management and flood controls works in rural areas.

20. www.ses.nsw.gov.au/local-region-information/mqr/record-floods/
21. Bureau of Meterology 2017, *Special Climate Statement 58—record September rains continue wet period in much of Australia*, Canberra

Image courtesy of Destination NSW.

2.2 The landscape and its water

The Macquarie-Castlereagh region is located in central NSW, west of the Great Dividing Range. It covers an area of around 92,000 km^2 [22] and includes the catchments of the Macquarie, Castlereagh and Bogan rivers. The region varies from steep terrain in the east to open plains in the west where the internationally significant Macquarie Marshes are located.

2.2.1 Water resources in the region

The Macquarie-Castlereagh region is supported by multiple sources of water (Figures 13 and 19), including:

- regulated surface water from the Macquarie and Cudgegong rivers[23]
- a system of creeks and unregulated rivers,[24] including the Bogan, Castlereagh, Talbragar, Campbell and Fish rivers
- floodplain harvesting during overbank flow events
- groundwater drawn from the Macquarie, Bell, Talbragar, Castlereagh and Cudgegong alluvial groundwater sources, the Great Artesian Basin and Oxley Basins, the Orange Basalt and the Lachlan Fold Belt
- reusing existing water sources, including recycled water from local water utilities
- local runoff from rainfall, some of which is captured in farm dams.

22. Department of Planning, Industry and Environment 2018, *Macquarie-Castlereagh Surface Water Resource Plan—Appendix A: Macquarie-Castlereagh Surface water resource plan Area Description*, p1, www.industry.nsw.gov.au/water/plans-programs/water-resource-plans/drafts/macquarie-castlereagh-surface
23. A regulated river or stream is one where the flow has been modified from its natural state through structures such as dams, weirs or off-takes. Major dams usually control the flow of water down regulated river.
24. An unregulated river or stream is not controlled by releases from a dam or through the use of weirs or gated structures. Water users are reliant on climatic conditions and rainfall.

Figure 13. Map of the Macquarie-Castlereagh region: key water resources and infrastructure

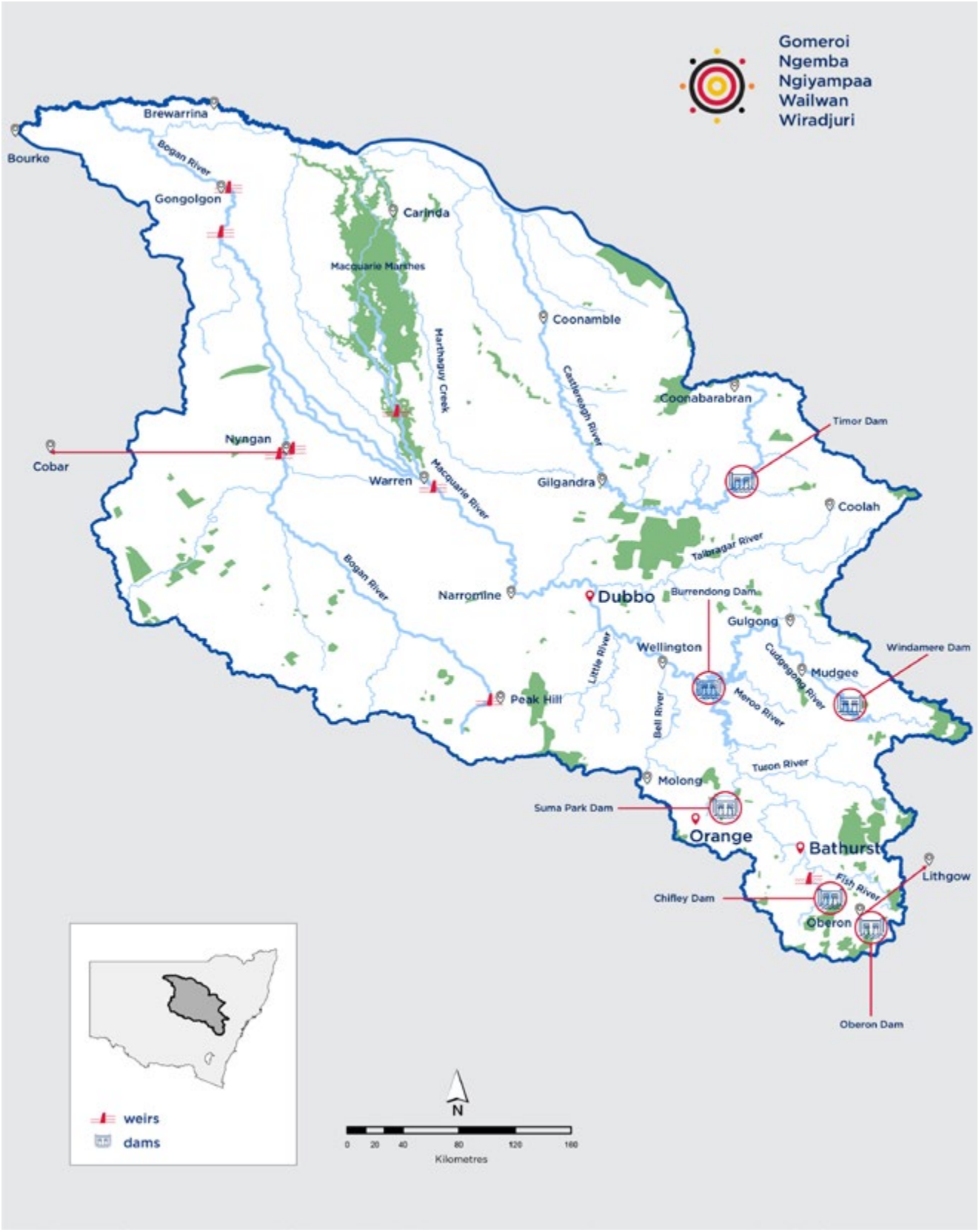


Image courtesy of Destination NSW.

Regulated rivers and infrastructure

Major water infrastructure in the region (Figure 13) includes:

- **Burrendong Dam** on the Macquarie River is the largest water storage in the region, with a capacity of 1,678,000 ML; however, 489,000 ML of this is only used on a temporary basis due to its function as a flood mitigation measure.
- **Windamere Dam** on the Cudgegong River has 368,120 ML capacity. It has filled to capacity only twice since it was constructed in 1984.[25]
- **Major in-stream weirs** include the Gin Gin Weir, Warren Weir, South Dubbo Weir and Marebone Weir. Some of these weirs—including Warren Weir, Duck Creek, Crooked Creek, Gunningbar Creek and Marebone regulator—currently have fish passage works. The weirs are owned by either WaterNSW or local councils.
- The **Albert Priest channel** is an unlined open channel that links the regulated Macquarie River near Warren to the Bogan River, supplying town water supply for Nyngan and Cobar, stock and domestic users and some water supply for Cobar mines.

Burrendong and Windamere dams provide water for:

- environmental flows, with environmental water held in the dam used to water the Macquarie Marshes and their connecting waterways
- stock and domestic water for landholders along the region
- town water supplies. Burrendong Dam is the primary water supply source to the towns of Wellington, Geurie, Dubbo, Warren, Nyngan and Cobar. Windamere Dam services Mudgee. Water from Burrendong Dam also provides Marra Creek, the lower Bogan and the lower Macquarie with replenishing flows for stock and domestic purposes

- industry uses, including general and high security licence holders such as mining, irrigation for broadacre cropping and horticulture and food processing
- other users like golf courses and the Taronga Western Plains Zoo.

There are also several major town water supply dams in the region, including:

- Chifley Dam supplying Bathurst
- Fish River scheme supplying water to the Lithgow Local Government Area and the upper Blue Mountains
- Oberon Dam supplying Oberon and the Fish River scheme
- Rylstone Dam supplying Kandos and Rylstone.

The Fish River Scheme also provides water for power generation (Energy Australia).

In addition to water supply, regulated storages provide recreational and tourism opportunities for nearby residents and visitors including fishing, boating, skiing, camping and sport and recreation centres.

In the regulated part of the Macquarie River, a substantial volume of water is required to deliver flows to some parts of the system for basic landholder rights, end of system flow targets, high security users (including town water supplies) and to meet seasonal general security orders by industry and the environment. Most parts of the regulated system experience continuous flows.

The river is over 960 km long, from its headwater to its junction with the Barwon River. The main water storage, Burrendong Dam, located near Wellington, is the start of the 500 km regulated section of the river. Dubbo and Narromine are located approximately midway. Towards the end of the system there are key environmental assets, such as the Macquarie Marshes downstream of Warren, and key economic areas such as Nyngan and Cobar.[26] Cobar is located outside the region but is supplied water from the Macquarie River via Nyngan, along with the nearby mines. The lower Macquarie River, downstream of the Macquarie Marshes, is unregulated. The largest water demands in the regulated river are along the mid-Macquarie River, between Narromine to just downstream of Marebone Weir. These demands include irrigators, who predominantly hold general security entitlements, and environmental water managers, who typically order water to provide flows to the Macquarie Marshes and other environmental assets in the lower end of the river system.

The length of the river system means delivering water to Nyngan and Cobar, the nearby Tritton Mine and the lower parts of the regulated system can be challenging in drought conditions.[27] Several landholders on unregulated distributary creeks also require replenishment flows from the Macquarie River for stock and domestic needs.[28]

Delivering water along the length of the river also maintains many flow-dependent ecosystems and helps to recharge groundwater systems. Under drought conditions, significantly more water is used to provide flows along a low or dry river. This may become unmanageable in an extreme drought and presents significant economic and environmental risks for the region.

25. Department of Planning, Industry and Environment 2018, *Macquarie-Castlereagh Surface Water Resource Plan—Appendix A: Macquarie-Castlereagh Surface Water Resource Plan Area Description*, p31, www.industry.nsw.gov.au/water/plans-programs/water-resource-plans/drafts/macquarie-castlereagh-surface
26. Murray-Darling Basin Authority 2019, Macquarie-Castlereagh: Snapshot, www.mdba.gov.au/discover-basin/catchments/macquarie-castlereagh
27. Infrastructure NSW, *State Infrastructure Strategy Update* 2014, www.infrastructure.nsw.gov.au/expert-advice/state-infrastructure-strategy/state-infrastructure-strategy-update-2014/
28. *Water sharing plan for the Macquarie and Cudgegong Regulated Rivers Water Source 2016,* www.legislation.nsw.gov.au/#/view/regulation/2015/630/part4/sec17

Image courtesy of Destination NSW.

Risks to Burrendong and Windamere dams storage volumes

Based on our new modelling data and information, we now understand more about the timing and volume of inflows to Windamere and Burrendong dams and possible future storage volumes (Figures 14 and 15).

There may be an increased risk for Burrendong Dam

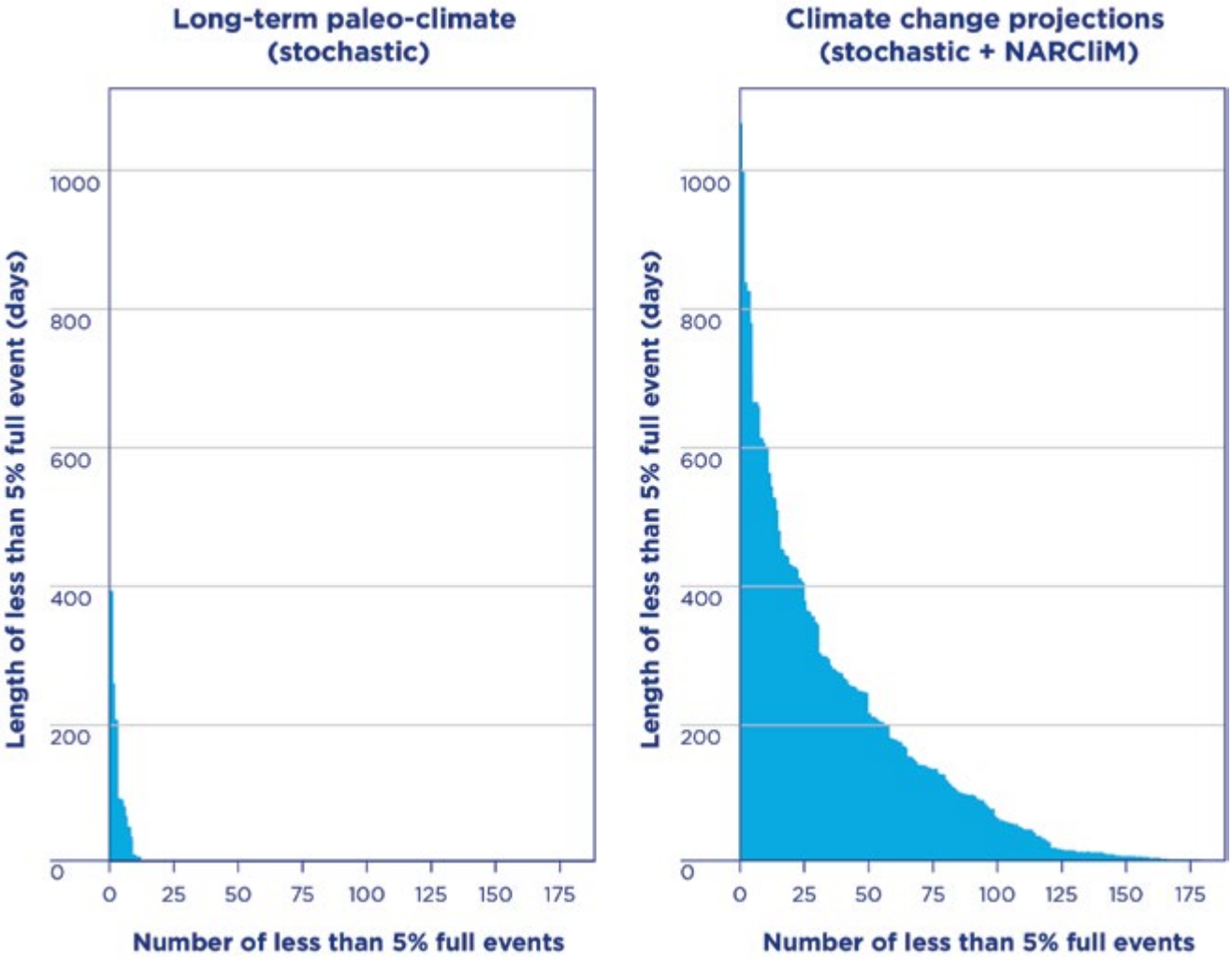
Our new modelling shows that Burrendong Dam could sit at or below 10% capacity for half of the time compared to 20% of the time in our historic records.[29] At 10% capacity Burrendong Dam can still meet the existing high priority needs, but cannot meet general security licence needs.

As the dam falls and remains at lower levels, it could place sustained pressure on towns and high priority water needs that rely on water from the dam. This is particularly so as the dam falls below 5% capacity:

- Within our observed historical records, Burrendong Dam has regularly fallen below 5% capacity—about 13% of the time. This was most recently the case for the 2019/20 water year, when Burrendong Dam dropped to 1.5% full in February 2020.
- This risk increases under a climate change projection where Burrendong Dam could fall below 5% capacity approximately 40% of the time, and in the worst of these simulated conditions, it could stay below that level for multiple years (Figure 14).

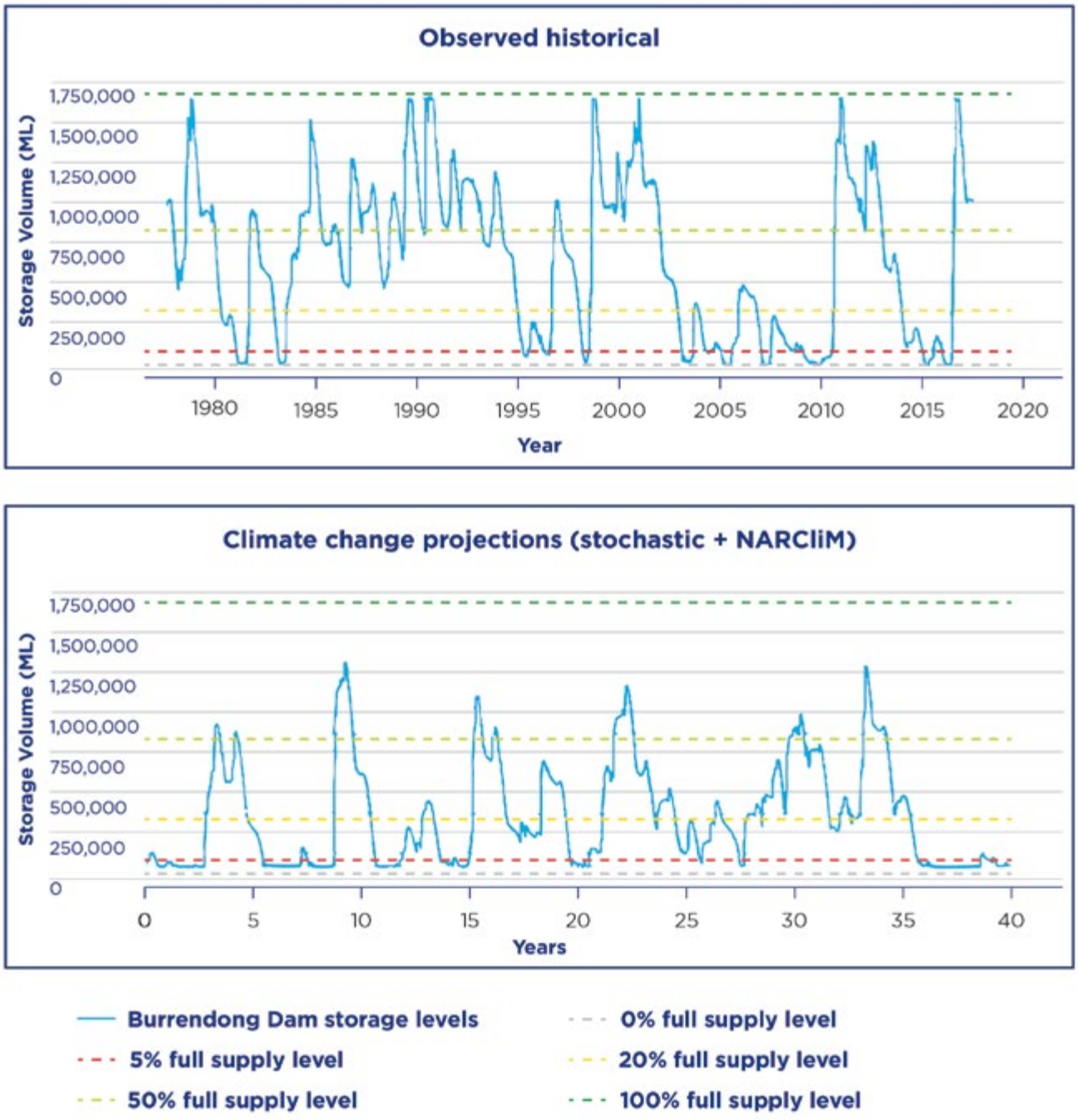
29. Time refers to the number of days during the 10,000 year simulation period

Figure 14. Ranked number and length of events when Burrendong could be below 5% full under the climate change projection



It is important to note that while the types of conditions assessed under our climate change scenario represent a possible/credible future, the probability of these outcomes occurring is small. The estimates are based on a deliberately conservative climate-projection scenario in which recent greenhouse gas emission rates and temperature increases are maintained into the future without any mitigation. These results also assume there is no change in how we operate the system, where in reality we would respond to ongoing drought conditions and operate the system to prolong the availability of water for critical human needs. These scenarios will not necessarily eventuate, but they give us an idea of the possible climate risks and allow us to begin planning to make sure we can mitigate these risks if they do arise.

Figure 15. Burrendong Dam storage levels for the average 40-year period



Source: Department of Planning, Industry and Environment—Water 2020, hydrological modelling

Note: The figure represents Burrendong Dam storage levels for the average 40-year climate period based on observed historical climate data (instrumental), and stochastic data (10,000-year period) with the addition of NARCliM (climate change projections). A 0% effective storage volume represents dead storage. The stochastic only information has not been presented as it represents a very similar result to the instrumental projection.

The risks for Windamere Dam are not as high

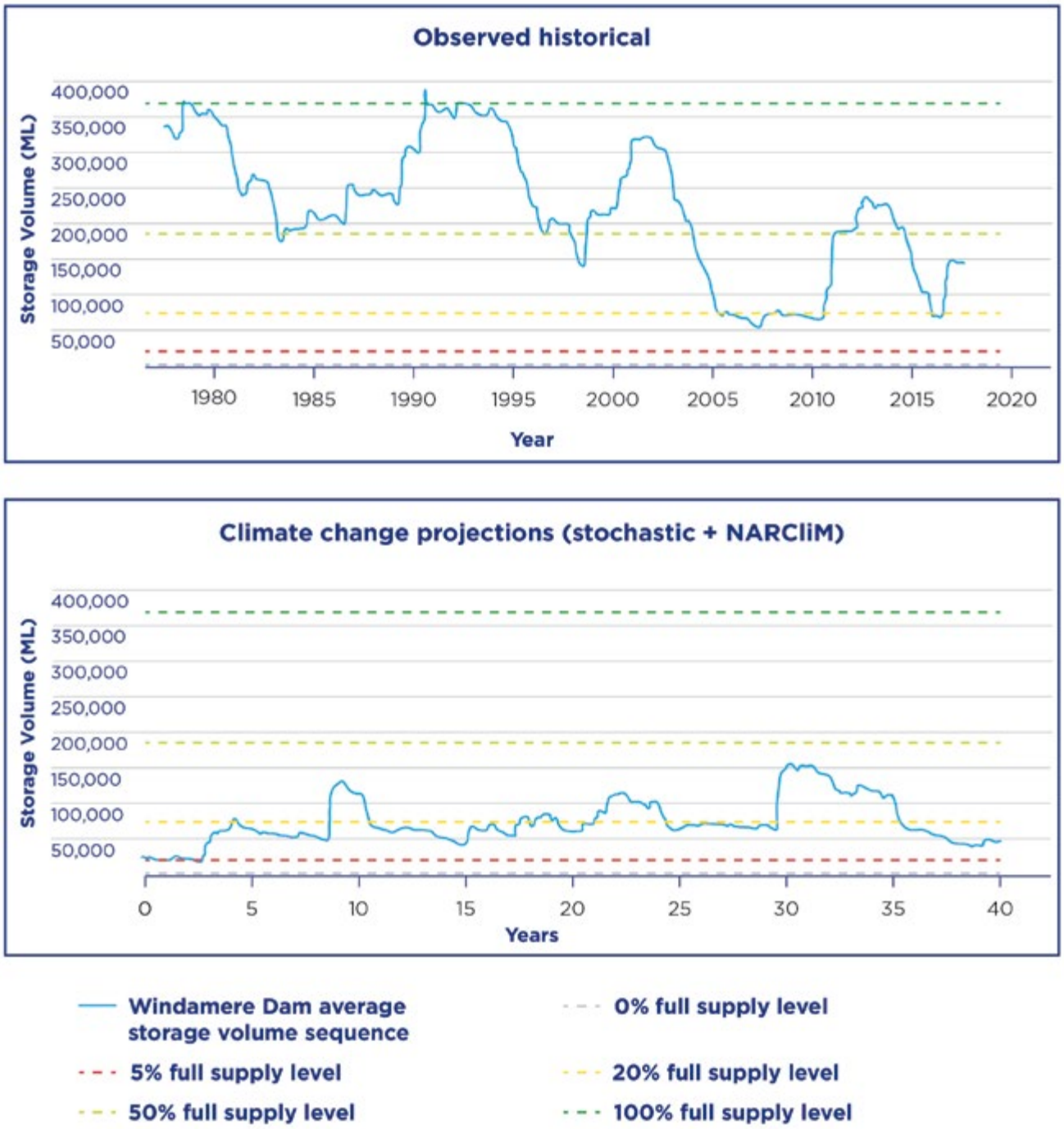
New data for Windamere Dam (Figure 16) shows that both during the period of observed records and long-term historic modelling, dam levels do not reach dead storage, even under the lowest simulated inflow sequences. This is mainly due to the current 70,000 ML reserve volume being in place, which also improves water reliability for water users on the Cudgegong system. During the 2017 to 2020 drought (the worst on record and significantly worse than any previously recorded), Windamere Dam only dropped to 26% of full capacity.

Under our adopted climate change scenario, there is a small (less than 1%) risk of Windamere Dam reaching 5% storage levels. On the occasions when storage levels drop below 5%, they may remain below this level for extended periods, with the median length of time this occurs under the climate change scenario being around 9 months.

Under these climate change conditions, Windamere Dam could conceivably reach 20% capacity for about 60% of the time, a significant increase from the estimated 15% under historical/long-term climatic conditions.

Image courtesy of Department of Primary Industries.

Figure 16. Windamere Dam storage levels for the average 40-year period



Source: Department of Planning, Industry and Environment—Water 2020 hydrological modelling

Note: The figure represents Windamere Dam storage levels for the average 40-year climate period based on instrumental data (using observed historical climate records) and stochastic data (10,000-year period) with the addition of NARCliM (climate change projections). The stochastic only information has not been presented as it represents a very similar result to the instrumental projection.

Connectivity with the Barwon-Darling River

The Macquarie-Castlereagh Catchment connects to the Barwon-Darling River. On average, 21% of the flows in the Barwon-Darling come from the Macquarie-Castlereagh catchment over the long term.[30] The Macquarie Marshes at the bottom of the system act as a sponge and limits the amount of water flowing into the Barwon-Darling.

Connectivity with the Barwon-Darling River generally occurs during wet periods when there are:

- large flows in the Macquarie River
- moderate and low flows into a wet Macquarie Marshes (depending on lower Macquarie River unregulated section water demands)
- unregulated flows in the Marthaguy Creek, Marra Creek or the Castlereagh and Bogan rivers or via the distributary creeks (Duck, Crooked and Gunningbar Creeks).

The Barwon-Darling River, and the communities along the river, rely on inflows from the Macquarie, Namoi, Gwydir and Border Rivers catchments of NSW along with a range of Queensland systems.

In recent years, the NSW and Australian governments have progressed a number of reforms to help improve water flows through the catchment and into the Barwon-Darling River. This includes:

- coordinated environmental water releases including the Northern Connectivity Event[31] and Northern Fish Flow event[32]
- protecting the first flow of water from extraction after the extended drought in early 2020
- changing rules in water sharing plans to enable environmental water to remain in the system as it moves downstream.

In addition, the Independent Panel Assessment of the Management of the 2020 Northern Basin First Flush Event[33] recommended that the NSW Government:

- develop clear arrangements around how decision makers will aim to achieve connectivity within and between water sources after an extended dry period
- engage with water users, Traditional Owners and communities on these arrangements, and
- embed these arrangements into the regulatory and policy framework for managing drought.

Given how connected the Macquarie-Castlereagh catchment is to the Barwon-Darling River, we may need to look at options that improve connectivity and enable all communities across NSW to have fair and equitable access to water. The Western regional water strategy may also consider options that have cross regional impacts.

30. Department of Planning, Industry and Environment 2019, Barwon-Darling Watercourse Resource Plan: Draft Surface Water Resource Description, www.industry.nsw.gov.au/__data/assets/pdf_file/0003/273747/appendix-a-barwon-darling-resource-description.pdf
31. More information available at www.environment.gov.au/water/cewo/northern-rivers
32. More information available at www.environment.gov.au/water/cewo/catchment/northern-fish-flow-2019
33. More information available at www.industry.nsw.gov.au/water/allocations-availability/northern-basin-first-flush-assessment#:~:text=The%20Independent%20Panel's%20final%20report,Northern%20Basin%20First%20Flush%20event

Reforms to improve northern Basin connectivity

Under the *Water Reform Action Plan*, the NSW Government committed to better management of water for the environment. To achieve this, changes to water sharing plans have been proposed to protect environmental water in unregulated systems in the northern Basin and improve connectivity within and between valleys in the north. The proposed changes include:

- **active management**: protect held environmental water in unregulated systems from extraction so that it can remain in rivers for the benefit of the environment
- **IDECs**: implementing limits (known as Individual Daily Extraction Components or IDECs) on the total volume of water that can be extracted daily by individuals in the Barwon-Darling catchment system will help to mitigate the local environmental impacts of water extraction and enable shared access to flows for both local and downstream users
- **resumption of flow rule**: the first flow of water through the Barwon-Darling system after an extended dry period would be protected from extraction under a resumption of flow rule to help maintain ecological assets (such as threatened fish species) during critical times, improve longitudinal connectivity between refuge pools and deliver downstream social and cultural benefits.

Unregulated rivers and streams

The majority of the unregulated licences (over 300,000 ML) managed through the *Macquarie-Bogan Water Sharing Plan* are located in the upper catchment on the Bell River, Molong Creek, Summerhill Creek and Macquarie River above Burrendong Dam. However, licensed volumes in these water sources are generally low. The majority of unregulated entitlement by volume is located in the lower end of the catchment, in the lower Bogan River and lower Macquarie River water sources, under unregulated and special (high flow) access licences. Most of the unregulated entitlement is used for the irrigation of crops including vegetables, fodder, seed crops and cotton.

Water extracted from the Castlereagh River is mainly used in spring and autumn as a supplement to rainfall for fodder and cereal crops. In the Castlereagh valley, water is primarily used for stock watering, dryland agriculture and town water supply.

The main unregulated river systems in the Macquarie-Castlereagh region are:

- **unregulated Macquarie and Cudgegong rivers** upstream of Burrendong Dam and Windamere Dam. Water is supplied to the growing regional centres of Bathurst and Orange. These large upstream townships manage their own water supplies

  The town of Oberon is part of the *Fish River Scheme*, which provides water for:

  - energy producers near Lithgow
  - primary or back-up water supplies to communities in the Lithgow City Council area
  - communities in some areas of the Blue Mountains (Sydney Water customers) when required during periods of drought[34]

34. WaterNSW 2019, *Fish River Water Supply Scheme*, www.waternsw.com.au/supply/regional-nsw/fish-river

- **unregulated Bogan River**—important for connectivity with the Barwon-Darling River, which receives water from the Macquarie River via the Gunningbar, Belaringar and Duck Creeks, and the Albert Priest Channel (supplies water to Nyngan and Cobar)

- **unregulated Castlereagh River**—towns such Coonabarabran, Gilgandra and Coonamble are largely reliant on groundwater to sustain supply between flood events in the Castlereagh River. Towns in Warrumbungle Shire are more reliant on surface water, but many have alternate supply sources or storages. There is primarily dry land cropping in this area.

Unregulated streams in the lower parts of the catchment include:

- parts of the Macquarie Marshes (such as Gum Cowal-Terrigal Creek and Northern Marshes)

- the lower Macquarie River downstream of the Macquarie Marshes

- a range of creeks with their own catchments that flow into the Macquarie River including Marthaguy Creek, Merri Merri Creek, Coolbaggie Creek and Ewenmar Creek

- the Bell, Little and Talbragar Rivers.

Many unregulated streams typically have significant periods of no flow. At these times, the aquatic environment and stock supplies rely on refuge pools, with water users often needing to access alternative water supplies and/or reduce their water needs (for example, farmers may choose not to plant a crop or to plant a different sort of crop in drier years).

Growth in town water use in the upper unregulated systems may impact inflows into Burrendong Dam, with implications for reliability of supply to downstream regulated water users. Similarly, proposals to capture more tributary and unregulated flows in the upper and mid-catchment may have implications for unregulated users, end of system connectivity and flow-dependent environmental assets and values downstream.

Securing water for users of unregulated rivers will become increasingly difficult in a future with even greater climate variability.

We have modelled the timing and volume of inflows to Chifley and Oberon dams in the upper Macquarie catchment.

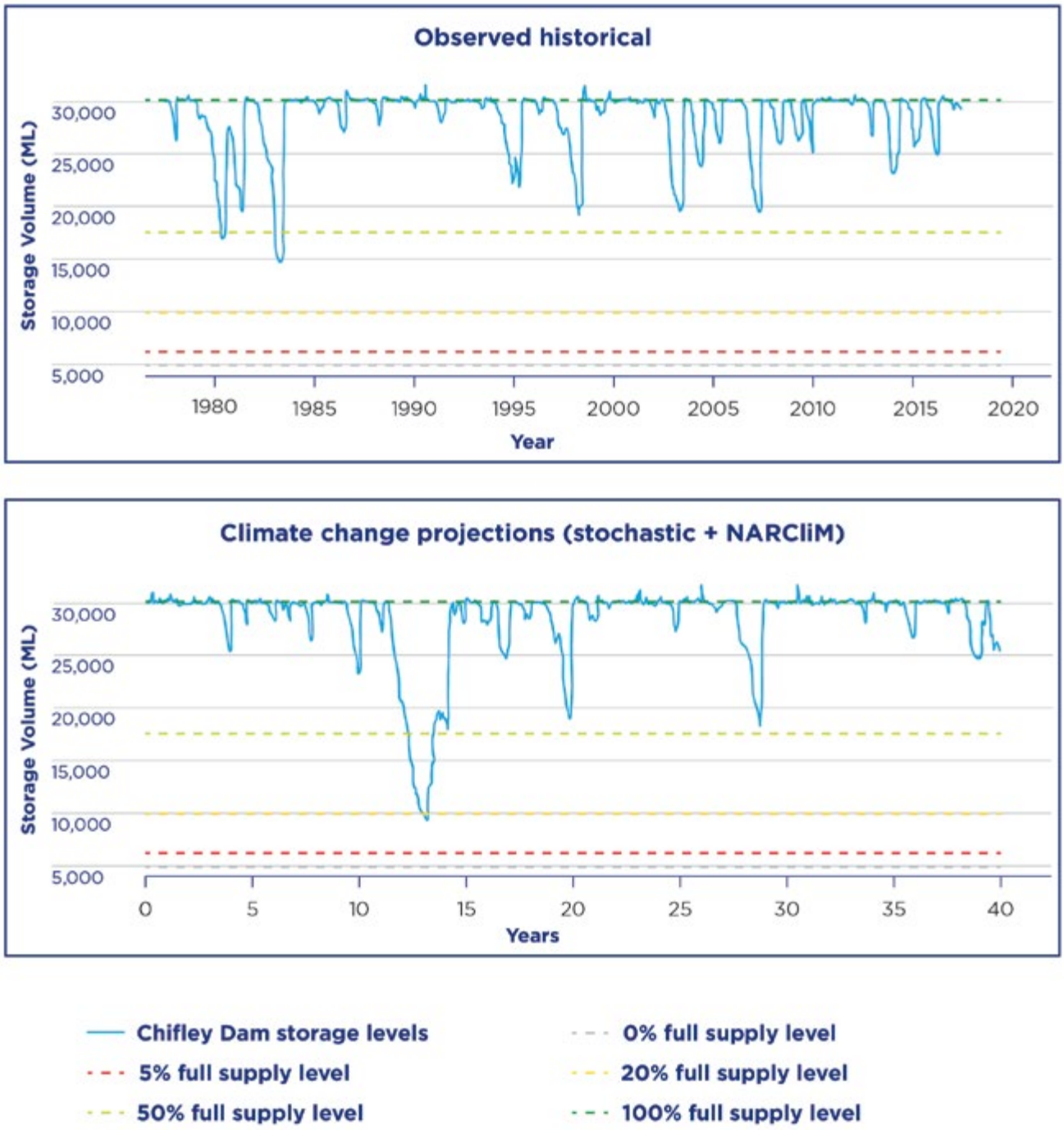
For Chifley Dam, which services Bathurst: (Figure 17):

- Under observed historical data, Chifley Dam's storage volume has not fallen below 5% capacity.

- In the longer-term data beyond the observed records (stochastic data), Chifley Dam is simulated as falling below 5% capacity 12 times in 10,000 years, with the longest duration below 5% being nearly 400 days.

- In the climate change projection scenario, Chifley Dam is simulated to fall below 5% capacity 175 times over the 10,000-year simulation period. In the worst of these simulated periods, the dam remains below this level for multiple years.

Figure 17. Chifley Dam storage levels for the average 40-year period



Source: Department of Planning, Industry and Environment—Water 2020 hydrological modelling

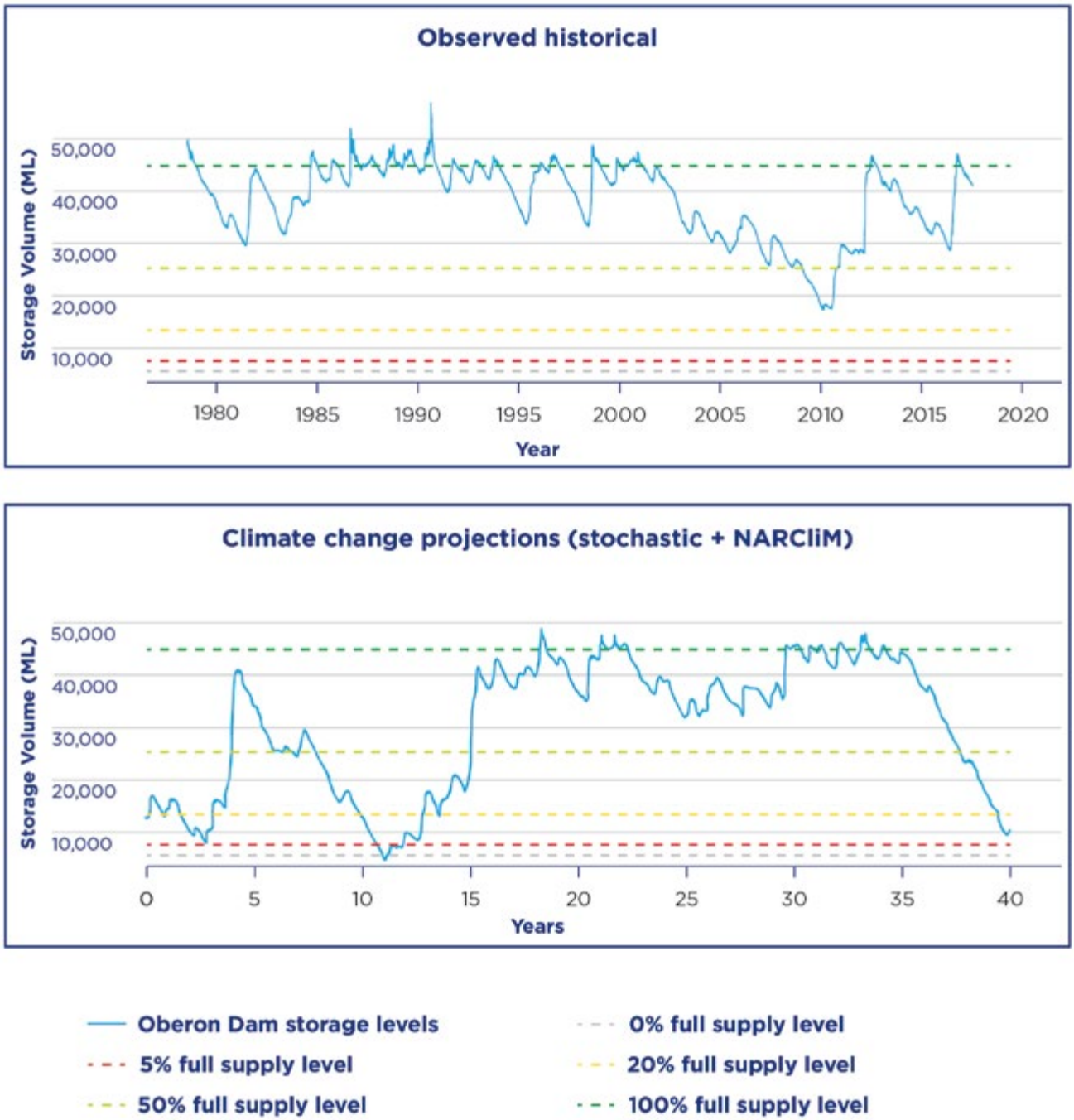
Note: Figure 17 represents Chifley Dam storage levels for the average 40-year climate period based on instrumental data (using observed historic climate) and stochastic data (10,000-year period) with the addition of NARCliM (climate change projections). The stochastic only information has not been presented as it represents a very similar result to the instrumental projection.

Under the climate change projections Oberon Dam could be expected to operate at generally lower levels than previously experienced and understood as 'normal', with associated risks as the sole water source for Oberon (Figure 18):

- Under historical and long-term climate scenarios, there is an estimated 0.5-1% probability that Oberon Dam storage volume falls below 6.5 GL (representing approximately 2-year supply for Lithgow and Oberon). This risk increases to an estimated 8-9% under a climate change scenario.
- The median length of time that Oberon Dam could be below 5% capacity is around 8 months.

Image courtesy of Destination NSW.

Figure 18. Oberon Dam storage levels for the average 40-year period



Source: Department of Planning, Industry and Environment—Water 2020, hydrological modelling

Note: The figure represents Oberon Dam storage levels for the average 40-year climate period based on instrumental data (using observed historical climate records) and stochastic data (10,000-year period) with the addition of NARCliM (climate change projections). The stochastic only information has not been presented as it represents a very similar result to the instrumental projection.

Floodplain harvesting

Some irrigation-based agriculture relies on capturing and using water that moves across the floodplain in high flow periods. Floodplain harvesting accounts for an estimated 13% of the total take of surface water in the Macquarie-Castlereagh region on a long-term average. About 75 floodplain harvesting properties have been identified in the region.

There has been growth in floodplain harvesting infrastructure over the last 20 years, with the amount of water being taken now estimated to be greater than the limit set in the region's water sharing plan. The NSW Government is implementing its Floodplain Harvesting Policy[35] (see box on page 65) in the Macquarie-Castlereagh region. This policy will help quantify and address this growth and bring it back within statutory limits. Licensing and managing floodplain harvesting within legal limits will provide business security and certainty while providing for downstream environmental and cultural outcomes.

The 2018 Floodplain Management Plan for the Macquarie Valley Floodplain sets clear rules for managing the development of flood control works and amendments to existing flood works. The plan seeks to protect the passage of floodwater through the floodplain, while recognising the need to minimise the risk to life and property.

The planning process has also identified existing high-risk floodplain works structures that are causing significant impacts on important environmental and cultural assets.

35. Department of Planning, Industry and Environment 2019, *Floodplain Harvesting Action Plan*, www.industry.nsw.gov.au/water/plans-programs/healthy-floodplains-project/harvesting

Better management of floodplain harvesting

The NSW Government introduced a Floodplain Harvesting Policy in 2013 so that it can be better managed within legal limits. The NSW Government recently announced the Floodplain Harvesting Measurement Policy 2020.

The policy brings floodplain harvesting within the current water licensing framework and caps the amount of water that is taken so that water use can return to the statutory limits set by the water sharing plans. Long-term average annual extraction limit estimates are being updated and other amendments made to the water sharing plans to incorporate floodplain harvesting.

In 2020 the NSW Government placed a temporary water restriction on floodplain harvesting, protecting the first flow of water after an extended dry period. This helped water flow down river systems, meeting critical human and environmental needs, both within the river and in downstream communities.

The *2019 Floodplain Harvesting Action Plan* sets out the NSW Government's commitments to use the best available facts, data and scientific analysis, consult and set clear rules, ensure rules are followed and improve floodplain harvesting management over time.

Groundwater

Across the Macquarie-Castlereagh region, groundwater is drawn from the Macquarie, Bell, Talbragar, Castlereagh and Cudgegong alluvial groundwater sources, the Great Artesian Basin and Oxley Basins, the Orange Basalt and the Lachlan Fold Belt (Figure 19).

Groundwater is an important source for stock, domestic, irrigation, industrial and town water supplies. Aquifer licences within the water sharing plan area cover a variety of purposes including irrigation, industrial, domestic and stock water. In 2016 there were nearly 16,000 bores in the three catchment areas, with 90% of these being used to access water for basic landholder rights such as domestic and stock purposes. There is also 123,000 ML of licenced groundwater for productive purposes such as irrigation, industry and other uses.

There is a large reliance on groundwater for town water supplies, with 13,872 ML of entitlement held by local water utilities within the catchments.

The Macquarie-Castlereagh region's groundwater users also source their water from Great Artesian Basin, Murray-Darling Basin Fractured and Porous groundwater sources. The Great Artesian Basin underlies the northern part of the Macquarie River catchment downstream of Warren. The primary groundwater extraction in the Macquarie valley is from fractured rock aquifers, minor alluvial systems in the Lachlan Fold Belt highlands and broad alluvial plains north and west of Narromine, underlain by sedimentary Great Artesian Basin aquifers.

Groundwater is not equally available across the valley. Some towns such as Narromine, Gulgong and Coonamble rely on groundwater for their town water needs. Warren and Gilgandra use groundwater as their primary drinking water source. Other towns such as Coonabarabran and Dubbo use groundwater as an alternate supply of water in drought. In other places, such as Nyngan and Cobar, there are limitations to gaining access to groundwater.

Groundwater, which includes water from shallow riverine aquifers and the deeper Great Artesian basin, is also an important source of water for stock and domestic supply on many rural properties in the region.

Extensive use of groundwater has led to a decline in water levels in some areas, particularly around Dubbo and Narromine.

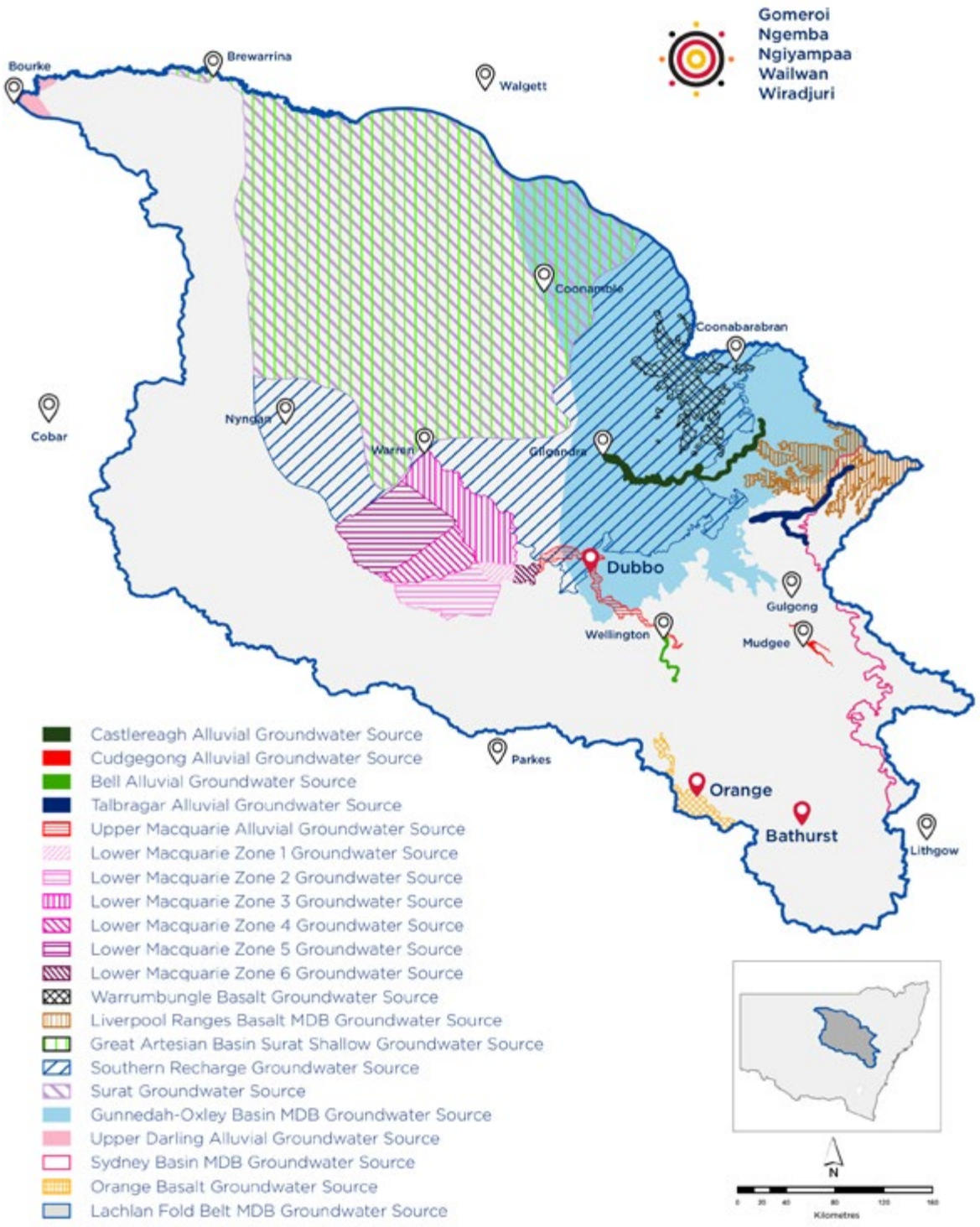
Groundwater is likely to become an increasingly important water source for the Macquarie-Castlereagh region in the future. During periods of drought with limited surface water availability, people with groundwater licences rely more on groundwater. But less rainfall also affects how groundwater resources replenish,[36] placing additional pressure on these resources.

An extensive groundwater monitoring network exists across regional NSW, with data going back to the 1970s. Continuing to improve our collective understanding of groundwater will enable better informed decisions about its management and use. In particular, providing more information to local councils can help them make well-informed decisions about which water sources they draw from at different times.

36. Department of Planning, Industry and Environment 2018, *Macquarie—Castlereagh Alluvial Resource Plan—Appendix A—Macquarie-Castlereagh Alluvium Water Resource Plan Groundwater Resource Description*, p68, www.mdba.gov.au/publications/mdba-reports/macquarie-castlereagh-water-resource-plan

NSW has a strong groundwater management framework that has undergone significant reform. However, opportunities still exist to continue to improve how we manage groundwater resources. In particular, the Draft Macquarie-Castlereagh Regional Water Strategy will consider options to improve the understanding of groundwater processes, provide reliable and sustainable access to groundwater and give greater clarity in managing groundwater extraction (see Options 3, 13, 26, 27, 34, and 38 in Table 5). These and other options aim to use groundwater more efficiently and innovatively to make sure groundwater of suitable quality is available for critical needs and to manage risks to the resource.

Figure 19. Map of groundwater sources in the Macquarie-Castlereagh region



Recycled water, stormwater and wastewater

Two thirds of water utilities in the Macquarie-Castlereagh region use recycled water, with around 6220 ML of water recycled annually (2017/18 figures). Recycled water is primarily used in agricultural production, but other uses include the delivery of recycled water from Orange to the Cadia Mine, which offsets water use from the nearby Belubula River (in the Lachlan region).

Stormwater and recycled water remain largely underutilised water sources with significant potential to improve water security for towns and communities in the region. The regional water strategies provide an opportunity to explore whether treated water should be used as a drinking water supply, along with other initiatives (such as stormwater harvesting) that could increase town water security (see Option 3 in Table 5).

37. Cooperative Research Centre for Water Sensitive Cities 2018, *Case Study: Orange Stormwater to Potable: Building urban water supply diversity*, p11, watersensitivecities.org.au/content/orange-stormwater-to-potable-case-study/
38. Orange City Council 2019, Stormwater Harvesting www.orange.nsw.gov.au/water/stormwater/

Stormwater harvesting: a successful venture for Orange

By August 2008, Orange was in the midst of a critical water shortage as a result of the Millennium Drought. Water storages had dropped below 26.7%.[37] At the time, inflows to storages on the outskirts of town were not enough to meet demand and few alternative supplies were available. Urban stormwater harvesting was identified as one solution to meet this shortfall.

Blackmans Swamp Creek and Ploughmans Creek stormwater harvesting schemes now operate in urban creek catchments. The schemes capture a portion of the high creek flows during storm events and transfer these into the nearby Suma Park Dam, where the water is then treated according to the Australian Drinking Water Guidelines.

Treated stormwater has the potential to supply over 25% of Orange's water demand[38] and this alternative water supply has improved the city's resilience to drought.

Image courtesy of Orange City Council.

2.2.2 Water and the regional environment

The Macquarie-Castlereagh region is renowned for its natural features and assets—from internationally recognised wetlands to highly fertile soil in the mid and lower end of the catchment. The region has rivers, floodplains, wetlands and groundwater-dependent ecosystems that support threatened and endangered plants and animals.

The region is home to the Macquarie Marshes wetland system, parts of which are listed under the international Ramsar Convention. The Marshes provide habitat for hundreds of species of plants and animals and are one of the largest colonial waterbird breeding sites in Australia. They include the largest River Red Gum woodland in the northern Basin, and the Northern Marshes reedbed, which is the largest continuous reedbed in Australia (varying from 1,800 to 3,000 hectares, depending on the time of year). The Marshes also support significant areas of other wetland vegetation and native fauna species.

The Macquarie Marshes are a significant Aboriginal cultural site and contribute economic value to the region. They draw tourists to the area and are part of an important agricultural area, with almost 90% held as freehold land that supports the floodplain grazing industry.[39]

Nineteen native fish species are known or expected to occur in the Macquarie-Castlereagh valley, including seven threatened or vulnerable species. Many are important recreational and cultural species such as the Murray Cod.[40] Some areas in the Macquarie valley have also been listed as part of the Lowland Darling Endangered Ecological Community under the *NSW Fisheries Management Act 1994*, recognising the ecological value and significance of all native fish and aquatic invertebrates in these systems.[41]

Overall, the fish community in the Macquarie-Castlereagh valley is in poor health, especially in the upper catchment. Many factors have contributed to this including barriers to fish passage, changes to water flow, degradation of in-stream habitat and riparian vegetation, the impact of pumps, land management practices and introduced fish species.[42] Coordinated activities throughout the valley will be required to significantly improve native fish outcomes.

Cold water pollution also impacts the life-cycles of fish, including their growth, reproduction and mortality rates.[43] Water delivered from large dams is often colder than natural flows. While infrastructure to address this has been tested at Burrendong and Windamere dams, it needs to be more effective to further improve outcomes for river health and native fish.

39. Murray-Darling Basin Authority 2015, *Macquarie Marshes Poster*, www.mdba.gov.au/publications/products/macquarie-marshes-poster
40. Office of Environment and Heritage 2018, *Draft Macquarie—Castlereagh Long Term Water Plan, Part A: Macquarie-Castlereagh Catchment*, p8, www.environment.nsw.gov.au/research-and-publications/publications-search/macquarie-castlereagh-long-term-water-plan-part-a-catchment
41. Department of Primary Industries 2019, *Darling River EEC,* www.dpi.nsw.gov.au/fishing/threatened-species/what-current/endangered-ecological-communities/darling-river-eec
42. Office of Environment and Heritage 2018, *Draft Macquarie—Castlereagh Long Term Water Plan, Part A: Macquarie-Castlereagh Catchment*, p8, www.environment.nsw.gov.au/research-and-publications/publications-search/macquarie-castlereagh-long-term-water-plan-part-a-catchment
43. Lugg and Copeland 2014, *Review of cold water pollution in the Murray–Darling Basin and the impacts on fish communities*, www.doi.org/10.1111/emr.12074

Healthy water sources are essential to supporting these environmental assets and species. A healthy environment also improves the liveability of the region, contributes to the health and wellbeing of communities and supports the region's industries.

The Murray-Darling Basin Plan sets the limit on the amount of water that can be extracted from water sources in the Macquarie-Castlereagh region. These limits are based on long-term models of the river system. Several constraints have been identified that affect the region's ability to meet environmental watering objectives:[44]

- Burrendong Dam's outlet has limited capacity (up to 8,200 ML/d when the dam is full), which limits the size of environmental water releases from the dam, particularly if these releases occur during times of high irrigation demand from general security licence holders.
- The channel capacity of some creeks, such as Marebone Break, Bulgeraga Creek and Duck Creek, is limited.
- Floodplain structures such as levees on private property limit the ability of water to flow down the system in some locations. These are identified in the *Draft Floodplain Management Plan for the Macquarie Valley Floodplain 2018*.
- A low level road crossing of the Cudgegong River at Rocky Waterhole constrains flow rates in the regulated Cudgegong.

These constraints can also impact river flows into other systems, such as the Barwon-Darling River.

A range of measures are available to improve the region's river health, including direct actions (such as works to alleviate constraints) or complementary measures (such as riparian restoration works, improving fish passage, mitigating cold water pollution and screens on extraction pumps).

For the environment, higher temperatures, increased evaporation, higher fire risk, changes to rainfall patterns and associated flows, and more intense dry and wet periods, have the potential to significantly impact water dependent ecosystems. These ecosystems have evolved over millennia to thrive in natural cycles that are now changing.

The effects of climate change in the Macquarie River catchment were determined by comparing metrics calculated on the long-term climate and climate change scenario.

These comparisons indicated the potential for changes to river flows over the coming 40+ years, which could impact on riverine and floodplain ecosystems.[45] In general, our modelling simulations estimate that the volume of water flowing each year on average in the regulated and unregulated river sections and to the Macquarie Marshes under our climate change scenario could reduce by 43% to 62%, impacting all components of the flow regime (Figure 20).

The magnitude of high flow events (flows with an average recurrence interval of 2.5 years or longer) are estimated to decrease by around 47% in the regulated Macquarie River and around 56% in the Bell River (an unregulated tributary of the Macquarie River), noting again the likely influence of Burrendong Dam storage behaviour on flood mitigation as described in section 2.1. If this modelled scenario comes to pass, this will limit the number of events that may trigger fish movement and spawning, and reduce large tributary flows that stimulate

44. Department of Primary Industries 2018, Macquarie—*Castlereagh Long Term Water Plan, Part A: Macquarie-Castlereagh Catchment*, www.environment.nsw.gov.au/research-and-publications/publications-search/macquarie-castlereagh-long-term-water-plan-part-a-catchment
45. Measured at 421090 Macquarie River ds Marebone & 421088 Marebone Break @ Marebone Regulator

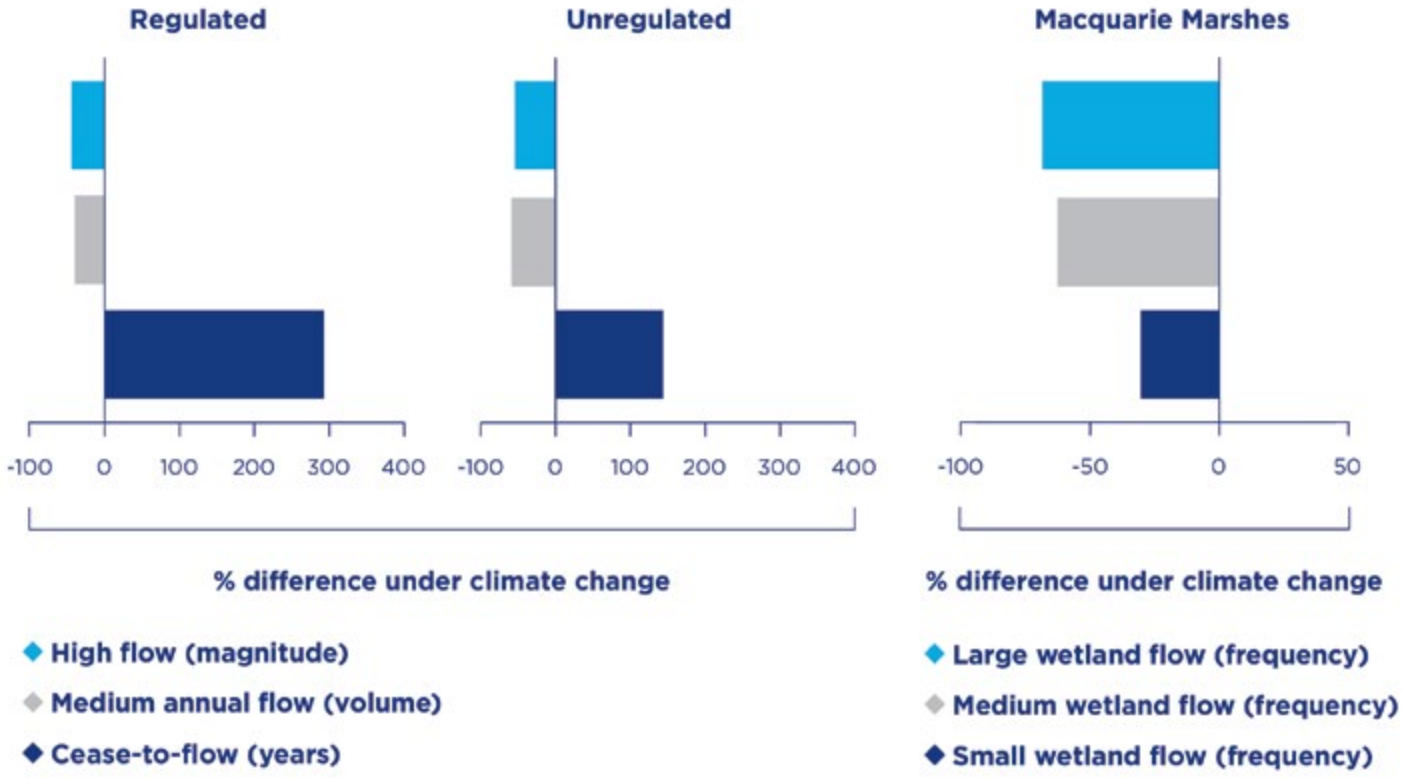
riverine productivity by transporting carbon and nutrients into the system. The frequency of small, medium and large over-bank inundation flows to the Macquarie Marshes will also substantially decrease, potentially leading to a decline in the diversity, condition and extent of the wetland vegetation community (Figure 20).

The long-term average annual volume of water flowing into Burrendong Dam is estimated to decline by about 50% under a climate change scenario, reducing the ability to inundate the Macquarie Marshes using held environmental water entitlements and the environmental water allowance. The decline in flooding in the Macquarie Marshes will also reduce opportunities for water birds to breed and successfully rear their young, and limit occasions when fish can temporarily access floodplain aquatic habitats to feed and reproduce. Furthermore, less frequent large flows may decrease productivity in the Macquarie River because water returning from the floodplain to the main-stem river carries dissolved carbon and organic detritus, micro-organisms and small plankton animals.

The modelling also projects an increase in the number of years in which a cease-to-flow event occurs and is most pronounced in the regulated river systems (Figure 20). Cessation of flow in rivers and streams will result in drying of flowing water habitats, increased sedimentation, water quality deterioration (elevated water temperatures and low dissolved oxygen levels) and the loss of connectivity throughout the river system, all of which will have damaging effects on the region's aquatic ecosystem.

Options being considered through the Draft Macquarie-Castlereagh Regional Water Strategy have a strong focus on improving the health of natural systems and protecting water-dependent species, such as native fish. These include measures to reduce the impacts of cold water pollution (see Option 22 in Table 5), works to improve environmental flows (Options 14, 16, 17, 18, 19, 23 and 24) and actions to improve the health of native fish species (Options 15, 20, and 21).

Figure 20. Impacts of climate risks on the flow regime



Water quality

Water quality in the Macquarie-Castlereagh varies across the region. Changes in water quality occur from a combination of factors. These include alteration to natural flow regimes, particularly disruption by water storages (Burrendong and Windamere dams) and changes to land use and catchment conditions.

Specific water quality issues in the Macquarie-Castlereagh region include:

- elevated levels of salinity, particularly in the Cudgegong River near Goolma and the Little, Bell and Talbragar rivers in the mid-Macquarie region. High levels of salinity in water used for irrigation can cause crop damage
- elevated levels of suspended sediments across the catchment. Increased sediments in the water may smother aquatic plants and native fish and impact social and cultural uses of water. It also reduces light penetration required for aquatic plants to produce oxygen, which is critical for ecosystem health
- elevated levels of nutrients in the lowlands area downstream of Dubbo and in the Talbragar River. Increases in nutrients can impact ecological, social and cultural values by causing harmful algal blooms, low dissolved oxygen and toxicity of aquatic plants and animals
- harmful algal blooms in Burrendong, Chifley and Windamere dams can pose a serious risk to human, animal and ecosystem health and increase treatment costs for drinking water providers and stock and domestic needs
- cold water pollution downstream of Burrendong and Windamere dams, which poses a risk to ecological values in the Macquarie and Cudgegong rivers.

In the regulated part of the catchment, water quality issues can be addressed through implementing water sharing plan rules, managing delivery of water from major storages, improvements to infrastructure and strategic environmental watering. In the unregulated part of the system, preventing pollutants such as sediment and nutrients from entering waterways through land, soil and vegetation management can help to manage water quality.

The Macquarie-Castlereagh water quality management plan provides a detailed assessment of water quality risks in the region and strategies to manage some water quality issues.[46]

The Macquarie-Castlereagh Regional Water Strategy is an opportunity to consider if additional actions are necessary to manage water quality in the region (see Option 28 in Table 5).

46. *Macquarie-Castlereagh Surface Water Resource Plan: Schedule H—Macquarie-Castlereagh Water Quality Management Plan*, www.mdba.gov.au/publications/mdba-reports/macquarie-castlereagh-water-resource-plan

Image courtesy of Peter Robey.

2.2.3 Managing water in the Macquarie-Castlereagh region

Water in NSW is managed and shared under the *Water Management Act 2000*, with specific water sharing rules in water sharing plans.

Dealing with extraction limits

The Murray-Darling Basin Plan sets the limit on the amount of water that can be extracted from sources in the Macquarie-Castlereagh region. The region uses approximately 4% of the surface water diverted for irrigation and accounts for approximately 11% of groundwater use in the Murray-Darling Basin.[47]

Total entitlements (Figure 21) for the Macquarie-Castlereagh are:

- 725,145 ML/year for regulated surface water including both the Macquarie and Cudgegong rivers
- 304,492 ML/year for unregulated surface water for the Macquarie-Bogan and the Castlereagh rivers
- 124,970 entitlement shares for lower and upper Macquarie groundwater sources (there is also additional entitlement in the fractured and porous rock groundwater sources that extends beyond the Macquarie-Castlereagh region).

The following plans operate in the Macquarie-Castlereagh region:

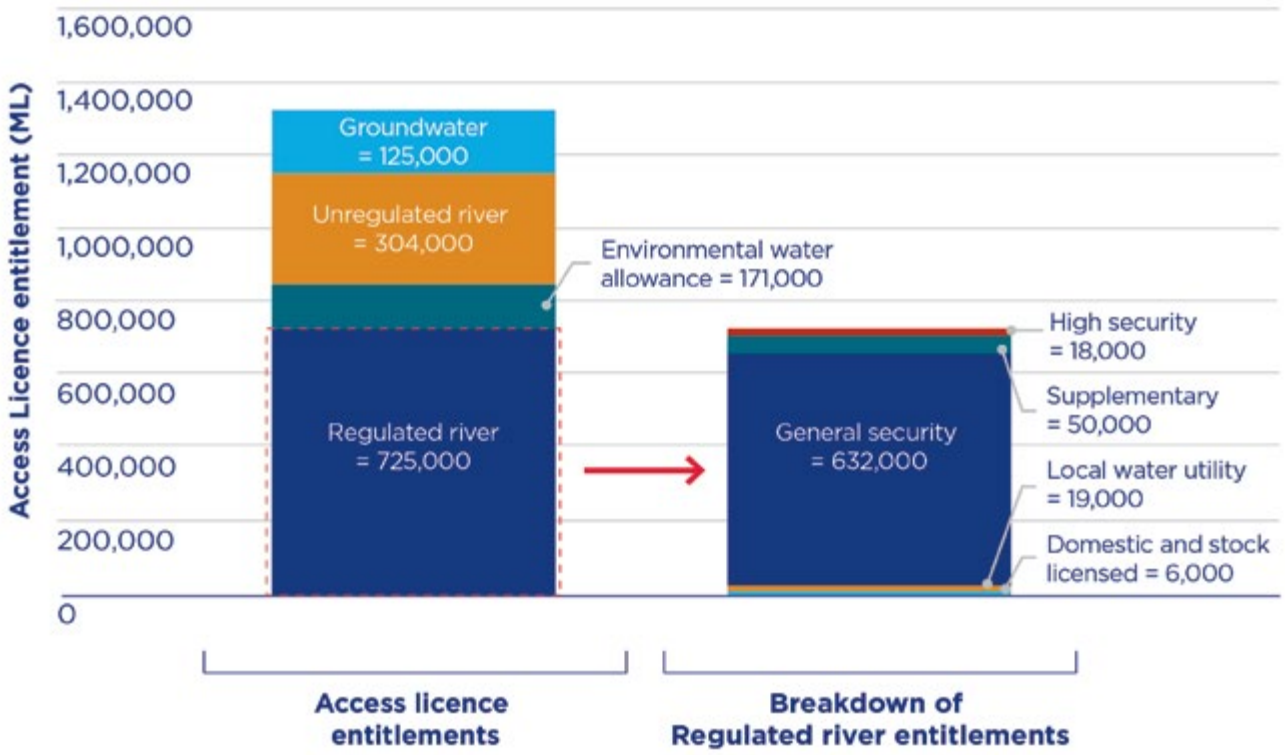
- *Castlereagh Unregulated River Water Sources Plan 2011*
- *Macquarie Bogan Unregulated Water Sources Plan 2012*
- *Macquarie Castlereagh Alluvial Groundwater Sources 2020*
- *Cudgegong Regulated Water Sources 2016*
- *NSW Great Artesian Basin Groundwater Sources 2020*
- *NSW Great Artesian Basin Shallow Groundwater Sources 2020*
- *NSW Murray Darling Basin Fractured Groundwater Sources 2020*
- *NSW Murray Darling Basin Porous Groundwater Sources 2020.*

Extraction in the Macquarie-Castlereagh catchment is managed through the various water sharing plans to ensure extraction remains within the limits. Because the system is capped at the limits set by the Basin Plan, no additional water entitlements can be created aside from some specific purpose access entitlements (for example, cultural and town water licences). All extractions have to be within the Sustainable Diversion Limits set by the Basin Plan. If growth in usage occurs, lower priority licences will get a lower allocation through the available water determination until the usage falls back below the plan limit. The current rules for allocating water in NSW regulated rivers are based on rainfall records from the 125 years prior to the development of the first water sharing plan. This historical data shows that short, severe droughts in the region occur on average every 20 years. Sufficient reserves are set aside to operate the river system through the 'lowest inflow sequence on record'.

The current estimate of the limit for the Macquarie valley is 598 GL per year.[48] There has been a reduction in overall diversions in the Macquarie valley in recent years, most likely due to the introduction of unlimited carryover for general security licence holders in 2004, in combination with the impacts of the Millennium Drought.

The rules do not anticipate a scenario different to those shown by the observed historical records—yet there have been two record-breaking droughts since 2000 and inflows at Burrendong Dam have been lower than the 'worst inflow sequence of record' since 2017.[49] Our new climate modelling gives us a better understanding of the duration and frequency of droughts. With the region's climate likely to be more variable into the future, we need to consider whether our policy settings continue to be appropriate.

Figure 21. Graph of water entitlements in the Macquarie-Castlereagh region



Source: Department of Planning, Industry and Environment 2018, *Macquarie-Castlereagh Surface Water Resource Plan* and Department of Planning, Industry and Environment water licence database

We need to consider a range of options to determine how the increasing demand for water in the region can be managed in a variable climate. The Macquarie-Castlereagh Regional Water Strategy is an opportunity to consider whether our resource assessment and allocation settings are right, based on best available information about regional trends and plausible future climate scenarios. Reviewing current water allocation and river operating rules is one option to improve water resilience. For example, allocations are typically assessed monthly and are based on water currently in storage, plus some assumed future inflow. This involves taking a small risk that the assumed future inflows may not actually arrive before supplies are exhausted. The current settings need to be reviewed to determine if this is still an acceptable level of risk, given the likely future changes to the climate. We may need to be more conservative in water allocations or create specific reserves within storages to ensure water security for towns during extreme events.

47. CSIRO 2008, *Water Availability in the Macquarie-Castlereagh*, publications.csiro.au/rpr/download?pid=procite:c1683dd8-8f35-42bc-bc3b-44f3bc4cf1c2&dsid=DS1
48. The sustainable diversion limit (SDL) is estimated based on a combination of an SDL updated Baseline Diversion Limit (BDL) scenario model as of 2019 (BD32, Macquarie BDL Report, 2019) and Murray-Darling Basin Authority's estimate for unmodelled components. It is calculated as total modelled diversions minus required 61.8 GL recovery (total shared and local recovery components). The SDL figures are considered to be draft until the Macquarie-Castlereagh Surface Water Resource Plan is accredited
49. The Millennium Drought from 2002 to 2010 saw the lowest inflows on record for the Cudgegong regulated river. The drought commencing in 2017 is a new record for the Macquarie regulated river.

Setting priorities for water sharing

The *Water Management Act 2000* sets out how we prioritise water sharing during normal operations, with the highest priority being for the environment, followed by basic landholder rights.

During extreme events, such as prolonged droughts, the priority changes. Basic landholder rights and essential town water services (authorised by an access licence) become the highest priority, followed by the environment.

This change in priorities is triggered when a water sharing plan (or part of a plan) is suspended. The aim is to operate within the plan rules for as long as possible because the plan provides certainty for all users of these water sources. The regional water strategy process provides an opportunity to consider whether the trigger needs to be reviewed (Table 3).

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: Based on priorities table in *Macquarie-Castlereagh Surface Water Resource Plan: Schedule G—Macquarie-Castlereagh Incident Response Guide*

Image courtesy of NSW Department of Primary Industries.

Gathering more and better information

Improving the information we have about the characteristics of the region's water sources, water use and water needs will help us to manage the Macquarie-Castlereagh region's water more effectively and ensure we can plan to have enough water available at the right time. Gathering more and better water use data will improve our understanding of the risks in the region for the environment and water users. More data and knowledge will also support future decisions about water sharing.

Improved information can also help water users, future investors and regions make more informed decisions about the industries most suited to each region.

NSW water reforms around water metering and investing in our hydrometric network will help fill some of the existing data gaps.

The Macquarie-Castlereagh region has several unregulated water courses where streamflow gauges are not installed and water extraction is not measured. This means there is limited data on water extraction and flow patterns from these rivers and streams, making it difficult to manage equitable sharing during dry conditions. This lack of data will be addressed through the implementation of the new non-urban metering framework announced by the NSW Government as part of its *2017 Water Reform Action Plan*.

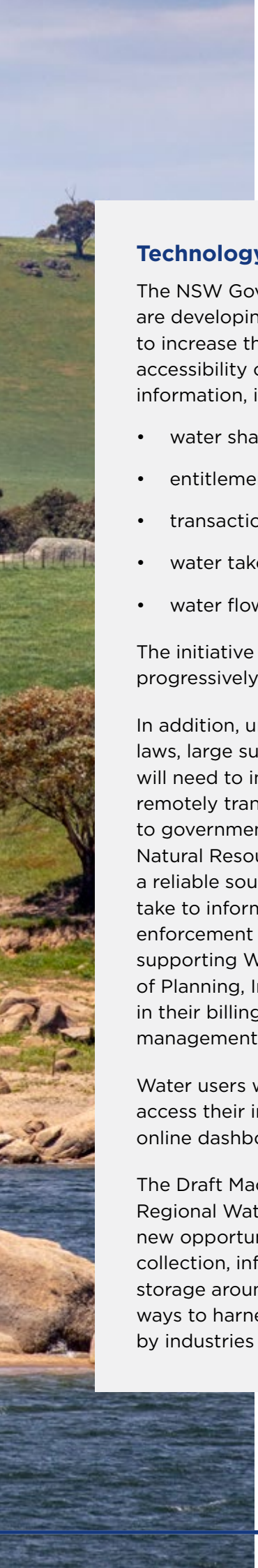
Under the framework, large surface water pumps (500 mm and above) in the Macquarie-Castlereagh will be required to be fitted with compliant metering and telemetry equipment by 1 December 2020. All remaining surface and groundwater works covered by the rules will need to be fitted with compliant metering equipment by 1 December 2021. An estimated 1,935 water supply works in the Macquarie-Castlereagh region will be subject to the metering rules: 1,117 in the unregulated rivers, 634 in the regulated systems and 185 in the groundwater systems.

The NSW Government is working with the Australian and Queensland Governments on hydrometric, metering and remote sensing products and data sharing in the northern Basin. This includes four key areas:

- improved measurement and monitoring
- a Public Water Information Portal
- an Entitlement Holder Interface
- remote sensing and water balance tools.

NSW is also working on a project to improve hydrometric networks in the northern Basin and develop remote sensing or other technologies to enhance monitoring, measurement and compliance across the Murray-Darling Basin.

Image courtesy of Destination NSW.



Technology can help

The NSW Government and WaterNSW are developing a new data platform to increase the availability and accessibility of critical non-urban water information, including:

- water sharing plan rules
- entitlements and works approvals
- transactions
- water take
- water flows.

The initiative will be developed progressively by 2025.

In addition, under the new metering laws, large surface water users will need to install telemetry and remotely transmit water information to government. This will give the Natural Resources Access Regulator a reliable source of data about water take to inform its compliance and enforcement functions, as well as supporting WaterNSW and Department of Planning, Industry and Environment in their billing and other water management activities.

Water users will also be able to access their information via a private online dashboard.

The Draft Macquarie-Castlereagh Regional Water Strategy will explore new opportunities to improve data collection, information, monitoring and storage around water use, including ways to harness water data collected by industries (see Option 38 in Table 5).

Enhancing our understanding of the interaction between surface water and groundwater resources can help us improve the resilience of our water sources. We need to understand where a change in groundwater use can influence flows to rivers and vice versa. Given the continuing demands on groundwater in the future, we need to better understand the interaction between surface water and groundwater resources in the Macquarie-Castlereagh.

We also need to understand how a changing climate is impacting the replenishment of groundwater resources. More broadly, we need to ensure ongoing investment in the groundwater monitoring network so we have the water quantity and quality information we need to manage the resource into the future.

In addition, the NSW Department of Primary Industries is undertaking a three-year program to identify and map important agricultural lands.[50] Knowing where this land is situated and understanding its location, value and contribution will assist in making decisions about current and future agricultural land uses, and their water needs. A comprehensive and consistent approach to collecting water statistics information will greatly help this process.

In recent years, the NSW Government has undertaken an extensive body of work including the assessment of water sharing plans and monitoring, evaluation and review, as well as an expansion in metering. More data and work is required, including a comprehensive and consistent approach to collecting water statistics information, to ensure we can plan to have the right water available at the right time and to give water users the information they need to better plan for their future needs.

50. Department of Primary Industries 2019, *Important Agricultural Land Mapping in NSW*, www.dpi.nsw.gov.au/agriculture/lup/agriculture-industry-mapping/important

Managing and using water for the environment

A significant amount of water has been recovered for the environment in the Macquarie-Castlereagh region (Figures 22 and 23). This water, known as Held Environmental Water (HEW), is managed by the NSW and Commonwealth environmental water managers. These are mostly general security licences. In addition, rules in the water sharing plans provide for amounts of water to be set aside for environmental purposes (known as planned environmental water).

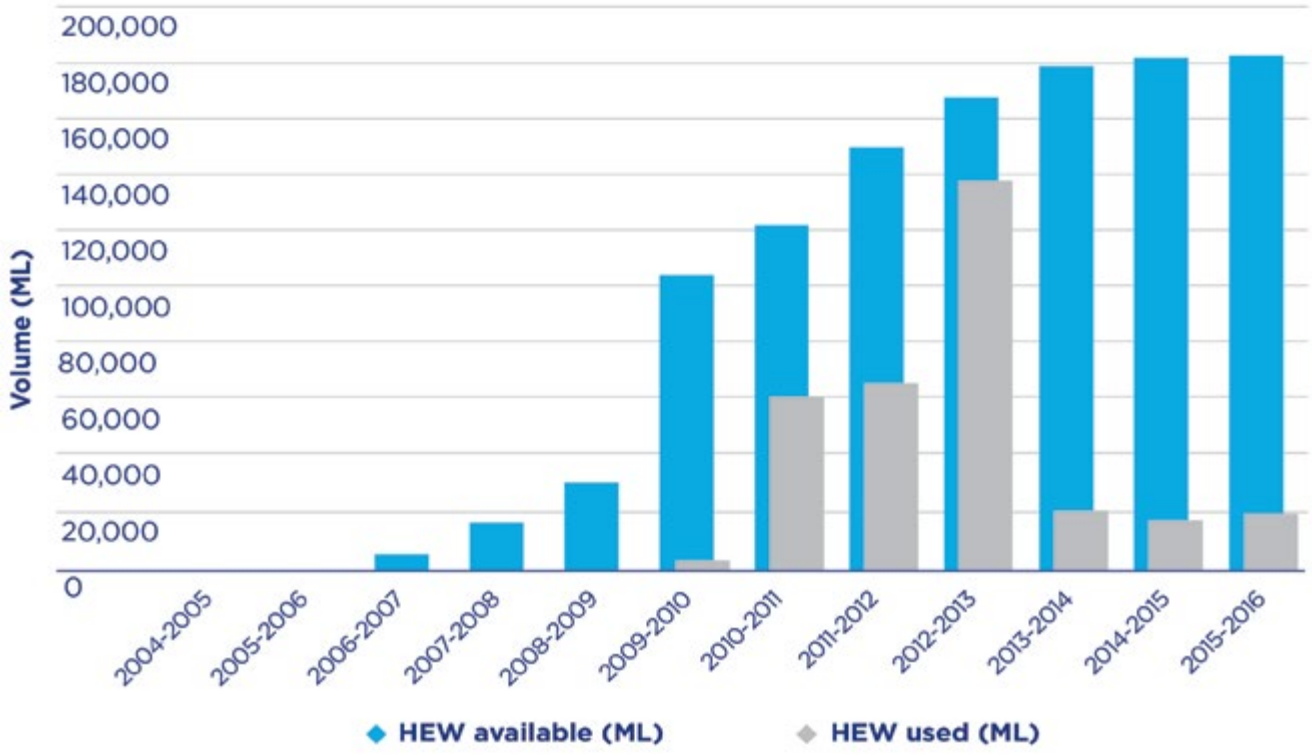
The amount and timing of 'actively managed' environmental water use depends on environmental demands and water availability: in extremely dry conditions there may be insufficient water to meet environmental needs. Even where environmental watering occurs, it may not be sufficient to sustain the condition of water dependent ecosystems over a longer period of time. For example, managed water for the environment was used in the mid-Macquarie and Macquarie Marshes over 2017 and 2018 in an attempt to buffer river ecosystems and the Macquarie Marshes from the drought.
But without any tributary flows to support these watering events, the condition of the Macquarie Marshes has declined.
The proposed use of carryover water in 2019 did not occur as the water was quarantined (along with other general security entitlements carryover in the catchment) to meet critical human needs.

HEW flowing from a regulated river to a downstream, unregulated river, can lead to an increase in the ability of other unregulated water users to take water. This is because the environmental water is left in the river, thereby raising the river levels: in the unregulated systems, water access is linked to the height of the river.

The NSW Government is committed to implementing enduring solutions to better manage water for the environment. These include actively managing access to flows to allow HEW to remain in-stream for environmental purposes. The amended water sharing plan for unregulated water sources in the Macquarie and Bogan Rivers include new rules for active management which commence on 1 December 2020. Active management changes when and how much licence holders can pump when held environmental water and environmental releases are present in the river system. It also changes how licence holders find out if, when and how much they can pump during an environmental water release.

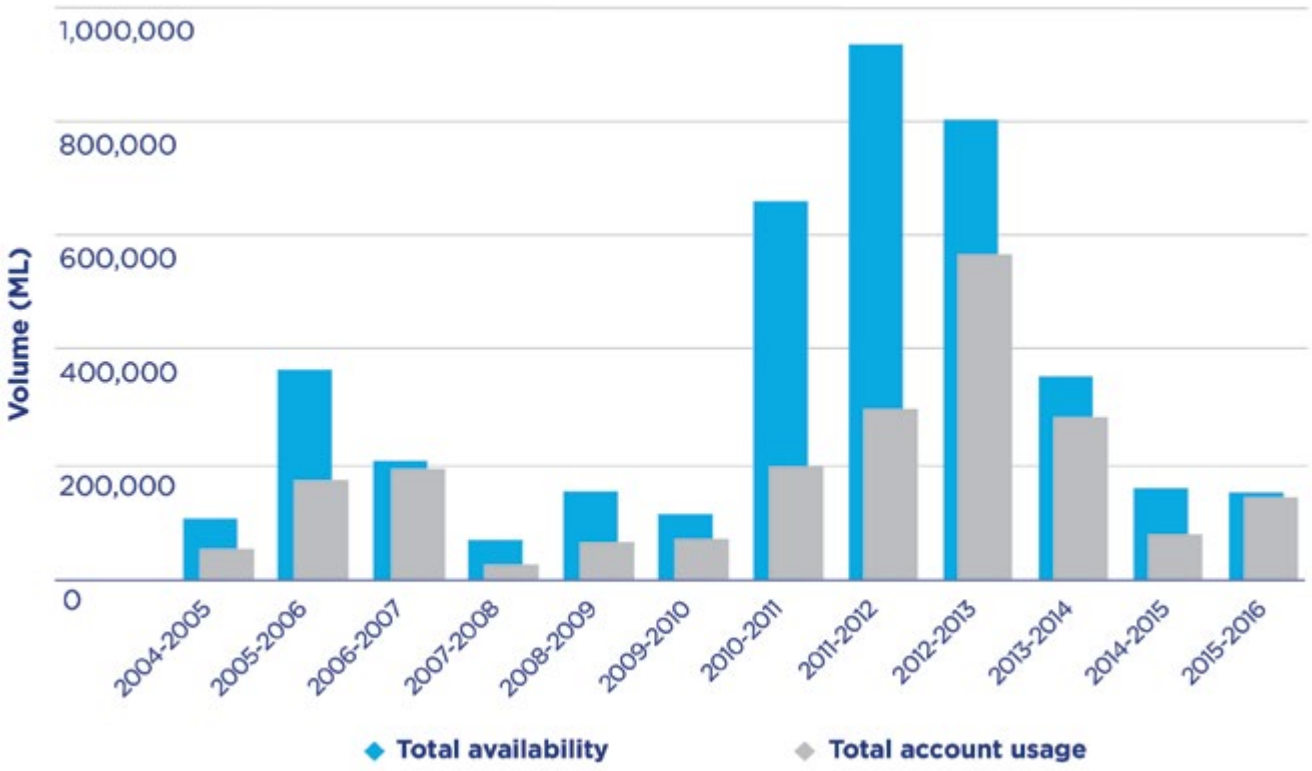
Active management rules in the Macquarie-Bogan apply in the Lower Macquarie River Water Source and Lower Marthaguy Creek management zones where HEW has been delivered to date. This will help to ensure that environmental water achieves its intended purpose, while also providing greater clarity to all water users about how flow events will be managed and improving transparency around when water can or cannot be taken.

Figure 22. Held environmental water entitlement (ML) in the Macquarie-Cudgegong river system



Source: *Macquarie-Castlereagh Water Resource Plan*, surface water description 2017

Figure 23. Planned environmental water (ML) in the Macquarie-Cudgegong River systems



Source: *Macquarie-Castlereagh Water Resource Plan*, surface water description 2017

2.3 People, industries and water use

2.3.1 Aboriginal people

The lands and water of the Macquarie-Castlereagh region have been cultivated and cared for by the Wiradjuri, Gomeroi, Ngemba, Wailwan, and Ngiyampaa Nations for over 60,000 years. Irrespective of European colonisation interfering with Aboriginal peoples' traditional land and water management, these nations have an ongoing obligation to care for Country.

Today, Aboriginal people make up around 12% of the total population in the region.[51]

Water is essential to Aboriginal's people's identity. We heard from Aboriginal people in the Macquarie-Castlereagh region that their identity is in Country: when the rivers are healthy, the people are healthy. Water fills sacred places, supports animals and fish, allows fishing and recreation, and provides gathering places for communities. Access to rivers and water is essential for fulfilling cultural obligations and passing down knowledge to the next generation.

There are many significant cultural water-dependent sites across the region. For the Wailwan Nation near Warren, the Beemunnel Aboriginal Place is a highly significant cultural and spiritual area. Originally, Aboriginal people settled near the banks of the Ewenmar (or Beemunnel) Creek at the site. We heard from local elders that water has not regularly flowed through Beemunnel for decades due to an upstream diversion. Returning flows to this place would help the wellbeing of the community and allow for connection to Country and culture.

Water used by Aboriginal people

Aboriginal people's 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 right to self-determination and the right to access traditionally owned lands and water. They also recognise the importance of maintaining the environmental 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, the 2007 Echuca Declaration, 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'.[52]

While there are some ways of accessing water for cultural purposes, we heard from Aboriginal people in the Macquarie-Castlereagh that the current provisions in the *Water Management Act 2000* are not meeting their spiritual, cultural, social and economic needs.

Australia's Native Title laws recognise the traditional rights and interests to land and water of Aboriginal people. Native Title allows the take and use of water for personal, domestic and non-commercial communal purposes. Native title holders often have aspirations related to water from the protection of water, to advice on water management practices in a determinations area, to water allocations. Over the coming years, there could

51. Australian Bureau of Statistics 2018, 3238.0.55.001—*Estimates of Aboriginal and Torres Strait Islander Australians*, www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3238.0.55.001June%202016?OpenDocument
52. Murray Lower Darling Rivers Indigenous Nations 2007, Echuca Declaration, Part 1. The full declaration is available here: www.mdba.gov.au/sites/default/files/pubs/sa-mldrin-echuca-declaration-2009_0.PDF

be more Native Title determinations in the Macquarie-Castlereagh region.

Currently, Aboriginal people can apply for an Aboriginal cultural water access licence. This provides up to 10 ML/year of water for cultural purposes.

During our consultation we heard that current cultural water access licences are inadequate to meet the social, spiritual, cultural and economic needs of Aboriginal people. These could be contributing factors to there being only two cultural water access licences operating in NSW and none in the Macquarie-Castlereagh region. We need to ensure the licences allow for equitable access to water and that the licence assessment framework is culturally appropriate and clearly communicated to Aboriginal people.

We also heard that Aboriginal people want ownership of cultural water entitlements that allow for economic benefit. While there are Aboriginal businesses, groups and Aboriginal Land Councils that own water access licences (which are available on the market for trading), generally the cost involved means that Aboriginal people cannot afford to buy these entitlements and allocations.

Within the Macquarie-Castlereagh, access to sacred and cultural landscapes is a significant issue. We heard concerns that fencing on Travelling Stock Reserves prevents gatherings and cultural practices.

Aboriginal people also want to be more involved in water management decision making. Increasingly, Aboriginal knowledge is recognised as an essential element of how we manage natural resources in Australia. However, the complexities of water management, legislation and licensing—along with a lack of opportunities to participate in decision making—are significant barriers to making better use of Aboriginal people's knowledge and skills. Aboriginal people would also like to see more economic opportunities around the management of water.

For Aboriginal people, uncertainties around climate and the health of waterways have a deep cultural impact, adding urgency to developing policy settings and programs fully recognise Aboriginal water rights and provide dedicated water allocations for Aboriginal people. This includes prioritising water for Aboriginal people in water sharing arrangements.

The Macquarie-Castlereagh Regional Water Strategy will consider options that recognise cultural values and deliver improved recognition of water rights for Aboriginal people in the region.[53] This includes a culturally appropriate water knowledge program (see Option 42 in Table 5), a project to identify and map water-dependant cultural sites (Option 43), a review of cultural water access licences (Option 47) and support for Aboriginal people to purchase water entitlements (Option 46). The draft strategy also includes options for an Aboriginal River Ranger Program (Option 29) securing flows for Beemunnel Aboriginal Place (Option 30), co-management of Travelling Stock Reserves (Option 48) and a Regional Aboriginal Water Advisory Committee (Option 45). These and other options could potentially be incorporated in a state-wide Aboriginal water policy.

We will also assess all draft options to determine whether they would have a positive or negative impact on outcomes to be achieved for Aboriginal people.

53. More information about our Aboriginal engagement approach is in the *Regional Water Strategies Guide.*

2.3.2 People and towns

The Macquarie-Castlereagh region is home to over 200,000 people, with more than half of the population living in the regional centres of Dubbo (35,000 people), Orange (38,000) and Bathurst (34,000).[54] These are service hubs for their surrounding areas and nearby towns, and are home to educational institutions, retail areas and health services. These centres are also at the junction of nationally significant rail and road corridors, with easy access to Sydney, Melbourne and Brisbane, as well as major regional cities such as Newcastle.

Smaller towns like Mudgee (11,000 people) and Wellington, Narromine, Nyngan and Warren (with populations of around 2,000 to 5,000) are spread across the region. The remainder of the population lives in small towns or rural areas located close to productive agricultural lands.

About 10% more people are expected to live in the Macquarie-Castlereagh region in the next 20 years.[55] Bathurst, Dubbo, Mudgee and Orange are expected to continue to expand and provide jobs and services for surrounding towns.[56]

The region has a strong education sector, which includes Charles Sturt University (with campuses in Bathurst, Orange and Dubbo) and the University of Sydney School of Rural Health in Dubbo and Orange. These and other institutions are expected to continue to attract young people to the region and to train and equip future professionals to work in regional NSW.

The NSW Government is also focused on improving employment opportunities for Aboriginal people in the Macquarie-Castlereagh region. The Aboriginal Participation in Construction Policy supports a minimum of 1.5% on Aboriginal participation for construction projects undertaken by NSW Government agencies.[57]

Investments in health, transport and community infrastructure are crucial to support a growing population of older people, workers and young families. The NSW Government is investing heavily in health care, community and digital connectivity infrastructure to cater for the region's future population, including:

- $70 million for Mudgee Hospital Redevelopment
- $241 million for Dubbo Hospital Redevelopment
- $35 million, with the Australian Government, for the Western Cancer Centre in Dubbo
- over $100 million for community and recreational infrastructure through grant programs such as Stronger Country Communities and Regional Sports Infrastructure Funds
- over $20 million in Growing Local Economies and Drought Stimulus Package to support economic and industry development in the region
- $132 million in upgrades to the Newell Highway in the region
- a $400 million package to improve digital connectivity across regional NSW.

54. Australian Bureau of Statistics 2019, 3235.0—*Regional Population by Age and Sex, Australia, 2018, Commonwealth of Australia*, www.abs.gov.au/ausstats/abs@.nsf/PrimaryMainFeatures/3235.0?OpenDocument
55. Department of Planning, Industry and Environment 2016, *NSW population projections*, www.planning.nsw.gov.au/research-and-demography/demography/population-projections
56. Department of Premier and Cabinet 2018, *A 20-Year Economic Vision for Regional NSW*, www.nsw.gov.au/improving-nsw/regional-nsw/a-20-year-economic-vision-for-regional-nsw/
57. www.buy.nsw.gov.au/policy-library/policies/aboriginal-participation-construction

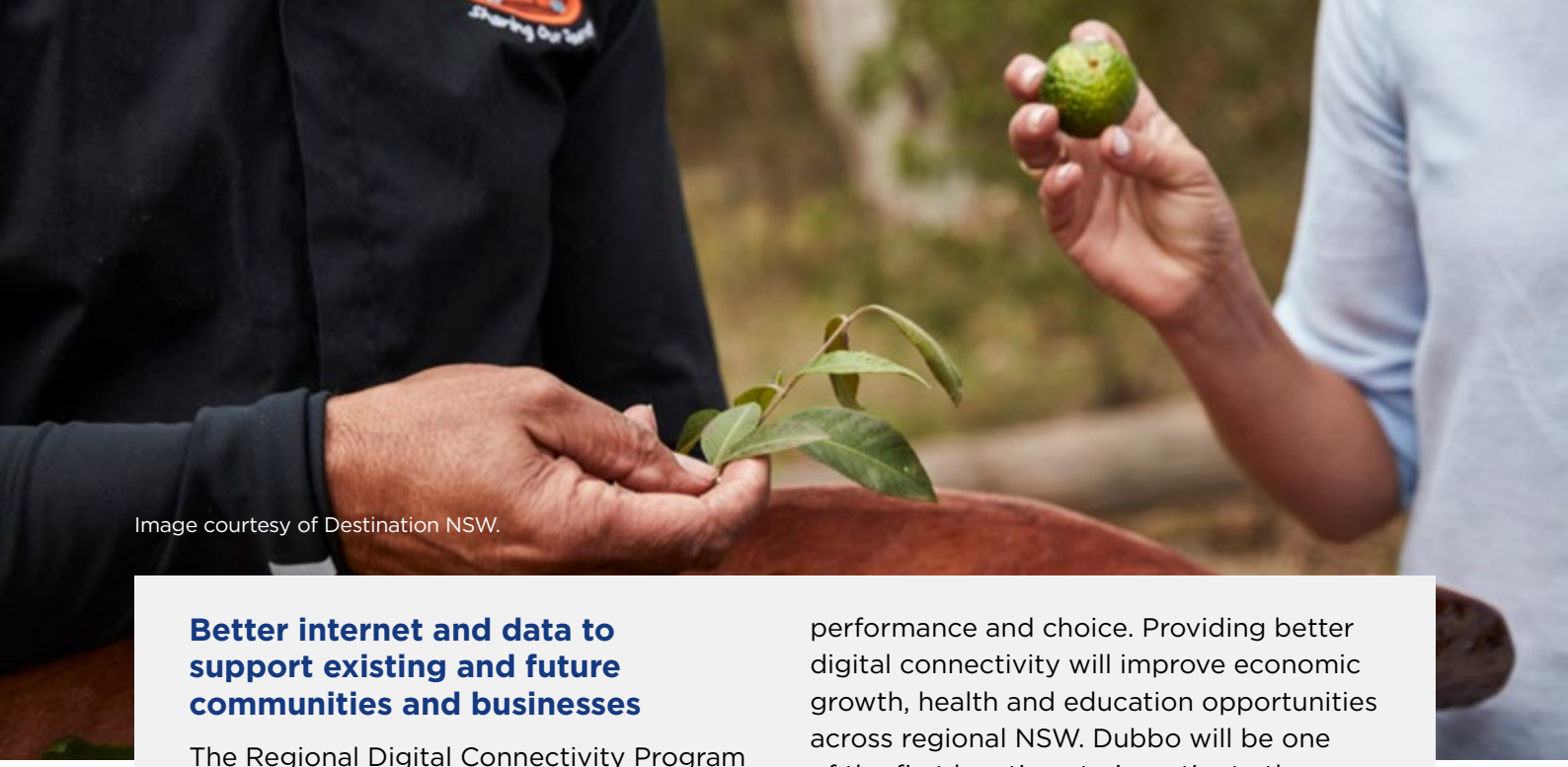


Image courtesy of Destination NSW.

Better internet and data to support existing and future communities and businesses

The Regional Digital Connectivity Program is designed to close the 'digital divide' between regional and metropolitan areas in NSW. This means delivering services for regional consumers, farms and businesses that are metro-level or better in price, performance and choice. Providing better digital connectivity will improve economic growth, health and education opportunities across regional NSW. Dubbo will be one of the first locations to investigate the design of data hubs and fibre cables to make internet connectivity faster and more reliable for surrounding areas.

Water for people and towns

Providing a secure and resilient water supply to regional centres, towns and outlying areas is vital for the long-term sustainability and resilience of the region, particularly in the context of future population growth and a changing, more variable climate.

Secure water supports a growing population and contributes to the amenity, liveability and wellbeing of residents and visitors. Water in regional towns and communities also provides broader social benefits. Through our discussions with councils, we have heard that town swimming pools, lakes and other water bodies can become an escape from the hardships associated with the drought. High quality open spaces and parks connected to water are also important community and recreational assets.

Rivers, weirs and wetlands, town swimming pools and infrastructure such as Burrendong, Windamere, Timor, Chifley, Oberon and Suma Park dams offer social and recreational opportunities, including fishing and camping.

The Bogan weir pool is a culturally significant site, as well as an important habitat for endangered fish. Similarly, the Gin Gin weir is a heritage site that includes a camping ground.

The responsibility for providing water and sewerage to communities across the Macquarie-Castlereagh region is shared by 17 local government water utilities. This responsibility extends to planning for and delivering secure water supplies.

Many regional centres and towns in the region, especially those within the unregulated areas (such as Bathurst and Orange), can access water from multiple sources including stormwater, recycled water and re-used mine water (Figure 24). A number of regional centres and towns can also be supplied water from, or can supply water to, other valleys: for example, Orange City Council is linked to the Central Tablelands water supply system in the Lachlan region. Despite this, very few towns have adequate water security in light of the current severe drought (see Table 6). This includes larger centres like Dubbo, Bathurst and Orange and smaller towns like Oberon, Nyngan and Cobar.

Water security for these populations is a high priority for the NSW Government and we are investing in improved water infrastructure for towns across the region.

For towns and communities, more extreme climate variability will mean less secure water supplies unless actions are taken to invest in diversified water sources and amend how we manage major storages.

Importantly, greater climate variability will not occur in isolation, but will coincide with water resource development, population growth, land use and agriculture changes, and associated changes to water management. This presents a long-term risk to river, wetland and floodplain health, making it more difficult to manage 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 enhance the region's vital environmental, economic, social and cultural assets into the future.

Based on our updated climate data and modelling, there is a generally low probability of future surface water supply shortfalls for Dubbo, Nyngan and Cobar, which are supplied from water stored in Burrendong Dam under long-term climate (stochastic modelling). However, the estimated risks of shortfall increase significantly under our adopted climate change scenario. As indicated within Figure 12 on page 44, our new climate modelling estimates that inflows into Burrendong Dam could potentially decline by up to 50% if the adopted climate scenario were to eventuate. This possible outcome has clear implications for Dubbo, Nyngan, Cobar and Wellington and the other towns that rely on water from Burrendong Dam.

The risks for Mudgee and the upper Macquarie towns of Oberon and Lithgow experiencing surface water shortfalls for the observed historical and long-term stochastic climate data are small. This is in part because the inflow reductions into Oberon and Chifley dams under the climate change scenario were not as high as for Burrendong Dam.

As previously noted, we have adopted a deliberately conservative climate change scenario to understand what are currently considered to be potential extreme/upper bound risks. While the probability of this level of climate change impact is considered to be small, the consequence of these towns experiencing water shortfalls are likely to be severe, and these towns represent the highest supply priority in the region during critical water shortages.

In addition to these modelled risks for surface water entitlement reliability, water security access risk analysis undertaken by local water utilities is also available (secure yield analysis undertaken as part of Integrated Water Cycle Management strategies). This additional analysis takes into account a local water utility's:

- headworks arrangement and capacities
- the physical water delivery system and operational rules under water sharing plans
- the utility's operating protocol and past experiences in delivering water in drought conditions.

This provides a water security access risk specific to each local water utility's town water supply system that is different to the modelled risk for surface water entitlement reliability. The water security access risk for each water utility is shown in Table 4.

Table 4. Water security risk for cities and towns in the Macquarie-Castlereagh region

Water utility	Drinking water supply system	Population served in 2014 (approx)	Water security risk
Bathurst Regional Council	Bathurst	31,845	Very High
Bogan Shire Council	Nyngan	2,073	Very High
Cabonne Council	Molong	1,629	Very High
Cobar Shire Council	Cobar + Canbelego	3,817	Very High
Coonamble Shire Council	Coonamble	2,446	Medium
Dubbo Regional Council	Dubbo, Brocklehurst, Wongarbon, Eumungerie and Moriguy	36,941	Very High
Dubbo Regional Council	Wellington	4,540	Very High
Dubbo Regional Council	Geurie	454	Medium
Gilgandra Shire Council	Gilgandra	2,664	High
Mid-Western Regional Council	Mudgee	9,830	Very High
Mid-Western Regional Council	Gulgong	1,866	Very High
Mid-Western Regional Council	Rylstone, Kandos and Charbon	2,119	Very Low
Narromine Shire Council	Narromine	3,871	Very High
Narromine Shire Council	Trangie	849	High
Oberon Council	Oberon	2,459	Very High
Orange City Council	Orange	39,115	High
Warren Shire Council	Warren - Potable	1,523	Very High
Warren Shire Council	Warren - Non Potable	1,523	Very High
Warrumbungle Shire Council	Coonabarabran	2,576	Very High
Warrumbungle Shire Council	Dunedoo	802	High
Warrumbungle Shire Council	Coolah	794	High

Note: The table only covers drinking water supply systems with a population greater than 500 people. These risks represent the (preliminary) water security risks as assessed by the Safe and Secure Water Program as of April 2020 and are subject to change over time based on further investigation, new information from councils and/or delivery of projects/solutions addressing these risks.

Source: NSW Government's Safe and Secure Water Program

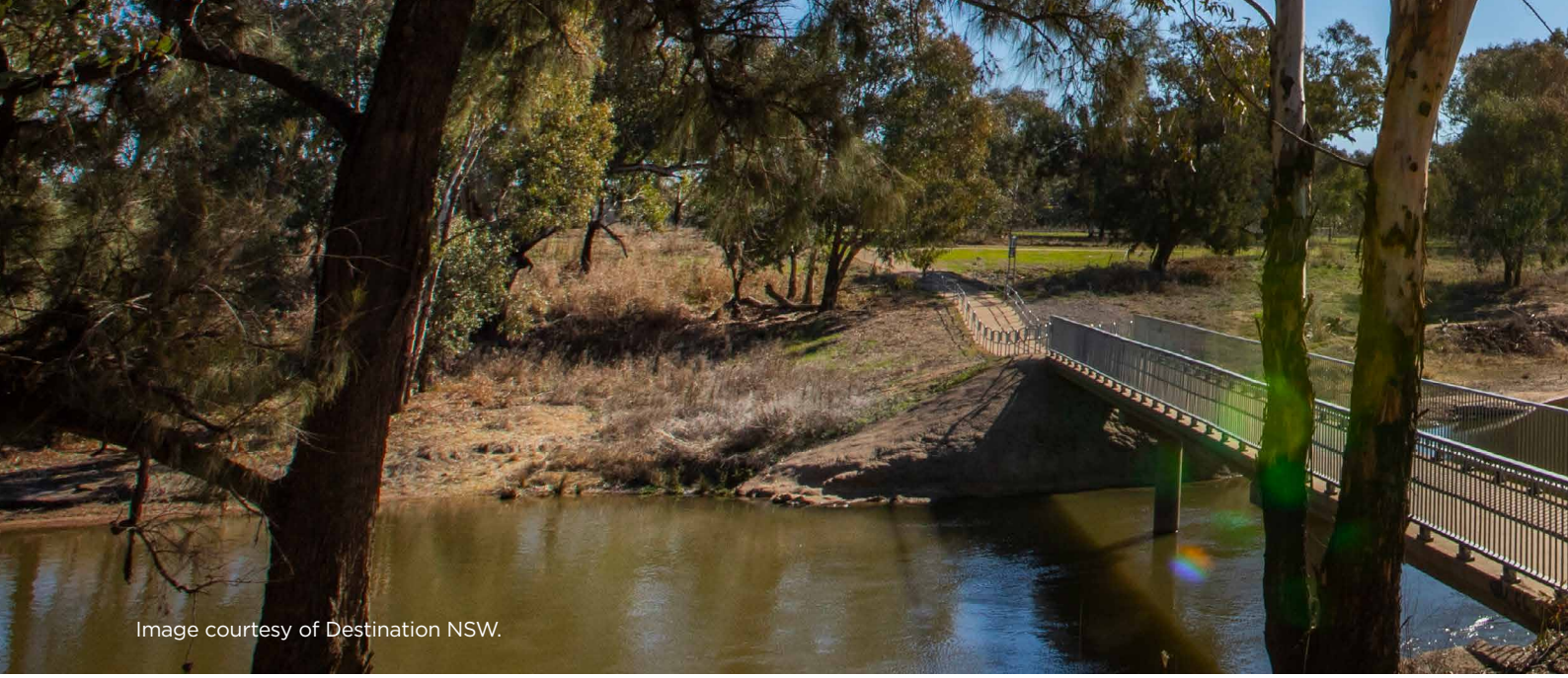
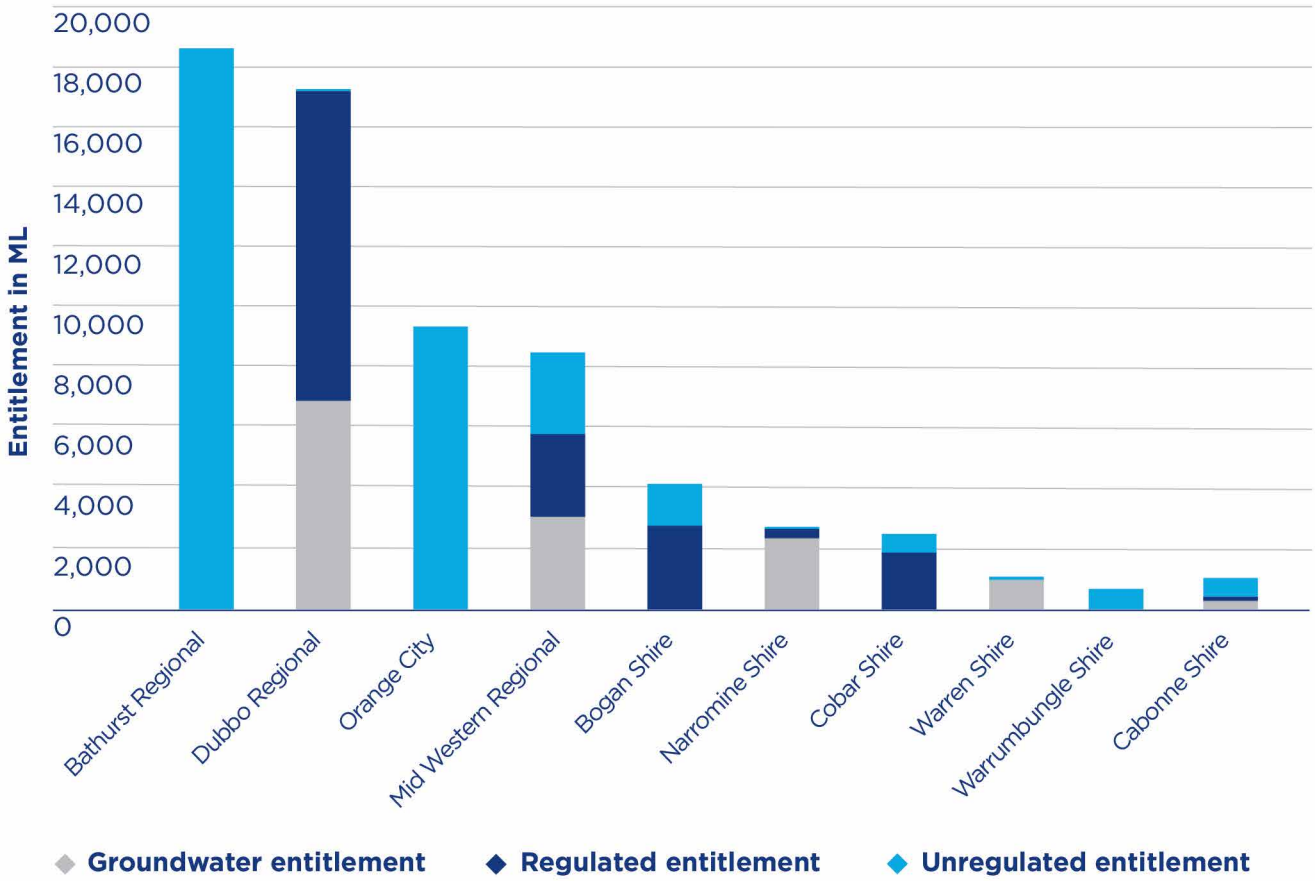


Image courtesy of Destination NSW.

Figure 24. Macquarie-Castlereagh entitlements by major town water supplier*



*Note: This data does not include access entitlements for towns which source water from the Great Artesian Basin. Great Artesian Basin is the primary water source for towns including Coonamble and Gilgandra

Source: NSW Department of Planning, Industry and Environment water licence database

A number of towns in the region rely on groundwater as either a primary or alternate source including Narromine, Coonamble, Warren, Gilgandra, Dubbo and Orange. Around one quarter of the region's population has a non-reticulated domestic water supply.[58] These people depend directly on water from creeks and rivers, aquifers, farm dams and rainwater tanks.

Town water supply constitutes about 2% of total water entitlements in the region. However, providing water for critical human needs to major and local town areas is a significant challenge especially during extreme droughts (Figure 24).

During the Millennium Drought and the 2017-2020 drought, funding from the Restart NSW Water Security for Regions Program and the Safe and Secure Water Program has supported water utilities to access groundwater to supplement water supplies during periods of limited surface water. Funding has been provided to Warren, Narromine, Collie, Nevertire, Gilgandra, Coolah, Mendooran and Binnaway to improve their access to groundwater (see section 1.4).

However, it is important to understand that during dry periods when surface water supplies are less reliable, any increased groundwater use by other users in the region can create groundwater drawdown in areas, putting town water supplies at risk.

Potential growth in Dubbo, Orange, Mudgee and Bathurst is also likely to result in increased water demand for surrounding smaller towns in the region. The construction of Inland Rail (see box on page 95) and other new developments and industries could also increase water demand.

For towns and Aboriginal communities in the Macquarie-Castlereagh region, the potential for more frequent and longer dry periods will mean less secure water supplies unless actions are taken now to invest in diversified water sources—including climate-independent sources—and change how we manage major storages. Making these decisions now will ensure that towns and communities have adequate water security into the future and that town water supplies are more resilient to water security risks and water quality issues. More diverse water sources may also open up new economic and employment opportunities in towns and communities.

The Draft Regional Water Strategy identifies potential options to deal with the implications of these findings and help cities, towns and communities meet their water needs in the context of future climate variability and climate change (for example see Options 1 to 11, 13, 32, 34, 36, 37, 39 and 40 in Table 5).

58. Department of Planning, Industry and Environment 2018, *Unpublished Department of Planning, Industry and Environment town water utility data; Australian Bureau of Statistics 2018 3235.0—Regional Population by Age and Sex, Australia, 2018, Commonwealth of Australia,* www.abs.gov.au/ausstats/abs@.nsf/PrimaryMainFeatures/3235.0?OpenDocument

2.3.3 Jobs and industries

The Macquarie-Castlereagh region contributes over $13.5 billion to NSW's total Gross Regional Product and employs almost 90,000 workers.

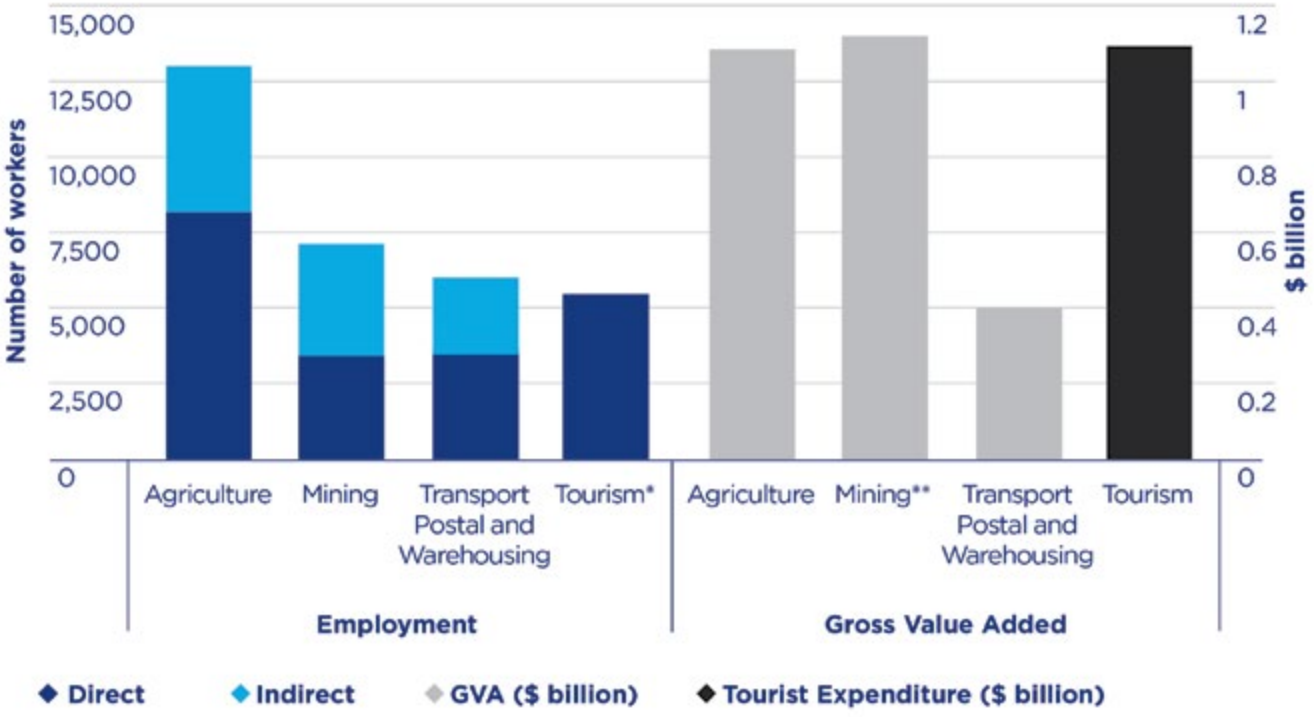
The three industries in the Macquarie-Castlereagh region with the greatest value added are rental, hiring and real estate services, healthcare and social assistance, and construction. These three industries are largely based in the region's cities and towns where most of the economic activity occurs. Securing town water supplies is vital for the continuation and growth of these industries and regional economies more broadly.

Many town-based industries are underpinned by a number of water-dependent industries such as agriculture, food processing, mining, tourism, construction and manufacturing. Water security is also critical to these industries.[59]

We know from history and the more recent drought experience that water availability influences employment and business growth—for example, the Millennium Drought had an adverse impact on agribusiness across the region.

Investments in enabling infrastructure, such as the Inland Rail Project, upgrades to the Newell Highway and improvements to digital connectivity (see section 2.3.2) will support further industry development and diversification in the region. While the COVID-19 pandemic will have an impact on regional communities and economies in the short term, we expect these investments to sustain and stimulate the economic contribution of the Macquarie-Castlereagh region in the longer term.

Figure 25. Employment and economic outputs of key industries in the Macquarie-Castlereagh region



Note:

* 'Tourism' is not a defined industry category, and indirect employment and contribution to Gross Value Added cannot be calculated. Listed value is total spend on Tourism services as defined by REMPLAN

** Mining in the Macquarie-Castlereagh region also contributes around $39 million in royalties annually

Source: REMPLAN Economy: custom data 2019

59. AgEconPlus Consulting 2018, Orange, *Blayney and Cabonne Regional Economic Development Strategy 2018–2022*, p4, www.thinkorangeregion.com.au/think-invest/regional-economic-development-strategy/

Agriculture

Agriculture is a significant contributor to economic activity in the region and the biggest user of water. The industry directly employs over 8,200 workers and indirectly employs almost 4,900 workers across secondary industries such as manufacturing and transport and logistics (Figure 25).[60]

The largest agricultural use of water in the valley is for irrigated cotton production downstream of Dubbo. Other significant irrigated crops in the Macquarie-Castlereagh region are lucerne, cereals, oilseeds, fruit (apples, cherries, citrus) and vegetables (cabbages, cauliflower and sweet corn). There is a transition towards specialised agriculture in the region, leading to a decline in grain production in favour of high-value produce such as specialised sheep and beef farming.[61]

Cotton is a significant contributor to the local economy but employment in the industry is decreasing. For example, employment in cotton growing across NSW has gone from 1,092 employees in 2006 to 680 employees in 2016.[62] This is largely due to advancements in technology.[63]

Permanent horticultural crops including citrus, apples, pears and grapes are concentrated in and around Orange, Narromine and Mudgee. This type of agriculture is highly dependent on reliable water sources.

The NSW Government is making strategic investments to ensure that the State's agricultural sector can grow and prosper into the future, including:

- Agricultural Technology (AgTech) investments, such as narrowband connectivity infrastructure and digitally-enabled devices to generate data to better inform on-farm decision making and productivity
- a $50 million World-Class Food and Fibre Infrastructure research and innovation program to boost on-farm productivity and protect the sector from devastating pests and diseases. In the Macquarie-Castlereagh region, this includes over $2.5 million for upgrades to biosecurity collections to support risk identification and control (Orange), new soil and planting processing infrastructure (Trangie) and improvements in pest insect and weed diagnostics capability (Orange).[64]

Irrigation for livestock production purposes is important for the region, supporting more than $20 million in production across the sheep, beef and dairy industries in 2015/16. The region also supports a significant livestock industry worth more than $700 million in 2015/16, which is heavily reliant on the region's various water sources to sustain production.

Given the surface water variability, those with access supplement their supply with groundwater to meet their needs. This is particularly the case for permanent plantings, vegetables and dairy producers. Producers of these high value crops are using multiple sources of water (including trading in entitlements and water allocations[65]) to ensure they have sufficient water to meet their requirements.

The region's future climate will also present challenges and opportunities to agricultural industries. To better understand the effects of climate variability, Department of Primary Industries—Agriculture is undertaking a vulnerability assessment to consider potential changes to yield and crop substitution (for example, substituting cotton for high value legume or speciality crops or other cereal crops) and highlight adaptation opportunities. These findings will be available in mid-2022 and will inform future water policy and actions.

60. REMPLAN 2019, *REMPLAN Economy: Custom data*, www.remplan.com.au/economy/
61. NSW Government 2018, *Central Orana Regional Economic Development Strategy 2018-2022*
62. 2006 Place of Work and 2016 Employment, Income and Education Census—Australian Bureau of Statistics
63. NSW Government 2018, *Western Plains Regional Economic Development Strategy 2018-2022*
64. Department of Primary Industries 2019, *Research and development: Projects*, www.dpi.nsw.gov.au/about-us/research-development/projects
65. For a description of how water trading operates in the Murray-Darling Basin, see www.mdba.gov.au/managing-water/water-markets-and-trade

AgTech: unlocking productivity and improving water efficiency on farms

Farm and Water is one of three priorities in the NSW Government's $400 million Regional Digital Connectivity Program. AgTech investments made through the program aim to boost the productivity of agribusinesses and help more people in regional areas make the transition to higher skilled jobs.

Practical on-farm, water-related AgTech enables farmers to:

- monitor water use in irrigated crop production
- monitor soil moisture to enable targeted sowing schedules and maximise efficiency
- remotely monitor tanks, water troughs and dams to reduce time performing these tasks and more quickly identify supply problems and wastage.

It is estimated that more widespread adoption of digital agriculture could increase the gross value of Australian agricultural production by more than $20 billion nationwide.[66]

Innovative agricultural businesses in the Macquarie-Castlereagh region are already using AgTech to improve on-farm productivity and water efficiency. In 2013, Narromine farmer Stewart Crawford converted 135 ha from siphon-fed furrow irrigation to subsurface drip irrigation. The drip system is controlled remotely using smart phone technology and provides greater flexibility and precision irrigation to grow high value crops and reduce waterlogging and erosion.

By using AgTech, Mr Crawford saved 296 ML from evaporation and seepage, a water saving of 30% to 40%, and increased his crop yield by 25%.[67]

Mining, resources and energy

The mining industry is a significant contributor to the local economy and employment. Located outside the region, but dependent on water delivered from the Macquarie River (less than 1% of Burrendong's storage) are Hera, Peak Gold, CSA Mine and Endeavor metallic mines, which produce copper, gold, lead, silver and zinc.[68] Tomingley Gold Operations and Tritton Copper Operations are major metallic mining operations within the region, producing copper and gold.

In 2018/19, the six metallic mines employed 1,407 people, had a total value of about $968 million and contributed almost $39 million to the NSW economy in royalties.[69]

Mining will continue to be important for the economy and jobs in the Macquarie-Castlereagh region into the future. Six mining projects are seeking approval or have been granted approval and are not yet in operation (Figure 23).[70]

66. Cotton Research and Development Corporation 2017, *Accelerating Precision to Decision Agriculture*, www.crdc.com.au/precision-to-decision
67. Department of Primary Industries 2019, *Sustaining the Basin Irrigated Farm Modernisation—Case Studies in Irrigation Infrastructure Improvement*, www.dpi.nsw.gov.au/agriculture/water/sustaining-the-basin
68. Although one of the state's largest gold and copper mines (Northparkes) lies within the Macquarie-Castlereagh region, it has been included in the Lachlan Regional Water Strategy as it draws water from the Lachlan River.
69. Department of Planning, Infrastructure and Environment 2019, *Extract from Resources and Geosciences corporate database*
70. Department of Planning, Industry and Environment 2019, Major Projects, www.planningportal.nsw.gov.au/major-projects

Mining water use

Mining operations use a mix of water sources: groundwater, regulated and unregulated surface water, harvested onsite stormwater and recycled water. The volume of water required by mining operations is a relatively small portion of the high security and general security entitlements in the region, compared to some agriculture water use. For example, mines supplied through the Macquarie regulated river system only require 3 GL of high security entitlements out of Burrendong's potential 1,188 GL available. However, access to this water is critical to their operation and contribution to the region's economy.

Having a reliable water supply is critically important to the mining industry. All private businesses, including mine operators, need to manage their own risk by purchasing water entitlements on the market to match their requirements. This risk can be minimised by purchasing higher reliability water entitlements and by diversifying water sources.

There are opportunities for mines to adopt measures to reduce demand and improve water efficiency. In addition, mining does not need high quality water for its production. There is an opportunity to explore options about whether water can be used more efficiently by supplying different levels of water quality for different water uses.

Until recently, the Macquarie-Castlereagh region was home to the Wallerawang power station near Lithgow, owned by Energy Australia. The power station played an important role in Lithgow's community for five decades, but has now been permanently closed due to ongoing reduced energy demand, operating costs and coal prices. The closure of the power station provides an opportunity to consider how its water entitlements could be used to support a changing industry landscape in a more variable future climate. Energy Australia's other power station, Mt Piper, has an operating life to 2042.

Image courtesy of Destination NSW.

Tourism

Across the Macquarie-Castlereagh region, tourism supports local businesses and communities, including through the food and beverage, accommodation, arts and recreation, and retail sectors. Tourism attractions and activities that rely on a healthy environment and water availability include:

- ecotourism destinations such as the Macquarie Marshes and Wellington Caves
- significant Aboriginal sites
- vineyards in Orange and Mudgee
- Taronga Western Plains Zoo
- recreational fishing, camping and boating
- event tourism including food, sports and music which require water supplies to maintain high-quality venues
- colonial history sites throughout the region.

The Central NSW tourism region, which includes the Macquarie-Castlereagh region, has experienced a steady increase in tourism since 2010. In 2018, the Central NSW region was host to 5.7 million visitors (including nearly nine million overnight stays) and a total expenditure of $1.5 billion.[71] Nearly $1.1 billion of that expenditure was spent in the Macquarie-Castlereagh region.[72] Over 5,600 people were employed in tourism related industries across the region in 2016.[73]

Coonamble Shire Council has noted that environmental water and economic prosperity outcomes in its municipality are closely linked. The Macquarie Marshes are a significant natural tourist attraction for Coonamble and surrounding areas. As the Marshes dry, the effects are felt by the local economy.

Tourism in the region has been impacted by the 2020 COVID-19 pandemic, as is the case for all other parts of Australia. However, over the long-term, tourism is expected to continue to be an important part of the Macquarie-Castlereagh region.

Enabling industries

Enabling industries, including manufacturing and transport, freight and logistics, will continue to be important in the success of the agriculture and mining sectors and are also dependent on increasing productivity in these sectors.[74]

Government investments that are stimulating jobs and economic growth in the region include the Inland Rail Project (which will provide fast, efficient and reliable freight connectivity to meet market demands), upgrades to the Newell Highway (which performs an important role in road freight and maintaining regional NSW's competitiveness in agriculture and mining) and a new regional rail maintenance facility in Dubbo.

While industries in the Macquarie-Castlereagh region are generally well-adapted to the variable climate, new approaches will be needed to keep pace with changing industry profiles and water needs, and to make sure that industries across the region have access to reliable water supplies. Options being considered in the draft Regional Water Strategy to maintain and diversify water supplies (for example, see Options 1, 3, 4, 6, 11, 12 and 13 in Table 5) or improve water efficiency (such as Options 6, 32 and 33) would benefit and potentially add value to existing regional industries, as well as opening up opportunities for emerging industries.

Reuse/recycle and stormwater projects (Option 7) and water efficiency projects (Option 33) may offer innovative solutions that expand the scope, scale and diversity of existing industries such as agriculture, food processing and tourism, while also attracting new businesses and supporting new industry development.

71. Destination NSW 2019, *Travel to Central NSW Time Series*, www.destinationnsw.com.au/tourism/facts-and-figures/regional-tourism-statistics/central-nsw
72. REMPLAN 2019, *REMPLAN Economy: Custom data*, www.remplan.com.au/economy/
73. REMPLAN 2019, *REMPLAN Economy: Custom data*, www.remplan.com.au/economy/
74. REMPLAN 2019, *REMPLAN Economy: Custom data*, www.remplan.com.au/economy/

Inland Rail: creating new regional opportunities

Inland Rail is a once-in-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—the project is expected to create 16,000 new jobs during construction, with an additional 700 ongoing jobs across the network
- better connections within the national freight network
- better access to and from NSW regional markets, with farms and mines moving goods via rail to domestic and international markets
- better transit time, reliability and cost savings—less than 24-hour transit time will mean that perishable goods can access markets faster
- transport cost savings, with horticulture and post processed food supply chains estimated to save on average $76 per tonne when travelling via inland rail (compared to road trips).[75]

During our targeted consultation on the regional water strategies, Gilgandra Council noted that the construction of Inland Rail is likely to generate significant additional demand for water, including water for dust suppression and mixing concrete and to supply water to workers' camps. Councils are concerned that the project will draw from the local water supply, placing addition pressure on town water supplies.

Industry water use and climate risks

There are seven private off-river irrigation schemes in the Macquarie catchment: Narromine, Trangie, Tenandra, Buddah Lake, Marthaguy, Nevertire and Greenhide. Together, these schemes account for approximately 30% of all the licensed entitlement in the regulated Macquarie and Cudgegong rivers.

The majority of water licences in the Macquarie-Castlereagh region are general security licences. Only 2.5% are held as high security licences. In very dry conditions, general security licence holders receive no water allocations and need to rely on alternative water sources. General security licence holders in the Macquarie-Cudgegong have historically received no water allocations in 10% of years including in 2006/07, 2018/19 and 2019/20.

Industries in the region are generally well-adapted to a variable water supply when they can tap into alternative water supplies such as groundwater, use their water conservatively and invest in crops with the flexibility to adjust to changes in water availability. For example, cotton is popular because it attracts good prices and can be managed as an annual crop in response to variable water supply. However, the current drought has revealed the vulnerability of some industries that rely exclusively on surface water from the regulated rivers.

Available water allocated to general security licences used by the irrigation industry tends to be used rapidly within a two-year period. This means that under very dry conditions, Burrendong Dam can go from full to near empty within 18 to 24 months.

75. Higgins AJ, McFallan S, Bruce C, Bondarenco A, McKeown A 2019, *Inland Rail Supply Chain Mapping: Parkes to Narromine Pilot*, www.apo.org.au/node/226701

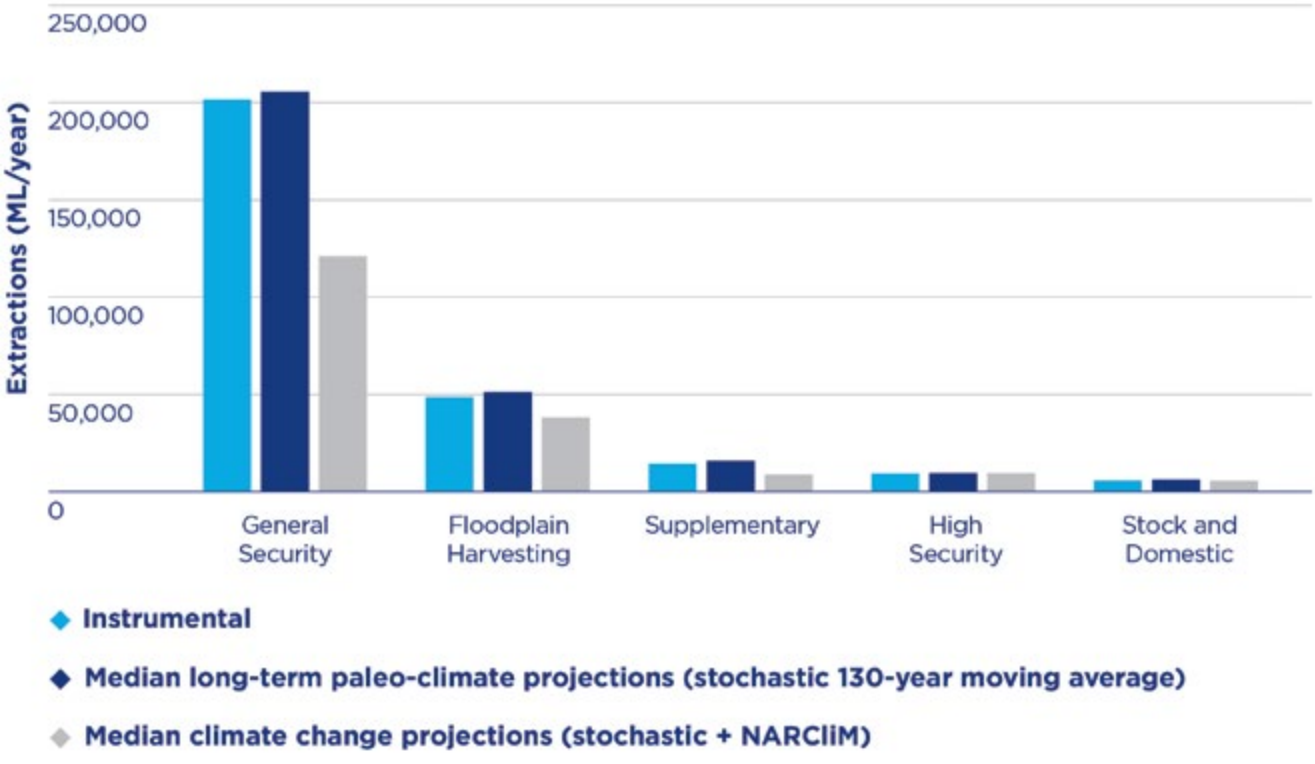
We have modelled a range of plausible climate scenarios to understand how future climate risks may impact on water licences in the regulated Macquarie River. Figure 26 below shows that, under a base case scenario:

- there are limited impacts on stock and domestic entitlements and high security entitlements, which includes high value industries such as the lower Macquarie mines—demonstrating these licences are relatively secure
- there may be some minor positive impacts for general security, floodplain harvesting and supplementary licences under a long-term climate scenario (stochastic data) when compared to the historical record
- there could be significant negative impacts for some entitlements under a climate change scenario over the coming 40+ years—general security licences and supplementary licences could be impacted by around 40% when compared to the historic record.

These results show that the given the priorities around water sharing, there are greater impacts on lower security and lower priority licences under the average climate change projections beyond our current 40-year strategic planning window.

The climate change modelling provides us with an estimate of what impacts may occur if some scenarios eventuate. Preparation of the regional water strategies provides us with an opportunity to invest in options that help mitigate or manage these risks (for example see Options 1, 3, 6, 8, 9, 10, 11, 12, 26, 27, 32, 33, 35, 36, 37, and 41 in Table 5).

Figure 26. Impacts on average annual extractions from the Macquarie-Castlereagh region's regulated river (ML/year)



Source: Department of Planning, Industry and Environment—Water 2020, hydrological modelling

Chapter 3

Options for the Macquarie-Castlereagh regional water strategy

Image courtesy of Destination NSW.

Snapshot

We have developed a long list of options that could be included in the final Macquarie-Castlereagh Regional Water Strategy.

- To identify these options, we have drawn ideas from previous studies, experience with the Millennium Drought, community consultation 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 Macquarie-Castlereagh region.
- The options have not been prioritised and not all options have been costed.

The options we are considering aim to tackle the challenges facing the Macquarie-Castlereagh region and maximise opportunities arising from regional change.

Options in the long list focus on:

- **maintaining and diversifying water supplies,** such as additional weirs and pipeline connections, improved access to stored water, more reliable access to groundwater and reuse, recycle and stormwater projects
- **protecting and enhancing natural systems,** including better protection for native fish, streamlining flows to wetlands and the removal of floodplain structures that impede the delivery of water to priority ecological assets
- **supporting water use efficiency and conservation,** including enterprise-based water efficiency programs and more efficient water delivery measures
- **strengthening community preparedness for climate extremes,** such as reviewing drought operation rules and allocation processes, improving data collection and sharing, and opportunities to maintain amenity in towns during drought
- **improving recognition of Aboriginal people's water rights, interest and access to water,** including a review of cultural water access licences, measures to ensure greater involvement of Aboriginal people in water management, a River Ranger Program and establishing regional Aboriginal water advisory committees
- In each of these areas, we are open to exploring fresh ideas and innovative solutions that add value to existing regional industries, leverage new investments and support new economic, employment and environmental opportunities.

Not all options will be progressed.

- Inevitably, these options will involve trade-offs and choices. To fully understand these impacts and trade-offs, we will first 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 in terms of achieving objectives, rather than on a cost basis.
- Preferred options, and packages of options delivered together, will be informed by a range of evidence including modelling, expert judgement and community input. These will form the final, comprehensive Macquarie-Castlereagh Regional Water Strategy.

Image courtesy of Department of Primary Industries.

3.1 Our vision for the Macquarie-Castlereagh Regional Water Strategy

The challenges in the Macquarie-Castlereagh region stem from the variable climate, the length of the Macquarie River system, and increasing water demand. We can't change today's climate or the basic hydrology of our river and groundwater systems. However, we can deliver better outcomes for the region by changing:

- infrastructure in the region, such as dams, weirs, pumps, pipes and channels
- how we operate the water system, such as water sharing arrangements, allocations, environmental flow requirements and flood mitigation
- how water is used and water user behaviour, including demand management measures
- any combination of the above three options.

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, health and community infrastructure.

Our vision for the strategy

Our vision for the strategy is to have healthy and resilient water resources for a liveable and prosperous Macquarie-Castlereagh 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 Aboriginal people, towns, communities, industries and the environment.

3.2 Identifying and developing the options

We have developed a long list of options that could be included in the final Macquarie-Castlereagh Regional Water Strategy. In preparing this list, we recognise that a great deal of work has been done over the last few years 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, joint organisations, Aboriginal communities and government agencies. The public consultation process will provide another opportunity to identify options and seek feedback on the long list of options. Bringing all of these options together will help us to align and better sequence the various water reform processes as we develop the strategy.

In developing the long list of options, we have specifically considered the following:

- Each option that has been identified is expected to address at least one of the regional water strategy objectives (Figure 4 in Chapter 1). 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 have all of the information at the moment 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.

- As discussed in section 1.3.1, the NSW Government has invested in new climate datasets and improved modelling to gain a more accurate understanding of potential future climatic conditions in the Macquarie-Castlereagh region. A number of options in the long list propose reviews of existing policy settings, operational rules and management plans considering this new data.

- As discussed in section 1.3, we have drawn on a range of sources to develop the options, including existing studies, past experience (such as river operations during the Millennium Drought), community engagement 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*.

- We have had conversations with local councils and local water utilities to understand their views on what options could be considered in the Macquarie-Castlereagh Regional Water Strategy to improve water security and quality for towns and communities (see section 1.3.3).

- We have included options following discussions with Aboriginal communities. These options and feedback are reflected in the long list of options.

- We have sought expert advice from government agencies.

We have not ordered or prioritised the options identified for the Macquarie-Castlereagh long list of options and many options on the list have not been costed.

Some options that have been considered previously for the Macquarie-Castlereagh region are not included in the long list. We carefully considered these options before determining they should not proceed further. Recent analysis completed by Water NSW also recommended these options should not proceed. These options and the reasons they are not included in the draft strategy are set out in the *Macquarie-Castlereagh: Long list of options* for the region.

3.3 Which options will be progressed?

Not all options in the long list will be progressed. Only feasible options will be progressed following an assessment process.

Inevitably, these options—and their priority in the Macquarie-Castlereagh 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, both national and international, and technical feasibility?

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 of 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 together) 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.

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 aquatic biodiversity and environmental assets

- demand management measures to make sure water users are operating as efficiently as possible

- policy and regulatory options that review whether the water sharing arrangements under altered conditions are appropriate.

However, 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 5.

Combining options for better results: improving town water security in the Macquarie-Castlereagh

The NSW Government is progressing a detailed business case for the construction of a mid-system re-regulating weir on the Macquarie River (government commitment 1 in the long list of options for the Macquarie-Castlereagh region). The proposed re-regulating weir will help to reduce delivery losses in the system and increase the resilience of the Macquarie valley to drought. WaterNSW manages the delivery of water on the regulated Macquarie River and is progressing this business case in collaboration with NSW agencies.

Following preliminary consultation with councils and local water utilities, Department of Planning, Industry and Environment—Water identified that the new re-regulating weir could be combined with other options to further improve town water security in the region and support economic prosperity. These options include a pipeline from the new weir to Nyngan and a 'cut off trigger' reserve for town water in Burrendong Dam. Bringing these options together could significantly enhance town water security for Nyngan and Cobar and the Cobar mines, as well as stock and domestic water users along the pipeline route. Investigation of the potential networking of pipelines both within the region and across regional borders will provide further opportunities for enhancing town water security.

Combining these infrastructure options will require a review of operational rules and relevant water sharing plan rules. In addition, potential impacts on the environment and cultural values will need to be more thoroughly considered.

The optimal combination of options to improve town water security in the Macquarie-Castlereagh region will also be contingent upon whether other opportunities for town water efficiency, reuse or recycling can be found. These more innovative measures, which will be an essential part of local integrated water cycle management strategies, will be critical in the development of regional town water strategies and may require refinement or reassessment of some of the infrastructure options.

As development of the strategy progresses, preferred options and combinations of options—and their trade-offs—will be informed by a range of evidence including modelling, expert judgement and community input. Improved data about potential future climatic conditions in the Macquarie-Castlereagh region, along with economic analysis, will be used to understand 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).[76]

Other important considerations when we arrive at shortlisted options will be who owns and maintains infrastructure options, who benefits from the option, what the impacts are and how to pay for the option: for example, should the cost be recovered from water users and what can be funded by the Australian or NSW Governments?

76. Murray-Darling Basin Authority 2019, *Sustainable diversion limits*, www.mdba.gov.au/basin-plan-roll-out/sustainable-diversion-limits

3.4 Macquarie-Castlereagh: Long list of options

Table 5 summarises the long list of options and existing government commitments we have identified for the Draft Macquarie-Castlereagh Regional Water Strategy. Detailed information about each option, the challenges it will address, its potential combination with other options or government commitments and further work required to progress the option is set out in *Macquarie-Castlereagh: Long list of options*.

The draft long list of options focuses on:

1. **maintaining and diversifying water supplies**
2. **protecting and enhancing natural systems**
3. **supporting water use efficiency and conservation**
4. **strengthening community preparedness for climate extremes**
5. **improving recognition of Aboriginal people's water rights, interests and access to water.**

Concentrating on these five actions enables us to address the challenges facing the Macquarie-Castlereagh region, while maximising opportunities for regional communities and industries, and supporting their aspirations. It will also ensure we preserve our important natural systems and include the extensive knowledge of our Traditional Owners in water management decisions.

We have heard from communities that the regional water strategies should not just focus on the risks and challenges of today. This is why our draft long list of options not only focuses on the issues identified in Chapter 2, but also includes a number of options that may become important in a few 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 continuously work with communities, local councils, environmental managers, Traditional Owners and industries to develop and refine these ideas further.

As noted previously, the options included in Table 5 are not ordered or prioritised and many have not been costed.

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 5. Long list of options and government commitments

Option	Description	Objective
Maintaining and diversifying water supplies—*Opportunities to improve town water security, maintain suitable water quality and support growth and jobs in the region.*		
1. A new mid system re-regulating weir on the Macquarie River	Preparation of a detailed business case for the construction of a new 6,000 ML re-regulating weir in close proximity to the existing weir at Gin Gin to assist with delivery efficiency to the lower reaches of the Macquarie River. This option would improve delivery efficiency and supply reliability for industry, towns and basic landholder rights under all climate conditions. **This is an existing government commitment.**	
2. Access water from Burrendong Dam's deep storage	Access 21,000 ML of deep storage volume normally not accessible in Burrendong Dam for critical town water supply during times of extreme water scarcity. **This is an existing government commitment.**	
3. Managed aquifer recharge investigations and policy	Investigation of possible sites for temporary storage of stormwater and river flows in aquifers to improve storage efficiencies. This is normally referred to as managed aquifer recharge (MAR). This option would develop a supporting policy to regulate the storage and recovery of this water. The potential for MAR is proposed to be investigated in several areas within the region.	
4. Improving town water security in the upper Macquarie unregulated river system	Conduct a feasibility study to identify options to improve water security for towns that rely on water from the upper Macquarie (unregulated) system, including Bathurst, Orange, Oberon and Lithgow. The study would identify water security deficiencies, potential water sources, delivery mechanisms and preferred options for further development.	
5. Drought protocols for Bathurst and Oberon town water supply	Review the water sharing plan for the Macquarie Bogan Unregulated and Alluvial Water Source to identify appropriate drought triggers and responses to protect the water supply for town use and critical needs in Bathurst and Oberon during extreme drought conditions.	
6. Inter-regional connections project investigation	Investigation of potential additional inter-regional pipeline connections between the Macquarie-Castlereagh region and neighbouring regions (such as the Lachlan region), with the aim of improving town water security (for example, during drought conditions) and giving regional towns access to more than one water source.	
7. Reuse, recycling and stormwater projects	Investigation of opportunities to maximise the use of surface water and groundwater for potable and non-potable uses through reuse/recycling initiatives or stormwater harvesting. Suitable options would need to be scoped; however, options could focus on improving water security for individual towns and providing options to maintain 'green' spaces—such as town lakes and parks—during extended drought.	

Option	Description	Objective
8. Burrendong Dam to Nyngan pipeline	Pipeline through the length of the catchment downstream for towns (Dubbo, Wellington, Narromine, Warren and Nyngan) and the Cobar mines. Potential sub-options are: • Option A—Burrendong Dam to Dubbo—two route options • Option A1—Burrendong Dam to Dubbo—includes Wellington with river route • Option A2—Burrendong Dam to Dubbo—highway route including Wellington and Geurie • Option B—Burrendong Dam to Narromine extension • Option C—Burrendong Dam to Nyngan with three water source options • Option C1—Supplementary bore water from Narromine • Option C2—Supplementary bore water from Warren/Nevertire • Option C3—Supplementary bore water from Nyngan.	
9. Pipeline from the proposed new mid-system weir near Gin Gin to Nyngan	The towns of Nyngan and Cobar and end-of-system mines rely on regulated supply from the Macquarie River and are located at the end of a long river system. Town water supplied through the Albert Priest Channel is subject to significant seepage and evaporation, reducing the reliability of supply. This option involves constructing a pipeline from the proposed Gin Gin or Rocky Point Weir to Nyngan, enabling water to be securely delivered to the towns and mines during wet, average and dry years.	
10. Gunningbar Creek pipeline	Replace Gunningbar Creek (from its offtake upstream of Warren to its junction with the Bogan River) with a pipeline to supply irrigators, stock and domestic users, and the Tritton mine. This could be an alternative to upgrading the Albert Priest Channel, as the potential water saving benefits (approximately 10 GL) of a Gunningbar pipeline are estimated to be higher than piping the channel (2 GL).	
11. Increase Burrendong Dam's Full Supply Level	Changing the operation of the Burrendong Dam to increase the Full Supply Level and use a portion of the flood mitigation zone to increase storage capacity (without requiring major construction). This option aims to improve water security and supply reliability under all climate conditions.	
12. Increase outlet valve capacity at Burrendong Dam	The maximum valve capacity at Burrendong Dam at Full Supply Level is 8500 ML/d (less at low dam levels). Increased outlet capacity could improve wetland watering opportunities and reduce potential conflict between the environment and consumptive water users.	
13. Reliable access to groundwater by towns	Strategic review and planning state-wide to identify towns where future water demands will exceed the capacity of surface water resources, groundwater resources that could be used as complementary supplies, regulatory issues and required infrastructure investments. This option would improve processes and policies to address challenges faced by towns accessing groundwater during the current drought.	

Option	Description	Objective
Protecting and enhancing natural systems—*Opportunities to protect and enhance environmental outcomes and realise broader community benefits through a healthy environment.*		
14. Address channel constraints to delivering environmental flows to the Macquarie Marshes	Environmental flows to the Marshes via Marebone Weir are currently constrained to 3,200 ML to 3,500 ML/d to avoid over bank flows, particularly via breaks to the Crooked Creek. These breaks appear to be eroding over time, further reducing channel capacity. Works would stabilise and re-establish high flow capacities in the main river.	
15. NSW Fish Passage Strategy	Remediation of fish passage at 46 priority weirs within the Macquarie valley to restore native fish access throughout mainstem waterways and to important off-channel habitat, including the Ramsar-listed Macquarie Marshes. This option would improve native fish access to core habitat in the Macquarie valley and add value to other options addressing fish passage and cold water pollution. It would also improve recreational fishing and regional tourism opportunities. **This is an existing government commitment.**	
16. Introduce flow variability in the distributary (effluent) creeks	Provide greater flow variability, including periods of drying, base flows and small freshes. This option would need to work with other options to provide security to water users along these systems.	
17. Determine the feasibility of delivering water to the Talga Wetland/ Overflow of the Lower Crooked Creek	Investigate the viability of watering the Talga Wetland/ Overflow in the unregulated Lower Crooked Creek, given potential flow constraints to the area. The option could also incorporate a trial of controlled watering using combined unregulated flows and managed environmental water. Other options for water delivery (via irrigation systems) could also be investigated.	
18. Undertake channel works to reinstate natural channel profiles in selected streams in the southern Macquarie Marshes	Undertake channel bed restoration works in the southern Macquarie Marshes to stabilise and restore incised channel profiles, allowing reconnection with wetlands and floodplains. This option would achieve environmental outcomes in the southern Marshes and would be informed by previous work undertaken as part of the *Southern Macquarie Marshes Geomorphic Scoping Study.*	
19. Formalise channel sharing arrangements	Develop formal channel sharing arrangements for managing the delivery of water when demands regularly exceed channel capacity. Arrangements could be established that provide river operators with clear guidelines and all users with greater certainty.	
20. Implement native fish restoration program	Undertake a series of targeted instream rehabilitation activities to assist in the recovery of native fish.	

Option	Description	Objective
21. Diversion screens to prevent fish extraction at pump offtakes	Install screens at pump sites and diversion regulators to retain native fish within waterways by preventing entrainment of adults, larvae and eggs. Screening infrastructure will also improve water delivery and extraction efficiency due to reduced debris blockages, resulting in associated on-farm cost savings.	
22. Cold water pollution mitigation measures	This option aims to mitigate the impact of cold water releases on downstream fish habitats to provide native and threatened fish species in the Macquarie valley with the necessary environmental cues and conditions to spawn, recruit, move and grow. Burrendong Dam presently has a thermal curtain installed and Windamere Dam has a variable offtake tower which allows mitigation of cold water pollution. This option will confirm the effectiveness of these structures and undertake additional cold water pollution mitigation measures if deemed necessary to achieve natural downstream water temperatures.	
23. Modification and/ or removal of existing floodwork structures causing adverse impacts	Some vital ecological assets in the region rely on a level of floodplain water to replenish and maintain critical elements of their systems. This option would modify or remove floodplain structures and barriers that impede delivery of water to priority ecological assets such as wetlands.	
24. Relieve flow constraints on the Cudgegong River at Rocky Waterhole Bridge	Cudgegong River flows are restricted to around 1,500 ML/day by the limited capacity of the Rocky Waterhole Bridge. This option would upgrade the Cudgegong River crossing to allow higher flows, improving environmental water delivery in the Cudgegong system.	
25. Improved understanding of groundwater processes	This option would progress the scientific understanding of five key groundwater processes: • recharge rates and their spatial-temporal variations • dynamics of groundwater levels • connectivity between groundwater and surface water systems • changing patterns in groundwater quality • water needs of ecosystems that are partly or wholly dependent on groundwater. This option would be delivered in collaboration with consultancies and research centres. Outcomes would provide the scientific evidence-base for future groundwater management decisions.	
26. Sustainable access to groundwater	This option would provide a systematic state-wide process to ensure ongoing access to groundwater resources by the environment, landholders, towns, agriculture, mining and other industries. It would review existing groundwater resource extraction limits to incorporate up-to-date information (including scientific studies that incorporate new climate variation/change datasets, insight into ways to improve the integration of surface water and groundwater management, and knowledge of social and economic impacts).	

Option	Description	Objective
27. Improved clarity in managing groundwater resources sustainably	This option will review, revise and develop the necessary policies to give greater transparency and clarity in managing: • extraction within Sustainable Diversion Limits • fully-allocated groundwater systems • areas of concentrated extraction.	
28. Investigation of water quality mitigation measures	Investigate opportunities to support the water quality management plans that have been prepared for the Macquarie-Castlereagh surface water and groundwater water resource plans.	
29. River Ranger Program	Investigate options to establish an Aboriginal River Ranger Program to assist in maintaining the health and management of rivers and wetlands in the Macquarie-Castlereagh region. This role could be involved in: • pest management (fish and weeds) • remediation and mitigation of impacts on waterways • restocking native fish and vegetation species • protecting and managing riparian zones along waterways.	
30. Secure flows for Beemunnel Aboriginal Place	Beemunnel Aboriginal Place holds significant cultural value for the local Wailwan Nation. This option would consider options for providing regular flows to Beemunnel.	
31. Connectivity with downstream systems	Explore options to improve connectivity between the Macquarie-Castlereagh region and the Barwon-Darling River during dry periods. The Barwon-Darling River, and communities along the river, rely on flows from the Queensland as well as the Border Rivers, Gwydir, Namoi and Macquarie-Castlereagh catchments. Improving connectivity to the Barwon-Darling River was a recommendation of the *Independent Assessment of the 2018/19* fish deaths in the Lower Darling and the *Independent Panel Assessment of the Management of the 2020 Northern Basin First Flush Event*.	
Supporting water use efficiency and conservation—*Opportunities to improve the efficiency of existing water delivery systems, increase productivity and address water security challenges through demand management options.*		
32. End of system efficient stock and domestic water delivery options	Reduce water losses and deliver water more efficiently to end users downstream of Warren, including delivering water through pipelines and/or bores, and on-farm infrastructure (pumps, pipes, tanks and troughs). This would benefit stock and domestic, irrigation, urban and industrial users.	
33. Enterprise water use efficiency programs	Investigate options to improve water use efficiency for larger enterprises, including research and development opportunities (for example, in the food processing sector). These options could improve industry water efficiency through conservative use, re-use and recycling of water.	

Option	Description	Objective
34. Market measures to support Dubbo's town water supply	Buying surface or groundwater entitlements to meet the city's urban water requirements. This would improve Dubbo's water security and reliability by giving the city alternate water sources.	
Strengthening community preparedness for climate extremes—*Opportunities to develop fit-for-purpose policies and regulation to protect town water security, strengthen community health and wellbeing and better manage risks.*		
35. Investigation of licence conversions	Consider the potential benefits from voluntary conversion of general security licences to high security licences. The investigation would help to determine the level of water security achievable in the Macquarie-Castlereagh region. It would potentially give water users more flexibility in production, including long-term transition to higher value enterprises that require high security water.	
36. New drought operational rules (Macquarie River)	Based on new climate data and updated modelling, this option would review the effectiveness of the Macquarie Incident Response Guide, including assessing the merit of changing the current system operational rules (for example, limiting the delivery of water to different sections of the regulated river) to minimise delivery losses during extreme events and 'pulsing' water to that section of the regulated river.	
37. Review of regulated river water accounting and allocation process	Review different settings of the current water accounting and water allocation process in the Macquarie regulated system. The review would explore more effective approaches to meet basic landholder rights and the needs of stock and domestic water users and high priority users, particularly during dry times or under potential climate change conditions.	
38. Improved data collection and information sharing	This option would investigate opportunities to refurbish existing infrastructure (such as groundwater monitoring bores) and install new infrastructure and technology to enable better collection of water flows, levels and quality parameters. It will also investigate ways to harness water data collected by industries (for example, in Environmental Impact Statements and annual compliance reports). The option would also consider how best to publicly share data, and what information products are needed for different types of water users.	
39. Capacity building program: **- new climate data/modelling** **- managing groundwater resources sustainably**	Training and information sessions on the new regional water strategies climate data and modelling to build confidence in the new approach and identify opportunities for wider use of the new datasets. Provide training and information to councils and communities about groundwater resources and how they are managed. This will assist councils to make more informed decisions about their water security. This option would also consider how best to publicly share data, and what data analytics and information products are needed for different types of water users.	

Option	Description	Objective
40. Investigation to maintain amenity for regional towns during drought	Investigate opportunities to maintain local parks, town water lakes and recreational areas during extended drought and make them less 'climate dependent' so they can be permanent features of regional towns.	
41. Land use change impact on water resources	Investigation of the potential impacts on water resources due to land use changes and growth in the Macquarie-Castlereagh region. The study would help the NSW Government in making decisions about future land use applications in the region. The option would also examine the feasibility of land use planning controls.	
Improving recognition of Aboriginal people's water rights, interests and access to water—*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.*		
42. Culturally appropriate water knowledge program	Options to develop a culturally appropriate water knowledge program that would aim to increase the capacity of Aboriginal people across the Macquarie-Castlereagh region so they can participate in negotiations on water management and policy related matters that affect them.	
43. Water-dependent cultural practices and site identification	Options for Aboriginal people to classify and map water-dependent cultural sites throughout the Macquarie-Castlereagh region. This would include identification and mapping of cultural sites, places of spiritual significance and places used by Aboriginal people for traditional and contemporary uses, such as hunting, recreation and economic uses.	
44. Shared benefit project (environment and cultural outcomes	Investigation of opportunities for shared benefits from using water for the environment to also achieve cultural outcomes. The aim of this option is to support and incorporate traditional Aboriginal ecological knowledge into water management action plans for the environment and support the cultural connection of Aboriginal people to water-sustained environments.	
45. Regional Aboriginal Water Advisory Committee	Establish an Aboriginal Water Advisory Committee to improve the ability of Aboriginal people across the region to have a unified voice on water matters that affect them and their communities.	
46. Water portfolio project for Aboriginal communities	Funding to support Aboriginal people to purchase water entitlements and infrastructure (such as pumps) to secure access to water for spiritual, cultural, social, environmental and economic purposes and open up opportunities for investment in water-dependent initiatives and cultural projects.	
47. Aboriginal cultural water access licences review	Review of the Aboriginal cultural water access licence provisions for Aboriginal cultural uses to determine their effectiveness and identify opportunities for improvement. This option aims to optimise water sharing mechanisms that support cultural values.	

Option	Description	Objective
48. Co-management investigation of Travelling Stock Reserves	Investigation of opportunities to improve the involvement of Aboriginal people in the co-management of Travelling Stock Reserves that connect Aboriginal people to waterways and water-dependent sites of cultural importance. The option aims to improve access to waterways and other water-dependent sites of cultural importance and to support the involvement of Aboriginal people in decisions that affect them.	
49. Regional Cultural Water Officer employment program	Investigate models for establishing Cultural Water Officer roles to assist with engaging Aboriginal people regarding water management in the Macquarie-Castlereagh. This option aims to improve the awareness and involvement of local Aboriginal people in the management of water resources across the region and enable Aboriginal people to use their local knowledge and skills to assist in decisions about water use and management.	

Image courtesy of Department of Primary Industries.

Chapter 4

Where to from here?

We have developed this draft strategy based on the new evidence we have, the latest policies and programs for the region and feedback from government agencies, local councils and Aboriginal communities.

The outcomes, challenges, opportunities and options we have identified in this strategy will be tested, evaluated and refined based on your input.

Image courtesy of Peter Robey.

4.1 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 2021.

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 Macquarie-Castlereagh 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.

4.2 Implementing the strategy

Community engagement does not end with consultation; it is a vital part of implementing the regional water strategies.

The final strategy for each region will include:

- a final package of actions approved by the NSW Government
- a plan for implementing the strategy within clear timeframes which includes existing commitments
- clearly defined roles, responsibilities and governance arrangements for delivering each action or combination of actions
- well-defined opportunities for local and regional partnerships to deliver actions
- a schedule and plan for monitoring and reviewing each strategy.

Critically, the ongoing monitoring, evaluation and review of the strategies will identify if any key underlying assumptions are no longer valid, and when a revision is required. This process will require regular re-evaluation of the strategy outcomes against any updates in the available climate data.

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
- that the direction and actions we pursue continue to be the right ones for each region.

Image courtesy of Forough Dorani.

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 and Aboriginal communities.

We would like to hear your views on 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 Macquarie-Castlereagh 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 options presented in this 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 Macquarie-Castlereagh Regional Water Strategy is on public exhibition from 25 September to 13 November 2020. A range of supporting information is available at www.dpie.nsw.gov.au/macquarie-castlereagh-regional-water-strategy

We will be meeting with people from the Macquarie-Castelreagh region over the coming months to help shape the final strategy. You can also have your say on the draft strategy by providing written feedback to the Department of Planning, Industry and Environment by midnight 13 November 2020 via:

Web: www.dpie.nsw.gov.au/macquarie-castlereagh-regional-water-strategy

Email: regionalwater.strategies@dpie.nsw.gov.au

Please note that all submissions will be published on the department 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, what the latest modelling is telling us and what the options for better managing water in the Macquarie-Castlereagh region could mean. Times and locations for these sessions can be found at www.dpie.nsw.gov.au/macquarie-castlereagh-regional-water-strategy

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

Image courtesy of CSIRO.

Attachment 1

Targeted stakeholder engagement

Overview

A thorough engagement program supports the development of the regional water strategies. The purpose of engagement is to inform, gain information and feedback, collaborate with key stakeholders on strategy development and build support for the regional water strategies.

Development of the Macquarie-Castlereagh Regional Water Strategy is supported by four engagement phases:

1. Targeted engagement with councils, local water utilities, joint organisations, Aboriginal people and peak bodies
2. Public exhibition of the draft Regional Water Strategy 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 and peak bodies
4. Public release of final regional water strategy.

An interagency panel was formed to assist in the development of the Draft Macquarie-Castlereagh Regional Water Strategy. This panel, chaired by Department of Planning, Industry and Environment—Water, included representatives from across the Department of Planning, Industry and Environment cluster including:

- Environment, Energy and Science
- Strategy and Reform
- Regional NSW.

Members of the panel also included representatives from WaterNSW and the Department of Primary Industries—Fisheries and Department of Primary Industries—Agriculture.

This report documents targeted stakeholder feedback during phase one of the development of the Macquarie-Castlereagh Regional Water Strategy.

Image courtesy of NSW Department of Primary Industries.

Engagement

Two rounds of stakeholder discussions were held with councils/local water utilities and Aboriginal communities between October 2019 and September 2020. The following organisations or communities participated in discussions.

Local council/local water utilities/ other organisation	Aboriginal community
Bathurst Regional Council	Brewarrina Local Aboriginal Land Council
Bourke Shire Council	Coonamble Local Aboriginal Land Council
Brewarrina Shire Council	Gamilaroi Traditional Owners
Cabonne Council	Mingaan Wiradjuri Aboriginal Corporation
Central Darling Shire Council	Narromine Local Aboriginal Land Council
Central NSW (CNSW) Joint Organisation	NSWALC Western Zone
Central Tablelands Water	Nyngan Local Aboriginal Land Council
Cobar Shire Council	Orange Local Aboriginal Land Council
Coonamble Shire Council	Warren Macquarie Local Aboriginal Land Council
Dubbo Regional Council	Wellington community
Gilgandra Shire Council	Tubba-Gah (Maing) Wiradjuri Aboriginal Corporation
Lithgow City Council	
Mid-Western Regional Council	
Narromine Shire Council	
Nyngan Shire Council	
Oberon Council	
Orana Joint Organisation	
Orana Water Utilities Alliance	
Orange City Council	
Warren Shire Council	
Warrumbungle Shire Council	

The purpose of discussions was to establish a collaborative relationship with local councils, local water utilities and Aboriginal communities and to gain an understanding of key water issues in the region.

Discussions with local councils and local water utilities focused on understanding challenges and risks to the management and supply of water, and to gain feedback on draft options and the options assessment process. Discussions with Aboriginal communities focused on cultural challenges and the development of cultural options.

Summary

Quick stats and hot topics

A total of 25 meetings were held and 114 people attended and participated in discussions during the targeted engagement phase. Information about participants and a summary of recurring themes and hot topics are outlined below.

Targeted council/local water utilities/ other organisation engagement	Targeted Aboriginal engagement
Quick stats	**Quick stats**
13 targeted meetings	Eight targeted meetings (100% of meetings held regionally)
55 people participated in discussions	48 people participated in discussions
69% of meetings held regionally	Six Local Aboriginal Land Councils and five other Aboriginal groups represented
Over 100 ideas, opportunities and challenges and suggestions identified	200 ideas, opportunities and challenges and suggestions identified
Recurring themes	**Recurring themes**
Different challenges exist in the upper and lower parts of the catchment	Cultural significance of the rivers, creeks and tributaries
Meaningful engagement is important and more realistic engagement timeframes needed	Access and protection of cultural heritage sites and practices
Drought response is the number one priority for councils	Culturally appropriate engagement and value of coming together in true partnerships
A consistent and integrated approach to water management is needed	Connectivity to land and water is essential to wellbeing and healthy communities
A greater focus on water security for all towns in the region	Cultural values need to be more clearly described in the Macquarie-Castlereagh Regional Water Strategy
Variability in regional population growth and impact on income for water services and economic prosperity	More information on how draft options will be implemented
Hot topics	**Hot topics**
Urgent town water supplies are emerging	True partnerships and a ‘seat at the table’ in the decision-making process
Groundwater knowledge and information gaps	Inclusion of Aboriginal knowledge in water management practices
Town water security to support economically significant sectors	Concern about how water is being managed and ‘owned’
Ongoing water asset ownership and maintenance costs	Coal seam gas mining impacts on water quality and creek flow

Detailed feedback

The following two tables summarise the feedback from round one and round two of the targeted engagement phase.

Council engagement

Topic	Comment

Collaboration and engagement	Attendees value ongoing and realistic collaboration and are supportive of regional scale water planning:
	• stressed the importance of ongoing partnerships so that issues and solutions are properly understood and communicated
	  - stated that ongoing feedback ensures everyone has access to the same information and can participate in the strategy process
	  - suggested a more integrated and flexible engagement approach for water management is needed
	  - expressed a desire for greater collaboration on new climate modelling
	• suggested that engagement in the catchment should be undertaken in two parts to ensure it is meaningful—above Burrendong (unregulated system in upper Macquarie) and below Burrendong (regulated system through to Nyngan and Cobar). The unregulated Castlereagh system could fall into either group
	• stressed the importance of engagement with Aboriginal people and stated that engagement should be undertaken in collaboration with local land councils and Aboriginal communities
	• suggested that some Macquarie-Castlereagh Regional Water Strategy options will require further analysis as this will not be possible within the timeframes. These options will need to be clearly identified so that further project planning can be undertaken
	• expressed fatigue with the large number of water-related discussions and suggest more realistic timeframes are required
	  - stated that drought response is a priority and advanced notification of meetings along with the provision of background material is needed
	• stressed the importance of moving forward with strategy development during the drought, even if the drought breaks, to ensure drought security projects are identified in the shortlist of options
	• stated that the Macquarie-Castlereagh Regional Water Strategy will both inform and be informed by a number of strategic planning projects such as the integrated water cycle management plan. This requires the dedicated focus of key council staff
	• suggested that Macquarie-Castlereagh Regional Water Strategy options are developed with consideration of catchment links within and outside the Murray-Darling Basin
	  - stated that links with the Lachlan, Duckmaloi Creek and Thompsons Creek catchments should be considered
	  - suggested that NSW Joint Organisations be included in future meetings regarding options development
	  - stated that Cobar is outside the region but relies on water from the region.

Topic	Comment
Town water security	Attendees want secure town water supplies and stressed the importance of reliable information to inform town water planning: • stressed the importance of reviewing the lessons of the current drought to identify the 'warning signs' and to inform drought planning • stressed the importance of groundwater and wanted to better understand the capacity and long-term sustainability of groundwater supplies - stated that Coonamble is groundwater dependent and expressed concern about the potential impact on groundwater supplies from coal seam gas mining - stated that groundwater is an important backup to other water sources in times of drought • stated that some towns on the regulated system rely on releases and have very little understanding of their water security situation. This makes it difficult for them to effectively plan for and manage drought • expressed concern that town water releases for Bathurst are being accessed for irrigation - stated that Bathurst is on an unregulated system • stated that local residents in the Warrumbungle Shire Council are concerned about coal seam gas activities and the impact this has on water sources.
Regional growth and water security	Attendees stressed the importance of water security for regional growth including tourism: • stressed the variability of regional growth noting that some areas are growing while other areas have declining populations - stated that Orange, Bathurst, Mudgee and Dubbo are experiencing population growth - stated that water security is prohibiting the growth of population and industry - stated that rating income and the capacity to provide water services are challenged in areas with declining populations • emphasised the importance of town water security to support economically significant sectors including healthcare, real estate and manufacturing • stressed the importance of local industries and business activity for economic prosperity and expressed concern that the ongoing sustainability of industry in some towns is difficult - stated that the abattoir in Coonamble is closing due to the drought and low stock numbers - stated that a motocross national event was cancelled due to lack of water for the track and a winery closed because of insufficient water—both in the Warrumbungle Shire • expressed concern that water security issues will impact on future economic activities - stated that an abattoir in Warrumbungle Shire was looking to reopen but is concerned about water supply issues - stated that water security concerns exist for the future development of inland rail as access to groundwater for dust suppression is being proposed • stated that the Macquarie Marshes is a natural tourist attraction in the region and lack of water in the Marshes has an impact on local economies • expressed concern about the possibility of a future decline in tourism as water restrictions had impacted accommodation providers and affected the ability to beautify town centres • stressed the importance of water for the viability of the local mining industry and the challenge to manage without compromising town water supply • requested that outcomes about regional growth and industry be included in the Macquarie-Castlereagh Regional Water Strategy.

Topic	Comment
Water management	Attendees stressed the need for a flexible and integrated approach to water management and greater clarity on the role of water management agencies: • stated there is a need for visibility between WaterNSW and the Department of Planning, Industry and Environment and suggested an annual communication loop with councils • expressed a desire for greater water management flexibility - stated that flexibility is needed between surface water and groundwater - stated that flexibility is needed to divert water between water resource plans - stated a need for an integrated network of water infrastructure to move water more efficiently between areas • expressed concern regarding infrastructure ownership and lifecycle costs and sought clarity on the ongoing management of infrastructure costs • sought further information on managing flood waters and flooding events - suggested that flood waters could be diverted for industry use - suggested that flood water should be counted as environmental water • expressed water quality concerns, with high salinity a problem in Baradine • expressed a need to better understand and account for productivity of urban water uses (high return per ML) • suggested that water restrictions should be standardised across council areas • noted the need to address issues of ownership, operation, maintenance and pricing for new infrastructure • advised that communities are passionate about maintaining ownership of assets. From a CNSW Joint Organisation board perspective, would like to see an administrative arrangement for the sharing of water through instruments, not through another entity.
Regional water strategy development and draft options	Attendees discussed infrastructure and non-infrastructure water security options and provided a range of comments on the Macquarie-Castlereagh Regional Water Strategy draft options: • general issues discussed - advised that people in the bush want dams - stated the construction of the Dickson Long Point Dam near Orange was supported by the Australian Government but not by the NSW Government - mentioned the dam built near Capevale Mountain is in the wrong location as it only reaches 20% full - mentioned raising the Timor Dam wall by 3 m (an extra 600 ML capacity) - mentioned raising the level of Burrendong Dam flood management zone from 100% to 120% (noted that WaterNSW has undertaken modelling work) - stated the need to set aside storage reserves for towns and connectivity - stated the need to further explore water re-use and partially treated industrial water options, noting that incentives may be needed - stated that a multi-source system is better than a single source system for sustainability in drought. Narromine Shire Council stated it had not recovered from the Millennium Drought - requested by Nyngan and Cobar councils to consistently review and implement the Macquarie-Castlereagh Regional Water Strategy, and to ensure planning is looking ahead to the next drought - suggested that existing proposals for piped town water networks in the upper and lower Macquarie should be considered - stated that waste water re-use must be considered in the regional water strategy, noting that work is needed to gain community support for this

Topic	Comment

Regional water strategy development and draft options (continued)	• option—Managed aquifer recharge (MAR) investigations and policy (with a feasible pilot project in Dubbo)
	  - CNSW Joint Organisation is keen for a couple of councils to do an MAR project
	• option—Improving town water security in the upper Macquarie unregulated river system and option – Inter-regional connections project investigation
	  - advised that the piped water network in interconnected regions is a key priority
	  - requested that a reference to the benefits of the Lake Rowlands pipeline option be made in the regional water strategy
	  - requested that pipelines of interest to upper Macquarie be included, as currently only the Nyngan to Narromine pipeline is being actively considered
	  - some councils in the lower Macquarie stated that they do not support the Nyngan to Narromine pipeline option
	• option—Burrendong Dam to Nyngan pipeline
	  - supported by Narromine Shire Council
	  - noted by Nyngan Shire Council that previous studies had indicated that the Warren to Nyngan pipeline proposal was not feasible due in part to the high operation and maintenance cost. Off-river storages are potentially better
	  - requested by Nyngan and Cobar councils to include Narromine to Nyngan as an option and to note that this option and the large Burrendong to Nyngan pipeline will need both pipeline and pump stations upgrades
	  - stated that the losses from Albert Priest Channel are excessive. Noted there are environmental/BLR/irrigation/flood mitigation benefits for keeping the channel flowing
	• options—Pipeline from the new Gin Gin weir to Nyngan and Gunningbar Creek pipeline
	  - noted by Cobar and Nyngan councils that these options are worth pursuing to see how both pipelines can more effectively deliver water and mentioned possible concerns for surrounding landholders
	  - Walgett Shire Council advised that the Gunningbar Creek pipeline is not of much interest to them, while Warren Shire Council noted environmental issues with the option
	• option—Increase Burrendong Dam's Full Supply Level
	  - Cobar and Nyngan councils advised that this option is supported by the local community
	• option—Reliable access to groundwater for towns
	  - CNSW Joint Organisation requested the regional water strategy not list specific towns
	  - Nyngan Shire Council requested that Nyngan be mentioned in this option.
	• option—Improving understanding of groundwater processes
	  - Nyngan and Cobar councils considered this to be a very important option
	• option—Investigation of licence conversions
	  - discussed by lower Macquarie councils; advised that it needs to happen.

Topic	Comment
Climate data	Attendees expressed a desire to better understand how climate data is being used in hydrological modelling: • expressed interest in the new climate data and want more information on how modelling is used for decision-making • suggested that Traditional Owner knowledge is also used to understand past climate • expressed an interest in accessing updated rainfall and evaporation data to inform their own secure yield modelling - stated that understanding secure yield is essential and should be considered in the Macquarie-Castlereagh Regional Water Strategy • stated that the Macquarie region is working collaboratively on integrated water cycle management planning and noted there are a range of benefits in working as a collective - stated that the Macquarie-Castlereagh Regional Water Strategy will impact the integrated water cycle management plan and synergies need to be identified to help cut out some of the costs for councils.
Groundwater	Attendees expressed an interest in expanding their knowledge of groundwater management: • expressed the need for more information on groundwater licences and impact of groundwater drawdown, especially during drought events • suggested opportunities to access groundwater for firefighting purposes should be explored • expressed the need for a better understanding of both the lower Macquarie aquifer and the upper Macquarie aquifers, noting that these are different • expressed an interest in storage and aquifer recharge and requested scenario descriptions in the Macquarie-Castlereagh Regional Water Strategy • stated that while surface water infrastructure adds to town security there are potential impacts on groundwater • requested that consistent guidelines be developed about reasonable versus excessive use of groundwater • stated that surface water supplies are cheaper for rate payers in the upper Macquarie councils. Groundwater comes at a higher cost • Warrumbungle Shire Council advised - Coonabarabran hasn't been able to draw water from the dam for two years. They have seven back-up bores. They are needing to rely more on groundwater but are running out of allocations - Mendooran ran out of river water. They put in a new bore last year but the deep water suffers from salination. The town runs out of water in summer because of the water take by irrigators - Binnaway has a strict licence for extracting water. There are issues with the bores - Dunedoo relies on bore water. The service water supply is being impacted by irrigators. Natural Resources Access Regulator (regulatory body) has been advised • stated that during flood events in Narromine there is an increase in nitrate levels of groundwater and expressed concern about water quality.

Aboriginal engagement

Attendees at some meetings requested their names be recorded against individual feedback. This information has been captured in the detailed meeting notes.

Topic	Comment
Cultural heritage	Attendees described the cultural significance of the region's rivers, creeks and tributaries and expressed the need to improve cross cultural understanding: • stressed the importance of accessing and protecting cultural and sacred sites • expressed concern that private property had restricted access and that sites, including artefacts, were not cared for • stressed the importance of identifying cultural sites so they can be protected and suggested that funding for further cultural mapping was needed • stressed the importance of water for cultural practices, noting that greater cultural awareness was needed • expressed concern that cultural knowledge was not valued - stated that cultural knowledge should be sourced from traditional knowledge holders - stated that Aboriginal people have immense knowledge of the region's rivers and creeks and were concerned they were being asked to hand over knowledge as volunteers - stated that traditional knowledge should be valued and paid for.
Connectivity and community wellbeing	Attendees expressed the importance of connection to water and its link with wellbeing and healthy communities: • stressed the importance of being on Country and access to water - stated that being on Country was very healing - stated that mental health is connected to the river system and water quality - stated that restricted access to water is impacting quality of life • outlined that it is a cultural responsibility to look after the river. This obligation was passed down from grandparents but has been taken away. Young Aboriginal people are now in limbo and this needs to be rectified • stressed the need to protect the water system (above and below ground) describing the rivers as veins in our bodies that connect everything • suggested that the Macquarie Marshes should be restored to provide connection to Country, cultural benefits for children and also provide economic benefits.
Coal seam gas mining	Attendees expressed concern about the impact of coal seam gas mining on water quality: • stressed the importance of protecting the great artesian basin • expressed concern that mining impacts on water quality and creek flow and this contributes to fish deaths • stated that drilling in the Pilliga will destroy the groundwater in a very sacred cultural area.
Engagement and partnership	Attendees expressed the importance of culturally appropriate engagement and a desire for true partnerships: • stressed the importance of engaging seriously and outlined concerns that stakeholder engagement will be a 'tick a box' process • stressed the importance of engagement for the duration of the regional water strategy including providing comments on proposed options and requested more engagement on the background science informing the strategy

Topic	Comment
Engagement and partnership (continued)	• suggested there is value in all stakeholders coming together and expressed concern that issues [relating to Aboriginal people] are handled in isolation • stressed the importance of establishing trust through the engagement process including the use of Aboriginal knowledge and the provision of information • expressed a desire for true partnerships, to have a 'seat at the table' and involvement in the decision-making process • stressed the importance of proper representation, noting that grassroots people are not being heard - stated that some traditional owners are not involved in the Local Aboriginal Land Councils - stated that many towns don't have representation from people that have been on Country.
Regional water strategy development and draft options	Attendees expressed a desire for the inclusion of amended cultural information in the draft regional water strategy, were generally supportive of the proposed draft options and provided a range of comments on the options: • expressed concern that cultural values are not adequately described - stated that the current explanation of cultural values is too narrow and needs to be updated and more clearly defined in terms of water. Further details regarding ecosystems and cultural sites are also needed - stated that the current listing of Aboriginal people needs to be reordered and provided details - suggested inclusions to the Macquarie-Castlereagh map to better reflect environmental and cultural issues • expressed a desire for more detailed information on how options could be implemented • option—Regional Aboriginal Water Advisory Committee - recommended that this be legislated and controlled by the community - recommended that the committee include community membership (including Traditional Owners) - recommended there be a committee for each regional water strategy area - suggested that the committee have clear terms of reference that reflect Country and culture and a proven governance model - state government appointees on the committee is not recommended • options—River Ranger Program and Regional Cultural Water Officer employment program - recommended that the Cultural Water Officer positions be known as 'Cultural Environmental Water Holders' - recommended that positions are involved in providing project advice and project monitoring, evaluation and reporting - recommended that positions are appropriately resourced • option—Culturally appropriate water knowledge program - supported this option • option—Water-dependent cultural practices and sites identification - supported this option and noted that funding would be needed to ensure its success • option—Water portfolio project for Aboriginal communities - supported this option and recommended that it could be used to train young people in contemporary water management - recommended that to be properly managed, this option needed to cover all sources of water and some attendees recommended to not allow trading

Topic	Comment

Regional water strategy development and draft options (continued)	• option—Aboriginal cultural water access licences review
	  - supported this option and recommended re-wording and clear criteria
	  - recommended the review be legislated and include monetary and non-monetary benefits
	• option—Co-management of Travelling Stock Reserves
	  - supported this option and offered to review the pilot locations and provide feedback
	• other options
	  - opposed the proposed new weir near Gin Gin on the basis that it will hold back more water destined for the Macquarie Marshes.

Water management	Attendees expressed concern across the region about how water is being managed and 'owned':
	• expressed concern that water management arrangements are inequitable and too complex
	  - stated that Aboriginal people get 'water rations' and want more involvement in water management practices
	  - stated that water users need to be more accountable and disparity exists in the use of water
	  - stated that more information and support is needed to assist in the management of water
	• expressed strong concern about supplementary water extraction practices and sought clarity on trigger events
	• expressed concern about irrigation and water trading in the context of foreign investment
	• suggested that resources are needed to address competing interests in the local catchment
	• stressed the importance of including Aboriginal knowledge in water management practices and suggested that water impact assessments (including the impact on cultural practices and sites) are needed
	• stressed the need to preserve groundwater
	• expressed a desire for more business opportunities so that Aboriginal communities could use traditional water knowledge in the management and improvement of waterways.

Water legislation	Attendees expressed the view that current water legislation needs to change and this should be undertaken in consultation with Aboriginal communities: • expressed concern with laws that stop access to water • suggested that Aboriginal communities should be included in current water sharing rules.

Environmental concerns	Attendees expressed concern about the state of the rivers, flora and fauna including deforestation near rivers, loss of reeds and other plants, sand beds, blue-green algae, carp populations and fish stranded by no or low flows:
	• stressed the need for government funding for carp and algae removal programs
	• suggested that rangers working in conjunction with Elders could be employed to monitor quality of water
	• expressed concern about the amount of water being used for irrigation and the use of pesticide by irrigators
	  - stated that pesticide use impacts on fish and water quality
	• stressed the need for cultural flows in order for more water to get to the Macquarie Marshes
	  - stated that water is being diverted from the Macquarie Marshes and that birdlife and grasses have been impacted
	  - stated that the natural level of the Macquarie Marshes from 30 years ago needs to be restored.

All feedback has been considered in developing the Draft Macquarie-Castlereagh Regional Water Strategy and stakeholders will continue to be engaged throughout the public exhibition process and the finalisation and implementation of the strategy.

Next steps

The Draft Macquarie-Castlereagh Regional Water Strategy will go on public exhibition from 25 September 2020 for a six-week period. During this period, additional targeted and general public engagement will take place and written submissions will be accepted regarding the strategy.

Following the review of the public exhibition period, further targeted engagement will be undertaken before the final regional water strategy documents are published.

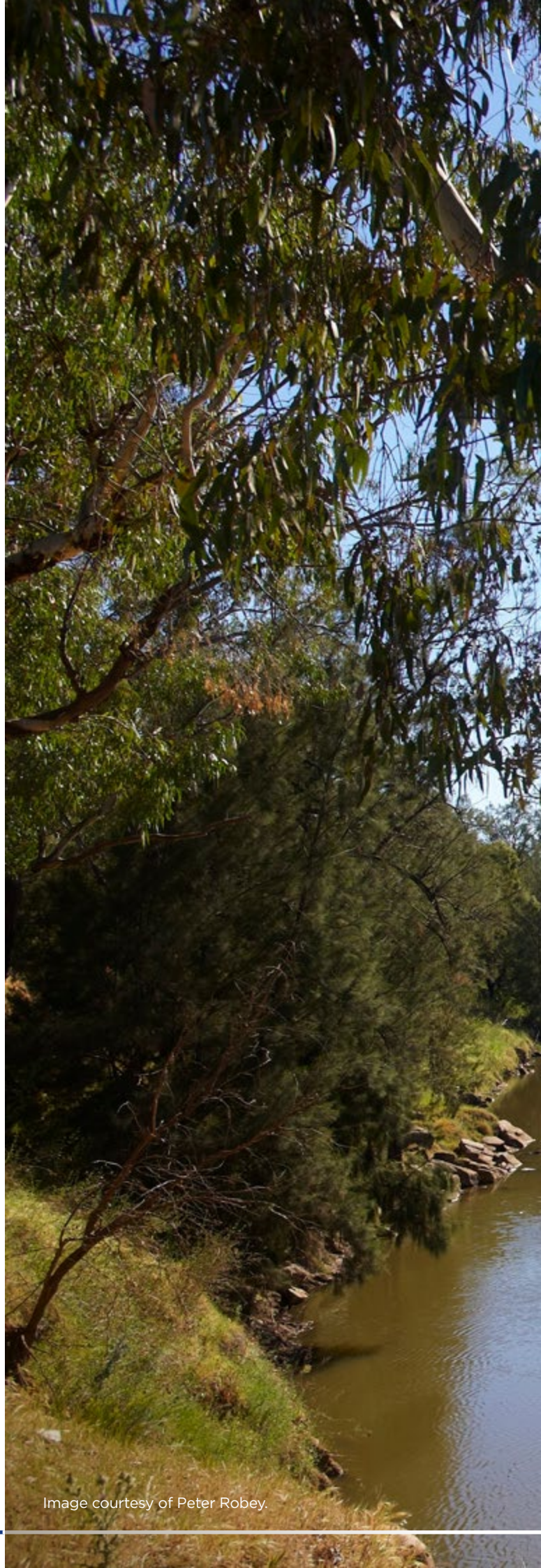


Image courtesy of Peter Robey.

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, and* *(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.
Annual crops	Annual (or broadacre) crops are harvested within 12 months of planting, and require replanting to produce a new crop. Annual crops are typically defined as winter or summer crops depending on their preferred growing season.
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 Commonwealth's *Native Title Act 1993.*
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.
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.

Term	Definition
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.
Cultural flows	While the NSW *Water Management Act 2000* does not define cultural flows, the Murray Lower Darling Rivers 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.'
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.
End of system	The last defined point in a catchment where water information can be measured and/or reported.
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.*
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. The Murray-Darling Basin Plan defines water-dependent ecosystems with particular characteristics as 'priority' environmental assets' for the purposes of environmental watering.
Environmental water	Water allocated to support environmental outcomes and other public benefits. Environmental water provisions recognise environmental water requirements and are based on environmental, social and economic considerations, including existing user rights.
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.
Extreme events	An extreme event is defined in section 10.51 of the Murray-Darling Basin Plan 2012 and in the *NSW Water Management Act 2000*. It includes extreme dry periods, extreme water quality events and any other type of event that has led to a management plan previously being suspended in the past 50 years.
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	The collection or capture and use of water flowing across a floodplain.
General security licence	A category of water access licence implemented under the *NSW Water Management Act 2000*. This category of licence forms the bulk of the water access licence entitlement volume in NSW and is a low priority entitlement (i.e. only 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.

Term	Definition
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 reshape the channel, creating habitats such as pools, bars and benches.
High security licence	A category of water access licenses in regulated rivers implemented under the *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.
Indirect employment	Jobs that are created by other businesses to support the primary employment sector.
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 (MAR)	Intentional recharge of water to aquifers for subsequent use or environmental benefit.
Operational rules	The procedures for managing releases and extractions of water (surface and groundwater) to meet the rules of relevant legislation and policy (e.g. water sharing plans, long term water plans).
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.
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.

Term	Definition
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,
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.
Replenishment flows	Flows provided from a regulated river along effluent systems to supply water for households, town use and stock.
Resilience	Resilient water resources as those that are able to 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.
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 regulated 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	Flow generated from rainfall falling on hard (impervious) surfaces.
Stormwater harvesting	The collection, treatment, storing and use of stormwater runoff from urban areas.
Supplementary licence	Where a surplus flow from rain events cannot be captured in storages or weirs, and this water is not needed to meet current demands or commitments, then it is considered surplus to requirements and a period of Supplementary Access is announced. Supplementary Water Access Licence holders can only pump water against these licences during these announced periods. Other categories of licence holders may also pump water during these periods.
Surface water	All water that occurs naturally above ground including rivers, lakes, reservoirs, creeks, wetlands and estuaries.

Term	Definition
Sustainable diversion limit	Sustainable diversion limits define how much water, on average, can be used in the Murray-Darling Basin by towns, communities, industry and farmers in a particular surface water or groundwater source. The limit is written into law in NSW through water sharing plans.
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	These are 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 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 *Commonwealth 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. 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 unacceptable water quality) and the level of acceptability they will pay for.
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 year	The annual cycle associated with the natural progression of hydrological seasons: starting with soil moisture recharge and ending with maximum evaporation/ transpiration. In NSW (as for all of the southern hemisphere), the water year runs from 1 July to 30 June.
Wetland	Wetlands are areas of land where water covers the soil—all year or just at certain times 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.

Image courtesy of NSW Department of Primary Industries.

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