Australian Government
Commonwealth Environmental Water Office

Commonwealth Environmental Water Office

Water Management Plan

2020–21

Acknowledgement of the Traditional Owners of the Murray–Darling Basin

The Commonwealth Environmental Water Office respectfully acknowledges the Traditional Owners, their Elders past and present, their Nations of the Murray–Darling Basin, and their cultural, social, environmental, spiritual and economic connection to their lands and waters.

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Foreword

It is a pleasure to present the *Commonwealth Environmental Water Management Plan for 2020-21*. Using a new, more accessible format, the Plan scopes options for where and when Commonwealth water for the environment may best be used across the Basin this year.

Our planning for 2020–21 is against the backdrop of three very dry years that have seen the environment and communities suffer. While the Bureau of Meteorology's outlook for winter and early spring rainfall is cause for optimism, we plan for all scenarios – from dry to wet - so we are prepared and can adapt to deliver the best we can for the environment.

For the first time, the Plan includes formal input from the Murray Lower Darling River Indigenous Nations and the Northern Basin Aboriginal Nations on First Nations' environmental objectives and outcomes across the Basin. This is a significant step in our on-going efforts to better integrate cultural objectives into the management of water for the environment and complements the work we do locally with First Nations people.

We have worked closely with local communities, including water managers, scientists, delivery partners, river operators, landholders, and First Nations peoples to plan our water use. Local knowledge is key to getting the best possible results for our environment – helping to prioritise and carefully plan what needs to be watered this year, river by river, wetland by wetland.

Central to our planning is matching supply with demand – comparing how much water we are likely to have with what the environment needs. What we aim to achieve is scaled to the seasonal conditions and depends on how much water is allocated to us. Every year is different.

In dry years, water is delivered to sites that provide drought refuge, helping native plants and animals survive so they can bounce back when the drought breaks. Sites in critical condition or supporting threatened plants and animals are prioritised over sites that can do without water for another year or two. In wetter years, we can piggyback on higher river flows to give wetlands a drink and reconnect billabongs and lagoons to the river so native fish can move and breed.

We begin 2020-21 with access to water carried over from the previous year. Through careful planning we set this water aside so we can deliver flows in winter and early spring when the environment most needs it. This year we have carried over 267 gigalitres in the Southern-connected Basin and 51 gigalitres in the Lachlan and northern valleys. This is the lowest volume of carryover of Commonwealth environmental water in a decade.

With storages across the Basin remaining low, early season allocations are expected to be low. In the southern Basin, our winter water use will likely be limited to maintaining river flow patterns to help native fish. We will scale our water use as the season unfolds. We hope prudent early-season use, with increased water availability will allow us to deliver larger late spring flows across northern Victorian tributaries, the River Murray, the Baaka/Lower Darling and the creeks and rivers in the Edward/ Kolety-Wakool.

In the northern Basin, unregulated flows helped to connect some rivers during late summer and autumn, however inflows to storages have been modest. Without further major rainfall, our water use will be limited to topping up refuges for native fish and possibly some small flows to internationally important wetlands such as the Macquarie Marshes, Gwydir Wetlands and Narran Lakes.

Our water use will continue to use the best science to build on successes and lessons learnt as we attempt to reverse the decline in the environmental health of the Basin over the past decades. The science is showing us water for the environment is achieving positive environmental outcomes, but recovery will take time.

In the last year, water for the environment contributed to the first major flows into the internationally important Narran Lakes in seven years; helped native fish survive in the Gwydir and Mehi rivers and Carole Creek; improved vegetation in Barmah-Millewa, Gunbower and Koondrook-Pericoota Forests, saw congolli abundant again in the Lower Lakes and reduced salt levels in the Coorong.

At the same time, and not unexpected during severe drought, we have seen no improvement in waterbird numbers; little recruitment in golden perch in the Edward/Kolety-Wakool and Lower River Murray, a decline in floodplain vegetation health and devastating fish deaths in the Baaka/Darling River.

Throughout 2020-21 we will continue working with communities across the Basin to understand local priorities and support community involvement in the planning and use of water for the environment. Individuals and groups are encouraged to get in touch with their nearest Local Engagement Officer to provide suggestions for how we can best use Commonwealth environmental water.

We will also consider all available options as we manage our water to maximise environmental outcomes, including the use of carryover and trade. The opportunity to trade water will continue to be evaluated throughout the year, however water can only be traded if our objectives have been met and there is no risk of harm to the ecosystems if environmental water is not provided in the near term.

Together we can work to deliver water for the environment to keep our rivers flowing and healthy, so they continue to sustain healthy communities.

JODY SWIREPIK

Commonwealth Environmental Water Holder

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1.1 Introduction

1.1.1 Water for the Environment

The rivers of the Murray-Darling Basin have experienced significant changes over the past 100 years. As agriculture, industries and communities have grown over time, water use has increased dramatically. While benefiting our food and fibre production, this has seen as much as 50 per cent of natural flows removed from the river in some locations. The changes in river flows have seen the health of our environment decline over many decades, which has had negative impacts on native fish, waterbirds, forests, woodlands and wetlands.

'Water for the environment' is water that is managed with the aim of restoring the health of the Basin's rivers for the benefit of all users. Water is allocated to federal and state environmental water holders across the Basin, who make decisions about when, where and how much water is released for the environment and deliver flows to where nature needs it.

1.1.2 Commonwealth Environmental Water Holder

The Commonwealth Environmental Water Holder (CEWH) is a statutory position established by the *Water Act 2007* (the Water Act) to manage the Commonwealth environmental water holdings. This water must be managed to protect or restore the rivers, wetlands and floodplains (and the native animals and plants they support) of the Murray-Darling Basin, to give effect to relevant international agreements.

Ms Jody Swirepik is the current CEWH. Ms Swirepik is supported by staff of the Commonwealth Environmental Water Office (CEWO) within the Department of Agriculture, Water and the Environment. The CEWO employs six full-time local engagement officers who live and work in regional centres across the Murray-Darling Basin.

The CEWH is governed by the Water Act and the *Basin Plan 2012* (Basin Plan) and must comply with the specific requirements and standards of Commonwealth and state legal, policy and environmental legislation and frameworks.

The water managed by the CEWH are a mix of entitlement types held across 24 catchments. The rules governing the entitlements vary across states and across valleys, but they are subject to the same fees, allocations, carryover and other rules as equivalent entitlements held by other water users.

1.1.3 What are the options for managing water for the environment?

The CEWH is a diligent, responsive and prudent operator. Commonwealth water for the environment is managed efficiently and effectively, focused on maximising beneficial outcomes. The options for managing this water include:

- delivering water to a river or floodplain to meet an identified environmental demand (**use**)
- leaving water in storage and carrying it over for use in the next water year (**carryover**)
- trading water (**trade**), which includes:
  - transferring water between connected catchments
  - buying and selling water allocations
  - using the proceeds from selling water to invest in activities that improve the outcomes from the use of water for the environment.

Each year the CEWO considers and plans for how it will manage Commonwealth water for the environment. This document explains the process by which we plan and manage this water and captures the key

information that will inform the CEWH's decisions in 2020–21. The plan reflects the collective effort of a multitude of government agencies, scientists, First Nations, and community organisations that have provided valuable input.

1.1.4 Providing feedback

The CEWO welcomes information from the community on how environmental water can best be managed. If you have any comments or suggestions, please call 1800 218 478 or send an email to: ewater@awe.gov.au.

Visit www.environment.gov.au/water/cewo for more information on Commonwealth water for the environment.

1.2 Planning Commonwealth environmental water use

Each year the CEWO considers and plans for how it will manage Commonwealth environmental water. The objective of the planning is to support the CEWH's decisions on making best use of the available water across years and across catchments. It also supports coordination of water deliveries with other environmental water holders and river operators.

Planning is undertaken at both basin scale and catchment scale and involves:

- having clear objectives and identified environmental water needs (demand)

- considering how much water is available under different scenarios (supply)

- robust planning and decision-making approaches that identify the different actions (including water use, carryover and trade) that may be undertaken under different scenarios (that is, matching supply to demand)

- collaboration and cooperation with delivery partners, river operators, site managers, First Nations, scientists, landholders and local community advisory groups

- learning from past actions and the latest information (which is underpinned by having robust monitoring, evaluation and reporting processes).

Further information on these elements are discussed below.

1.2.1 What we are trying to achieve for the environment

Under the **Water Act**[1], the CEWH functions are to be performed for the purpose of protecting or restoring the environmental assets of the Murray-Darling Basin. These give effect to relevant international agreements such as Ramsar and Bonn conventions, and migratory bird agreements with Japan, China and Republic of Korea. The Water Act[2] also states that the CEWH must manage holdings in accordance with the Basin Plan's environmental watering plan.

The Basin Plan's **environmental watering plan**[3] establishes the objectives, processes and principles that guide the management of water for the environment by the Murray-Darling Basin Authority (MDBA), Basin States and the CEWH. The environmental watering plan also sets broad targets[4] to measure progress towards meeting the objectives (Figure 1).

The **Basin-wide environmental watering strategy** provides the next level of detail on the environmental objectives and targets. It describes the environmental outcomes expected over the next decade as a result of implementing the Basin Plan and associated water reforms. These outcomes focus on four components: river

[1] *Water Act 2007* s105(3a)
[2] *Water Act 2007* s105(4a)
[3] Chapter 8 of the *Murray-Darling Basin Plan 2012*
[4] *Murray-Darling Basin Plan 2012* s8.08 and Schedule 7

flows and connectivity; native vegetation; waterbirds; and native fish (Figure 1). The CEWH must act consistent with this strategy.

Refer to Chapter 8 of the Murray-Darling Basin Plan (2012) and MDBA's Basin-wide environmental watering strategy (2019) for more detail.

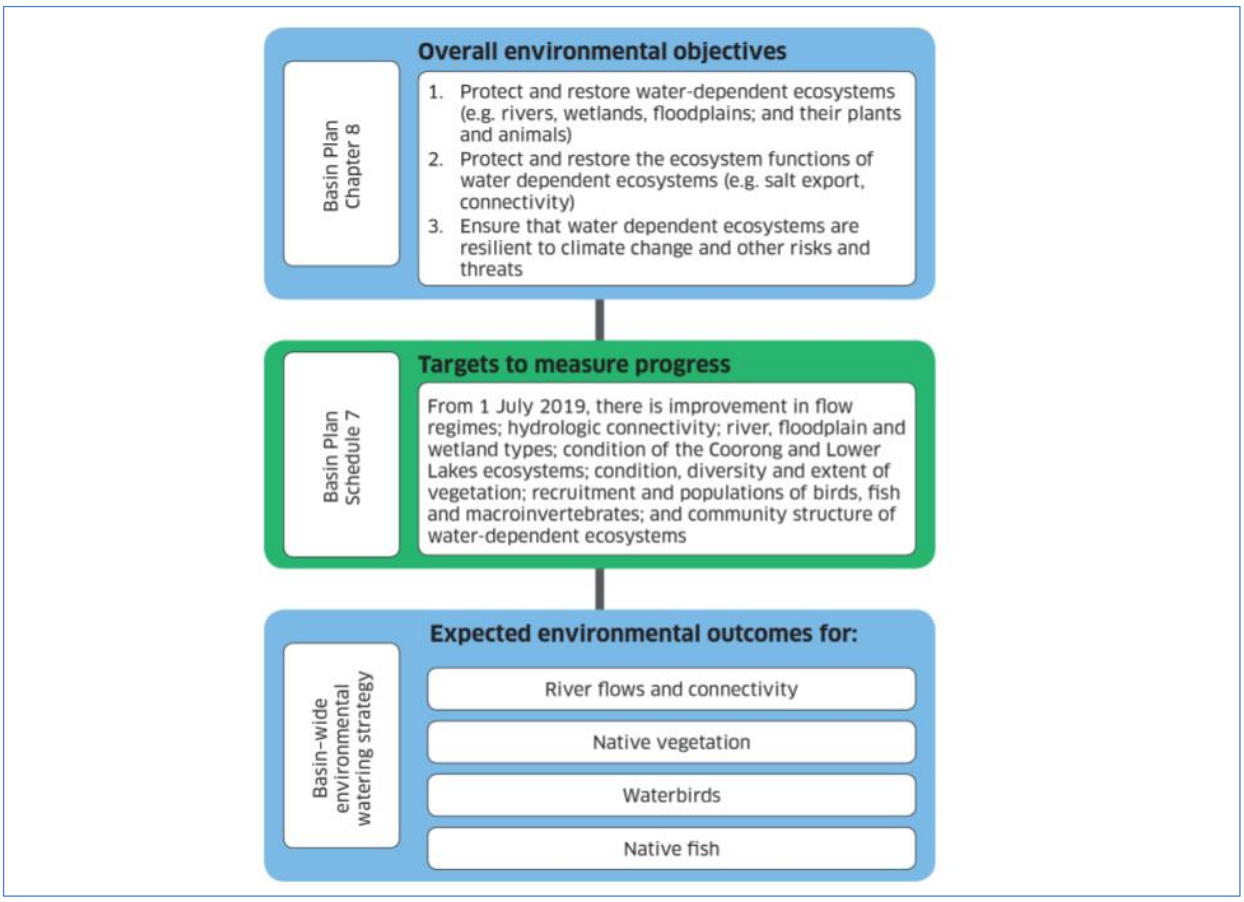

Figure 1: Hierarchy of environmental objectives, targets and expected outcomes for the Murray-Darling Basin[5].

At a valley scale, **long-term watering plans** are prepared by Basin state governments. These plans identify the key rivers and floodplains in each valley, and the objectives, targets and environmental watering requirements for each river or floodplain. They provide the key information on the long-term environmental water requirements within the valley.

These plans are being progressively developed over the coming years. Plans are currently available for catchments in South Australia, Victoria and western river valleys of Queensland, while plans are still being prepared for catchments in New South Wales and the Australian Capital Territory. Environmental water managers will continue to draw on information from the many existing documents that describe environmental watering requirements for specific wetlands and catchments, as well as local knowledge and monitoring results.

Links to long-term watering plans can be found here:

- Victorian long-term watering plans
- South Australian long-term watering plans
- Queensland long-term watering plans
- New South Wales Draft long-term watering plans

[5] *Basin-wide environmental watering strategy* (MDBA, 2019)

Prior to the start of each water year, **annual environmental watering priorities** are prepared by Basin state governments (for each valley) and by the MDBA (for the Basin as a whole). These articulate the environmental water needs (or demands) for the coming year.

The Basin annual environmental watering priorities establish both the context and key environmental water needs at a basin scale through describing the priority environmental values and the desired trend from a whole of basin perspective. The Basin priorities for 2020-21 are described in Chapter 2, Section 0 of this Plan.

The valley priorities provide local information on the key environmental demands in the coming year, under different climatic scenarios. They can provide details on the past and current environmental health of the valley, the objectives for the coming year, and the volumes and timing of desired environmental flows. Valley priorities are developing in close consultation with catchment management agencies, site managers, First Nations representatives, local landholders and community advisory groups.

First Nations environmental and cultural outcomes

Under the Basin Plan, environmental water holders must have regard to Indigenous values when undertaking environmental watering. One way this is occurring is through incorporating First Nations environmental objectives into planning processes. This occurs at the local level, with First Nations representatives typically involved in the development of watering proposals at particular sites or valleys. For the first time this year, this is also being complemented by First Nations environmental objectives at the system-scale, which have been developed by the Murray Lower Darling River Indigenous Nations (MLDRIN) and the Northern Basin Aboriginal Nations (NBAN) (see Chapter 2, Section 2.4).

There is variation between the level of First Nations input and consistency of engagement at a valley scale. This is a reflection of CEWO's journey to enhance how we work with First Nations people in the management of environmental water. We still have work to do and are continuously looking for opportunities to improve.

1.2.2 Providing water to meet environmental demands

Commonwealth environmental water planning is primarily driven by supply (how much water is available) and how this can be used to meet identified demands (what are the environment's needs).

The scope of watering actions and the environmental outcomes that can be achieved will be limited by availability of water (or 'supply') to achieve these outcomes. The Commonwealth considers current water availability and estimates its likely future supply of environmental water based on factors such as rainfall, flow conditions and forecasts of water allocations. Other important considerations include the availability of other sources of water and other likely demands in the system that can either assist or hinder the ability to deliver water to meet environmental demands.

The Commonwealth Environmental Water Portfolio Management Framework has been developed to support decisions on the best mix of water delivery, carryover and trade under different levels of supply and demand. By considering both supply and demand, the framework identifies four different purposes for managing the portfolio (Figure 2) and the outcomes that are in scope under each purpose.

In planning for the new water year, we need to be prepared for all scenarios—from very dry through to very wet, providing flexibility and ability to adapt quickly to changing conditions.

Further information on how we plan can be found within the Framework for determining Commonwealth Environmental Water Use available at:
http://www.environment.gov.au/water/cewo/publications/framework-determining-cew-use

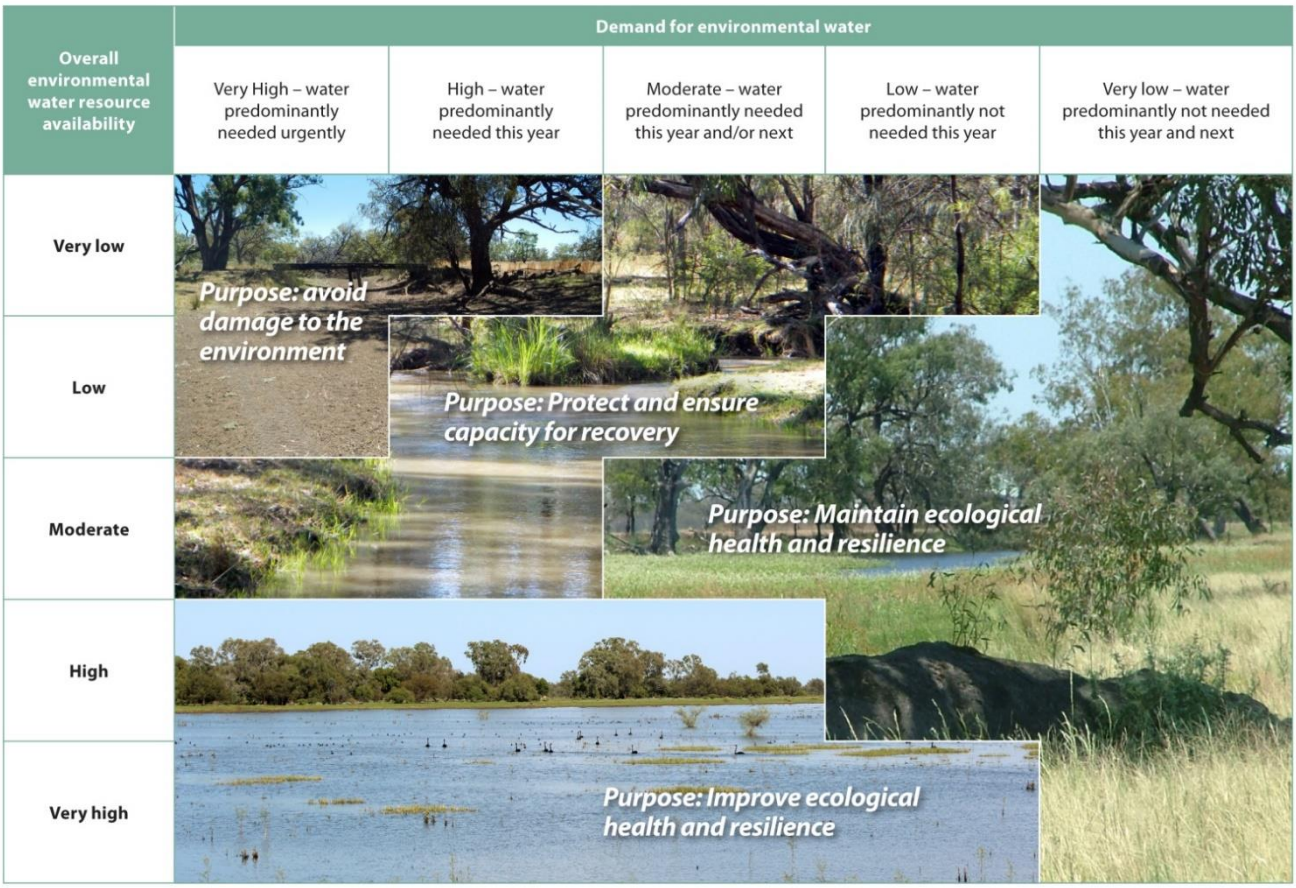

Figure 2: Environmental demand and water available influence the purpose of Commonwealth environmental water management

Our water management planning occurs at both the valley and Basin-scale. Valley annual water management plans (refer Chapter 3), include a summary of the objectives and long-term flow regime required to meet environmental demands. A multi-year approach is then taken to identifying water management intentions, considering the:

- past watering history and its impact on environmental demands and asset condition
- likely effects of planned actions on environmental demands in future years.

Once initial valley planning has been undertaken, this is then fed into a Basin-wide planning process. This process considers:

- key demands across the Basin
- opportunities to use allocation trade (purchase, sale or transfer) to rebalance the portfolio to better match differing demands across catchments
- opportunities to align environmental outcomes from watering, such as multi-site watering events in hydrologically connected catchments.

1.3 From planning to decision making

Once planning is completed, decisions on the use of Commonwealth environmental water need to be made. Many local factors influence these decisions on water delivery, carry over and trade (Figure 3).

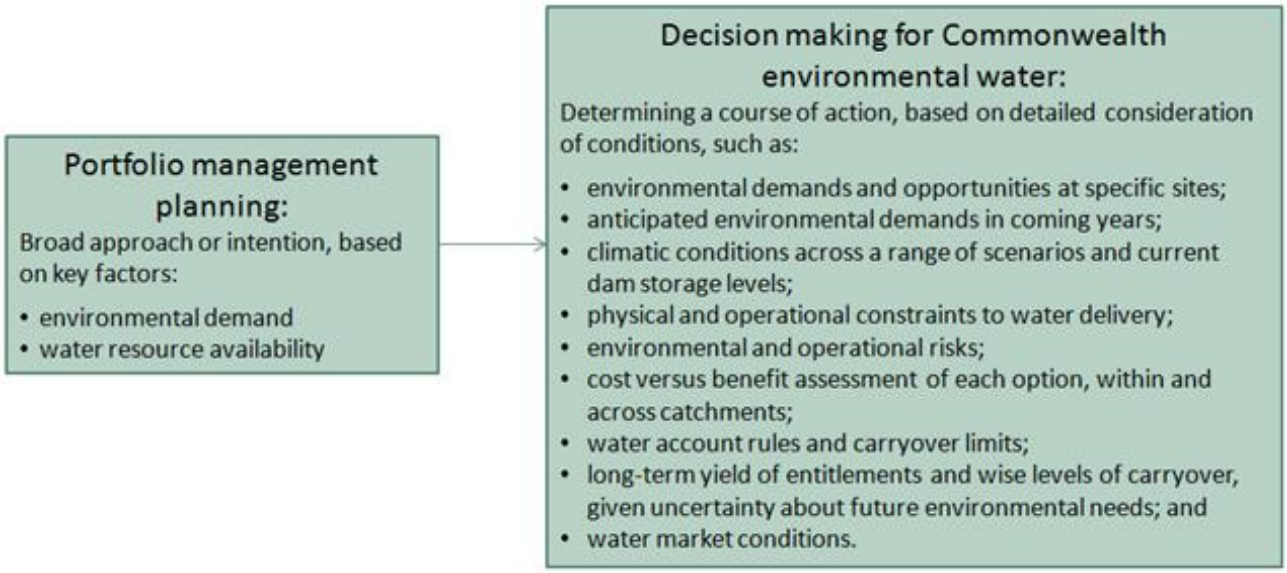

Figure 3: Factors informing planning and decision-making for Commonwealth environmental water.

1.3.1 Making Commonwealth environmental watering decisions

Towards the beginning of the new water year, the focus shifts from planning to implementation. Greater consideration is given to current and forecast catchment conditions and water availability to determine whether the watering intentions identified during the planning process can feasibly be implemented. Local on-ground knowledge is important for detailing a specific watering action including the flow magnitude, timing, triggers for commencement, rates of rise and fall and the area to be inundated.

Once an action has been scoped in more detail, an assessment is undertaken against the following criteria:

- ecological value of the river, floodplain or wetland
- expected outcomes from watering
- potential risks of watering
- long-term sustainability and management of the site
- cost effectiveness and feasibility of watering.

When a decision is made by the CEWH to proceed with a watering action, arrangements for implementation are made with delivery partners. This includes river operators, who manage the delivery of the water and operational monitoring. Local involvement is crucial at this stage of implementation and during water delivery as conditions can change rapidly and may result in the need to adjust, suspend or even cancel the watering action.

For further information see the *Framework for Determining Commonwealth environmental water use* and the *Criteria for assessing options for Commonwealth environmental water use* (available at: www.environment.gov.au/water/cewo/publications/framework-determining-cew-use).

1.3.2 Carryover

Carryover rules are set by state governments and vary markedly for different entitlements and in different water plan areas across the Basin. The carryover limits, account limits and use limits apply to all entitlement holders including the Commonwealth.

When making carryover decisions, under the rules set by Basin states, considerations include:

- having sufficient water in accounts for environmental watering actions that occur early in a water year
- considering the risk of carryover of water in accounts that may be subject to trade or use restrictions through the following water year
- considering the cost-effectiveness with regard to the cost of water delivery and transfer fees against the potential market cost of water being reallocated under State rules
- minimising the risk of water being reallocated under State rules by carrying over water in accounts with better carryover provisions
- during droughts, the minimum amount of water that can be used to sustain environmental assets whilst maintaining some carryover for future years.

1.3.3 Trade

The primary purpose behind any selling or purchase of Commonwealth environmental water is to improve environmental outcomes. The trade of Commonwealth environmental water can only occur on the open water market when the volume held in an account is excess to environmental requirements and there is no risk of harm to the ecosystems if environmental water is not provided in the near term. Under the law, water set aside for the environment cannot be given away or borrowed.

Decisions to sell water allocations are made by the CEWH consistent with the obligations under s.106 of the Water Act. Broadly, Commonwealth environmental water can be sold if one of two conditions are met:

1. If allocations are not required during the water year and either:
   a) cannot be carried over, or
   b) retaining the water is likely to result in forgoing future allocations due to account limits[6].
2. If the proceeds will be used to purchase water and/or invest in environmental activities, where the CEWH reasonably believes this will provide greater capacity to achieve environmental objectives[7].

The decision to trade water is made after considering: the current and forecast volume of water available in Commonwealth accounts; the balance of available environmental water (supply) to meet identified environmental demands; and (where appropriate) the prudent level of carryover. Decisions to trade also include undertaking a market assessment, which informs the mechanisms available to trade water, the volume of water to be pursued or made available from the holdings, the price at which the CEWH is willing to enter the market and (in the case of purchases) the available budget.

Information on current trading actions and trade intentions is available at:

http://www.environment.gov.au/water/cewo/trade.

Further information on the process and framework for conducting a trade can be found here:

http://www.environment.gov.au/water/cewo/trade/trading-framework.

[6] *Water Act 2007* s106(2)
[7] *Water Act 2007* s106(3)

1.4 How we consult and engage

Commonwealth environmental water cannot be delivered without the coordinated effort of many stakeholders. The planning, delivery and monitoring of Commonwealth environmental water is undertaken in partnership with a range of organisations and communities across the Basin.

To this effect, the CEWH regularly meets with individuals and representatives of First Nations, local government, business, landholders and peak bodies, to discuss the planning, management, and monitoring of Commonwealth environmental water. These meetings occur at locations throughout the Basin and in Canberra.

This outreach activity is complemented by the work of the CEWO, including the six local engagement officers who live and work in Basin communities. These officers are in Moree, Walgett, Griffith, Albury, Mildura and Berri. These six officers, alongside other officers of local land and water management agencies, work closely with all levels of government as well as local communities and businesses to assist members of the community to participate in environmental water planning and decision making. For further information please refer to: http://www.environment.gov.au/water/cewo/local-engagement.

1.4.1 Delivery partners

Planning for Commonwealth environmental water use involves conversations with state government departments and agencies, river operators, catchment management and land service agencies, local environmental watering advisory groups, wetland managers, holders of environmental water, the MDBA, landholders and communities, as well as the organisations responsible for the monitoring the outcomes from environmental water. These conversations identify environmental demands, relevant lessons learnt and outcomes from previous watering, barriers to delivery (e.g. infrastructure maintenance), potential risks, other complementary sources of water and any relevant operational plans.

The CEWH has entered into formal partnership agreements with the Victorian Environmental Water Holder, the New South Wales Department of Planning, Industry and Environment, the South Australia Murraylands and Riverland Landscape Board, and the Renmark Irrigation Trust. A formal partnership agreement with South Australian Department for Environment and Water is currently in the final stages of development. These agreements outline the way in which the CEWH and staff of the CEWO will work with partners to coordinate the management of environmental water. The CEWH also continues to work collaboratively with other partners where formal agreements are not in place.

1.4.2 Working with First Nations

The CEWO is committed to working with First Nations across the Basin in how we plan, deliver and monitor water for the environment.

In some cases, this is achieved through direct partnerships, where Nations can propose, plan, deliver and monitor watering events. In other cases, collaboration relies on State and local delivery partners who have working relationships with local communities and established processes for First Nations participation in management of important environmental sites, including use of environmental water.

This may include involvement in community reference groups, environmental water advisory committees or engagement with local and regional engagement officers. Many First Nations have articulated their desired environmental outcomes through these mechanisms, water resource plan consultation and/or Aboriginal Waterway Assessments.

In addition, the CEWO works with the MLDRIN and NBAN representative bodies.

1.4.3 Community engagement

Local information and experience are critical to being able to effectively manage and deliver Commonwealth environmental water. We are very grateful for the expertise, advice, feedback and support provided by our delivery partners, environmental water holders and members of regional advisory groups who invite us to

participate in their processes, and the many landowners who work with us to plan, manage and monitor the use of environmental water in the Basin.

The CEWO is involved in state government-led local engagement processes such as environmental water advisory groups. These local forums enable the CEWH to keep abreast of local information whilst accessing a range of people who are experienced in local water and land management issues. This includes community representatives (landholders, Aboriginal community representatives and others) with intimate knowledge of how their rivers, floodplains and wetlands work.

1.5 Monitoring, Evaluation, Reporting and Improvement

Monitoring, evaluation and reporting are essential to improving the planning and use of Commonwealth environmental water. Each year the evaluation of monitoring results and past delivery events expands our knowledge of managing water for the environment. This knowledge is then used to inform next year's planning (Chapter 2 and 3 of this plan) enabling adaptation and trialling of new ways to achieve improved outcomes.

To guide CEWO monitoring, evaluation and reporting activities and to ensure we fulfil our legislative and Basin Plan obligations, the CEWO has developed the Commonwealth Environmental Water Monitoring, Evaluation, Reporting and Improvement (MERI) Framework. The activities done as part of this framework assist in developing new knowledge to enhance the management of Commonwealth environmental water management. This provides the critical evidence we need to understand how water for the environment is helping protect and restore the ecosystems and native species across the Murray-Darling Basin.

Further information on the CEWO Monitoring, Evaluation, Reporting and Improvement Framework can be found here: http://www.environment.gov.au/water/cewo/monitoring.

The CEWO Monitoring, Evaluation and Research Program (Flow-MER) is a core activity within this framework. It integrates and continues monitoring and research activities under the former Long-Term Intervention Monitoring (LTIM) and Environmental Water Knowledge and Research (EWKR) projects.

The Flow-MER program has the following components:

- Basin scale – Basin evaluation, research and engagement
- Seven selected areas – On-ground monitoring, evaluation, research and engagement in the following areas:
    - Junction of the Warrego and Darling rivers
    - Gwydir river system
    - Lachlan river system
    - Murrumbidgee river system
    - Edward-Wakool river system
    - Goulburn River
    - Lower Murray River

Further information on the Flow-MER program can be found here: http://www.environment.gov.au/water/cewo/monitoring/mer-program and

https://flow-mer.org.au/.

Further information on the Long-term Intervention Monitoring (LTIM) program can be found here: http://www.environment.gov.au/water/cewo/monitoring/ltim-project.

Further information on the Environmental Water Knowledge and Research (EWKR) projects can be found here: http://www.environment.gov.au/water/cewo/monitoring/ewkr.

2 Managing Commonwealth water for the environment in 2020-21

2.1 Adaptive Management – 'Learning by Doing'

Outcomes from monitoring, evaluation and research play a key role in informing adaptive management of Commonwealth water for the environment. Collectively, we draw on the best available science, and the knowledge, insights and experiences of those people living and working in the Basin.

Environmental water delivery is still a relatively new practice, which means trialling and learning by doing from various events and outcomes. These learnings continue to be incorporated into the way water for the environment is managed to support adaptive management and help build knowledge.

Lessons Learned

The following tables (Table 1 and Table 2) provide a summary of key learnings and considerations at a Basin-scale that are contributing to inform water planning for 2020–21. The findings are drawn from the results of the past five years of LTIM and EWKR projects. For site scale lessons, please refer to the Valley Water Plans in Chapter 3.

Table 1: Basin scale key learnings from LTIM and EWKR projects

Theme	Learnings
Hydrology	• Delivery of water for the environment has contributed to restoring flow regimes through the provision of base flows. • Water for the environment has contributed to maintaining connectivity.
Productivity	• In-channel flows using water for the environment can result in increased productivity. • Source of water doesn't matter (although some exceptions apply).
Fish	• Fish responses are linked to provision of fresh and baseflows. • Impact of fish kills will be significant, and recovery will take time. • Low flow conditions and river regulation has limited spring/summer flow pulses which is linked to limited spawning and recruitment of Golden perch.
Vegetation	• Water for the environment contributes to plant species diversity and vegetation community diversity both locally and at Basin scales. • Basin vegetation communities are very diverse and support a diversity of communities – over watering can compromise native vegetation outcomes and if other areas are underwatered this may result in reduced diversity of vegetation communities at the landscape scale. • Wetting and drying regimes are important for promoting diversity and seedling growth.
Ecosystem and Biodiversity	• Water for the environment is supporting a diverse array of aquatic ecosystems that are representative of the Basin.
Waterbirds	• There is a common movement route between the north and the south of the Basin. • Waterbird chicks require a large quantity (8 tonnes of small fish/36 big macs) of food to support survival.

Table 2: Key considerations for water planning

Theme	Learnings
Hydrology	• Promoting lateral and longitudinal river connectivity to support Basin Watering Strategy outcomes is beneficial for the health of the Basin.
Productivity	• Small amounts of extra water are valuable in boosting food for fish and waterbirds. Timing for delivery is important and should be considered in terms of the intended outcome e.g. linking timing with needs for fish populations at different life-stages or waterbird breeding. • Likely to get more benefit (higher quality food resources) if water can be reconnected from floodplain and backwaters following the initial inundation. Timing is critical to avoid blackwater events.
Fish	• For fish outcomes, water for the environment should provide a range of hydraulic diversity (flow rate and depth) and hydrological connectivity. • During drought conditions, the primary objective is to support native fish persistence, including base flows. Fresh flows are important to maintain refuges, water quality and food availability. • After fish kills, it is critical to provide base flows and freshes to maintain refugia habitats, water quality and promote connectivity. • For Golden perch, where possible spring and summer freshes or pulse events should be used to trigger spawning, recruitment and dispersal of young. Water for the environment should also aim to consider the large spatial scale in which this species operates, the need for hydrological and physical connectivity for all life stages.
Vegetation	• All watering is likely to enhance plant species and vegetation community diversity at the Basin scale in some way. • Watering lignum once in every 1-3 years assists in greatest clump size which supports waterbird recruitment.
Ecosystem and Biodiversity	• Repeated annual watering of some ecosystems can have negative impacts on vegetation diversity and the diversity of flora and fauna it supports. • Multi-year watering approaches are encouraged to help maintain ecological character of Ramsar sites – consider both wetting and drying cycles and protecting biodiversity hotspots.
Waterbirds	• Basin scale thinking and coordination in planning water for the environment is required for waterbird recruitment outcomes. • For maximum impact, water for the environment could be managed to support foraging habitat and stopover within the north and south route. This could occur both between and during breeding events. • Improvements in productivity (see above) will help ensure food sources are available to support waterbird breeding events and survival of juveniles.

Reports for LTIM and EWKR: https://www.environment.gov.au/water/cewo/publications

2.2 Current conditions and seasonal outlook

The Murray-Darling Basin has just experienced the hottest and driest three-year period on record. This has significantly impacted water resources throughout the Basin, including groundwater, soil moisture and water held in storages. At the end of 2019, dam levels were at record lows. The northern Basin held just over 5 per cent capacity on average, which was 7 per cent less than the lowest levels during the Millennium Drought. The southern Basin also experienced below average winter rainfall, however total storage volumes were higher relative to the north and didn't fall lower than Millennium Drought levels, despite some low water allocations.

The ongoing dry conditions had a significant impact on rivers and most northern rivers ceased to flow by December 2019. While streamflows in the south were also below average, they didn't reach the same critical levels experienced in the north.

Above average rainfall, particularly in the north, between January and April 2020 replenished surface soil moisture levels and flows resumed temporarily in some rivers. However, there was only limited recovery in critically low major water storage levels in the north of the basin. This was reflected in the generally minor easing of northern NSW allocation restrictions. Many months of above average rainfall is needed to substantially improve water availability across the Basin.

The harsh conditions over the past three years have had devastating impacts on the Basin's ecology, with large-scale fish deaths, permanent waterholes drying up, limited waterbird breeding and declines in the health of some floodplain woodlands. Bushfires have also affected the upper reaches of some valleys, with significant amounts of ash being washed into waterways.

The recent rainfall and inflows have provided some relief. Flows reached Narran Lakes in early 2020 (which included Commonwealth water), providing the first significant watering of this Ramsar-listed wetland since 2013. Unregulated flow events also delivered water to the Macquarie Marshes and Gwydir Wetlands. Some inflows to Menindee Lakes were released into the lower Darling, connecting to the River Murray in April. This was the first time in over two years there has been full connectivity of the Barwon–Darling River from Mungindi to Wentworth. Commonwealth water that flowed from the Culgoa and Warrego rivers contributed to this important first flush and connectivity event.

Water for the environment in regulated river systems has played an important role in maintaining key parts of the Basin's environment over this period, including:

- connecting and replenishing waterholes for native fish in the Gwydir
- maintaining the health of vegetation in the core wetland habitats (and providing waterbird refuge habitat) in the lower Lachlan, the mid and lower Murrumbidgee floodplains, Barmah-Millewa Forest and Gunbower Forest
- providing elevated baseflows and freshes to support riverbank vegetation, native fish and other animals that live in northern Victorian rivers, the creeks and rivers of Mid-Murray (Barmah-Millewa, Gunbower and the Edward-Wakool system), and down the entire length of the River Murray
- maintaining the Lower Lakes at levels that avoid the exposure of acid sulphate soils
- maintaining a continuous flow into the Coorong to export salt, support fish migration and freshen the estuarine habitat.

2.3 Basin Annual Environmental Watering Priorities

Prior to the start of each new water year, the MDBA must publish Basin annual environmental watering priorities (Table 3). They are developed having regard to the annual environmental watering priorities developed by Basin States for each catchment. All environmental watering, including by the CEWH, must be undertaken having regard to these priorities.

Commonwealth environmental watering actions will seek to contribute to the Basin annual environmental watering priorities, subject to conditions as they unfold throughout the year.

Table 3: Basin annual environmental watering priorities 2020-21

	Rolling, multi-year priorities	2020–21 annual guidance
River flows and connectivity	• Support lateral and longitudinal connectivity along the river systems • Support freshwater connectivity through the Lower Lakes, Coorong and Murray Mouth	• Protect drought refuges • Build ecosystem resilience by providing or enhancing connectivity
Native vegetation	• Allow opportunities for growth of non-woody wetland vegetation • Allow opportunities for growth of non-woody riparian vegetation • Maintain the extent, improve the condition and promote recruitment of forests and woodlands • Maintain the extent and improve the condition of lignum shrublands • Expand the extent and improve the condition of Moira grass in Barmah-Millewa Forest • Expand the extent and improve resilience of ruppia in the southern Coorong	• Maintain core wetland vegetation and refuges • Avoid critical loss and (where possible) improve vegetation condition in areas where drought conditions persist • Support and build on watering events that have happened in previous years • Provide follow-up watering to consolidate improvement in lignum communities at Narran Lakes • Support growth of ruppia in the southern Coorong
Waterbirds	• Maintain the diversity and improve the abundance of the Basin's waterbird population • Maintain the abundance of key shorebird species in the Lower Lakes and Coorong	• Provide follow-up watering to build resilience in the Narran Lakes system or to support waterbird breeding and recruitment • Provide water to the Macquarie Marshes to support waterbird habitat • Support productive shorebird habitat and foraging resource availability in the Coorong, Lower Lakes and Murray-Mouth
Native fish	• Support Basin-scale population recovery of native fish by reinstating flows that promote key ecological processes across local, regional and system scales in the Southern-connected Basin • Improve flow regimes and connectivity in northern Basin rivers to support native fish populations across local, regional and system scales • Support viable populations of threatened native fish, maximise opportunities for range expansion and establish new populations	• Protect or provide flows that protect existing populations, support connectivity and sustain short-lived species recruitment • Support recruitment from breeding events and subsequent dispersal of new recruits in the northern Basin • Maintain existing populations and ensure hydrological integrity of flows in the southern Basin rivers

2.4 First Nations environmental water objectives and outcomes

First Nations environmental watering outcomes describe tangible benefits experienced by First Nations' people from the delivery of water for the environment on Country. These benefits can include:

- healthy rivers and wetlands that sustain Country in a way that allows for populations of culturally significant species to thrive,
- the improved health of culturally important places through seasonally appropriate flows.

Achieving First Nation environmental watering outcomes is therefore essential, to ensure First Nation peoples' health, wellbeing and cultural resilience.

The below advice on environmental water objectives for the northern and southern Basin have been provided directly by NBAN and MLDRIN through the First Nations Environmental Watering Guidance project. This information has been collected through the collaborative efforts of representatives from 16 Nations across the southern Basin and 16 Nations from the Northern Basin.

MLDRIN and NBAN developed their own guidance, using different approaches to reflect the differences in climate, water management and cultural diversity in the northern and southern Basin. In recognition that First Nations cannot prioritise one species over another, NBAN identified indicator species that reflect the health of Country. MLDRIN identified shared priorities for waterways and places in need of environmental water, improved flows and connectivity, vegetation, waterbirds and fish and threats to the cultural health of Country for environmental water planning in 2020–21. Environmental flows will aim to contribute to these objectives where possible.

These objectives represent a great wealth of information. However, they are not fully representative of all the Nations in the Basin and do not capture the detail, depth and complexity of Nations' localised water-related objectives. The CEWH is committed to continuing to strengthen engagement with all First Nations to support those Nations to articulate objectives for water management and shape water planning in a way that supports self-determination.

2.4.1 Northern Basin Priority Sites and Indicator Species

Table 4 lists priority sites and indicator species provided by representatives from NBAN for the northern Basin. These species are listed as they are species which are endemic to river stretches and if they were seen to be flourishing reflect the health of Country (NBAN Ltd, 2020).

Table 4: NBAN priority sites and indicator species for the northern Basin (NBAN Ltd, 2020).

River flows and Connectivity
• Paroo River must connect to Darling River (when possible) for cultural obligations to other Nations. • Macquarie River must flow at all times. • Culgoa and Warrego Rivers need to connect to Gerrera and Tego Springs. • Sufficient flows to maintain abundant animal life in Narran Lakes. • Moonie River connection event to support fish recruitment (Catfish, Yellowbelly). • Nebine River to have water at all times for ephemeral lakes and creeks, gilguuys, waterholes and connection to billabongs. • Lachlan River must flow at all times, and flow into Booberoi Creek and Willandra Creek. *Other flows and connectivity:* • Reduction of river velocity to reduce erosion. • Adequate quantity to support flows. Release soft flows (more permanent) • Ephemeral creeks to flow for lateral connectivity. • Water quality to ensure downstream river health.

Native Vegetation
Indicator species: Murray Lily, Lignum, Red Gum, Bullrush, Box Tree, Native Grasses, Mitchell Grass, Kangaroo Grass, Nardoo, Sedges, Native Spinach, Duckweed, Will Bill, Lomandra, Snotty Gobble (Mistletoe), Coolabah Belah. *Other priority species:* Iron Bark, Black Box, Sandalwood, Stringy Bark, Karrajon Tree, Ruby Saltbush, Quandong, Quinine, Water Ribbons, Blue Gum, Tea Tree, Yellow Box, Bimble Box, Naipan, Emu Bush, Gumby Gumby, Bush Onion, Yam, Eurah (*Eremophila sp*.).
Native Birds
Indicator species: Brolga, Kingfisher, Waterhen, Black Duck, Pelican, Bush Turkey, Eagle, Black Cockatoo (glossy and red tail), Australian Painted Sniper, Wood Duck, Black Koel, (Storm Bird), Red-Winged Parrot, Black Swan, Teal, Willy Wagtail, Major Mitchell Cockatoo, Whistling Kite (Red), Finch, Tawny Frogmouth, Emu.
Native Animals
Indicator species: Water Spider, Macquarie Perch, Yellowbelly, Catfish, Cod, River Blackfish, Spiny Cray, Platypus, Crucifix Frog. *Other priority species:* Water Dragon, Golden Perch, Yabbies/Bogglies, Shrimp, Mussels, Purple-Spotted Gudgeon, Jewfish, (Silver Perch), Long-Tailed Eel, Bony Breem, Kangaroo, Wallaby, Water Rat, Echidna, Bat (all varieties), Possum, Red Belly Black Dingo, Ants (all varieties), Goanna (Sand and Black), Tiny Brown Frog, Tree Frog, Bogan Moth, Longnecked Turtles.
Connecting with Country
A healthy environment is required for: communal living, research, fishing, trade, camping, weaving, gathering, transfer of knowledge, storytelling, teaching, healing, ceremony, initiation, identity and belonging, spiritual connection, wellbeing.

2.4.2 Southern Basin First Nations Environmental Watering Priorities Statement 2020-21

Representatives of 16 First Nations across the southern Murray-Darling Basin have contributed information about their priorities for the use of environmental water in 2020-21 as part of the First Nations Environmental Water Guidance project.

First Nations share common concern for all major rivers across the region. In particular, multiple Nations submitted priorities relating to the Murrumbidgee, Baaka (Darling River), Lachlan, Campaspe, Murray and Edward-Wakool systems. First Nations understand that declining river health and low flows in one part of the Basin can affect communities and cultural outcomes across the region.

Nations want to see improvements in water quality and the volume and timing of flows in all major rivers, and particularly in degraded river systems. Improved seasonality of flows, informed by First Nations' science and traditional knowledge, is a key to sustaining the cultural health of major waterways. Addressing barriers and constraints, such as barriers to fish movement, is essential to sustain the interconnectivity which underpins First Nation stories and cultural values. Improving the health of tributary waterways and ensuring adequate flows, is also a key to revitalising major rivers.

Participating Nations' contributions stressed the significance of wetlands, billabongs and floodplains. Nations want to see life return to these culturally significant places through watering activities that create connectivity between rivers and floodplains and restore the hydrological cycles of degraded wetlands, thereby supporting cultural values and resources.

Participating Nations identified key plant and animal species that are most in need of watering in the 2020-21 watering year. Key culturally significant fish such has Murray Cod, Golden Perch (Yellowbelly) and catfish were identified as priorities by most Nations. More than half of all contributing Nations highlighted black swans, pelicans and duck species as culturally significant waterbirds that would benefit from environmental

watering. Improved health and abundance of old man weed and other medicinal plants were noted as priorities for vegetation, alongside improved outcomes for river redgums, blackbox, cumbungi and lignum.

Critically, Nations stressed the importance of considering outcomes beyond fish, waterbirds and vegetation. Nations also want to see improved outcomes for aquatic fauna such as turtles, yabbies, frogs, platypus and rakali (water rat). The contributions also stressed the importance of environmental watering in sustaining healthy populations of important terrestrial fauna such as kangaroo and emu.

Participating Nations have identified a range of key threats to the cultural health of waterways as well as preferences for improved participation in environmental water planning for 2020-21. Water holders should consider these preferences alongside the detailed, locally specific watering objectives produced by Nations. It is essential that water holders continue, and strengthen, direct engagement with First Nations to empower participation in environmental water planning and delivery.

2.5 Water availability

Water words

Entitlement: Also known as a licence or holding. An entitlement is a legal right to a share of the water available at a location, subject to rules and conditions. Water entitlements can be used for a range of purposes, including household use, industry, irrigated farming or the environment. A bucket is a good metaphor for a water entitlement – the bigger the water entitlement, the bigger the bucket.

Allocation: the amount of water made available in proportion to the entitlement (how full the bucket is). Available water varies from year to year, depending on how much water is in storage and how much it has rained. Dry/drought years will have low water allocation/low availability, while average/wet years have a higher water allocation/high availability. Whether or not an allocation is made may depend on the type and/or security of the entitlement. Generally, each entitlement (bucket) gets filled with water (allocation) as more water becomes available in storage. Some entitlements are not linked to water storage (unregulated entitlements) and allow diversion of in-river flows above a certain height/rate or flows in excess of what is needed to supply consumptive users.

Carryover: the amount of water allocated and not used in a water year that can be used in subsequent years, depending on the rules and conditions of the entitlement. Carryover is sometimes used by water holders as a strategy to get through dry times.

Security/reliability: the higher the security/reliability level of the entitlement, the more certainty of a water allocation each year.

Commonwealth water entitlements are subject to the same state government regulations, fees, allocations and other rules as apply to equivalent entitlements held by other water users. In valleys where carryover is available, Commonwealth entitlements are governed by the same rules as other water users. Environmental water managers need to make careful decisions about how much water to use, trade or carryover, just like other water users.

In times of drought, allocations are reduced the same way for all water users – including environmental water holders. The Basin Plan prioritises water for critical human needs (drinking and household water) before being allocated for any other use.

In unregulated river systems, water cannot be ordered from public storages at a particular time – environmental water can only be sourced as a share of an unregulated flow event. Thus, carryover and management of account balances cannot generally be used to influence the timing and volumes of environmental water in these river systems.

Table 5 summarises the carryover and allocation forecasts for regulated Commonwealth environmental water. Allocation forecasts through until 30 June 2021 are sourced from the relevant state agencies where the information is available and long-term averages where state agencies do not provide these forecasts.

Information on allocations to Commonwealth environmental water holdings and volumes transferred for delivery can be found at http://www.environment.gov.au/water/cewo/portfolio-mgt/holdings-catchment. This information is updated monthly.

Table 5: Carryover and forecast allocation of regulated (surface water) Commonwealth environmental water in 2020-21

Catchment	Carryover from 2019-20 (GL)	Forecasts of regulated allocations (including carryover) in 2020-21 (GL)					
		Very dry ◄					► Very wet
		95 percentile	90 percentile	75 percentile	50 percentile	25 percentile	10 percentile
Border Rivers	2.2	4.9	5.2	6.5	9.4	11.4	12.9
Gwydir	12.0	16.5	16.5	16.5	32.8	56.5	90.4
Namoi	0.6	0.7	0.7	1.6	4.6	9.2	15.0
Macquarie	22.7 ^	22.7	23.7	31.5	92.1	148.9	148.9
Lower Darling	10.8	15.0	16.5	17.6	25.8	25.8	25.8
Lachlan	16.0^^	16.7	16.9	16.9	67.4	103.9	121.2
Murrumbidgee	62.0	107.5	146.2	223.8	301.5	350.9	350.9
Ovens	0	0.1	0.1	0.1	0.1	0.1	0.1
Upper Broken Creek and Broken River	0.1	0.1	0.3	0.5	0.5	0.5	0.5
Goulburn	55.2	198.1	233.1	369.6	372.8	372.8	372.8
Campaspe	0.4	0.7	1.7	5.1	7.0	7.0	7.0
Loddon	0	1.1	1.9	3.3	3.4	3.4	3.4
Wimmera	0	0	0	0	0	0	0
Murray – NSW	20.0	47.5	47.8	97.6	185.7	353.3	425.4
Murray - Vic	118.4	288.7	310.4	451.7	480.7	480.7	480.7
Murray - SA	0	162.1	162.1	162.1	162.1	162.1	162.1
Southern-connected Basin Total[8]	**267**	**821**	**920**	**1 332**	**1 539**	**1 756**	**1 829**
Regulated Total	**320**	**882**	**983**	**1 405**	**1 746**	**2 086**	**2 217**

^ until conditions improve, only 40% of carryover is available for environmental use with remaining quarantined for drought reserve accounts

^^until conditions improve, 100% carryover is quarantined in drought reserve accounts and is unavailable for environmental use

2.6 Water delivery in 2020–21

Approximately 333 gigalitres of CEWH water was carried over into the new water year, with about 267 gigalitres carried over in the southern-connected Basin, 31 gigalitres of groundwater, and the remaining 53 gigalitres in the Lachlan and northern valleys. At the start of the water year, 31 gigalitres of the 53 gigalitres in the Lachlan and northern valleys was quarantined in drought reserves and is unable to be called for delivery until inflow conditions improve. This is the lowest volume of carryover of Commonwealth environmental water in a decade, reflecting the dry conditions experienced in 2019-20. In addition, storages across the Basin remain low and as such, early season allocations are low.

[8] The Southern-connected Basin is the network of rivers that feed into the Murray River between the Hume Dam and the sea. This includes the Lower Darling, Murrumbidgee, Murray, Ovens, Goulburn-Broken, Campaspe and Loddon valleys.

Consequently, environmental water use in winter in the Southern-connected Basin is likely to be limited to helping maintain minimum baseflows, with more significant water use delayed until spring. This could include providing spring freshes across several catchments (such as the northern Victorian tributaries, the River Murray, the Lower Darling and the creeks and rivers in the Edward-Wakool system). The size of these flows will be dependent on the prevailing conditions, with the volumes scaled up under wetter conditions. Similarly, the opportunity to provide flows to important off-channel wetlands will increase as conditions get wetter.

In the northern Basin, unregulated flows have provided some connectivity during late summer and autumn. However, inflows into northern storages have been modest and without further significant inflows, water use may be limited to contributing to refuges for native fish and possibly some small flows to internationally significant wetlands, in addition to contributing to unregulated flow events.

2.7 Trading water in 2020–21

The CEWH protocols governing the trade of Commonwealth environmental water are detailed in the Commonwealth environmental water Trading Framework, available at: https://www.environment.gov.au/water/cewo/publications/water-trading-framework-nov2016

Should the CEWH decide to enter the retail water market at any time during 2020-21, information will be publicly disclosed to inform participants in the retail water market ahead of any trade of Commonwealth environmental water at http://www.environment.gov.au/water/cewo/trade

2.7.1 Commercial trade

The CEWH has no plans to either buy or sell entitlements in the July to September 2020 period and is unlikely to enter the entitlement market until water recovery to meet the volumetric water recovery targets established in the Basin Plan 2012 have been reached.

Large parts of the Basin are currently experiencing pressures from water scarcity, with declining storage levels, low allocations and rainfall deficiencies evident in most catchments. The extended dry conditions have seen parts of the environment experience stress and declining health, particularly in the Darling River and its tributaries. There is low likelihood of the CEWH selling water allocations under these conditions.

Trade opportunities are reviewed in all valleys throughout the water year and as conditions change.

2.7.2 Administrative Transfers

In 2020-21, administrative transfers may be required between environmental water accounts in the Southern-connected Basin trade zones 6, 6B, 7, 10A, 10B, 11 and 12 to enable environmental water delivery. Based upon water resource availability at the time of the watering event and scale of the event, this may include:

- small transfers for environmental watering activities
- moderate transfers (~ 50 gigalitres) through the Barmah choke from trade zone 7, if required and allowable given the Barmah Choke trade limit
- large transfers (>100 gigalitres)
    - within trade zones, due to the large size of environmental watering activities.
    - From New South Wales Murray and Victorian Murray to South Australia, most likely during Summer-Autumn for environmental outcomes in the Coorong and Lower Lakes.

2.8 Carrying over water for use in 2021–22

The volume of water carried over for use in 2021-22 will depend upon how the 2020–21 water year unfolds, overall water availability and both current and future environmental demands.

If very dry conditions eventuate in 2020-21, there may be very little water to carryover for use in the following year, as it is expected that most of the available environmental water will be required to meet key environmental needs. However, under dry to wet scenarios in the southern Basin, a volume of water will be reserved to help meet early season needs in 2021-22.

In the north, given the low volumes of water in storage at the start of the water year, the opportunity to carryover water for 2021-22 in the regulated northern valleys will be limited by inflow conditions into storages as the water year unfolds. Under a very dry scenario, water carried over into 2021-22 would be set aside to maintain key environmental needs. Under moderate to wet scenarios, carryover volumes may be used to assist in the recovery of core wetland and native fish communities over multiple water years.

3 Valley Water Plans

This chapter describes the specific environmental objectives, recent conditions, supply, demand, priorities and monitoring outcomes/lessons learned for each of the following valleys:

3.1 Border Rivers

3.1.1 Region overview

(a) River system

The Border Rivers catchment covers around 49 500 km^2 in southern Queensland and north eastern NSW, with roughly an equal area in each state. The system is based around the Macintyre and Dumaresq rivers, which merge upstream of Boggabilla and continue as the Macintyre River (**Figure 4**). The Dumaresq, Macintyre and the part of the Barwon River downstream of the junction of the Weir River to Mungindi (the end of the Border Rivers system) forms the border between NSW and Queensland for approximately 470 kilometres. The Weir River, wholly in Queensland, is the only significant tributary of the lower Macintyre River.

Rainfall in the Border Rivers catchment is summer-dominant and highly variable, resulting in highly variable stream flows between years.

The major public storages are Pindari Dam on the Severn River in NSW (312 gigalitres), Glenlyon Dam on Pike Creek in Queensland (254 gigalitres), and Coolmunda Dam on Macintyre Brook in Queensland (69 gigalitres). The volume of on-farm storage is comparable to public storage, reflecting the importance of unregulated flows to irrigation supplies in the catchment. On a long-term average basis unregulated entitlement (supplementary water licences in NSW and unsupplemented water allocations in Queensland) and diversions in the Border Rivers catchment exceed regulated water entitlements and use.

(b) Traditional Owners

The lands of the Border Rivers catchment have been important to Aboriginal people for more than 25 000 years. Aboriginal nations of the region include the Bigambul, Euahlayi, Githabul, Kambuwal, Gomeroi/Kamilaroi, Kwiambul, and Ngarabal. Traditional owners have longstanding and continuing ties to country and hold the many billabongs along the rivers in this catchment in high regard. Of particular importance is the Morella Watercourse/Boobera Lagoon/Pungbougal Lagoon complex located on the Macintyre River floodplain south of Goondiwindi.

(c) Important sites and values

Key environmental assets in the Border Rivers catchment include:

- the Border Rivers main channels (Severn, Dumaresq, Macintyre and Lower Macintyre Rivers to Mungindi and the Weir River
- anabranches downstream of Yetman/Texas
- Queensland Macintyre River billabongs
- wetlands, billabongs and lagoons in the Lower Dumaresq/NSW Severn and Lower Macintyre rivers
- Toomelah station near the junction of the Macintyre and Dumaresq rivers.

The Border Rivers catchment supports a number of species and endangered ecological communities listed under the *Environment Protection and Biodiversity Conservation Act 1999*, the *NSW Biodiversity Conservation Act 2016,* or the *NSW Fisheries Management Act 1994*. These include native fish species such as Murray cod, silver perch, purple-spotted gudgeon, olive perchlet and eel-tailed catfish. Various wetlands and waterholes also support internationally and nationally significant waterbirds, for example, brolgas, Australian painted snipe, black-necked stork and magpie geese.

Parts of the Border Rivers are also included in the Lowland Darling River aquatic ecological community, which is listed as endangered under the *NSW Fisheries Management Act 1994*. This includes the Macintyre River below Graman Weir, Severn River below Pindari Dam and the Dumaresq River below the junction with the Mole River, along with their associated lagoons, billabongs, anabranches and floodplains.

(d) Stakeholder engagement

In the Border Rivers catchment, the planning, management, and delivery of Commonwealth water for the environment is undertaken conjunction with a range of partners and stakeholder groups. Key stakeholders in the NSW part of the catchment include the NSW Department of Planning, Industry and Environment (DPIE), the Department of Primary Industries (DPI) – Fisheries, Local Land Services and WaterNSW. In Queensland, key stakeholders include the Queensland Department of Natural Resources, Mines and Energy (DNRME), Department of Agriculture and Fisheries (DAF), Department of Environment and Science (DES) and Southern Queensland Landscapes. Advice on the use of Commonwealth water for the environment in the Border Rivers is also provided by landholders, traditional owners, the Boomi Trust, local and regional councils, and Border Rivers Food and Fibre.

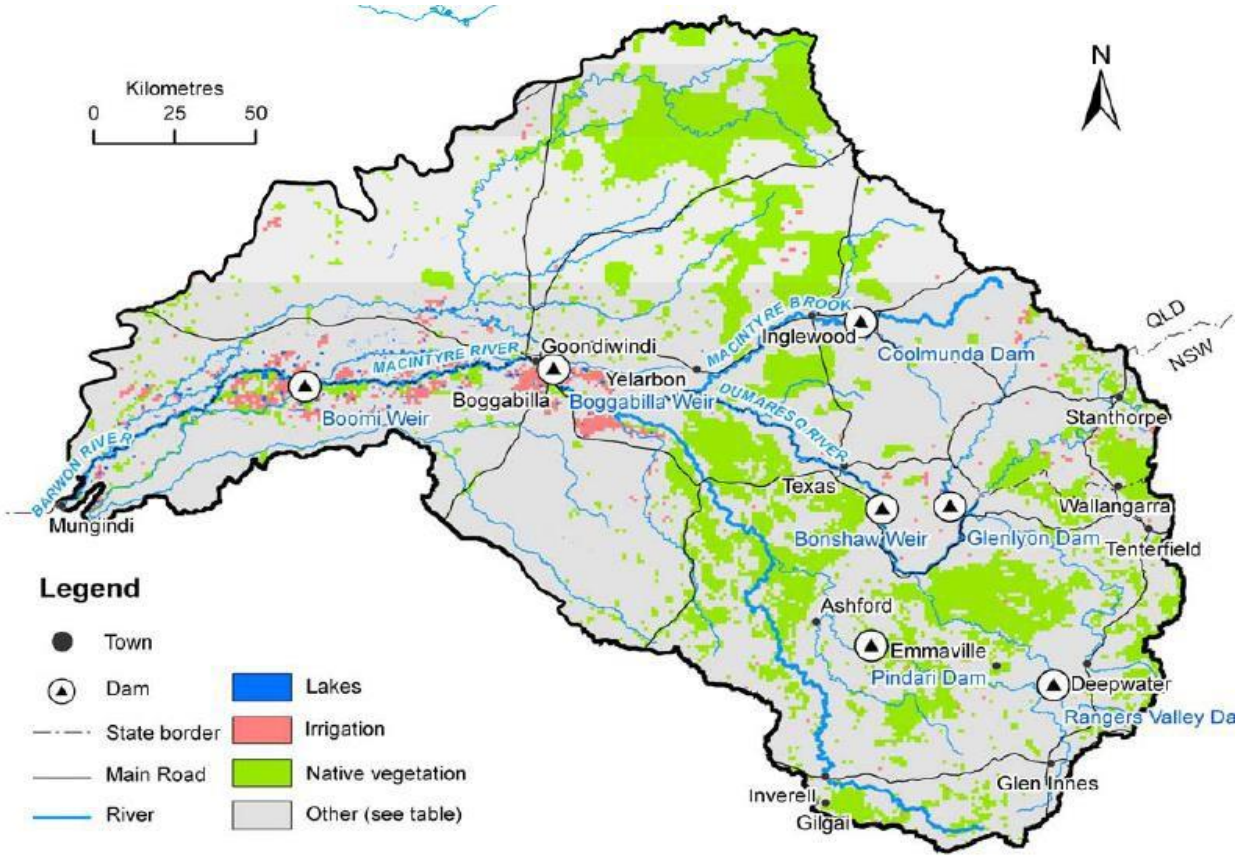

Figure 4: Map of the Border Rivers catchment (CSIRO 2007).

3.1.2 Environmental objectives

Based on long-term environmental objectives in the Basin Plan, draft state long-term watering plans, site management plans, and best available knowledge, the following objectives are relevant for environmental watering in the Border Rivers River catchment.

The objectives that are targeted in a particular year may vary, depending on available water, catchment conditions, operational feasibility, and demand for environmental water. These objectives will continue to be revised as part of the Commonwealth Environmental Water Office's (CEWO) commitment to adaptive management.

Vegetation: Maintain the condition, growth and survival of riparian, in-channel, floodplain and wetland vegetation.

Waterbirds: Increase waterbird abundance and maintain species diversity by supporting naturally triggered breeding events, and maintaining suitable refuge, feeding and breeding habitat at targeted floodplain sites.

Native fish: Prevent loss of native fish species and improve population structure and distribution, by supporting opportunities for movement, dispersal, reproduction, and recruitment.

Other vertebrates and invertebrates: Support opportunities for the reproduction and recruitment of other native aquatic species, including frogs, platypus, native water rats, turtles, and freshwater mussels.

Connectivity: Support longitudinal connectivity, including with the Barwon River, and lateral connectivity between the river, wetlands and floodplains.

Processes/water quality/resilience: Support key ecosystem functions and promote productivity; maintain water quality in channels and pools; and maintain drought refuge habitat.

3.1.3 First Nations environmental watering objectives

Representatives of the First Nations peoples of the Border Rivers have identified environmental objectives for their country for 2020–21 (

Table **6**). These objectives were developed through the First Nations Environmental Guidance project undertaken by the Northern Basin Aboriginal Nations organisation.

CEWO identifies the need to establish working partnerships with local Traditional Owners and the local Aboriginal communities in the Toomelah-Boggabilla and Mungindi communities of the Border Rivers. Government has had very little engagement with these communities to date. This lack of engagement has left these communities feeling neglected and will require healing, which we hope to begin to address via a more formal process. CEWO is looking to grow relationships around environmental water management with these and other Traditional owners and Aboriginal communities in the Border Rivers. Toomelah-Boggabilla and Mungindi community members place great value on the flows in rivers and creeks and connectivity to lagoons and billabongs to support life for all creatures, including human beings. There are many places of great importance in the Border Rivers, especially Boobera Lagoon, as well as the Morella – Pungbougal lagoons complex, along with many sites and parts of the Dumaresq and Macintyre Rivers, the Barwon River at and around Mungindi, Whalan Creek and Boomi River.

Some of these objectives sit outside the scope of water for the environment to influence, while for others, the link between water for the environment and the site or species is not well understood.

The CEWO is committed to working with First Nations groups to better understand their objectives. The CEWO will use environmental flows to contribute to these objectives where possible and where this is consistent with the Commonwealth Environmental Water Holder's statutory responsibility of protecting and restoring environmental assets in the Basin.

Table 6: First Nations environmental objectives for the Dumaresq and Macintyre rivers for 2020–21 (NBAN Ltd. 2020)

River flows and Connectivity
Priority sites: Macintyre River – provide backflow at Rainbow Reserve for waterbird breeding and nesting. Macintyre Brook and Dumaresq River – provide flows to support local platypus populations. Grinding grooves site [i].
Other flows and connectivity: (All Border Rivers) maintain flows. Local advice is needed to inform this objective. Regular flow events which support instances of breeding and reproduction for shellfish and crustaceans (including mussels and shrimp). Maintain flows at Texas and Inglewood so that a healthy waterway is achieved, allowing us to continue to practise our way of life [i].
Native Vegetation
Indicator species: Gidgee gum [i], blue gum [i], bulrush, water lily, sedges, tea trees [i], sandalwood [i], iron bark (poplar box) [i], bloodwood [i], lomandra and other aquatic reeds and grass species.
Native Birds
Indicator species: Brolgas, teals, crimson wings [i], budgerigar [i], ground parrot [i], wood duck, black duck, water hen.
Native Animals
Indicator species: Dhufish (eel-tailed catfish), yellowbelly, purple-spotted gudgeon, platypus, crucifix frog, silver perch, mussel, turtle, shrimp, water dragon (and other lizards), water rats.
Connecting with Country
To continue practising our way of life in a way that is not only healthy for the river and environment but keeps us healthy as well [i]. Collection of reeds and grasses for weaving [i]. Gathering (fishing, swimming and camping) Collection of bush tucker and medicine [i]. Hunting and tool making [i]. To gather and heal together [i].

[i] Water for the environment targeting other environmental outcomes may influence this species or objective

3.1.4 Recent conditions and seasonal outlook

(a) Recent conditions and environmental water use

In 2018–19 and the first half of 2019–20, the Border Rivers experienced very hot and dry conditions, with some areas experiencing the lowest rainfall and highest temperatures on record. Storage levels in the Border Rivers were very low, and there was zero access to water for general security users. From August 2019, the catchment was managed under Stage 4 (the highest level) of the NSW Extreme Events Policy, with water prioritised for critical human needs. A block release from Glenlyon Dam was made in September and October 2019 to move water to Boggabilla for Goondiwindi town water supply.

Conditions began to improve in early 2020, with above average to very much above average rainfall across the catchment, resulting in an increase in soil moisture and small flows into Pindari and Glenlyon dams. Good flows occurred in the regulated system downstream of the dams, and in most unregulated tributary and distributary systems. Temporary orders were put into place in late February 2020 to protect these flows.

These improvements in water availability meant that supplementary access was announced in the NSW Border Rivers in late February, March and April 2020. It also resulted in the restrictions on access to high and general security water being eased in February 2020, and the system was downgraded to Stage 3 of the NSW Extreme Events Policy in March 2020.

However, the episodic rainfall following extended hot and dry conditions resulted in rapid reductions in dissolved oxygen in the Border Rivers. This led to localised fish kill events in some locations in early 2020, and large-scale deaths of freshwater mussels. Bushfires also affected parts of the Border Rivers in spring 2019, resulting in fish deaths in November (Reedy Creek and Dumaresq River, downstream of Reedy Creek, Tenterfield Creek and Millers Creek in the vicinity of Tenterfield). In the NSW parts of the catchment fish rescue measures were undertaken in spring and summer 2019–20.

The resource shortfall in the Border Rivers has eased, with the possibility of general security allocation being announced in the future, should inflows continue. Nevertheless, further significant inflows are still required before there is sufficient water available to meet all system requirements in 2020–21 or announce any new allocations.

Commonwealth environmental water use in the Border Rivers in 2019–20 was limited to Queensland 'unsupplemented' (unregulated) entitlements in February 2020. The total contribution of Commonwealth environmental water was 3 165 megalitres.

Details of previous Commonwealth environmental use in the Border Rivers catchment are available at: http://www.environment.gov.au/water/cewo/catchment/Border Rivers/history.

(b) Seasonal outlook

According to the Bureau of Meteorology outlook on 2 July 2020, above median rainfall is forecast across the Border Rivers from late winter through spring. While this forecast indicates that the severe dry conditions may ease, several months of above average rainfall are needed to see a recovery from the current long-term drought. Additionally, maximum temperatures are likely to remain above average over the coming months.

(c) Water availability

The volume of Commonwealth environmental water carried over in the Border Rivers for use in 2020–21 is 2.2 GL (1.3 GL in Queensland and 0.9 GL in NSW (NSW DPIE 2020). The Commonwealth also has 1 437 megalitres in NSW supplementary entitlement, and up to 19 986 megalitres in Queensland 'unsupplemented' entitlements. However, as these entitlements rely on large inflows in excess of regulated river requirements, they are also unlikely to be available unless resource availability significantly improves.

Based on the expected available volume of water held by the Commonwealth and other water holders, as well as recent and forecast catchment conditions, it is expected that the overall resource availability will be very low to low in 2020–21. Should conditions remain dry, no environmental water will be available for use in 2020–21.

(d) Environmental demands

Considering the ongoing drought, the potential for further hot and dry conditions in the Border Rivers Catchment in future, and need to avoid further damage to key assets, there are a number of environmental demands that require water urgently in 2020–21.

The environmental water demands for assets in the Border Rivers Catchment in 2020–21 are represented in **Table 7**, Note that the capacity to contribute to these environmental demands is contingent on a substantial improvement in water availability in the catchment.

Table 7: Environmental demands, priority for watering in 2020–21 and outlook for coming year in the Border Rivers catchment

Environmental assets	Target values	Indicative demand (for <u>all sources of water</u> in the system)[6]		Watering history[7]	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Border Rivers main channels: Dumaresq, Severn (NSW), Macintyre, lower Macintyre to Mungindi (including Weir River) Native fish Instream aquatic ecosystems	Native fish resilience, reproduction, conditioning and maintenance. Maintain in-channel habitats during low flows, water quality and longitudinal connectivity. Instream aquatic ecosystem processes e.g. scouring habitat inundation	**Baseflows, flow variability and connectivity** <u>Dumaresq</u> 100 ML/day baseflow (BF) at Glenarbon <u>Severn/Macintyre Rivers</u> 50 ML/day BF at Ducca Marrin <u>Lower Macintyre River</u> 400 ML/day at Mungindi for connectivity Duration and frequency of baseflows dependent on outcomes required (e.g. 7 days in Sept–March in 1 in 1–2 years to provide connectivity and sufficient depth for fish movement).	As required in extreme dry conditions or to provide variability. Potential triggers extended cease-to-flow: <10 ML/day for more than 25 days gauged at Glenarbon (Dumaresq) and <2 ML/day at Ducca Marrin (Severn) impacting on persistence of larger waterholes in the Dumaresq or Severn) To provide variability (triggers: cease to flow (<30ML/d) for more than 30 days at Mungindi).	<u>Dumaresq</u> Demands were met annually since 2012 to 2018–19. In 2019–20 demand was met but flows at Glenarbon were <20 ML/day from July to September 2019 and mid-October 2019 to early February 2020. Required annually – therefore a high demand. <u>Severn/Macintyre</u> Demand met annually since 2012. Demand partially met in 2019–20 (flows >50 ML/day at Ducca Marrin on 18/02/2020 only, but flows were >2 ML/day throughout 2019–20. Required annually – therefore a high demand. <u>Lower Macintyre</u> Demand met annually 2012–18 with exception of 2014–15. Demands not met 2018–19. Extended cease-to-flow conditions (<30 ML/day) at Mungindi from June 2019 to February 2020 but demands met February–March 2020 and again in April 2020. Required annually – therefore a high demand.	High	A high priority for watering in 2020–21, including under a low resource availability scenario.	High
		Fish spawning/recruitment flow targeting long-lived in-channel specialist species (small in-channel fresh for 14–34 days) <u>Dumaresq River</u> Spawning – 515–1 040 ML/day at Roseneath for minimum 14 days (small fresh – SF) Recruitment – 340–600 ML/day at Roseneath for minimum 20 days <u>NSW Severn / Macintyre rivers</u> Priming pulse – initial peak of 2 000 ML/day at Ducca Marrin followed by recession (duration variable) (large fresh – LF) <u>Lower Macintyre River</u> Large scale spawning and recruitment aligned with large unregulated pulse in the Weir River post winter (at least 2 m rise and water temp >23ºC)	8 in 10 years July–Aug (Priming pulse before spawning and recruitment) Aug–Oct (Peak recruitment season for Murray cod and freshwater catfish)	<u>Dumaresq River and NSW Severn/Macintyre</u> Demands not met 2012–2015, met 2015–16 to 2017–18. Not achieved in 2018–19. Dumaresq recruitment demands not met in 2019–20 but spawning demands were met. NSW Severn/ Macintyre spawning and recruitment not met in 2019–20 (priming pulse). Moderate to high demand 2020–21, moving to moderate in 2021–22 if watering occurs as planned. <u>Lower Macintyre River</u> Met 2015–2017. Not met in 2017–18, 2018–19 or 2019–20. High demand 2020–21, becoming moderate to high in 2021–22 if watering occurs as planned.	Moderate to High High	Secondary priority for Commonwealth environmental watering. Will occur only if natural trigger is met, or under moderate–high resource availability. Demand may be met by other means.	Moderate Moderate to High
		Fish spawning/recruitment flow targeting long-lived flow dependent specialists (small to medium fresh for at least 3 days) <u>Dumaresq River / NSW Severn / Macintyre rivers</u> Flow height with at least a 2 m rise and water temp >23ºC	8 in 10 years Oct–April (Recruitment season for silver and golden perch)	<u>Dumaresq River</u> Dumaresq: Not met 2012–2015, achieved 2015–18. Not achieved 2018–19. Achieved in 2019–20 (flow spike with flow height rise at Roseneath of at least 2 m in February 2020). Moderate to high demand in 2020–21, moving to moderate if watering occurs as planned. <u>Severn/Macintyre</u> Not achieved in 2018–19 or 2019–20. Moderate to high demand in 2020–21, moving to moderate if watering occurs as planned. <u>Lower Macintyre River</u> Demand met 2015–16 and 2016–17. Not met 2018–19 or 2019–20. High demand in 2020–21, becoming moderate to high if watering occurs as planned.	Moderate to High Moderate to High High	Secondary priority for Commonwealth environmental watering. Will occur only if natural trigger is met, or under moderate–high resource availability. Demand may be met by other means.	Moderate Moderate Moderate to High

Environmental assets	Target values	Indicative demand (for all sources of water in the system)[6]		Watering history[7]	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Border Rivers main channels (ctd)		**Fish condition and maintenance flow targeting long lived in-channel specialists and flow-dependent fish guilds (small/large fresh for minimum 5 days)** Dumaresq River Up to 2 300–6 250 ML/day at Roseneath (SF) NSW Severn / Macintyre rivers Peak up to 2 000 ML/day at Ducca Murrin (LF) Lower Macintyre River Natural inflows in the lower Macintyre River reach, including Weir river. Optimal flow height, duration and volume unknown.	1 in 1–2 years (Maximum dry interval unknown) June–July (Pre-spawning conditioning) March–May (Pre-winter maintenance)	Dumaresq River Not met 2018–19. Met in 2019–20 (bankfull flows at Roseneath in February 2020, peaking at 15 000 ML/day) (pre-winter maintenance). Moderate demand in 2020–21, remaining moderate if watering occurs as planned. NSW Severn / Macintyre rivers Met 2015–2018. Demand not met 2018–19 or 2019–20. High demand in 2020–21, moving to moderate to high if watering occurs as planned. Lower Macintyre River Not met from 2017–2019. Met in 2019–20, with natural inflows in the lower Macintyre River reach, including Weir River in February–April 2020. Moderate to high demand, moving to moderate if watering occurs as planned.	Moderate High Moderate to High	Secondary priority for Commonwealth environmental watering. Will occur only if natural trigger is met, or under moderate–high resource availability. Demand may be met by other means.	Moderate Moderate to High Moderate
	Fish movement/spawning/ reproduction/ recruitment flows targeting short-lived stable low flow spawning fish species.	**Stable low flow for 7–60 days (spawning*/ reproduction/recruitment)** ** A minimum stable low flow 7–21 days needed for spawning* Dumaresq River Up to 100 ML/day at Roseneath (BF) NSW Severn and Macintyre rivers 50 ML/day at Ducca Marrin (BF)	1 in 1–2 years (low uncertainty) Up to 3 years (high uncertainty) Sept–Dec (Peak spawning season for olive perchlet, includes purple-spotted gudgeon)	Dumaresq River Met 2015–16, 2016–17 and 2018–19. Not met in 2019–20. Moderate to high demand in 2020–21, moving to moderate if watering occurs as planned. Severn and Macintyre rivers Stable flows not met 2015–20. High to critical demand in 2020–21, moving to high if watering occurs as planned.	Moderate to High High to Critical	Secondary priority for Commonwealth environmental watering. Will occur only if natural trigger is met, or under moderate–high resource availability. Demand may be met by other means.	Moderate High
	Scouring, inundate inter-connected riparian areas and improved longitudinal connectivity for fish movement, (including maintenance and conditioning) of all native species	**Large in-channel fresh (Aug–Dec)** Dumaresq River Peak between 6 250–19 000 ML/day at Roseneath (LF) NSW Severn and Macintyre rivers Flows >2 000 ML/day at Ducca Marrin to change periphyton species (LF)	All reaches Up to 3 years for scouring (Max. dry interval unknown) Anytime (only if naturally occurring)	Dumaresq River Achieved 2016–17, not achieved 2017–18, 2018–19 or 2019–20 (within August–Dec time window). Assessed as moderate to high for 2020–21, moving to moderate if watering occurs as planned. NSW Severn and Macintyre rivers Achieved in 2016–17, 2017–18 and 2018–19. Not achieved in 2019–20. Assessed as low to moderate, remaining low if watering occurs as planned.	Moderate to High Low to Moderate	Secondary priority for Commonwealth environmental watering. Will occur only if natural trigger is met, or under moderate–high resource availability. Demand may be met by other means.	Moderate Low
	Inundate key habitat (large woody debris), support key ecosystem functions (nutrient, sediment and carbon cycling) and support recruitment opportunities for a range of native aquatic species (fish, frogs, turtles and invertebrates)	**Small in-channel fresh** Lower Macintyre and Barwon Rivers 4 000 ML/day at Mungindi (end of system) for a minimum 5–11 days (SF).	1 in 3–4 years (Max. dry interval of 7–14 years Oct–Dec (inundate habitat) 1 in 2–3 years (Max. dry interval of 6–8 years Oct–Mar (support key ecosystem functions) Occur twice a year every 1 in 3–4 years (max. dry interval unknown) Oct–Dec (needs of threatened native fish)	(Inundate habitat and meet needs of threatened fish species (Oct–Dec) Last met 2016 (not met 2013, 2014 or 2015). Not met 2017–18, 2018–19 or 2019–20. Environmental demand high in 2020–21, moving to moderate to high if watering occurs as planned. Oct–March (key ecosystem functions) Met in 2012–13 (not met between 2013–14 and 2018–19). Partially met in 2019–20 (mean daily flows at Mungindi >4 000 ML/day for five days between 23 February 2020 and 27 February 2020). Environmental demand high, moving to moderate to high if watering occurs as planned.	High	Unable to receive Commonwealth environmental water due to constraints.	Moderate to High

Environmental assets	Target values	Indicative demand (for <u>all sources of water</u> in the system)[6]		Watering history[7]	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
In channel assets – Boomi River	Inundate key habitat Boomi (large woody debris and fallen timber on bench platforms and inset floodplain areas), native fish assets (including recorded or expected threatened native fish species).	BF (>5 ML/day) for 7 days (Sept–Mar) at Boomi River upstream of Boomi Weir Offtake SF1 (>20 ML/day at Boomi River upstream of Boomi Weir Offtake) for minimum 10 days (Oct–Apr) SF2 20–750 ML/day for minimum 14 days (Sept–Apr) LF1 (>750 ML/day) for 5 days (Jul–Sept) LF2 (>750 ML/day) for five days (Oct–Apr)	1 in 1–2 years (75%) (baseflow) (max. dry interval unknown) Annual (100%) (SF1) (max. dry interval 1 year) 1 in 1–2 years (75%) (SF2) (LF1) 1 in 1–2 years ((75%) (LF1) 1 in 2–3 years (42%) (commencing as a rising flow only) (LF2)	Base flow met annually since 2013–14. Required every 1–2 years so moderate environmental demand, moving to low if watering occurs as planned. SF1 met in each year between 2013–14 and 2019–20. Required annually, therefore a high environmental demand. SF2 met in each year between 2013–14 and 2019–20. Required every 1–2 years so moderate environmental demand, moving to low if watering occurs as planned. LF1 Not met since 2013–14. Required every 1–2 years, therefore a critical environmental demand. LF2 Not met in 2013–14, 2014–15, 2015–16, 2017–18 or 2018–19, but met in 2016–17 and 2019–20. Required every 2–3 years, therefore a moderate environmental demand moving to low–moderate if watering occurs as planned.	Moderate High Moderate Critical Moderate	A low priority for Commonwealth environmental water contribution under low water resource availability scenarios, however Commonwealth unregulated entitlements could contribute unregulated flows, if triggered.	Low High Low Critical Low to Moderate
Anabranches downstream of Yetman/Texas Nutrient and carbon cycling, enhanced primary production. Support fish movement and condition.	Infrastructure assisted watering to maintain refuge habitat E.g. Morella watercourse lagoons (if agreed with landholders) 1 500–4 000 ML per action (infrastructure assisted) to target specific wetlands with long-term flow deficit	1 500–4 000 ML per action (infrastructure assisted) to target specific wetlands with long-term flow deficit	Maximum: up to 10 years between filling (Morella watercourse)	Little to no inflows since 2010, however local rainfall provided some water to Morella watercourse and Boobera Lagoon in 2019–20. Moderate environmental demand, moving to low–moderate if watering occurs as planned.	Moderate	Additional information needed before supporting a watering action.	Low
Wetlands, lagoons and billabongs	Support movement, spawning and recruitment of aquatic species. Riparian vegetation health. Nutrient and carbon cycling Maintain refuge for aquatic biota and fish Lateral and longitudinal connectivity, support movement, spawning and recruitment of aquatic species. Maintain riparian habitat for other species i.e. water birds	**Connection to lower Dumaresq wetlands / NSW Severn wetlands** <u>Dumaresq River</u> SF to connect >30% of wetlands in the Dumaresq reach > 1 040 ML/day at Roseneath (SF) <u>NSW Severn and Macintyre rivers</u>: 1 200 ML/day at Ducca Marrin (LF) to connect upper reach wetlands	1 in 3 to 4 years for wetland vegetation 1 in 2 to 3 years for fish outcomes	<u>Dumaresq River</u> Demands met 2017–18, 2018–19, and 2019–20 but not met between 2012–2017. Low demand, remaining low if watering occurs as planned. <u>NSW Severn and Macintyre rivers</u> Met annually from 2012 to 2018–19 but not met in 2019–20. Moderate environmental demand, moving to low if watering occurs as planned.	Low Moderate	A low priority for CEW under low to moderate water resource availability scenarios. Potential for contribution under a high water resource availability scenario, in conjunction with similar flow requirements for fish outcomes A low priority for CEW under low water resource availability scenarios, however, Commonwealth unregulated entitlements could contribute unregulated flows, if triggered.	Low Low

Environmental assets	Target values	Indicative demand (for <u>all sources of water</u> in the system)[6]		Watering history[7]	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Wetlands, lagoons and billabongs (ctd)	Fish (all guilds) and other aquatic dependent biota refuge Aquatic ecosystems	**Connection to lower Macintyre River wetlands** <u>Connect wetlands and anabranches - Goondiwindi to Mungindi</u> >20 000 ML/day (low connectivity) (bankfull-small overbank flow) >60 000 ML/day (high connectivity) (large overbank event) at Goondiwindi for 7 days <u>Low level wetland connection in Lower Macintyre</u> 10 000–15 000 ML/day at Goondiwindi (bankfull) 4 000–6 000 ML/day at Terrewah (LF and bankfull) for 4–8 days in Oct–Mar	1 in 3–4 years for wetland vegetation 1 in 2–3 years for native fish outcomes Every 3 years for small fish outcomes	<u>Connectivity for wetlands and anabranches from Goondiwindi to Mungindi</u> Not met since 2012–13. High to critical environmental demand, moving to moderate if watering occurs as planned. <u>Low level wetland connections in Lower Macintyre</u> Not met from 2012–13 to 2018–19. Met in 2019–20 (flows at Goondiwindi >10 000 ML/day 16–22 February 2020 and flows at Terrewah >4 000 ML/day from 16–26 February 2020). Low environmental demand, remaining low if watering occurs as planned.	High to Critical Low	Unable to receive Commonwealth environmental water due to constraints. (Unregulated entitlements could contribute to flows at Goondiwindi if there are in-range announced flows)	Moderate Low

Note: contributions to meet Barwon–Darling environmental requirements may be considered subject to water availability, antecedent conditions, and environmental demands. Refer to CEWO's Water Management Plan 2020-21: Chapter 3.7 Barwon–Darling.

All watering history sourced from advice from NSW Department of Planning, Industry and Environment and Queensland partner agencies, WaterNSW Water Balance Reports, and data from the following gauges (WaterNSW 2020 and DNRME 2020):

416040: Dumaresq River at Glenarbon
416067 Severn River at Ducca Marrin
416001: Barwon River at Mungindi
416011: Dumaresq River at Roseneath
416207A: Weir River at Mascot
416201A: Macintyre River at Goondiwindi
416047: Macintyre River at Terrewah
416037: Boomi River at Boomi Weir offtake

Key - potential watering in 2020-21

- High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)
- Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate - high water resource availability); or water demand likely to be met via other means
- Low priority for Commonwealth environmental watering (under high - very high water resource availability)
- Unable to provide Commonwealth water because of constraints or insufficient water

Key - environmental demands

- Critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
- High demand for water i.e. needed in that particular year
- Moderate demand for water i.e. water needed that particular year and/or next
- Low demand for water i.e. water generally not needed that particular year
- Very low demand for water i.e. water generally not needed that particular year or the following year

Note that demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime

3.1.5 Water delivery in 2020–21

Based on the demand for water for the environment, water availability (supply), and catchment conditions, the overall purpose for managing Commonwealth water for the environment in the Border Rivers catchment in 2020–21 (subject to water resource availability improving significantly) is to avoid damage and protect the health and resilience of aquatic ecosystems. This includes in-channel habitats, drought refugia and fish condition and resilience, particularly in the Border Rivers main channels.

In the Border Rivers catchment, the capacity to deliver regulated water for the environment in 2020–21 is contingent on an increase in water availability, and there being no further restrictions on accessing water from Glenlyon and/or Pindari Dams. It also requires there to be sufficient reserves in the dams to resume normal river operations.

Consistent with the demands and purpose identified, the CEWO is considering supplying water for the environment to the following actions in 2020–21.

Subject to an increase in water availability, and in some cases the occurrence of other flow events, deliver water to:

- Avoid extended cease to flow conditions, provide flowing water habitats, and maintain suitable river depth. This will help to support native fish and other native aquatic animals such as freshwater mussels and shellfish, shrimp, platypus, turtles, frogs, water dragons, water rats (rakali).
- Contribute to suitable flow regimes to help maintain and restore instream and riparian vegetation at important sites in the Dumaresq, Severn and Macintyre systems.
- Contribute to suitable flow regimes in the Dumaresq, Macintyre and Severn rivers to support priming, reproduction, conditioning and movement opportunities for native fish communities, including Murray cod, silver perch, freshwater catfish, purple-spotted gudgeon and olive perchlet.
- Contribute to suitable flow regimes to support refuges, feeding resources and breeding opportunities for waterbirds including listed migratory and threatened species, and species of economic, social and cultural importance.

As in previous years, the use of Commonwealth water for the environment in the Border Rivers will be adaptively managed throughout 2020–21, in response to changing water resource availability and environmental conditions and demands.

3.1.6 Monitoring and Lessons learned

(a) Monitoring

In the Border Rivers Catchment, monitoring is undertaken by NSW and Queensland agencies including NSW DPI – Fisheries (native fish), NSW DPIE Water (water quality) and Queensland DNRME, DAF and DES. The CEWO has also funded a number of short-term intervention monitoring projects to evaluate the environmental responses of native fish, and to map aquatic habitat in the Dumaresq and Macintyre Rivers.

Details of monitoring activities funded by the CEWO in the Border Rivers Catchment can be found at: https://www.environment.gov.au/water/cewo/catchment/border-rivers/monitoring

(b) Lessons learned

Outcomes from monitoring and lessons learned in previous years are a critical component for the effective and efficient use of Commonwealth water for the environment. These learnings are incorporated into the way environmental water is managed.

Key findings from fish[9], aquatic habitat[10] and flow monitoring[11] in the Border Rivers Catchment is summarised in Table 3.

Table 8: Key lessons learned in the Border Rivers Catchment

Theme	Lesson learned
Native fish and aquatic invertebrates	• Water for the environment benefits the relatively healthy and diverse native fish community in the Border Rivers, which includes a number of nationally and state listed threatened species (e.g. Murray cod, olive perchlet). For example, water for the environment helps maintain habitat, supports condition and recruitment, and provides opportunities for movement and increased productivity. • The unregulated Weir River in the Border Rivers catchment has relatively healthy spawning and recruitment of golden perch, which are largely absent from other areas in the Border Rivers. • Water for the environment in the Border Rivers during late winter/early spring contributes to increased Murray cod and freshwater catfish spawning and recruitment. It also provides benefits to unspecked hardyhead, Murray-Darling rainbowfish and carp gudgeon (abundance, spawning and recruitment). • Rapid assessment of priority refuge pools in parts of the Border Rivers through the NSW native fish drought response process suggests that the Lower Macintyre fish community may be in relatively poor condition. Extensive die-off of freshwater mussels was also observed at some sites. There are also concerns about the status of the Darling River hardyhead in the Border Rivers.
Aquatic habitat	• Mapping of aquatic habitat features in parts of the Border Rivers (Dumaresq from Pike Creek to connection with the Macintyre) has identified habitat that is important for native fish and other animals. Riparian vegetation condition was also mapped. Key habitat features noted included large woody habitat, refuge pools, and bars and benches.

Connectivity	• Recent learnings from water management in the Border Rivers and connection with the downstream Barwon–Darling suggest that:
	  ○ The volume of water needed to replenish waterholes and allow for seepage is much greater if a river has already ceased-to-flow and antecedent conditions are dry, compared to when a river is still flowing.
	  ○ Within catchment water requirements need to be balanced with broader system needs when environmental water availability is low.
	  ○ Travel times for regulated releases from storage need to be considered when coordinating flows between systems.
	• The Northern Connectivity Event in 2017–18 and the Northern Fish Flow in 2018–19 have highlighted the importance of coordinated flow delivery and protection of environmental flows from the Border Rivers and Gwydir system into the Barwon–Darling. Further monitoring undertaken by Queensland DRNME and NSW DPI – Fisheries will help to better understand the role of protecting unregulated tributary

[9] NSW DPI and Q DAF 2019
[10] NSW DPI 2018b
[11] DAWE 2020

Theme	Lesson learned
	flows for waterhole persistence and connectivity, water quality, and native fish response.
Other aquatic animals	• There are platypus colonies in the Border Rivers catchment, including in the Severn River (Sundown National Park, near Ashford and reaches downstream of Pindari Dam), Tenterfield Creek; the Dumaresq River downstream of Glenlyon Dam; and also possibly Macintyre Brook. There are historical records of platypus in lowland areas of the Border Rivers as far downstream as Goondiwindi, but these populations are no longer present. • Delivery of the Pindari stimulus flow in previous years (NSW planned environmental water) took the flow needs of platypus into account, and research in other parts of Australia has also sought to better understand their environmental flow needs. The Rakali or native water rat is also widespread throughout the Border Rivers but little is known about their flow requirements in the catchment. • Additional information on these water dependent species is required to better inform the future management of water for the environment.

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3.2 Condamine–Balonne

3.2.1 Region overview

(a) River system

The Condamine–Balonne system is one of the largest catchments in the Murray–Darling Basin and covers the north eastern corner of the Basin. The system is bounded by the Moonie catchment to the east, the Warrego catchment to the west and the Barwon River in the south (Figure 5). The main rivers of the catchment, the Condamine and the Maranoa, rise in elevated country in Queensland. Two-thirds of the catchment is flat floodplain country, with a complex system of rivers and creeks joining and breaking away from the Balonne River as it moves downstream of St George. This system of creeks, channels and flat floodplain areas is generally referred to as the Lower Balonne Floodplain.

While a few main waterways of the catchment flow to the Barwon River, most end in lakes and wetlands in south west Queensland and north-west New South Wales (NSW). Most of the catchment is located in Queensland with only 16 per cent in NSW.

The catchment's extensive floodplains provide habitat for a diverse range of plants, including endangered vegetation communities. The region also provides habitat for waterbirds, native fish and many vulnerable and endangered species. There are several wetlands of national importance in the region as well as the Ramsar-listed Narran Lake Nature Reserve.

The extent of river regulation in the Condamine–Balonne is low. Public dams account for only 13 per cent of stored water in the catchment. The two largest public storages are Leslie Dam (106 gigalitres) near Warwick, and Beardmore Dam (82 gigalitres) near St George, which were built in the 1960s to secure town water and irrigation supplies.

Large-scale irrigation in the region is supported by large capacity pumps or large regulating structures that divert water during natural flow events into on-farm storages for later use. Most of the water use and entitlement is in the form of diversion of river flows and water during natural flow events that breaks out of rivers and becomes overland flows across floodplains.

(b) Traditional Owners

The lands of the Condamine–Balonne catchment have been important to Aboriginal people for thousands of years. Many First Nations retain a connection with the region, and their history, culture and livelihoods are closely intertwined with its river systems. First Nations of the region include Barunggam, Bidjara, Bigambul, Euahlayi, Gomeroi/Kamilaroi, Giabel, Githabul, Gunggari, Guwamu/Kooma, Jarowair, Kambuwal, Mandandanji, Murrawarri, and Wakka Wakka.

(c) Important sites and values

The floodplains of the Condamine–Balonne catchment are ecologically significant because they support endangered ecological communities, such as the brigalow–gidgee woodland/shrubland in the Mulga Lands and Darling Riverine Plains Bioregions. The wetlands support a diverse range of flora and fauna providing habitat for migratory birds and vulnerable and endangered species, such as silver perch, Murray cod, freckled duck, Australian painted snipe, the great egret and the cattle egret.

Wetlands of national importance include the Great Artesian Basin Springs, Lake Broadwater, The Gums Lagoon, the Culgoa River Floodplain, and the Dalrymple and Blackfellow creeks.

The Lower Balonne is a complex floodplain channel system containing a number of nationally significant wetlands, as well as the internationally significant Narran Lake Nature Reserve, which includes significant areas of Ramsar-listed wetlands.

Narran Lake Nature Reserve

The Ramsar site within the Narran Lake Nature Reserve is in north-west NSW about 50 kilometres east of Brewarrina. One section of the site was listed under the convention in 1999, and a further 3 104 hectares were added in 2015. The site was extended to capture more breeding and feeding habitat for waterbirds. Currently the site covers a total area of 8 447 hectares and comprises the whole floodplain area within Narran Lake Nature Reserve. The site was listed under the Ramsar Convention because of its significant values, which include:

- some of the largest expanses of lignum in NSW
- the ability to support:
    - three wetland dependent threatened species – Australasian bittern, Murray cod and winged peppercress
    - a large number of migratory bird species, including 19 listed under international agreements
    - substantial breeding of waterbirds, including colonial nesting species such as ibises, cormorants, egrets and spoonbills.
- the capacity to provide drought refuge for waterbirds following floods.

The Nature Reserve is also important to Aboriginal people and they are involved in managing the site through the Narran Lake Nature Reserve Aboriginal Co-Management Committee. Key values of the site for Aboriginal people include:

- being a traditional meeting place for Aboriginal tribes in the region
- several Dreaming paths culminate at the lakes
- containing many relatively undisturbed Aboriginal objects.

(d) Stakeholder engagement

In the Condamine–Balonne system, the planning and management of Commonwealth water for the environment is undertaken in conjunction with a range of partners and stakeholder groups. Key stakeholders include the Queensland Departments of Natural Resources, Mines and Energy (DNRME), Environment and Science (DES) and Agriculture and Fisheries, NSW Department of Planning, Industry and Environment (DPIE), NSW Department of Primary Industries (DPI) – Fisheries, SunWater, WaterNSW, the Narran Lake Nature Reserve Aboriginal Co-Management Committee, and the Lower Balonne Working Group.

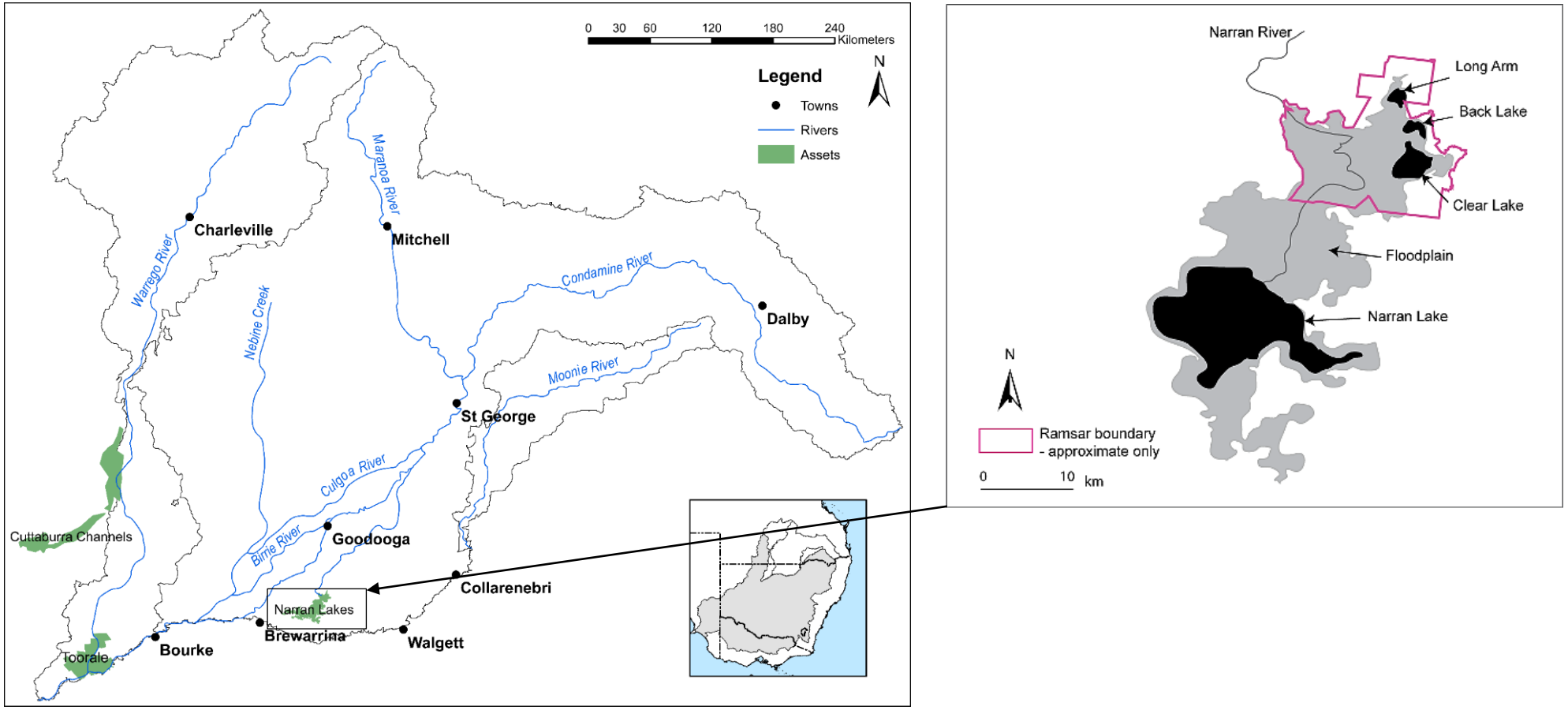

Figure 5: Map of the Condamine–Balonne and surrounding systems, including an inset of the internationally significant Narran Lakes system.

3.2.2 Environmental objectives

Based on long-term environmental objectives in the Basin Plan, relevant state long-term watering plans, site management plans (including Ramsar site ecological character descriptions), and best available knowledge, the following objectives are relevant for environmental watering in the Condamine–Balonne system.

Because of the generally unregulated nature of the Condamine–Balonne system, the objectives that can be achieved in a particular year may vary and are highly dependent on catchment conditions and rainfall events. These objectives will continue to be revised as part of the Commonwealth Environmental Water Office's (CEWO) commitment to adaptive management.

Vegetation: Maintain and improve the condition, growth and survival of riparian, in-channel, floodplain and wetland vegetation.

Waterbirds: Maintain foraging, roosting and breeding habitats at targeted sites on the floodplain to support waterbirds.

Native fish: Improve habitat condition, and support different life stages (migration, spawning, recruitment and refuge), natural flow variability, and connectivity between river channels, wetlands, anabranches and floodplains.

Other vertebrates: Support survival and recruitment of other native aquatic species, including frogs and turtles.

Invertebrates: Maintain and improve the micro and macroinvertebrate communities by providing a variety of habitat and flow conditions.

Connectivity: Support longitudinal connectivity, including with the Barwon River, and lateral connectivity with and between the rivers, wetlands and floodplain systems.

Processes/water quality/resilience: Support key ecosystem functions, biotic dispersal and promote productivity; maintain water quality in channels and pools; and maintain drought refuge habitat.

3.2.3 First Nations environmental objectives

Representatives of the First Nations peoples of the Condamine-Balonne system have identified environmental objectives for their country for 2020–21 (Table 9). These objectives were developed through the First Nations Environmental Guidance project undertaken by the Northern Basin Aboriginal Nations organisation.

Some of these objectives sit outside the scope of water for the environment to influence, while for others, the link between water for the environment and the site or species is not well understood.

The CEWO is committed to working with First Nations groups to better understand their objectives. The CEWO will use environmental flows to contribute to these objectives where possible and where this is consistent with the Commonwealth Environmental Water Holder's statutory responsibility of protecting and restoring environmental assets in the Basin.

Table 9: First Nations environmental objectives for the Condamine-Balonne system for 2020–21 (NBAN Ltd. 2020)

River flows and Connectivity
Upper Condamine: Maintain a healthy sustainable flow so that native animal and plant species can thrive to benefit everyone.
Maranoa-Balonne priority sites: The junction between Maranoa and Balonne rivers; the Lakes that feed off the Maranoa River
Maranoa-Balonne river connectivity: Flowing water throughout the system, at all times. There are hardly any fish in the Maranoa because of Beardmore Dam.
Narran Lakes: Sufficient flows to support an abundance of birdlife and bird eggs, as well as fish for food during gatherings.
Culgoa and Nebine rivers: Low and medium flows in both the Culgoa and Nebine Rivers; sufficient flows to increase and protect the health of the rivers; maintain natural flows and restore historical timing of flows. Maintain connectivity.
Native Vegetation
Upper Condamine indicator species: River gum, bulrush, water lily, sedges, sandalwood[i], iron bark (poplar box)[i].
Maranoa -Balonne indicator species: Iron bark[i], blackberries[i], wild bananas[i], salt bush, black box, snotty gobble (mistletoe)[i].
Culgoa and Nebine rivers indicator species: Lignum, water grasses, river redgum, Willbill, black box, coolabah, and snotty gobble (mistletoe)[i].
Native Birds
Upper Condamine indicator species: Kookaburra[i], kingfisher, black cockatoo[i], crimson wing, duck, water hen, shag.
Maranoa -Balonne indicator species: Night owl[i], barking owl[i], pelican, eagle[i], black hawk[i], white dove[i], brolga.
Culgoa and Nebine rivers indicator species: Duck, pelican, heron, ibis, brolga, bush turkey[i], kingfisher, black duck, wood duck and bustard.
Native Animals
Upper Condamine indicator species: River blackfish, spiny crayfish, cod, yellowbelly, platypus[i], catfish, mussel, crayfish, turtle.
Maranoa -Balonne indicator species: Tiger snake[i], carpet snake[i], black goanna[i], red kangaroo[i], native bee[i], brown frog, crucifix Frog, yellowbelly, cod.
Culgoa and Nebine rivers indicator species: Yellowbelly, booglies, black bream (silver perch), cod, shrimps, mussels, catfish, turtles, water spiders, wallabies[i], goanna[i], emu[i] and frogs.
Connecting with Country
Upper Condamine: Water quality to ensure downstream river health.
Maranoa -Balonne: Ceremonies based around water.
Culgoa and Nebine rivers: Increased populations of native birds, as they are a food source and totemic species, which are important for Gatherings.

[i] Water for the environment targeting other environmental outcomes may influence this species or objective

3.2.4 Recent conditions and seasonal outlook

(a) Recent conditions and environmental water use

The Condamine–Balonne system experienced very hot and dry conditions between July 2017 and January 2020, with rainfall being well below average, and maximum temperatures the highest on record for some months. Flows passed St George have also been extremely low during this time.

These factors resulted in some downstream sections of the Narran River not flowing for over 650 days, and the Culgoa River for 390 days. These long periods of low or no flow saw a reduction in the number and quality of refuge pools within the river channels of the Lower Balonne floodplain. The reduction in drought refuges is likely to have had a significant impact on the aquatic communities of the Culgoa, Narran and Birrie/Bokhara River systems.

During late summer and early autumn 2020, widespread rainfall occurred across most of the Condamine-Balonne system. This saw most parts of the system receive around 100 mm of rain. During this period, a series intense summer storms saw 200-350 mm of rain fall across the mid and upper sections of the Condamine and Maranoa catchments.

The rainfall generated significant flows particularly in the Condamine and Maranoa Rivers with flows at St George peaking at around 190 000 ML/d. The flows recorded at St George passed the full length of the Lower Balonne system filling the three lakes within the Narran Lake Nature Reserve. It also connected to the Barwon and Darling rivers. Flow rates and total flow volumes for various parts of the Lower Balonne network are shown in Table 10.

Table 10: Maximum flow rate, duration and total flow volume at key flow gauges across the Lower Balonne distributaries

Site	Description	Maximum Flow Rate (ML/d)	Flow Duration (Days)	Total Flow Volume (ML)
Wilby Wilby (Narran River)	Located mid-way between the Queensland/NSW border and the Narran Lake Nature Reserve	5 700	~55	89 000
Narran Park (Narran River)	Located on the western boundary of the Narran Lake Nature Reserve	3 300	~55	61 000
Brenda (Culgoa River)	Located near the Queensland/NSW border	14 000	>80	174 000
Downstream of Collerina (Culgoa River)	Downstream of where Nebine and Birrie systems connect to the Culgoa River. The most downstream gauge	8 800	>85	176 000
Bokhara (Bokhara River)	The most downstream gauge	2 100	~60	32 000

As part of these flows, over 150 000 megalitres of Commonwealth water for the environment, along with 10 000 megalitres contributed by Cubbie Station helped to enhance the condition of the Lower Balonne system.

To further enhance the condition of habitat within the Narran Lakes Nature Reserve Ramsar Site, the Commonwealth implemented the Narran Lakes Water Reimbursement Project. Through this project, a water allocation holder that was legally entitled to pump water from rivers that flow to the Narran Lakes was provided with a grant not to pump from the flow event. The grant contributed a further 9 000 megalitres of water for the environment, most of which inundated the Ramsar site.

The project was a pilot (or 'interim measure') from which the lessons learned will support any future implementation of event-based mechanisms. Event-based mechanisms are a 'Toolkit measure' under the Intergovernmental Agreement on Water Reform in the Murray–Darling Basin. The CEWO will evaluate the benefits from the trial before any consideration of any future implementation of event-based mechanisms.

Before these flows, floodplain and terminal wetland systems, including the Narran Lakes Nature Reserve Ramsar site, had not been inundated for an extended period. The last time flows where sufficient to enter Clear Lake (the largest of the Lakes contained with the Ramsar Site) was in October 2016. Similarly, core lignum areas within the Ramsar site had not been completely inundated since March 2013, and extensive inundation of the broader Lower Balonne floodplain had not occurred since February 2012. The extended period between watering events has resulted in a significant decline in the condition of lignum shrublands across the Ramsar site as well as riparian and floodplain vegetation communities located across the entire Lower Balonne floodplain.

(b) Seasonal outlook

According to the Bureau of Meteorology outlook on 2 July 2020, above median rainfall is forecast to occur across the Condamine–Balonne system from winter through into spring. While this forecast suggests that the recent severe dry conditions may continue to ease somewhat, follow up rain over the forthcoming summer is needed to ensure continued recovery from the drought. Wetter conditions can return suddenly in the northern Basin. Maximum temperatures are also forecast to remain above average over the coming months.

(c) Water availability

The Condamine–Balonne's two main public storages have a combined storage volume of 188 gigalitres, while the average annual stream flow at St George is 1 305 gigalitres. Thus, entitlements reliant on regulated releases from these storages are relatively small compared to the entitlements used to access unregulated or natural flow events. Consistent with this, Commonwealth environmental water holdings in the Condamine–Balonne system are almost exclusively made up of unregulated entitlements and can only be sourced as a share of an unregulated flow event determined by entitlement conditions.

Availability of water for the environment in the Condamine–Balonne depends on the nature of flow events that occur. Unregulated entitlements provide opportunistic access to unregulated river flows and overland flows when water resource plan rules are triggered, and a period of access is announced. Each entitlement will contribute to restoring in-stream flows reflecting its particular flow access windows, take rates and location. Daily, instantaneous, annual or multi-year limits cap overall diversions in any given year or flow event, and likewise the in-stream contributions that can be attributed to unregulated Commonwealth entitlements.

(d) Environmental demands

Considering the prolonged drought and the need to support recovery of key assets, there are a number of environmental demands that require water in 2020–21.

The environmental water demands for assets in the Condamine-Balonne system in 2020–21 are represented in Table 11. Note that the capacity to contribute to these environmental demands is contingent on the nature of flow events that occur in the catchment.

Table 11: Environmental demands, priority for watering in 2020–21 and outlook for coming year in the Condamine-Balonne System.

Environmental assets	Indicative demand (for all sources of water in the system)			Watering history	2020–2021		Implications for future demands
	Physical and process assets	Flow/volume	Average required frequency (maximum interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Lower Balonne River channels (Culgoa River, Narran River and inner distributary channels) and Barwon–Darling	Drought refuge (waterholes)	Flow reaches end of all channels within a three-month period, indicated by: • 30 ML/day Birrie River @ Talawanta for 1 day • 30 ML/day Bokhara River @ Bokhara for 1 day • 30 ML/day Culgoa River @ Weilmoringle for 1 day • 30 ML/d Narran River @ Narran Park for 1 day	Annually (no longer than 12 months between last flow)	Water is required annually to replenish refugial waterholes (contributing to persistence, connectivity and quality). Since 2009–10, flow requirements for the maintenance of drought refuges have generally been met. Requirements specified for the Bokhara and Culgoa have been met each year since 2009–10. The requirements specified for the Birrie and Bokhara systems are more difficult to achieve, with the Birrie requirement met 8 out of 11 years and the Narran requirement met 10 out of 11 years. While a filling flow recently passed through each of the 4 targets systems (March–April 2020), these flows are needed each year, so the requirement remains high.	High	**Moderate priority for CEW under all water resource availability scenarios.** The demand should be met by planned environmental water (environmental stock and domestic flows). After a water harvesting event has been announced, water left in the river as a result of the Commonwealth owning licences will be distributed across channels in the lower Balonne.	High
	Culgoa River – longitudinal connectivity	Small in channel fresh 1 000 ML/day @ Brenda for 7 days	8 in 10 years	Small freshes have occurred 7 in 10 years, including the flow event during March–April 2020. However, the average required frequency has not been met so the requirement for this demand is high.	High	A high priority for CEW under all water resource availability scenarios.	High
	Narran River – fish migration	Large in-channel fresh 1 700 ML/day @ Wilby Wilby (August–May) for 14 days	4–6 in 10 years	Large in-channel freshes have been met in 4 of the past 10 years, including during March–April 2020. While the average required frequency has been met, the requirement was not achieved during the period between the 2012–13 and 2019–20 water years. To increase recruitment opportunities, the requirement for this demand is high.	High	A high priority for CEW under all water resource availability scenarios.	Moderate
	Culgoa River – fish migration	Large in-channel fresh 3 500 ML/day @ Brenda (August–May) for 14 days	4–6 in 10 years	The last large in-channel fresh that met the demand occurred 8 years ago, which exceeds or approaches the lifespan of short-lived fish species. A large fresh is required in 2020–21 to provide opportunities for the dispersal and recruitment of native fish species.	Critical	Possible use of CEW, however, requires further investigation. Uncertain if sufficient additional flows could be obtained, and would likely have to target one channel not whole system.	High
Lower Balonne River floodplain	Connectivity with the riparian zone	9 200 ML/day Culgoa River @ Brenda for 12 days	Every 2–3 years	The last flow of this magnitude occurred 8 years ago, which exceeds the critical interval (3 years) to maintain condition of river red gum, ephemeral wetlands and lignum communities. Inundation is required in 2020–21 to maintain ecosystem health and function.	Critical	Possible use of EW, however, requires further investigation, including ecological outcomes from watering.	High
	Connectivity with the inner floodplain	15 000 ML/day Culgoa River @ Brenda for 10 days	Every 3.5–4 years	The last flow of this magnitude occurred 8 years ago. Inundation is required in 2020–21 to maintain ecosystem health and function.	Critical	Low priority for use of CEW. Benefit of supplying additional Commonwealth environmental water would be negligible.	High
	Connectivity with the mid floodplain	24 500 ML/day Culgoa River @ Brenda for 7 days	Every 6–8 years	The last flow that met the demand occurred 8 years ago. Inundation is required within the next year to maintain ecosystem health and function	High	Low priority for use of CEW. Benefit of supplying additional Commonwealth environmental water would be negligible.	Low
	Connectivity with outer floodplain	38 000 ML/day Culgoa River @ Brenda for 6 days	Every 10–20 years	The last flow that met the demand occurred 8 years ago. Critical interval for inundation will be in 2021–22.	Low	Low priority for use of CEW. Benefit of additional Commonwealth environmental water would be negligible.	Low

Environmental assets	Indicative demand (for all sources of water in the system)			Watering history	2020–2021		Implications for future demands
	Physical and process assets	Flow/volume	Average required frequency (maximum interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Narran Lakes	Waterbird breeding habitat in northern lakes (Ramsar site**)	25 GL @ Wilby Wilby (Narran River) over 60 days	Every 1–1.3 years	This demand has been met 4 out of the past 10 years, which exceeds the frequency range for this requirement. While this demand was met by the flow event during March–April 2020, the requirement for this demand is high	High	A high priority for CEW under all water resource availability scenarios.	Moderate
	Waterbird breeding and foraging habitat northern lakes zone**	50 GL @ Wilby Wilby over 90 days	Every 1.3–1.7 years	This demand has been met 4 out of the past 10 years, which exceeds the frequency range for this requirement. While this demand was met by the flow event during March–April 2020, the requirement for this demand is high. Inflows are required this year to sustain lignum shrublands and maintain condition of riparian red gum forests.	High		Moderate
	Trigger and maintain large scale colonial waterbird breeding	154 GL @ Wilby Wilby Narran Park over 90 days	Twice in every 8–10 years	This demand was last met 8 years ago. While significant flows entered the Narran Lakes systems during March–April 2020, the last large-scale waterbird breeding event was in early 2013. An event is required this year or next to provide ibis populations (with Narran site fidelity) with 2 breeding opportunities in their lifetime. An acute and chronic shortage of waterbird breeding across the Basin and the likelihood of this demand not being met in the long term, increases its urgency.	High	Commonwealth water portfolio is likely to contribute during large flow events	Moderate
	Water all floodplain and wetland habitat in Narran Lakes complex, initiate waterbird breeding, provide long-term refuge**	250 GL over 180 days @ Wilby Wilby	Every 10 to 12 years	This demand was met 8 years ago. Following the 2010–11 and 2011–12 floods, the critical interval for inundation will be from 2022 (if not received before then).	Low	Commonwealth water portfolio is likely to contribute during large flow events	Low

**Vegetation types/communities that are identified as critical components of the Ramsar site include lignum shrublands, riparian forest/woodland and ephemeral herbfields. All other critical components, processes and services of the Ramsar site would be supported by meeting the indicative demand.

Note: Contributions to meet Barwon–Darling environmental requirements may be considered subject to water availability, antecedent conditions, and environmental demands. Refer to CEWO's Water Management Plan 2020-21: Chapter 3.7 Barwon–Darling.

Key - potential watering in 2020-21

- High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)
- Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate - high water resource availability); or water demand likely to be met via other means
- Low priority for Commonwealth environmental watering (under high - very high water resource availability)
- Unable to provide Commonwealth water because of constraints or insufficient water

Key - environmental demands

- Critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
- High demand for water i.e. needed in that particular year
- Moderate demand for water i.e. water needed that particular year and/or next
- Low demand for water i.e. water generally not needed that particular year
- Very low demand for water i.e. water generally not needed that particular year or the following year

Note that demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime

3.2.5 Water delivery in 2020–21

Unregulated entitlements provide opportunistic access to unregulated river flows and overland flows when a flow event reaches levels specified in entitlement conditions and/or water resource plan triggers at which a period of access may be announced are met. Each entitlement will make a contribution to restoring in-stream flows reflecting its particular flow access windows, take rates and location.

3.2.6 Monitoring and Lessons learned

In the Condamine–Balonne catchment, monitoring is undertaken by Queensland and NSW agencies, including Queensland DNRME and DES (flow, hydrology, water quality, native fish) and NSW DPIE (vegetation, waterbirds and other animals), NSW DPI – Fisheries (native fish), and WaterNSW (hydrology and flow delivery data). The CEWO is also funding several short-term intervention monitoring projects to evaluate the environmental responses of native fish, waterbirds and vegetation in the Condamine-Balonne.

Details of monitoring activities funded by the CEWO in the Condamine-Balonne catchment can be found at: https://www.environment.gov.au/water/cewo/catchment/northern-unregulated-rivers/monitoring

Outcomes from monitoring and lessons learned in previous years are a critical component for the effective and efficient use of Commonwealth water for the environment. These learnings are incorporated into the way environmental water is managed. In 2016 the Murray-Darling Basin Authority re-assessed the environmental water requirements of the Condamine-Balonne system based on an improved science base[1]. There are also ongoing research activities contributing to our understanding of environmental water requirements of the Condamine–Balonne catchment (and other Northern Basin catchments) including the joint-venture science program and state planning assessments as part of the long-term water plans.

The Commonwealth funded the Murray-Darling Environmental Water Knowledge and Research (EWKR) project (for five years to June 2019) which provided important information, including several research projects in the Lower Balonne, to support environmental water management in the Basin[2].

Key findings from fish,[3] native vegetation[4], flows[5] and waterbird[6] monitoring in the Condamine-Balonne is summarised in Table 4.

Table 12: Key lessons learned in the Condamine–Balonne catchment

Theme	Lesson learned
Native fish	• Lagoons in the Lower Balonne (Queensland) have been known to provide habitat for fish species including golden perch, Australian smelt, spangled perch, bony bream, carp gudgeons, Murray-Darling rainbow fish, olive perchlet and Hyrtl's tandan. Historically, the native fish communities in the NSW Narran and Culgoa rivers were assessed as being in moderate to good condition. • Several refugial waterholes on the Narran River system, including one waterhole that was previously identified as persistent, went dry in 2017–18, increasing the population extinction risk for native aquatic fauna, including golden perch.
Native vegetation	• The CEWO has funded a short-term intervention monitoring (STIM) project on vegetation condition at Narran Lakes from early 2020 to December 2021. The first vegetation monitoring survey was undertaken by staff from the University of New England (UNE) in early March 2020 in collaboration with staff from the CEWO, NSW National Parks and Wildlife Service (NPWS), NSW DPIE along with local indigenous

[1] MDBA 2016
[2] (CEWO 2019, Mynott and Balcombe 2019, Dunne 2019, Senior 2019).
[3] (Benson 2004, QDES 2018, SoNSW and NSW DPIE 2019, Mynott and Balcombe 2019, QDES and CEWO unpublished)
[4] (QDSITI and QDNRM 2017, UNE unpublished)
[5] (CEWO 2020, BOM 2020)
[6] (CEWO 2020)

Theme	Lesson learned
	representatives from the Narran Lakes Nature Reserve Joint Management Committee (JMC). • Preliminary results suggest that vegetation of all community types suffered as a result of drought in recent years, with river red gum appearing to be the most obvious tree species affected. Large swathes of dieback was evident in lignum, especially in areas that had not received runoff from recent rains. Ground cover was also very low throughout. Floodplain vegetation appeared to respond to rains received in mid-February 2020, including lignum resprouting on the edges of the floodplain and low-lying areas. Despite large areas of lignum dieback, lignum may still offer suitable habitat for waterbird nesting following lake inundation from flood water delivery.
Waterbirds	• Regular waterbird surveys undertaken by state agencies since significant flows arrived in the Lower Balonne in early 2020 has detected thirty species so far including freckled duck, plumed duck, pelicans and darters. Straw-necked ibis were also detected but no breeding evident. Further rainfall in 2019-20 and 2020-21 may support waterbird breeding outcomes.
Connectivity	• The Murray-Darling Basin Authority has been using satellite data to track the 2020 flows in the Lower Balonne. The Bureau of Meteorology also completed a 'Water in Focus' report on the Lower Balonne, finding that the summer of 2019-20 saw the Condamine-Balonne river system go from severe drought to floods. These flows replenished water supplies and enabled the first significant flow into the internationally significant Narran Wetlands in eight years. A small volume of water also made it down the Culgoa River channel to the Darling River during March and April 2020.

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3.3 Warrego and Moonie rivers

3.3.1 Region overview

(a) River valleys

The Warrego and Moonie rivers are characterised by highly variable rainfall and ephemeral (intermittent) stream flows (**Figure 6**). Significant flow events generally result from heavy rainfall in elevated headwater areas. These northern unregulated systems are highly intermittent, and no flow periods of several months are common, extending to several years during prolonged dry conditions.

The flat landscape, low local runoff and intermittent flow conditions have led to the evolution of distinctive ecology in lowland river reaches. Aquatic and floodplain species are adapted to high flow variability and 'boom and bust' cycles. This is characterised by episodes of intense reproduction and high productivity by opportunistic plants and animals—the boom—associated with periods of flooding, followed by periods of stress and reduced production—the bust.

The Moonie River is a predominantly unregulated system and has no water major storages. A weir was built over the river at Thallon in 1959 to supply town water. Almost all irrigation in the Moonie depends on surface water. However, these diversions are small, accounting for only 0.2% of surface water diverted for irrigation in the Basin. Small to medium weirs are dispersed along the Moonie river for irrigation purposes, predominantly for cotton. The majority of water stored is harvested through capture of overland flows and the diversion of floodwater during episodic flow events. Water is stored in large shallow floodplain storages known as ring tanks or turkey nest dams.

The Warrego River is largely unregulated, other than the State-owned Allan Tannock Weir at Cunnamulla. Only a small volume of surface water in the Warrego catchment is diverted for irrigation and urban use. Some water is also taken from the river by diversion of flow or overland flows into private off-channel storages.

Water use and planning information on the Condamine–Balonne and Barwon–Darling are provided in separate sub-chapters.

(b) Traditional Owners

The lands and waters of the Warrego and Moonie catchments hold significant spiritual and cultural importance for Aboriginal people. Many Aboriginal nations retain a connection with the region and their history, culture and livelihoods are closely intertwined with its river systems. The Warrego catchment takes in (or closely borders) the traditional lands of the Yuwaalaraay/Euahlayi, Bidjara, Gwamu/Kooma, Gunggari/Kungari, Kunja, Mandandanji, Mardigan, Githabul and Murrawarri nations. The Moonie catchment includes the traditional lands of the Bigambul, Gomeroi/Kamilaroi and Mandandanji nations.

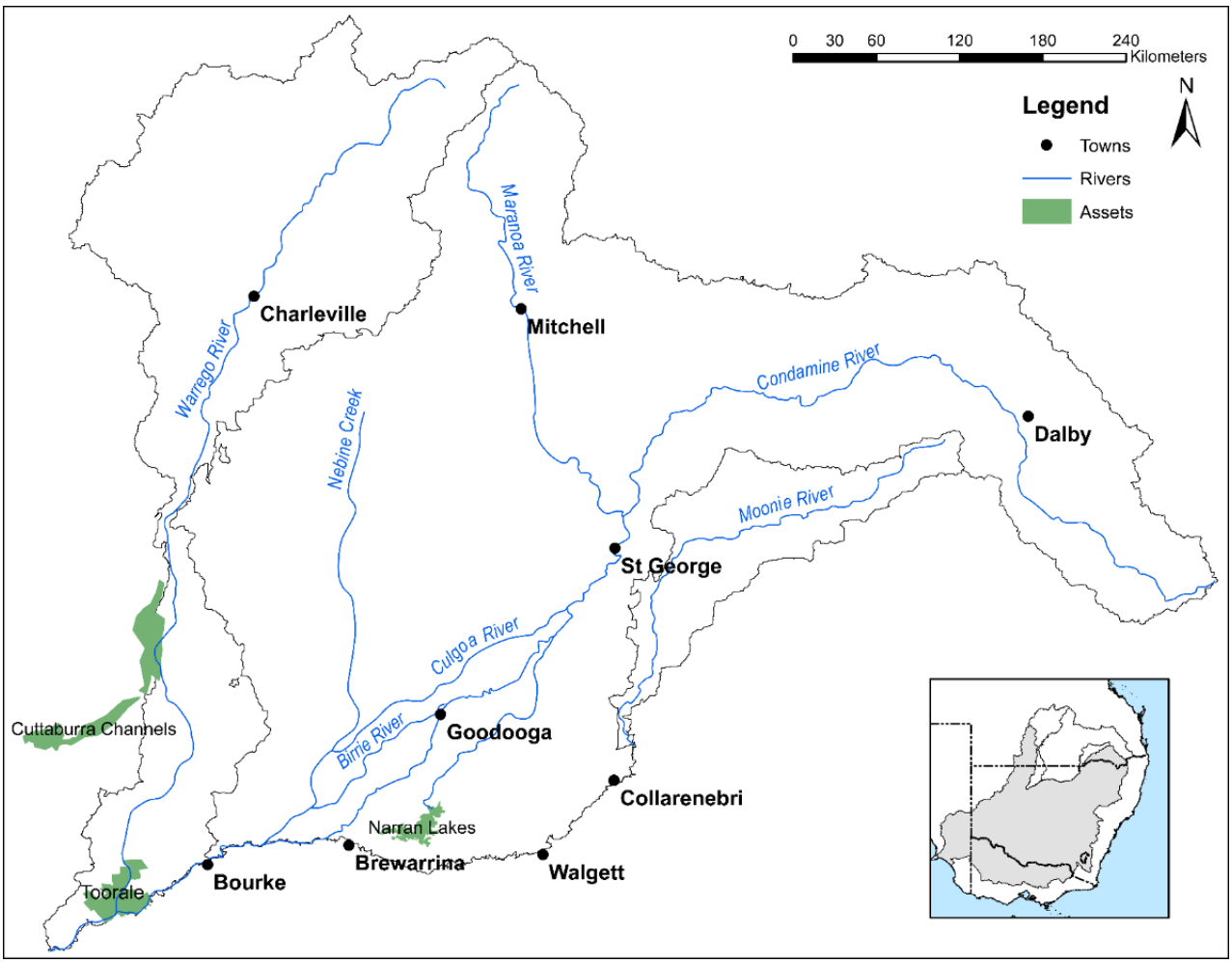

Figure 6: Map of the Warrego and Moonie rivers.

(a) Important sites and values

There are many environmental assets in the Warrego and Moonie catchments including species and communities of fish, waterbirds and vegetation and important habitats such as wetlands and drought refuges.

There are over more than 100 wetlands along the Moonie River floodplain. Even though the wetlands are not recognised as nationally or internationally important, they provide significant waterbird habitat within the Basin, including for the threatened Australian painted snipe and the freckled duck. They also support threatened and endangered plant species and three endangered vegetation communities.

The Warrego catchment supports large areas of wetlands. The Cuttaburra Channels and nationally significant Yantabulla Swamp (a mosaic of channels, floodways and wetlands) consistently support large numbers and a high diversity of waterbirds and provides breeding sites for ducks and colonial waterbirds when flooded. Waterholes along the Warrego near Charleville are an important breeding area for native fish including Murray cod and silver perch. Toorale's Western Floodplain is also an ecologically important floodplain wetland, providing important feeding and breeding habitat for a range of water dependent species in wet conditions. These ecological populations and habitats are connected to the Barwon–Darling River, providing a critical drought refuge and movement corridor for fish and waterbirds.

Native vegetation in the Warrego and Moonie rivers includes important riparian and floodplain communities in the dryland catchment areas such as lignum, river red gum, river cooba, black box and coolibah. There is a high proportion of remnant vegetation in good condition in some areas including the floodplains of the Warrego, such as stands of coolibah, black box and lignum. The Western Floodplain also supports 'tiny teeth' (*Dentella minutissima*) a plant species listed as threatened under NSW legislation.

The Warrego and Moonie rivers support several species listed as endangered or vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999*, for example, Murray cod, silver perch, Australian painted snipe, Australasian bittern, and examples of the threatened ecological community of coolibah-blackbox woodland. Additionally, these rivers support important remnant populations of olive perchlet, purple spotted gudgeon, and freshwater catfish that are less prevalent or no longer present in the southern Basin.

In between boom periods, channels typically dry to a series of disconnected waterholes, which are drought refuges that are reconnected by the next significant flow event. Semi-permanent and permanent waterholes in the main river channels and distributary creeks and anabranch systems are critical to ensuring the survival of species between boom periods and their capacity to recolonise the system in subsequent flow periods. Much of the riverine fauna (e.g. fish, turtles, invertebrates) of the Warrego and Moonie rivers is dependent upon the persistence of a network of refugial waterholes during frequent and often prolonged no flow periods.

(c) Stakeholder engagement

In the Warrego and Moonie rivers, planning, management, and delivery of Commonwealth water for the environment is undertaken in conjunction with a range of partners and stakeholder groups. Key stakeholders in the Warrego and Moonie include the Queensland Departments of Natural Resources, Mines and Energy (DNRME), Environment and Science (DES), and Agriculture and Fisheries (DAF), NSW Department of Planning, Industry and Environment (DPIE), NSW Department of Primary Industries (DPI) – Fisheries, NSW National Parks and Wildlife Service and the Toorale Joint Management Committee.

Local Engagement Officers from the Commonwealth Environmental Water Office (CEWO) also work with different stakeholders as part a broader program of engagement around the management of the Commonwealths' portfolio of environmental water entitlements. As part of this work, the CEWO's Local Engagement Officers have been engaging directly with members of the local Aboriginal community. This work has focused on aligning priorities for water use with Aboriginal community objectives for sites, values and species significant to the all Nations in the Warrego and Moonie catchments.

3.3.2 Environmental objectives

Based on long-term environmental objectives in the Basin Plan, state long-term watering plans, site management plans, and best available knowledge, the following objectives are relevant for environmental watering in the Warrego and Moonie rivers. These objectives will continue to be revised as part of the CEWO's commitment to adaptive management.

Vegetation: Maintain and improve the condition, growth and survival of riparian, in-channel, floodplain and wetland vegetation.

Waterbirds: Maintain foraging, roosting and breeding habitats at targeted sites on the floodplain to support waterbirds.

Native fish: Improve habitat condition, and support different life stages (migration, spawning, recruitment and refuge), natural flow variability, and connectivity between river channels, wetlands, anabranches and floodplains.

Invertebrates: Maintain and improve the micro and macroinvertebrate communities by providing a variety of habitat and flow conditions.

Other vertebrates: Support survival and recruitment of other native aquatic species, including frogs and turtles.

Connectivity: Support longitudinal connectivity, including with the Barwon River, and lateral connectivity with between the river(s), wetlands and floodplain.

Processes/water quality/resilience: Support key ecosystem functions, biotic dispersal, and promote productivity; maintain water quality in channels and pools and support more natural water temperatures and processes to provide water quality benefits; and maintain drought refuge habitat.

3.3.3 First Nations environmental objectives

The First Nations peoples of the Warrego and Moonie catchments have identified environmental objectives for their country for 2020–21. These objectives have been determined based two processes: one through the First Nations Environmental Guidance project with the Northern Basin Aboriginal Nations (NBAN); and the second through direct engagement with members of the local Aboriginal community*. These processes have identified objectives (Table 13) across a range of sites, issues and values.

Some of these objectives sit outside the scope of water for the environment to influence, while for others, the link between water for the environment and the site or species is not well understood.

The CEWO is committed to working with local First Nations groups to better understand their objectives. The CEWO will use environmental flows to contribute to these objectives where possible and where this is consistent with the Commonwealth Environmental Water Holder's statutory responsibility of protecting and restoring environmental assets in the Basin.

Table 13: First Nations environmental objectives for the Warrego and Moonie rivers for 2020–21

River flows and Connectivity
NBAN Priority Sites: The Warrego River to flow into the Paroo River, during flood times.
NBAN other flows and connectivity: Annual flood periods that will be the stimuli for breeding seasons, which can occur 3 – 6 months after an inundation.
Local Aboriginal community objectives: Water is life and connects all things, and all things are interconnected; rivers and wetlands need water, need flows; reed to care for Country in a physical and spiritual sense; need to look after country and to fulfil cultural obligations; need to look after own mob and for downstream mobs
Native Vegetation
NBAN indicator species: River redgum, coolabah, gidgee, and water reed.
Local Aboriginal community indicator species: Vegetation species that are resources growing in and along rivers and in wetlands and billabongs, and on floodplains – bush tucker, medicines and cultural practices.
Native Birds
NBAN indicator species: Water hen, wood duck, pelican, galah[i], cockatoo [i] and pigeon[i].
Local Aboriginal community indicator species: Species of special importance or are important resources including: brolga, ducks, magpie geese.
Native Animals
NBAN indicator species: Yellowbelly, black bream (silver perch), mussel, goanna[i], emu [i,] echidna[i], wedge-tail eagle [i].
Local Aboriginal community indicator species: Look after native fish, both own importance and resource for community; Look after the critters, everything needs water, make sure things can survive and live; need to look after critters, care for all as part of whole picture, and to look after totem species and significant species.

* Objectives determined through recent and past engagement activities by local engagement officers from the CEWO as well as through reports completed based on input from local Aboriginal community members.

Connecting with Country
NBAN: Nation gathering and teaching. Camping and fishing.
Local Aboriginal community objectives: Sharing stories and knowledge are important to the Northern Intersecting Streams people and the following assist in doing this: Being able to go out on Country to reconnect and share knowledge about landscape and resources, about spiritual and creation stories, and educate the younger generation, Connecting to and Caring for Country – opportunities to go out on Country, and obligations to care for Country.

[i] Water for the environment targeting other environmental outcomes may influence this species or objective

3.3.4 Recent conditions and seasonal outlook

(a) Recent conditions and environmental water use

Unregulated entitlements in both the Warrego and Moonie rivers were triggered in 2019–20. The Commonwealth's entitlements in the Moonie were activated from the end of January to April 2020, with an estimated Commonwealth water for the environment contribution of 4.5 gigalitres.

The Commonwealth's Toorale licences on the Warrego River were also activated in March 2020. The CEWO accessed 200 per cent of the share component of these river licences, contributing 16.2 gigalitres of the 45 gigalitres that flowed from the Warrego River into the Darling River, helping meet downstream environmental demands. Over 11 000 hectares of the Western Floodplain at and around Toorale National Park was also inundated, with flows connecting with the Darling from the floodplain via the Talowla channel for the first time since 2010.

Unregulated flows from the NSW parts of the Moonie and Warrego rivers, along with other northern Barwon–Darling tributary systems in NSW were protected from irrigation extraction using temporary protection orders in early 2020.

Vegetation on the Western Floodplain in the Warrego catchment has responded to the flows, with lignum flowering and showing new growth. Native fish including golden perch are also expected to have benefited from the flows. However, dry periods before flows in early 2020 have limited the abundance and diversity of waterbirds and frogs.

Details of previous Commonwealth environmental water use in the Warrego and Moonie rivers are available at: http://www.environment.gov.au/water/cewo/catchment/northern-unregulated-rivers/history.

(b) Seasonal outlook

According to the Bureau of Meteorology outlook on 2 July 2020, above median rainfall is forecast for the Warrego and Moonie catchments in August to October. While this forecast suggests that the recent severe dry conditions may ease somewhat, several months of above average rainfall are needed to see a recovery from the current severe drought. Stream flows may be less than expected during the recovery. However, wetter conditions can return suddenly in the northern Basin. Maximum temperatures are also forecast to remain above average over the coming months.

(c) Water availability

The Warrego and Moonie rivers have fewer regulating structures than other areas of the Murray–Darling Basin, which limits options for the managed delivery of water for the environment at a predetermined volume and time. Rather, Commonwealth water for the environment in the Warrego and Moonie rivers can generally only be sourced as a share of an unregulated flow event or in some cases targeted management within an event. Most Commonwealth unregulated entitlements are left in-stream to provide environmental benefits by restoring flows that were formerly extracted and improving flow variability.

Water availability depends on the flow events that occur. Unregulated entitlements provide opportunistic access to unregulated river flows and overland flows when a flow event reaches levels specified in entitlement conditions and/or water resource plan triggers at which a period of access may be announced are met. Each entitlement will contribute to restoring in-stream flows reflecting its particular flow access windows, take rates and location. Daily, instantaneous, annual or multi-year limits cap overall diversions in any given year or flow event, and likewise the in-stream contributions that can be attributed to unregulated Commonwealth entitlements.

There is some capacity to direct flows at the junction of the Warrego and Darling rivers through infrastructure on the Toorale site (managed by the NSW National Parks and Wildlife Service in consultation with the Toorale Joint Management Committee). However, this is limited by the nature of the Commonwealth's entitlements in the Warrego and Darling rivers and day to day operations of the Toorale infrastructure. Upgrades and changed management of the Toorale structures is underway through the Toorale Infrastructure Project.

(d) Environmental demands

Considering the ongoing drought, the potential for further hot and dry conditions in the Warrego and Moonie rivers, and the need to avoid further damage to key assets, there are a number of environmental demands that require water urgently in 2020–21.

The environmental water demands for assets in the Moonie and Warrego rivers are represented in Table 14. Note that the capacity to contribute to these environmental demands is contingent on the occurrence of rainfall and unregulated flow events in the catchment that enable access to flows.

Table 14: Environmental demands and priorities for 2020–21

Environmental assets	Physical and process assets	Indicative demand (for <u>all sources of water</u> in the system)		Watering history	2020–21		Implications for future demands
		Flow/volume	Required frequency (maximum interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Moonie (at Gundablouie)	Native fish dispersal and condition Native fish spawning and recruitment Native vegetation Aquatic ecosystem function	Very low flow (VLF) (>30 ML/day) Timing in line with natural (anytime). Minimum duration: typically 60 days/year exceed VLF threshold but not less than 9 days/yr.	At least 96% of years. (Max. interval 70 days (but not more than 283 days))	Met in all years since 2010–11 excluding in 2018–19. Required annually therefore a high demand for water in 2020–21.	High	Possible use of CEW to contribute to an unregulated flow event.	High
		Small fresh 1: >314 ML/day any time (ideally Oct–April). Minimum duration 10 days	3–8 years in 10 (55%). (Max. interval 4.5 years)	Met 2010–11, 2011–12, 2012–13, partially met 2014–15, not met 2015–16, met 2016–17, not met 2017–18, not met 2018–19, met 2019–20. Moderate environmental demand for water in 2020–21, moving to low if watering proceeds as planned.	Moderate		Low
		Small fresh 2: >314 ML/day (Sept–April) duration 14 days	2–6 years in 10 (40%). (Max. interval 6.5 years)	Met between 2010–11 and 2012–13, not met between 2013–14 and 2015–16, met 2016–17, not met 2017–18 or 2018–19, and met 2019–20.	Moderate		Low
		Large fresh 1: >3 909 ML/day (any time) duration 5 days	2–6 years in 10 (45%). (Max. interval 6.5 years)	Met between 2010–11 and 2012–13, not met between 2013–14 and 2015–16, met 2016–17, not met 2017–18 or 2018–19, and partially met 2019–20.	Moderate	Possible use of CEW to contribute to an unregulated flow event.	Moderate
		Large fresh 2: >3 909 ML/day (Oct–April) duration 5 days.	2–5 years in 10 (35%). (Max. interval 6.5 years)	Met between 2010–11 and 2012–13, not met between 2013–14 and 2015–16, met 2016–17, not met 2017–18 or 2018–19, partially met 2019–20.			
		Large fresh 3: 5 100–18 787 ML/day (any time) duration 7 days	2–5 years in 10 (40%). (Max. interval 6.5 years)	Met in 2010–11, 2011–12, 2012–13, partially met 2013–14. Not met since then.	High		Moderate
		Overbank: >18 787 ML/day (any time) duration 1 day.	0–3 years in 10 (15%). (Max. interval 20 years)	Met 2010–11, 2011–12, 2013–14. Not met since 2013–14.	Moderate		Low
		In-channel flows: Up to 600 ML/day for minimum 10 days to enable fish passage and movement.	Ideally 5–10 in 10 years (Max. interval 2 years)	Met in all years since 2010–11 excluding 2012–13.	Low	A high priority for CEW under all water resource availability scenarios.	Low

Environmental assets	Physical and process assets	Indicative demand (for <u>all sources of water</u> in the system)		Watering history	2020–21		Implications for future demands
		Flow/volume	Required frequency (maximum interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Cuttaburra Creek (at Turra)	Native fish dispersal and condition Native fish spawning and recruitment Native vegetation Aquatic ecosystem function	Small fresh 1: <1 000 ML/d for 23 days (anytime)	4 years in 10	Met in 2010–11 and 2011–12. Not met in 2012–13 or 2013–14. Met in 2014–15, 2015–16, 2016–17. Not met in 2017–18. Met in 2018–19 and 2019–20.	Moderate	Possible use of CEW to contribute to an unregulated flow event.	Low
		Large fresh 1: Up to 3 000 ML/d for 45 days (anytime)	2.5 years in 10	Met in 2010–11. Not met in the last 10 years. Nearly met in 2011–12 (43 days).	Critical	Possible use of CEW to contribute to an unregulated flow event.	Low
	<20% wetland inundation Provides feeding and foraging habitat	Wetland inundation 1: 82 000 ML in 60 days (anytime)	1–2 years in 10	Met in 2010–11 and 2011–12. Not met in 2012–13, 2013–14, 2014–15 or 2015–16. Met in 2016–17. Not met in 2017–18. Met in 2018–19 and 2019–20.	Low	Possible use of CEW to contribute to an unregulated flow event.	Low
	50% wetland inundation Small breeding of non-colonial species	Wetland inundation 2: 166 000 ML in 90 days	1–2 years in 10	Met in 2010–11, 2011–12 and 2019–20.	Low	Low priority for use of CEW. Benefit of contributing additional water would be negligible.	Low
	100% wetland inundation Large scale colonial waterbird breeding	Wetland inundation 3: 724 000 ML in 90 days	1–2 years in 10	Not met in the last 10 years.	Critical	Low priority for use of CEW. Benefit of contributing additional water would be negligible.	High
Warrego River (at Barringun)	Native fish dispersal and condition Native fish spawning and recruitment Native vegetation Support refuge habitat (frogs, fish, waterbirds) Aquatic ecosystem function	**Small fresh (SF):** SF1: >217 ML/d for at least 10 days in the Warrego Barringun in Oct–Apr (but can occur at any time) (native fish condition and dispersal). SF2: >217 ML/d for at least 14 days in the Warrego Barringun, in Sept–Apr (spawning of in-channel specialists and generalists)	SF1: Annually (Max. interval: 1 year) SF2: 5–10 in 10 years (Max. interval 2 years)	Met in 2010–11 and 2011–12. Not met in 2012–13 or in 2013–14. Met in 2014–15. Partially met in 2015–16. Met in 2016–17. Partially met in 2017–18. Met in 2018–19 and 2019–20.	Moderate to High	Possible use of CEW to contribute to an unregulated flow event.	Moderate to High
		Large fresh (LF): LF1: >2 242 ML/d for at least 5 days in the Warrego Barringun, in Jul–Sept (but can occur at any time) (native fish condition and dispersal). LF2: >2 242ML/d for at least 5 days in the Warrego Barringun, in Oct–Apr (spawning flow specialists).	LF1: 5–10 years in 10 (Max. interval: 2 years) LF2: 3–5 years in 10 (Max. interval: 4 years)	Met in 2010–11 and 2011–2012. Not met in 2012–13, 2013–14, 2014–15 and 2015–16. Met in 2016–17. Not met in 2017–18 and 2018–19. Met in 2019–20.	High	Possible use of CEW to contribute to an unregulated flow event.	High

Environmental assets	Physical and process assets	Indicative demand (for <u>all sources of water</u> in the system)		Watering history	2020–21		Implications for future demands
		Flow/volume	Required frequency (maximum interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Warrego River (Boera Dam to Darling)[1]	Refuge habitat (waterbirds, frogs, fish) Instream aquatic ecosystems Riparian vegetation In-stream aquatic ecosystems Fish connectivity and movement Riparian vegetation	Flows to replenish refuges and connect to the Darling.	Annually (Max. interval: 1 year)	Met every year except 2012–13.	High	A high priority for use of CEW under all water resource availability scenarios.	High
		In-channel flows: Up to 600 ML/day for minimum 10 days to enable fish passage and movement[1].	Ideally: 5–10 in 10 years (Max. interval: 2 years)	Met every year except 2012–13.	Moderate	A high priority for use of CEW under all water resource availability scenarios.	Moderate
Toorale Western Floodplain Wetland and floodplain vegetation Threatened species (*Atriplex infrequens, Dentella minutissima,* and *Osteocarpum scleropterum)* and ecological communities such as coolibah-blackbox woodland Migratory birds (e.g. Eastern great egret; glossy ibis; oriental pranticole; rainbow bee-eater) Native fish nursery and frog habitat	Minor inundation Northern and Central parts of the floodplain (2 420 ha)	7 GL to the Western Floodplain within 30 days to inundate vegetation such as lignum, coolibah, river cooba, chenopod, forbs.	Preferably: 1 to 1.5 years (lignum); 1 to 3–5 years (river cooba, river red gum, black box); 7–15 years (Coolibah). 5–10 years in 10 (Max interval: 2 years)	Met in 2010–11, 2011–12, 2016–17, 2018–19 and 2019–20.	High	A high priority for use of CEW under all water resource availability scenarios.	Moderate
	Inundation of around half the floodplain (4 459 ha)	16 GL to the Western Floodplain within 30 days to inundate vegetation such as lignum, coolibah, river cooba, chenopod, forbs.	Anytime Ideally: 4–8 in 10 years (Max interval: 3 years)	Met in 2010–11 and 2011–12. Partially met in 2016–17 (over a period of more than 30 days), 2018–19 and 2019–20.	Moderate	A high priority for use of CEW under all water resource availability scenarios.	Moderate
	Inundation of entire Western Floodplain (7 104 ha)	33 GL to the Western Floodplain within 30 days to inundate vegetation such as lignum, coolibah, river cooba, chenopod, forbs.	Any time Ideally: 3–6 years in 10 (Max interval: 6 years)	Met 2010–11, 2011–12 and 2019–20.	Moderate	Possible use of CEW to contribute to an unregulated flow event.	Moderate
	Boom inundation of more than entire Western Floodplain, Uteara lake, reconnections to Darling and return flows to the Warrego. Darling may backup to provide greater inundation. (11 847 ha)	75 GL/year to the Western Floodplain to inundate vegetation such as lignum, coolibah, river cooba, chenopod, forbs.	Any time Ideally: 1–3 years in 10 (Max interval: 10 years)	Met in 2011–12 and 2019–20.	Moderate	Possible use of CEW to contribute to an unregulated flow event.	Moderate

[1] Currently some fish movement may occur via secondary channels including the Western Bywash around Booka Dam and breaches in embankments when flows are large enough to activate these channels.

Environmental assets	Physical and process assets	Indicative demand (for <u>all sources of water</u> in the system)		Watering history	2020–21		Implications for future demands
		Flow/volume	Required frequency (maximum interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Darling River (downstream of the junction with the Warrego)[2] Native fish habitat, movement, refuge and spawning In-stream aquatic ecosystems and riparian vegetation Provides connectivity and movement between Darling and Warrego catchments Support refuge habitat Frog and waterbird habitat and refuge Improve water quality	Drought refuge Fish refuge: all guilds Aquatic ecosystems	Darling River is considered a priority (above all other priorities) when conditions in the Darling River at Louth exceed one or more environmental water requirements from *the Barwon Darling LTWP*: 1. When cease to flow conditions have occurred for more than 110 days; 2. There has been more than 135 days of flow less than 450 ML/d, or; 3. It has been more than one year since a small fresh of at least 1 500 ML/d occurred for at least 10 days as measures at the Louth gauge.	Annual	Refer to Barwon–Darling Plan 2020–21 for a detailed watering history.	High	A high priority for use of CEW under dry to moderate conditions.	High

Note: contributions to meet Barwon–Darling environmental requirements may be considered subject to water availability, antecedent conditions, and environmental demands. Refer to CEWO's Water Management Plan 2020-21: Chapter 3.7 Barwon–Darling.

Key - potential watering in 2020-21

- High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)
- Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate - high water resource availability); or water demand likely to be met via other means
- Low priority for Commonwealth environmental watering (under high - very high water resource availability)
- Unable to provide Commonwealth water because of constraints or insufficient water

Key - environmental demands

- Critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
- High demand for water i.e. needed in that particular year
- Moderate demand for water i.e. water needed that particular year and/or next
- Low demand for water i.e. water generally not needed that particular year
- Very low demand for water i.e. water generally not needed that particular year or the following year

Note that demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime

[2] Demands in the Darling which flows from the Warrego may contribute to downstream of Louth. Other environmental demands in the Darling are described in the *Barwon–Darling Long Term Watering Plan*.

3.3.5 Water delivery in 2020–21

Unregulated entitlements provide opportunistic access to unregulated river flows when a flow event reaches levels specified in entitlement conditions and/or water resource plan triggers at which a period of access may be announced are met. Each entitlement will contribute to restoring in-stream flows reflecting its particular flow access windows, take rates and location.

Management of the Commonwealth's unregulated holdings on the Warrego River at Toorale are managed in accordance with the management strategy for use of these entitlements at Boera Dam (**Figure 7**) to meet environmental demands outlined in Table 2. The CEWO does not have access to the Toorale Warrego River licences in 2020–21 having already accounted for 300 per cent of the share component for these licences between 2018–19 and 2019–20. Operations of the Toorale infrastructure will continue to be managed by the NSW National Parks and Wildlife Service and DPIE, in consultation with the Toorale Joint Management Committee and the CEWO.

Further information on environmental demands in the Barwon–Darling is provided in the CEWO Water Management Plan 2020-21: Chapter 3.7 Barwon–Darling.

3.3.6 Monitoring and Lessons learned

(a) Monitoring

Operational monitoring is undertaken for all Commonwealth environmental watering actions and involves collecting on-ground data about Commonwealth environmental watering such as volumes used, impact on the river systems hydrograph, area of inundation and river levels. It can also include observations of environmental outcomes.

In the Warrego Valley, the five-year Long-Term Intervention Monitoring (LTIM) Project (2013–2014 to 2018–19) included the junction of the Warrego and Darling Rivers as a focus area. It aimed to understand the environmental response from Commonwealth environmental watering with respect to the targeted objectives by carrying out monitoring of site condition over many years.

This monitoring is being continued under the CEWO Monitoring, Evaluation and Research three-year program from 2019–20 onwards. Details of monitoring activities funded by the CEWO in the Junction of the Warrego and Darling Rivers can be found at: http://www.environment.gov.au/water/cewo/catchment/northern-unregulated-rivers/monitoring.

(b) Lessons learned

Outcomes from monitoring and lessons learned in previous years are a critical component for the effective and efficient use of Commonwealth water for the environment. These learnings are incorporated into the way environmental water is managed. Key findings from Long Term Intervention Monitoring at the Junction of the Warrego and Darling Rivers[3], The Warrego-Darling Monitoring, Evaluation and Reporting (MER) selected area project[4] and relevant other monitoring[5] is summarised in Table 15.

[3] Eco Logical Australia (2019b)
[4] UNE unpublished
[5] CEWO 2020

Table 15: Key lessons learned in the Warrego and Moonie rivers

Theme	Lesson learned
Native fish	• Flows in the Warrego, including environmental water, support breeding and recruitment in many fish species. During 'wetter' times, multiple species have been observed to breed, recruit and maintain their population structure, e.g. golden perch, spangled perch, bony herring, Hyrtl's tandan. • Golden perch spawn on river rises in the Warrego, and recruits from the catchment are likely to be contributing to the wider Darling Basin golden perch population. • The fish community in the Warrego River are highly resilient and can survive over highly variable flow conditions, including drying down. Fish communities were able to recolonise and recruit following larger flow events. Golden perch, spangled perch and bony herring have demonstrated an ability to move, colonise and opportunistically recruit in the Warrego in response to increased flows. • Retaining water at all times in at least some of the five main waterholes on the Warrego River will ensure that when the system is reconnected, there are founder populations present that can distribute and recolonise across the lower sections of the Warrego. This will help prepare native fish populations for the next drying phase. • The Moonie has relatively long and deep waterholes that have been shown to be critical refugia for sustaining native fish populations in the often-long periods between flows in the system. Species including golden perch, bony bream, eel tailed catfish and smelt moved significant distances (up to 70 kilometres) in response to waterhole reconnecting flows, enabling recolonisation of the system and genetic mixing.
Frogs	• Inundation of the Western Floodplain, including with environmental water, supports increased frog abundance and richness. This is because greater areas of highly productive habitat is created, which is capable of supporting breeding and larger frog populations. • The more permanent sites in the Warrego River provide more stable habitat for local frog populations. • Frog monitoring under the MER project in late 2019 and early 2020 found relatively low numbers and diversity of frog species (likely because of dry conditions). Species detected included plains froglet, Peron's tree frog, desert tree frog, barking marsh frog, painted marsh frog, plains froglet and green tree frog. Frog species are expected to recover following further rainfall in the Warrego catchment.
Waterbirds	• When inundated, the Western Floodplain supports diverse and abundant waterbird populations and can support waterbird breeding. • The Warrego River waterholes appear to provide longer-term refugia that support more stable populations of waterbirds. Boera Dam consistently had the greatest richness and diversity of waterbirds.
Connectivity	• Environmental water has been observed to successfully increase longitudinal connectivity between the Warrego and Darling rivers, and laterally, with parts of the Western Floodplain. By increasing connectivity, water for the environment improves water quality, increases available habitat and productivity, and supports native fish movement between rivers. The resulting productivity booms can also generate an increase in the abundance and diversity of invertebrates, frogs and waterbirds on the floodplain.

Theme	Lesson learned
	• Environmental water can successfully increase the size of flows through the Warrego system, increasing connectivity between the Warrego and Darling rivers. This is important for improving water quality, increasing productivity and allowing the movement of native fish between rivers for spawning, dispersal and recruitment. • Environmental water can also increase connectivity and inundation of parts of the Western Floodplain. The resulting booms in productivity have supported the highest abundance and diversity of invertebrates, frogs and waterbirds compared to the Warrego and Darling sites.
Water Quality	• Water for the environment delivered through the Warrego consistently helps improve the quality of Darling River water downstream of the confluence. Observed improvements include, reduced pH, conductivity, turbidity and algal productivity, and increased nutrient cycling and habitat when compared with periods without environmental water.
Productivity/ food webs	• Environmental water that contributes to connection for a long duration (>6 months) stimulates a boom in productivity, which provides food for higher order predators such as waterbirds. • The Western Floodplain is important for highly dense and species rich invertebrate communities. More diverse macroinvertebrate communities may offer a wider range of feeding opportunities for higher level consumers such as frogs, fish, waterbirds and other aquatic vertebrates. • The Warrego and Western Floodplain are productive systems, species such as shrimps and tadpoles responded quickly to inundation. Species such as fairy and shield shrimps are known to rely on an egg bank that is desiccation resistant, which may help survival and responsiveness. • Using environmental water to inundate channel and floodplain habitats during warmer periods can maximise the diversity and density of invertebrates and frogs by increasing the range of food and habitat available. Inundating in-channel habitat features such as snags, benches and anabranches promotes the transfer of nutrients and organic material, which drives the food webs of the river.
Vegetation	• The condition of vegetation communities on the Western Floodplain is driven by inundation, which has been enhanced by Commonwealth environmental water. Flooding of the Western Floodplain increased the cover and richness of vegetation communities, including annual herbaceous ground cover species. • Lignum condition improved when inundated more frequently. Extended dry periods (greater than 2.5 years) on the floodplain resulted in declines in vegetation cover and condition. However, lignum condition improved again in response to inundation in 2019 and early 2020. • Grazing and competition for resources are likely to impact on tree recruitment more than inundation alone.
Refuge	• Warrego River waterholes act as longer term refuges for native fish, waterbirds, turtles and frogs, supporting more consistent ecological communities over time. Boera and Booka dams provide the most persistent refuges. Environmental water can help replenish and re-connect refuge habitat in the Warrego River and the Darling River near Toorale.

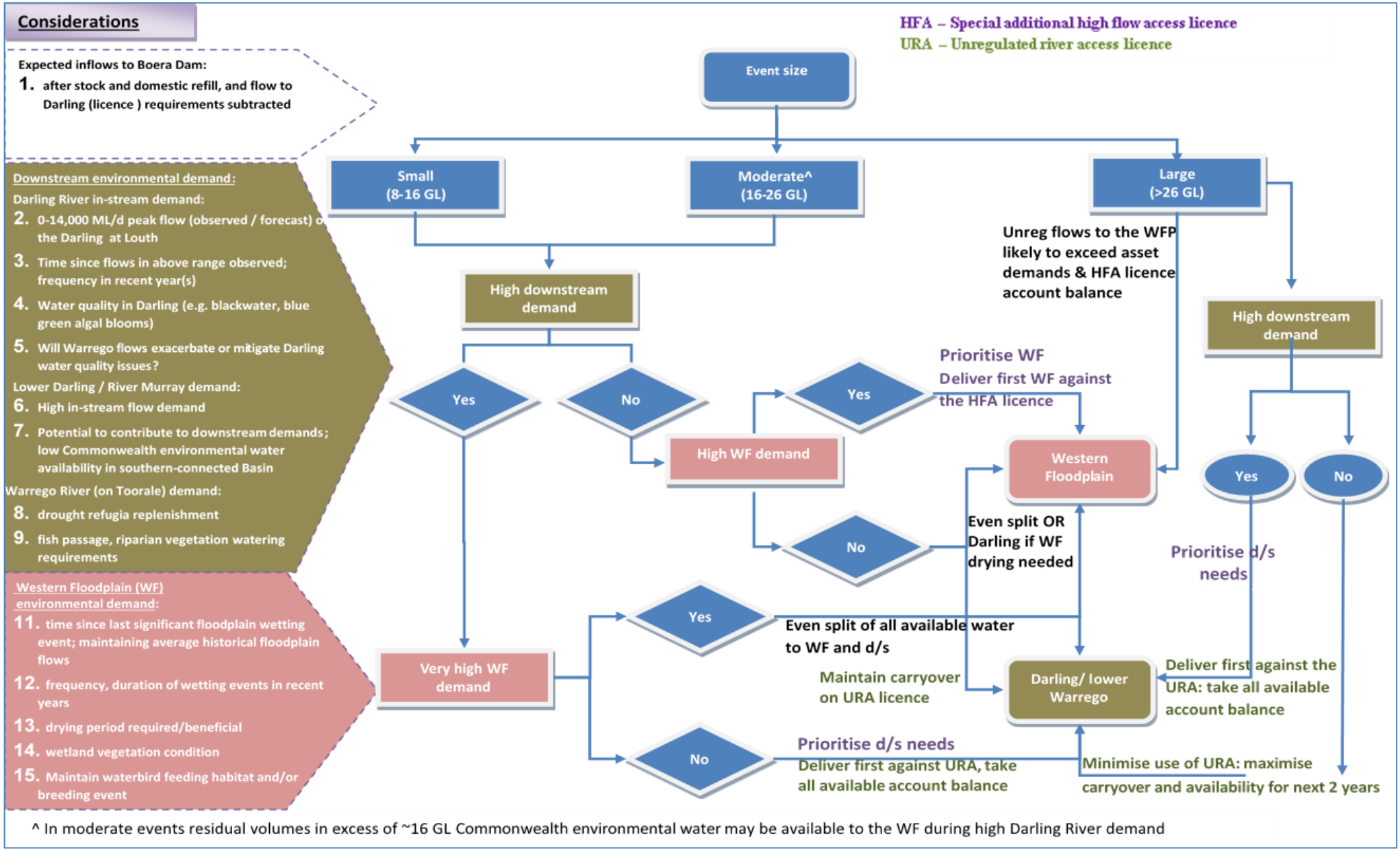

Figure 7: Management strategy for Commonwealth environmental water at Toorale (Subject to change as new information becomes available)

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3.4 Gwydir Valley

3.4.1 Region overview

(a) River valley

Copeton Dam is the major regulated water storage in the system (with a capacity of 1 364 gigalitres). Copeton Dam regulates on a long-term average of approximately 55 per cent of system inflows, however, this is highly variable from year to year. Several unregulated tributaries flow into the Gwydir River below Copeton Dam, including the Horton River. These unregulated tributaries can provide significant unregulated flows into the Gwydir River.

In the lower sections of the Gwydir system, re-regulating structures at Tareelaroi, Boolooroo and Tyreel manage low to medium flows from the Gwydir River into the Mehi River, Carole Creek and the Lower Gwydir River/Gingham Watercourse. There are also re-regulating structures on the Mehi River at Combadello and Gundare, which control low to medium flows between the Mehi and the Moomin and Mallowa creeks.

(b) Traditional Owners

The rivers and wetlands of the Gwydir Valley hold significant spiritual and cultural importance for Aboriginal people. Most of the Gwydir system falls within the traditional lands of the Gomeroi/Kamilaroi people. The Gomeroi is a large Nation, which extends from around Singleton in the Hunter Valley through to the Warrumbungles in the west, and through the Namoi and Gwydir valleys to just over the Queensland border. The eastern headwater around Guyra, Uralla and Tenterfield is the traditional lands of the Anaiwan people.

(c) Important sites and values

The Gwydir Wetlands is a terminal wetland in the lower reaches of the Gwydir River and Gingham Watercourse. Four sites within the wetlands are listed as Wetlands of International Importance under the Ramsar Convention: Old Dromana on the Lower Gwydir Watercourse and Goddard's Lease; Windella; and Crinolyn on the Gingham Watercourse. These sites were recognised for their important habitat value for waterbirds, sustaining up to hundreds of thousands of breeding colonial waterbirds when flooded. This includes those listed under international migratory agreements (JAMBA, ROKAMBA, and CAMBA). The Ramsar site contains a range of habitats including large areas of coolibah woodland, water couch, and part of the largest stand of marsh club rush in New South Wales (NSW). These vegetation types have been identified as critical components of the Ramsar site that help support its ecological character.

Another key asset in the Gwydir River Valley is the Mallowa Wetlands. While it is not Ramsar-listed or as extensive as the Gwydir Wetlands, the Mallowa Wetlands have less lippia (weed) and support a diverse range of wetland and floodplain vegetation, which is representative of the Gwydir River valley's native vegetation. The native vegetation of Mallowa Creek also provides valuable habitat for waterbirds, woodland birds, and other fauna; and prior to river regulation supported large scale waterbird breeding events.

The Gwydir River system supports several native fish species identified as threatened in NSW and/or Commonwealth legislation. These include silver perch (critically endangered) and Murray cod (vulnerable) listed under the *Environment Protection and Biodiversity Conservation Act 1999*, and olive perchlet and freshwater catfish (endangered populations), and purple spotted gudgeon (endangered species), listed under the *NSW Fisheries Management Act 1994*.

The Mehi River and Carole Creek connect the network of rivers and creeks within the Gwydir valley to the Barwon-Darling system. Maintaining connection between these two river networks is important for native fish movement and recruitment. Flows from the Mehi and Carole systems into the Barwon River can provide critical low flows to downstream reaches, which can minimise the length of cease to flow periods. These flows help the survival of native fish and other river dependent fauna species by reconnecting the larger persistent pools and waterholes along the Barwon and Darling Rivers. Following the recent drought, connection between the Barwon-Darling system and its tributaries will be important to ensure the recovery of native fish communities across the northern Basin.

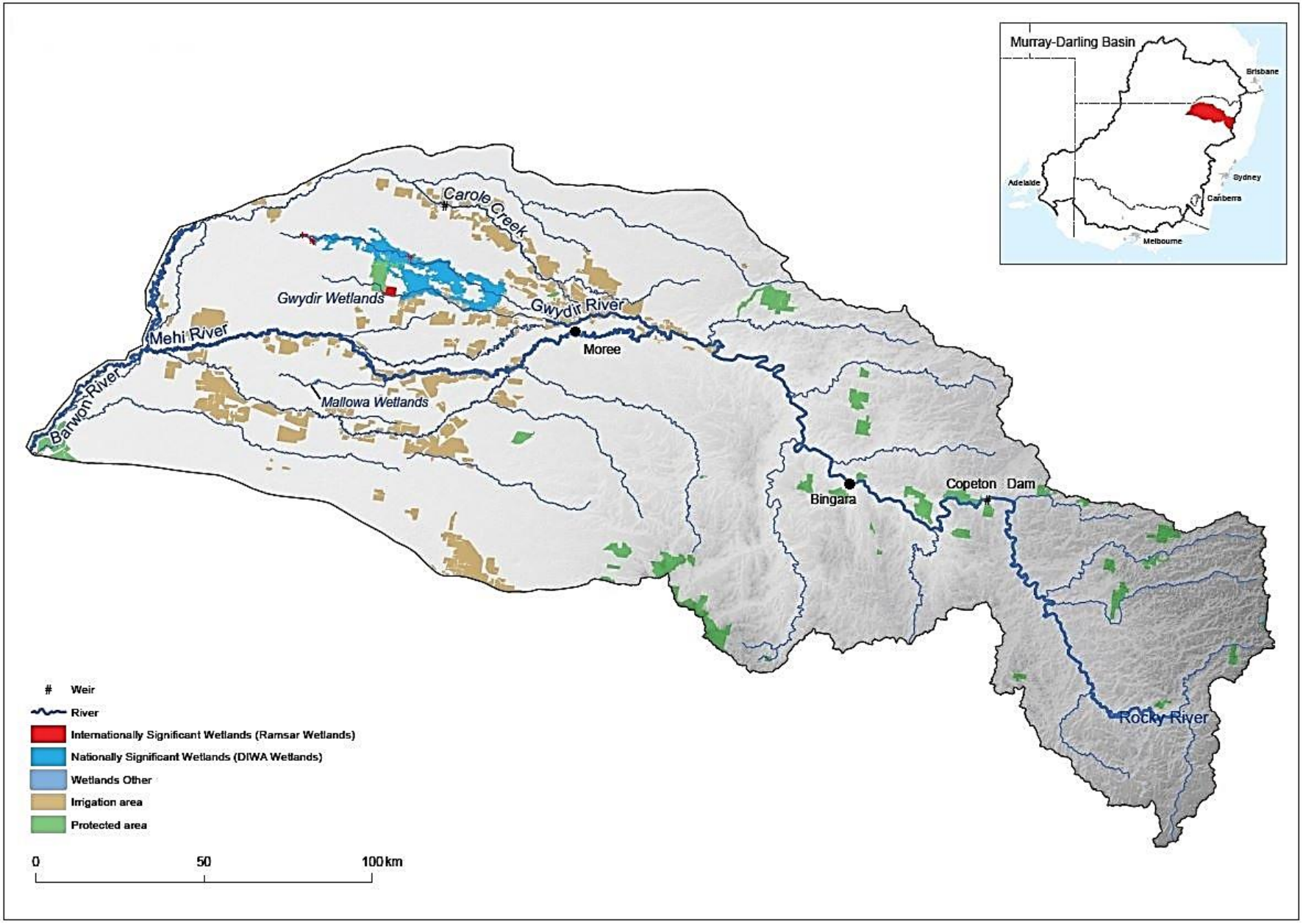

Figure 8: Map of the Gwydir River Valley (CEWO 2015).

(d) Stakeholder engagement

In the Gwydir River Valley, the planning, management, and delivery of Commonwealth water for the environment is undertaken in conjunction with a range of partners and stakeholder groups. Key stakeholders in the Gwydir include the NSW Department of Planning, Industry, and Environment (DPIE) – Environment, Energy and Science (EES), DPIE – Water, WaterNSW, and the Gwydir Environmental Water Advisory Group known as the Environmental Contingency Allowance Operations Advisory Committee (ECAOAC).

The ECAOAC provides advice to water managers on priorities for water use and includes representatives from local landholders, Gwydir Valley Irrigators, the local Aboriginal community, independent scientists, and environmental representatives, as well as Government organisations involved in water and environmental management (DPIE – Water, National Parks and Wildlife Service, DPIE – EES, North West Local Land Services, NSW DPI – Fisheries, and WaterNSW).

Local Engagement Officers (LEOs) from the Commonwealth Environmental Water Office (CEWO) also work with a range of stakeholders as part of a broader program of engagement around the management of the Commonwealth's portfolio of environmental water entitlements. As part of this work, CEWO's Local Engagement Officers engage directly with members of the local Aboriginal community, Local Aboriginal Land Councils (LALCs), and other Aboriginal community groups. This includes working with community around environmental water, to learn and improve on how environmental water may be able to support the local Aboriginal communities' objectives for sites, values, and species significant to the Gomeroi/Kamilaroi Nation in the Gwydir catchment. Engagement with the local Aboriginal community is also being undertaken as part of the current CEWO Monitoring Evaluation and Reporting (MER) Program, which is being undertaken in the Gwydir by the University of New England (UNE) and 2rog.

3.4.2 Environmental objectives

Based on the long-term environmental objectives in the Basin Plan, draft state long-term watering plans, site management plans, and best available knowledge, the following objectives are relevant for environmental watering in the Gwydir River Valley.

The objectives that are targeted in a particular year may vary, depending on available water, catchment conditions, operational feasibility, and demand for environmental water. These objectives will continue to be revised as part of the CEWO's commitment to adaptive management.

Vegetation: Maintain the condition, diversity and extent of riparian, floodplain and wetland vegetation.

Waterbirds: Increase waterbird abundance and species diversity, and support waterbird breeding events (reproduction and fledging) through to completion.

Native fish: Support viable populations of threatened native fish and maximise opportunities for range expansion and the establishment of new populations.

Macroinvertebrates: Support recruitment and maintain macroinvertebrate diversity and habitat.

Connectivity: Improve flow regimes and increase connectivity in the Gwydir River system, including with the Barwon River, and lateral connectivity between rivers and the floodplain.

Processes/water quality/resilience: Support key ecosystem functions including primary production, decomposition, nutrient and carbon cycling, and the mobilisation and dispersal of biotic/abiotic material; maintain water quality in channels and pools; and maintain drought refuge habitat.

3.4.3 First Nations environmental objectives

Representatives of the First Nations peoples of the Gwydir valley have identified environmental objectives for their country for 2020–21. These objectives have been developed through two processes. The first process was the First Nations Environmental Watering Guidance project undertaken by the Northern Basin Aboriginal Nations organisation. The second process was direct engagement by the CEWO's Local Engagement Officers with members of the local Aboriginal community[1]. These processes have identified objectives (Table 16) in more detail that most valleys across a range of sites, issues and values. These processes have also identified sites of special significance for First Nations in the Gwydir valley.

Some of these objectives are outside the scope of water for the environment to influence, while for others, the link between water for the environment and the site or issues is not well understood and needs further consultation with local Aboriginal groups to better define these links between environment, the site and Aboriginal cultural practice in relation to land and water. Environmental flows will then aim to further contribute to identified objectives, where possible. In addition, the Commonwealth Environmental Water Holder (CEWH) is committed to working with the local Aboriginal community to better understand their objectives and the environmental water requirements for key values and sites.

Table 16: First Nations environmental objectives for the Gwydir system for 2020–21

River flows and Connectivity
NBAN priority sites: Gwydir River always needs to flow at a certain level[i].
Local Aboriginal community: Water is life and connects all things, and all things are interconnected[i]; rivers and wetlands need water, need flows; need to care for Country in a physical and spiritual sense; need to look after country and to fulfil cultural obligations[i] Need to look after own mob and for downstream mobs.
Native Vegetation
NBAN indicator species: Gidgee gum[i], blue gum[i], bulrush, water lily, sedges, tea trees, sandalwood[i], iron bark[i], poplar box[i].
Local Aboriginal community indicator species: Vegetation species that are resources growing in and along rivers and in wetlands and billabongs, and on floodplains – bush tucker, medicines and cultural practices[i].
Native Birds
NBAN indicator species: Teal, crimson wing, storks, white long-legged heron.
Local Aboriginal community indicator species: Brolga, ducks, magpie geese.
Native Animals
NBAN indicator species: Dhufish (eel-tailed catfish), yellowbelly, codfish. black bream (silver perch).
Local Aboriginal community indicator species: Look after native fish, both own importance and resource for community ; look after the critters, everything needs water, make sure things can survive and live; need to look after critters, care for all as part of whole picture, and to look after totem species and significant species.
Connecting with Country
NBAN: The Gomeroi people need to: tell and share our stories; be able to hunt and fish along the rivers; gather at the river as a Nation; go camping.

[1] Objectives determined through recent and past engagement activities by LEOs from the CEWO as well as through reports completed based on input from local Aboriginal community members.

Local Aboriginal community input: sharing stories and knowledge are important to the Gomeroi people and the following assist in doing this: being able to go out on Country to reconnect and share knowledge about landscape and resources, about spiritual and creation stories, and educate the younger generations; connecting to and Caring for Country – opportunities to go out on Country, and obligations to care for Country. Important values include modified trees, burial sites, scar trees, stone artefacts and a midden site.
Other notable water-dependent sites
Local Aboriginal community input: Gwydir Wetlands, including the Gingham and Lower Gwydir watercourses and wetlands and significant places in and along these wetlands including Gingham Waterhole, Bunnor Lagoon, Wandoona (Troy) Waterhole and Gin Holes. The Mallowa Creek and its wetlands, including Valetta swamps and wetlands. Moomin Creek sites. Mehi River sites (especially Top and Bottom Camps). Mid-section of the Gwydir River include Gravesend, Elcombe, and Gum Flat. Other lagoons and billabongs including Tillaloo, Baroona Waterholes, the Glen Swamp; Poison Gate (Derra) Billabong; Whittaker's Lagoon and Collymungle.

[i] Water for the environment targeting other environmental outcomes may influence this species or objective

3.4.4 Recent conditions and seasonal outlook

(a) Recent conditions and environmental water use

It is preferred to use natural flow triggers for a 'reactive' or responsive use of environmental water in the Gwydir system. Reactive use of environmental water can be in response to dry flow patterns leading to extended cease to flow periods or in response to rainfall and un-regulated (natural) flow events.

Where a 'reactive' approach is insufficient to achieve inundation of priority wetland and floodplain system in a three-year period, a 'proactive' approach is applied. Proactive environmental watering involves the delivery of a larger volume of environmental water to support the continued health of the wetlands. A proactive approach reflects the available water, constraints, and modifications of the system.

The Gwydir River Valley has experienced hot and dry conditions since 2017–18, with lowest on record rainfall and highest on record temperatures occurring during that time. Inflows to Copeton Dam were low for most of this period, with storage levels dropping to around 6 per cent of capacity in January 2020. No new allocations were made in 2019–20 for general security entitlements, and the delivery of water was restricted to block releases, including water for the environment.

Ongoing drought conditions meant many parts of the Gwydir River system stopped flowing in September and October 2019, and January 2020. During these drying phases, refuge pools began to dry and water quality declined. Responding to these dry conditions, Commonwealth and NSW water for the environment was delivered to the Gwydir and Mehi rivers and Carole Creek between October and January. This water helped refresh refuge habitat, improve water quality, and support native fish survival.

Conditions began to improve following significant rainfall events across parts of the northern Basin between January and February 2020. During this period, between 300-350 mm of rainfall was recorded across the Gwydir Valley with Copeton Dam receiving around 60 000 megalitres of inflow. Rainfall resulted in increased river flows during February and March 2020, with around 55 000 megalitres flowing past Pallamallawa on the Gwydir River and providing inflows into the Gingham and Lower Gwydir watercourse. These flows also provided connection between the Gwydir and Barwon systems via end of system flows in the Mehi River and Carole Creek.

In response to rainfall and natural flows, supplementary water for the environment was also provided in the February and March events. This portion of water was directed to the Gingham, Lower Gwydir and Mallowa systems to help improve river and wetland conditions. These inflows provided inundation of wetland areas including a section of the central Gingham Wetlands that had been burnt by wildfire in spring 2019. Mallowa Creek and Wetlands, along with Ballin Boora Creek and other floodplain systems received large inflows on up to four occasions from local runoff after localised heavy/intense rainfall events. Lower natural flows have continued in most parts of the system into May 2020.

Details of previous Commonwealth environmental water use in the Gwydir River Valley is available at: http://www.environment.gov.au/water/cewo/catchment/gwydir/history.

Monitoring undertaken during February-March 2020 revealed that the increased flows had enhanced the condition of the lower Gwydir system with:

- 40 water bird species observed across the system, with hundreds of birds recorded at some sites.
- The Gingham Waterhole providing important habitat for a range of aquatic species including Eastern longneck and Murray River turtles.
- Improved condition and diversity of species within important wetlands of the Gwydir Wetlands State Conservation Area.

(b) Seasonal outlook

According to the Bureau of Meteorology outlook in July, above median rainfall is forecast across the Gwydir River Valley from late winter into spring. While this forecast suggests that the recent severe dry conditions may ease somewhat, several months of above average rainfall are needed to see a recovery from the current severe drought. Stream flows may be less than expected during the recovery. However, wetter conditions can return suddenly in the northern Basin. Maximum temperatures are also forecast to remain above average over the coming months.

(c) Water availability

The volume of Commonwealth environmental water carried over in the Gwydir River Valley for use in 2020–21 is 12 gigalitres. The 1 July 2020, NSW water allocation statement indicated full (100) allocation for high security entitlements in 2020–21, which would add an additional 4.5 gigalitres of water for the environment against Commonwealth high security entitlements. However, there may be restrictions on deliverability.

As of 1 July 2020, Copeton Dam was at 13 per cent capacity. In the absence of further rainfall, there may be insufficient water available to meet all system requirements in 2020–21. This may limit the capacity to deliver water for the environment.

Based on the expected available volume of water held by the Commonwealth and other water holders, as well as recent and forecast catchment conditions, it is expected that the overall resource availability will be low to moderate in 2020–21. A moderate water resource availability scenario is only possible should more rainfall and inflows occur.

(d) Environmental demands

Considering the prolonged drought conditions and the need to avoid further damage, build resilience, and support the recovery of key assets in the Gwydir Valley, there are a number of environmental demands that require water urgently in 2020–21.

The environmental water demands for assets in the Gwydir River Valley in 2020–21 are represented in Table **17**. Please note that the capacity to contribute to many of these environmental demands is contingent on further improvements in water availability in the catchment.

Table 17: Environmental demands, priority for watering in 2020–21 and outlook for coming year in the Gwydir River Valley.

Environmental assets	Target values	Indicative demand (for <u>all sources of water</u> in the system) #		Watering history	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution?	Likely environmental demand in 2021–22 if watering occurred as planned in 2020–21
Refuge pools along the Gwydir and upper Mehi Rivers as well Carole Creek Refuge habitat Native fish Water quality	Critical drought refuge habitat Native fish maintenance and survival	**Cease-to-flow Triggers** <u>Gwydir River</u> 0 ML/d (Gwydir @ Yarraman) for around a maximum of 30–60 days (depending on conditions) Mehi River 0 ML/d (Mehi @ Moree) for around a maximum of 40–80 days (depending on conditions) <u>Carole Creek</u> 0 ML/d (Carole Creek near Garah) for a maximum of around 40–80 days (depending on conditions).	Cease to flow period should not exceed periods of 40–80 days	The Northern Connectivity Event in April–May 2018 and the Northern Fish Flow April–June 2019 contributed to meeting this demand in key reaches (mainly in the Mehi and to a lesser extent in the Carole). Reflecting the extremely dry conditions that persisted through most of 2018–19 and 2019–20, environmental water was delivered to protect critical aquatic and fish refuge habitat in the Gwydir, Carole and Mehi systems to help meet this demand between Oct 2019 and Jan 2020. Feb–March rainfall events have moved systems towards more moderate conditions. However, overall the system is still dry, and demand for water has been assessed as high.	High	A high priority for CEW under very low water availability scenario, subject to availability. Using regulated environmental water entitlements, respond to extended dry periods to protect critical floodplain refuge habitat	High
Gwydir Wetlands Areas of Ramsar listed wetlands* Nationally significant wetlands Waterbird breeding and habitat Habitat and breeding ground for frogs Native fish habitat Endangered ecological communities Lagoons and wetlands which have important values for the Gomeroi local Aboriginal community. Key sites include: • Old Dromana Wetland • Bunnor Wetland • Gingham Waterhole • Gin Holes	Core wetland inundation Refuge habitat for native fish, waterbirds, frogs and other aquatic species Maintenance and Regeneration of Wetlands Ecosystem function	**Small wetland (WL) inundation:** WL1 (Protect Core Wetland)^: • >6 GL event over 3–6 months (Gwydir @ Millewa) at any time. • >15 GL event over 1–3 months (Gingham @ Teralba) at any time. • >15 GL event over 2–6 months (Gingham @ Tillaloo) at any time. • >3 GL event 1–4 months (Gingham & Gingham Bridge) WL2 (Maintenance and Regeneration of Wetlands)^: • >36 GL over 3–6 months (Gwydir @ Allambie) in Sept–Mar (but can occur at any time). • >30 GL over 1–3 months (Gingham @ Teralba) • >30 GL over 2–6 months (Gingham @ Tillaloo) in Sept–Mar (but can occur at any time). • > 15 GL over 1–4 months (this should have been 2–6 months) (@ Gingham Bridge)	WL1: 9–10 in 10 years (Max. interval: 1 year) WL2: 8–9 in 10 years (Max. interval: 2 years)	The 2016–17 water year was the last time wetland maintenance and regeneration targets were met across the entire Gwydir Wetlands. Wetlands across the Gingham and Lower Gwydir systems experienced dry conditions during 2017–18 with WL1 flow targets at the Millewa in the Lower Gwydir and Teralba, Tillaloo and Gingham Bridge in the Gingham gauges met. During 2018–19 an extended environmental watering events (based on a proactive water delivery strategy) enabled all WL1 flow targets to be met. This enabled most of the core wetlands across both the Gingham and Gwydir systems to be inundated. Natural flows occurred during Feb–Mar 2020 meeting WL1 flow targets, at Millewa and Teralba. Large parts of core wetlands in the Upper and Central Gingham were inundated, but a limited area in the Lower Gingham and limited duration in areas downstream from Gingham Waterhole. The Goddard's Lease part of the Ramsar site has been inundated but flows did not reach the Crinolyn or Windella Ramsar site areas. In the Lower Gwydir systems most, but not all, core wetland areas and with only with limited duration in some more western and higher sections of these wetlands were inundated. Most of the Old Dromana Ramsar area and most of the marsh club-rush areas received inundation. The inundation was supported by significant rainfall which fell across much of the lower Gwydir system during February and March. Core wetlands have been watered 2-3 times in the last three years, while the flows required to maintain and regenerate wetlands have exceeded their maximum flow interval.	High	A high priority for CEW under low to moderate water resource availability scenarios, subject to occurrence of unregulated flow event and water availability. A combination of entitlements may be used to respond to unregulated flow events, to protect (supplementary) and potentially restore (regulated) parts of a natural flow. Use of supplementary water to protect natural flow events will be a high priority. Given the low volumes of regulated environmental water available, using regulated releases to restore parts of a natural flow is currently a low priority for 2020–21.	Moderate to High (subject to occurrence of unregulated flow events)
	Maintenance and regeneration of floodplain vegetation (including lignum) Waterbird habitat and potential breeding Native fish Ecosystem function	**Large wetland (WL) inundation^:** WL3 (Regeneration of Floodplain Vegetation): • >45 GL over 3–6 months (Gwydir @ Allambie) in Oct–Apr • >45GL over 1–3 months) Gingham @ Teralba • >40 GL over 2–6 months (Gingham @ Tillaloo) in Oct–Apr • >20 GL over 1–4 months (@ Gingham Bridge) WL4 (Maintenance of Floodplain Vegetation) ^: • >65 GL over 2–6 months (Gwydir @ Allambie) in Aug–Feb (but can occur at any time) • >60 GL over 2–6 months (Gingham @ Tillaloo) in Aug–Feb (but can occur at any time). • >30 GL over 1–4 months (Gingham @ Gingham Bridge) in Aug–Feb (but can occur at any time).	WL3: 5–8 in 10 years (Max. interval: 3 years) WL4: 3–5 in 10 years (Max. interval: 5 years)	The 2016–17 water year was the last time a large wetland inundation event occurred across the Gingham and lower Gwydir systems. During 2019–20 very dry conditions persisted, with no significant inflows entering the central parts of the Gingham and Gwydir systems for much of the year. However, the condition of floodplain vegetation was improved by widespread rainfall, which occurred across the Gingham and Lower Gwydir systems in early 2020. The maximum flow interval for the regeneration of floodplain vegetation has now been exceeded, and water is required in 2020–21. Water will also be required in the next 1–2 years to support the maintenance of floodplain vegetation.	Moderate to High	Possible use of CEW under moderate to high water resource availability scenarios, subject to occurrence of unregulated flow event and water availability. Given the low volumes of regulated environmental water available, proactive delivery is currently a low priority for 2020–21, while use of supplementary water to protect natural flow events is a higher priority.	Moderate to High (subject to occurrence of unregulated flow events)

Environmental assets	Target values	Indicative demand (for all sources of water in the system) #		Watering history	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution?	Likely environmental demand in 2021–22 if watering occurred as planned in 2020–21
Mallowa Wetlands Waterbird breeding and habitat Habitat and breeding ground for frogs Endangered ecological communities Lagoons and wetlands which have important values for the Gomeroi local Aboriginal community. Key sites include Valetta swamps and surrounding wetlands	Core wetland inundation Refuge habitat for native fish, waterbirds, frogs and other aquatic species Wetland and riparian vegetation Ecosystem function	**Small wetland (WL) inundation:** WL1 (Protect Core Wetland): >3 GL over 2–4 months at the Mallowa Regulator in Oct–Mar (but can occur at any time). WL2 (Maintenance and Regeneration of Wetlands): >8 GL over 2–4 months at the Mallowa Regulator in Sept–Mar (but can occur at any time).	WL1: 9–10 in 10 years (Max. interval: 1.5 years) WL2: 7–9 in 10 years (Max. interval: 2 years)	The Mallowa wetlands experienced dry conditions during 2017–18. During 2018–19 an extended environmental watering event (based on a proactive water delivery strategy) enabled all flow targets to be met, helping to protect, maintain and regenerate core wetland areas. The Mallowa wetlands again experienced dry conditions during and 2019–20, with no significant inflows entering the system from the Mehi River. However, several intense high rainfall events across most of the Mehi, Mallowa and Moomin systems in early 2020 provided flows along and into the Mallowa Creek, improving the condition of wetlands across the Mallowa system. Because of system constraints, core wetland areas in the Mallowa require frequent inundation and are approaching the maximum interval between inundation events. Therefore, the demand for water has been assessed as high for flows necessary to support the protection of core wetland areas during 2020–21.	High	A high priority for CEW under low to moderate water resource availability scenarios, subject to occurrence of unregulated flow event and water availability. Use of supplementary water to protect natural flow events will be a high priority. Given the low volumes of regulated environmental water available, using regulated releases to restore parts of a natural flow is currently a low priority for 2020–21.	Moderate to High (subject to occurrence of unregulated flow events)
	Wetland vegetation (including lignum) Waterbird habitat and potential breeding Native fish Ecosystem function	**Large wetland (WL) inundation:** WL3 (Regeneration of Floodplain Vegetation): >15 GL over 2–4 months at the Mallowa Regulator in Oct–Apr WL4 (Maintenance of Floodplain Vegetation): >22 GL over 2–6 months at the Mallowa Regulator in Aug–Feb (but can occur at any time)	WL3: 5–7 years in 10 (Max. interval: 3 years) WL4: 3–5 years in 10 (Max. interval: 5 years)	Like wetland systems, floodplain areas within the Mallowa system experienced dry conditions during 2017–18. During 2018–19 an extended environmental watering event (based on a proactive water delivery strategy) enabled the flow target for regeneration of floodplain vegetation to be met. The Mallowa wetlands again experienced dry conditions during 2019–20, with no significant inflows entering the system. However, the condition of floodplain vegetation communities was improved by widespread rainfall, which occurred across the Mallowa Creek system in early 2020. Flows to support the regeneration of floodplain vegetation (WL3) have occurred once in the last three years but have not reached the maximum interval between events. WL4 requires natural flow events to occur to enable it to be achieved and has not been met in the last 3 years. Overall the demand for large wetland inundation flows was assessed as moderate.	Moderate	Possible use of supplementary water (if available) to protect natural flow events.	Moderate (subject to occurrence of unregulated flow events)
Carole Creek Waterbird habitat and refuge Habitat and refuge for frogs Native fish habitat, breeding, recruitment and refuge Aquatic communities	Native fish dispersal and condition Native fish spawning (in-channel specialists and generalists, e.g. Murray cod) Native vegetation Aquatic ecosystem function	**Small fresh (SF):** SF1: >200 ML/d for at least 10 days on the Carole near Garah, in Oct–Apr (but can occur at any time) (native fish condition and dispersal). SF2: 200–900 ML/d for at least 14 days on the Carole near Garah, in Sept–Apr (spawning of in-channel specialists and generalists)	SF1: Annually (Max. interval: 1 year) SF2: 5–10 in 10 years (Max. interval: 2 years)	The 2017–18 water year was the last time small fresh flow targets were met. The Carole Creek system experienced dry conditions during both 2018–19 and the initial parts of the 2019–20 water years, with no significant inflows entering the system for extended periods. During this period environmental water delivery focused on low flows to maintain drought refuges. Natural flows occurred during Feb–Mar 2020 meeting the SF1 flow target, resulting in this target being met 3 out of the past 4 years. Natural flows in the early part of 2020 were insufficient to meet the SF2 flow target. The SF2 flow target has not been met since the 2017–18 water year and the maximum interval for this flow requirement has now been exceeded. The importance of the SF2 flow target in providing potential spawning conditions for native fish means that the requirements for a small fresh event between September and August is high.	High	A high priority for CEW under low to moderate water resource availability scenarios, subject to occurrence of unregulated flow event and water availability. Use of supplementary water to protect natural flow events will be a high priority. Given the low volumes of regulated environmental water available, using regulated releases to restore parts of a natural flow is currently a low priority for 2020–21.	Moderate to High (subject to occurrence of unregulated flow events)
		Large fresh (LF): LF1: >900 ML/d for at least 5 days on the Carole near Garah, in Jul–Sept (but can occur at any time) (native fish condition and dispersal). LF2: >900 ML/d for at least 5 days on the Carole near Garah, in Oct–Apr (spawning flow specialists).	LF1: 5–10 years in 10 (Max. interval: 2 years) LF2: 3–5 years in 10 (Max. interval: 4 years)	Flows occurring in February 2020 met the LF1 flow target, however, during the previous 3 water years the LF2 flow target for has not been met. Flow targets for large freshes along Carole Creek require large unregulated flows. Overall the demand for large fresh flows was assessed as moderate, requiring water in the next 1–2 years.	Moderate	Possible use of supplementary water (if available) to protect natural flow events.	Moderate to High (subject to occurrence of unregulated flow events)

Environmental assets	Target values	Indicative demand (for <u>all sources of water</u> in the system) #		Watering history	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution?	Likely environmental demand in 2021–22 if watering occurred as planned in 2020–21
Ballin Boora Riparian Areas In-channel and riparian habitat Aquatic communities	Water bird habitat and refuge Habitat and breeding ground for frogs Native fish habitat	600–1 200 ML event delivered at 10–50 ML/d (via infrastructure) for 12–120 days. May occur at any time.	Frequency subject to further examination (Max. interval: 3 years).	Environmental flows were delivered for the first time to the Ballin Boora system during 2018–19. For the 3 water years preceding 2018–19 no environmental flows or other flows had been delivered. The Ballin Boora ran from local runoff following localised intense heavy rainfall several times in Feb–March 2020 (local landholder feedback as per Mallowa). The need for environmental watering in 2020–21 is subject to further examination of environmental demand and operational requirements. However, based on the maximum interval between flows to the Ballin Boora, the demand has been assessed as moderate, needing water in the next 1–2 years.	Moderate	Use of CEW would occur only if resource availability increases.	Moderate
Mehi River Waterbird habitat and refuge Habitat and refuge for frogs Native fish habitat, breeding, recruitment and refuge Aquatic Communities Reaches within the system contain important values for the Gomeroi local aboriginal community	Native fish dispersal and condition Native fish spawning (in-channel specialists and generalists, e.g. Murray cod) Native vegetation Aquatic ecosystem function	**Small fresh (SF):** SF1: for at least 10 days in Oct–Apr (but can occur at any time) for native fish condition and dispersal • >345 ML/d at Moree • >220 ML/d d/s Combadello • >100 ML/d d/s Gundare SF2: in Sept–Apr (spawning of in-channel specialists and generalists) • 345–2 800 ML/d at Moree for at least 10 days • 220–1 500 ML/d d/s Combadello for at least 14 days • 100–850 ML/d d/s Gundare for at least 14 days SF3: >90 ML/d d/s Collarenebri for at least 10 days in Oct–Apr (but can occur at any time)	SF1: Annually (Max. interval: 1 year) SF2: 5–10 in 10 years (Max. interval: 2 years) SF3: Within 12 months of a large fresh (LF5) (Max. interval: 4 years)	Flow targets for small fresh flows (both SF1 and SF2) were met at Moree in each of the last 4 water years. Flow targets to support native fish condition and dispersal (SF1) have also been met downstream of Combardello and Gundare weirs each year since at least 2016–17. However, the flows required to support spawning of in-channel specialists and generalists (SF2) were not achieved at those sites in 2018–19. To ensure the maximum interval is not exceeded, particularly for small freshes 1 and 2, water is required in the next 1–2 years. Therefore, the overall the demand for small fresh events along the Mehi River was assessed as low to moderate.	Low to Moderate	Environmental water for other actions could contribute to these demands	Low to Moderate
	Native fish dispersal and condition Native fish spawning (flow specialists, e.g. golden perch) Native vegetation Frog breeding Aquatic ecosystem function	**Large fresh (LF):** LF1: for at least 5 days in Jul–Sept (but can occur at any time) for native fish condition and dispersal • >1 500 ML/d d/s Combadello • >850 ML/d d/s Gundare LF2: for at least 5 days in Oct–Apr for spawning of flow specialists • >1 500 ML/d d/s Combadello • >850 ML/d d/s Gundare	LF1: 5–10 in 10 years (Max. interval: 2 years) LF2: 3–5 in 10 years (Max. interval: 4 years)	Flow targets for large freshes along the Mehi River require large unregulated flows to pass the full length of the system. Each large fresh flow target has occurred once in the previous 4 years. Given the desired frequency range, the demand for large fresh events along the Mehi River was assessed as high.	High	Reliant on the use of supplementary entitlements to protect natural flow events	High

Environmental assets	Target values	Indicative demand (for <u>all sources of water</u> in the system) #		Watering history	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution?	Likely environmental demand in 2021–22 if watering occurred as planned in 2020–21
Gwydir River Downstream of Copeton Dam Native fish habitat, spawning and recruitment In-stream aquatic ecosystems Reaches within the system contain important values for the Gomeroi local Aboriginal community	Refuge habitat Native fish survival Aquatic ecosystem function	**Very low flow:** >30 ML/d for at least 200 days at Gravesend. May occur at any time.	Annually (Max. interval: 1 year)	The very low flow target is generally met by water delivered for a variety of purposes and has been met in 2 out of the last 3 years. The very dry conditions experienced during 2019–20 and implementation of drought management strategies for the Gwydir system meant the target was unable to be met last year. Feb–March rainfall events have moved the Gwydir system away from the dry or very dry conditions experienced over the last two water years. If recent rainfall patterns are maintained during 2020–21, current drought management strategies are likely be relaxed, making it easier to attain the flow target.	Moderate to High	A secondary priority for CEW, as this demand is likely to be met through the delivery of water to meet other downstream demands, depending on conditions and water availability.	Moderate
	Native fish movement, condition and recruitment (in-channel specialists and generalists, e.g. Murray cod) Native vegetation Aquatic ecosystem function	**Baseflow (BF):** BF1: >440 ML/d for at least 160 days at Gravesend, at any time (native fish movement and condition). BF2: >440 ML/d at Gravesend for at least 100 days in Sept–Mar (recruitment of in-channel specialist and generalists).	BF1: Annually (Max. interval: 1 year) BF2: 5–10 in 10 years (Max. interval: 2 years)	The combination of timing and duration of required flows means that water for consumptive and environmental use as well as operational flows is required to meet the baseflow target. Recent drought conditions mean that baseflow targets have only been met 1 out of the last 3 years (last met in 2017–18). Feb–March rainfall events have moved the Gwydir system towards more moderate flow conditions. If these conditions continue, water for consumptive and environmental use as well as operational flows are likely to meet the small fresh flow targets during 2020–21. Overall the demand for baseflows downstream of Copeton Dam was assessed as high.	High	Copeton Dam can regulate a high proportion flows from upstream systems. Demand unable to be met at desired frequency	Moderate to High
	Native fish dispersal and condition Native fish spawning (in-channel specialists and generalists, e.g. Murray cod) Native vegetation Aquatic ecosystem function	**Small fresh (SF):** SF1: >990 ML/d at Gravesend for at least 10 days in Oct–Apr (but may occur at any time) (native fish condition and dispersal). SF2: 990–8 600 ML/d at Gravesend for at least 14 days in Sept–Apr (spawning of in-channel specialists and generalists)	SF1: Annually (Max. interval: 1 year) SF2: 5–10 in 10 years (Max. interval 2 years)	Small fresh flow targets were last met in 2018–19 (SF2) and 2019–20 (SF1). The very dry conditions experienced during 2019–20 meant the 14 day target for the spawning of in-channel specialists and generalists (SF2) was unable to be met. Freshes to support native fish condition and dispersal are required annually, so the demand for water to provide these flows has been assessed as high for 2020–21. Freshes to support the spawning of in-channel specialists and generalists are required 5–10 in 10 years and require water in the next 1–2 years. The demand for these small freshes has been assessed as moderate. Feb–March rainfall events have moved the Gwydir system towards more moderate flow conditions. If these conditions continue, water for consumptive and environmental use as well as operational flows are likely to meet the small fresh flow targets during 2020–21.	Moderate to High	A secondary priority for CEW as this demand is likely to be met through the delivery of water to meet other downstream demands, depending on conditions and water availability.	Moderate to High
Gwydir, and Gingham, and Mallowa systems Bird breeding	Support large scale colonial waterbird breeding events	10–15 GL	As required, All years	Colonial waterbird breeding requirement has not been triggered in the past 6 years and requires large scale natural flows event to trigger. Therefore, the demand has been assessed as moderate. However, under extended very dry conditions this contingency is likely to be used to meet critical environmental water needs.	Moderate	Respond to naturally triggered bird breeding, if required	Moderate

* Four sites in the Lower Gwydir and Gingham are internationally recognised under the Ramsar Convention and other international agreements for migratory species and for their special habitat value for waterbirds. These are Old Dromana on the Lower Gwydir system as well as Goddard's Lease, Windella and Crinolyn on the Gingham Watercourse. The primary ecological features of the wetlands include large areas of coolibah woodland, water couch and marsh club-rush. By maintaining this wetland vegetation, other critical components of the Ramsar site may be supported, including waterbird breeding and foraging habitat.

\# The Gwydir Long Term Water Plan (2018) sets out a series of 5, 10 and 20 year objectives to maintain and enhance the health of rivers and wetlands within the Gwydir system, however, some of these may need to be reviewed with improved knowledge . The Plan also describes the environmental water requirements (EWRs) needed to achieve the specfied ecological objectives. The EWR's defined within the Gwydir Long Term Water Plan have been used to inform indicative environmental demands for key assets located within the Gwydir system.

^ Volumes are net of any irrigation deliveries

Key - potential watering in 2020-21

- High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)
- Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate - high water resource availability); or water demand likely to be met via other mear
- Low priority for Commonwealth environmental watering (under high - very high water resource availability)
- Unable to provide Commonwealth water because of constraints or insufficient water

Key - environmental demands

- Critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
- High demand for water i.e. needed in that particular year
- Moderate demand for water i.e. water needed that particular year and/or next
- Low demand for water i.e. water generally not needed that particular year
- Very low demand for water i.e. water generally not needed that particular year or the following year

Note that demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime

3.4.5 Water delivery in 2020–21

Based on the demand for water for the environment, water availability (supply), and catchment conditions, the overall purpose for managing Commonwealth water for the environment in the Gwydir River Valley in 2020–21 is to:

- avoid damage or loss of significant communities and species
- protect the health and resilience of aquatic ecosystems
- maintain the long-term condition of core wetland and riparian areas.

Consistent with the demands and purpose identified, the CEWO is considering supplying water for the environment for the following actions in 2020–21.

Within the confines of environmental water availability during 2020–21, deliver water in the following ways:

- Should dry conditions return and rivers and creeks across the lower part of the system stop flowing, NSW and Commonwealth water for the environment would be used to maintain the condition of drought refuges across the lower Gwydir system pools. Refuges along the Gwydir River between Tareelaroi weir and Brageen Crossing as wells as the Mehi River upstream of Combadello and Carole Creek upstream of the Garah gauge would be the focus of this watering action.
- Should unregulated tributary flows enter the Gwydir River upstream of Pallamallawa, NSW and Commonwealth water for the environment may be used to restore the condition of core wetland and riparian areas in the lower parts of the Gwydir system, including along the Lower Gwydir and Gingham watercourses as well as Mallowa and Carole Creeks.

Four sites in the Lower Gwydir and Gingham are internationally recognised under the Ramsar Convention, these are Old Dromana on the Lower Gwydir as well as Goddard's Lease, Windella and Crinolyn on the Gingham Watercourse. This watering action would seek to support the values of the Ramsar site by maintaining condition of wetland communities, including water couch and marsh club-rush communities within the Old Dromana and Goddard's Lease sites.

As in previous years, the use of Commonwealth and NSW environmental water in the Gwydir River Valley will be adaptively managed throughout 2020–21, in response to changing water resource availability and environmental conditions and demands.

3.4.6 Monitoring and Lessons learned

(a) Monitoring

Monitoring and evaluation are key elements of the CEWO's response to the requirements of the Water Act and Basin Plan. They support improved decision making through the application of adaptive management principles. Monitoring and evaluation are critical steps in the management of Commonwealth environmental water; supporting the efficient and effective use of Commonwealth environmental water within the planning framework and demonstrating the achievement of environmental objectives.

The Monitoring, Evaluation and Research (MER) Program (previously the Long-Term Intervention Monitoring Project 2014-2019) has sites in the Gwydir River Valley. In particular, the program focuses on the Lower Gwydir and Gingham Watercourse wetlands, sections of the Mehi River, the Mallowa Creek and wetlands, and the Gwydir River downstream of Copeton Dam. The MER program is completed jointly with NSW DPIE – EES with support from NPWS for the monitoring of vegetation and waterbirds. The MER program aims to understand the environmental response to Commonwealth environmental watering over a number of years, to help inform future water management.

Details of monitoring activities funded by the CEWO in the Gwydir River Valley can be found at: http://www.environment.gov.au/water/cewo/catchment/gwydir/monitoring.

Monitoring information is also provided by NSW agencies, including NSW DPIE – EES (vegetation, waterbirds and frogs), NSW DPI – Fisheries (native fish), and WaterNSW (hydrology and flow delivery data).

(b) Lessons learned

Outcomes from monitoring and lessons learned in previous years are a critical component for the effective and efficient use of Commonwealth water for the environment. These learnings are incorporated into the way environmental water is managed.

Key findings from water delivery and monitoring in the Gwydir River Valley is summarised in Table 18.

Table 18: Key lessons learned in the Gwydir River Valley

Theme	Lesson learned
Native fish	• The fish population in the Gwydir River system remains under stress, with many native species and endangered species in low abundance. This may reflect the carrying capacity of the system in its current state. While some species appear to be breeding and recruiting, others, especially some of the more iconic species such as golden perch, freshwater catfish and Murray cod, are not recruiting sufficiently to improve their populations. • Flow events delivered earlier in the water year (winter/spring) improve water quality, stimulate fish to move through the system and encourage the development of diverse invertebrate communities. Primary and secondary production during flows at this time of year are limited by colder water temperatures. • Along with providing environmental flows, other options such as habitat rehabilitation, restocking and barrier remediation should be considered to improve fish community condition.
Vegetation	• Delivery of water for the environment, in combination with natural inflows, has been effective in improving the extent and condition of wetland vegetation. In particular, water couch-spike rush meadows, cumbungi and marsh club-rush tall sedgelands and wetland areas of coolibah woodlands have benefited from watering. These areas are key to maintaining the ecological condition of Ramsar sites within the Gwydir.
Wetlands	• Providing flows to wetlands in the Gwydir system promotes invertebrate production and supports waterbird populations and vegetation condition. • While small frequent flows to the Gingham and Lower Gwydir wetlands can occur both from protected portions of natural flows and small deliveries of water for the environment, these small flows tend to only reach into the more eastern portions, and do not result in effective inundation of the central and western portions of wetlands in the Gingham and Lower Gwydir. A larger volume event, be it by natural flooding or a larger delivered volume from dam accounts is required at least once every three years to preserve and conserve the water dependent assets over time. The Mallowa wetlands rely almost solely on environmental water deliveries for all inflows except for inflows that occur from the larger natural flooding events. • While it is preferred to use natural flow triggers for a 'reactive' use of water for the environment to inundate the east, central and western portions of the wetlands in the western Gwydir catchment, it is important to ensure that the wetlands within valley receive water across their entire length at least once every three years. Where a 'reactive' approach is insufficient to achieve inundation in the three-year period, a 'proactive' approach, involving the use of a larger delivered volume from dam accounts into the wetlands, is then undertaken to ensure the continued health of the wetlands. This proactive approach reflects the available water, constraints and modifications of the system. Larger scale proactive environmental watering in 2014-15 and 2018-19 successfully contributed to the recovery of wetland vegetation in the Lower Gwydir and Gingham Watercourses. The Old Dromana and

Theme	Lesson learned
	Goddard's Lease Ramsar sites, can be successfully inundated with a large-scale proactive watering action (60 gigalitres with around 30 gigalitres each to the Gingham and Lower Gwydir), helping to support areas of coolibah woodland, water couch, cumbungi and marsh club-rush.
Ramsar sites	• Four sites within the wetlands are listed as a Wetland of International Importance under the Ramsar Convention: Old Dromana on the Lower Gwydir Watercourse, and Goddard's Lease, Windella and Crinolyn on the Gingham Watercourse. The inundation extent achieved by environmental water deliveries varies between the four Ramsar parcels. • Environmental water deliveries during the 2018–19 water year effectively inundated the two upstream Ramsar parcels on Old Dromana and Goddard's Lease. However, environmental water deliveries did not spill into the wetland areas located on Crinolyn and Windella but continued past these sites and reached Morialta Road downstream. These deliveries have demonstrated that while the upstream Ramsar parcels can be watered relatively easily, the two downstream sites require rehabilitation to allow flows to inundate them. This is because channelisation and works in the mid and lower sections of the Gingham Watercourse has resulted in a deepening of the old stock and domestic channel. This means that higher flow rates and/or remediation works are required for environmental water to be able to flow out onto the wetlands at the Crinolyn and Windella parcels.
Survival (Managing extended Cease to Flow Periods)	• Avoiding extended cease to flow periods is important in key river and creek reaches. Guidelines would help to understand how water for the environment could be managed to help prevent maximum intervals between flows from being exceeded, and how to manage low dissolved oxygen/water quality when restarting rivers. For example, cease to flow conditions reached ~100 days in the Mehi River in 2019, and the outcomes of this experience could be used to guide future water delivery during dry conditions.
Productivity	• Flows delivered over the summer/autumn period tend to improve water quality and promote primary and secondary production. This supports animals further up the food chain such as fish, frogs and waterbirds.
Connectivity	• Connectivity between Gwydir and Barwon rivers can be achieved using water for the environment, and is important for supporting native fish habitat, and allowing the movement of native fish between rivers for spawning, dispersal and recruitment. • The Northern Connectivity Event and Northern Fish Flow delivered from the Gwydir via the Mehi River and/or Carole Creek systems into the Barwon–Darling system during the 2017–18 and 2018–19 water years were critical actions. These events reconnected channel habitats and promoted fish movement among the channels of the lower Gwydir system via the Mehi and Carole and between the Gwydir and Baron Darling systems. Protecting environmental water delivered in these events from extraction was essential for success. In the absence of appropriate protection, these watering action would not have provided the same level of environmental outcomes.
Other	• The principle management strategies employed in the lower sections of the Gwydir system of multi-year wetting and drying and using multiple flow types to target a range of wetland and channel outcomes, is helping to sustain the ecology of the system.

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3.5 Namoi Valley

3.5.1 Region overview

(a) River valley

The Namoi River valley is located in north-eastern New South Wales, extending westwards of Nundle to Walgett. Rainfall in the upper catchment drives river flows and can be highly variable between years. Water for regulated delivery throughout the valley is stored in Split Rock and Keepit dams (Figure 5). There are also a number of smaller regulating weirs downstream of Keepit Dam.

The Namoi River is the primary riverine asset and is a major tributary of the Barwon River. Major tributaries of the Namoi include Cox's Creek and the Mooki, Manilla and the Peel rivers, which join the Namoi River upstream of Boggabri. Flows are confined in-channel until the floodplain begins to broaden at Gunnedah. The Pian (an anabranch of the Namoi River), Narrabri, Baradine and Bohena creeks contribute flows to the Namoi River downstream of Boggabri. The Namoi River connects with the Barwon–Darling near Walgett.

Flows in the Peel River are regulated out of Chaffey Dam and flow into the Namoi River slightly downstream of Keepit Dam. Major tributaries into the Peel River are Goonoo Goonoo Creek, the Cockburn River and Dungowan Creek.

(b) Traditional Owners

The rivers of the Namoi River Valley hold significant spiritual and cultural importance for Aboriginal people. The Namoi and Peel rivers are within the traditional lands of the Gomeroi/Kamilaroi people.

(c) Important sites and value

The Peel and Namoi rivers support a number of threatened fish species including Murray cod, silver perch, freshwater catfish, olive perchlet, purple spotted gudgeon and the river snail. Riverine vegetation in the Namoi River Valley includes emergent aquatic plants and river oaks, rough-barked apple and river red gum.

The aquatic community of the Namoi River forms part of the *Lowland Darling River aquatic ecological community*, which is listed as endangered under the *NSW Fisheries Management Act 1994*. This community includes 21 native fish species and hundreds of native invertebrate species that are found within the Darling River and its associated streams, wetlands and anabranches within NSW.

(d) Stakeholder engagement

In the Namoi River Valley, the planning, management, and delivery of Commonwealth water for the environment is undertaken in conjunction with a range of partners and stakeholder groups. Key stakeholders in the Namoi River Valley include the NSW Department of Planning, Industry and Environment (DPIE), the Department of Primary Industries (DPI) – Fisheries, and WaterNSW.

CEWO is looking to build engagement around the planning, management and delivery of Commonwealth water with the local Aboriginal community, by developing relationships with local individuals and organisations. It is important to work with those who have a direct kinship right to the Namoi system, as well as the broader Aboriginal and community groups in the Namoi-Peel.

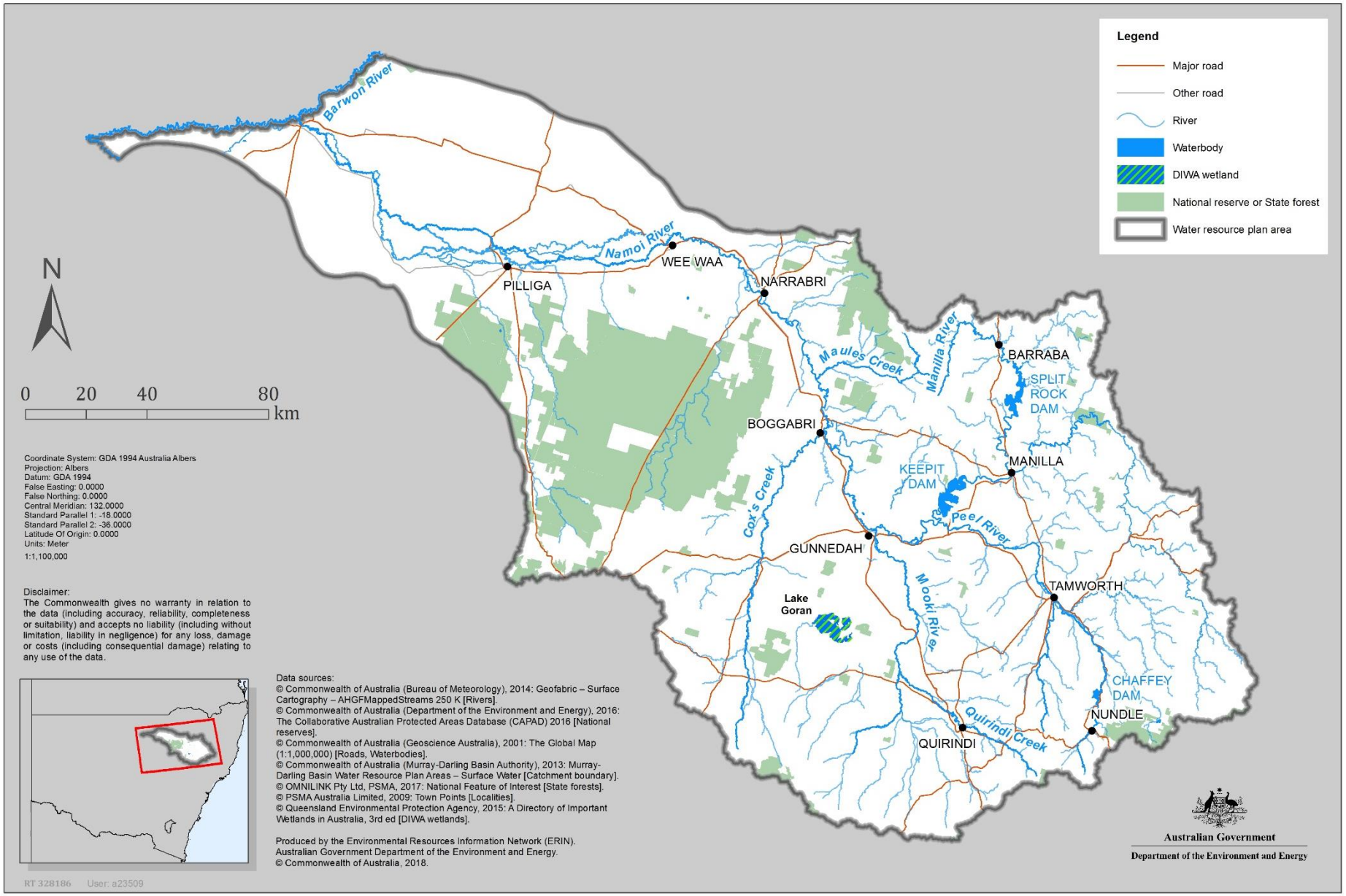

Figure 9: Map of the Namoi River Valley (produced by the Department of Environment and Energy, June 2018).

3.5.2 Environmental objectives

Based on long-term environmental objectives in the Basin Plan, draft state long-term watering plans, and best available knowledge, the following objectives are relevant for environmental watering in the Namoi catchment.

The objectives that are targeted in a particular year may vary, depending on available water, catchment conditions, operational feasibility, and demand for environmental water. These objectives will continue to be revised as part of the Commonwealth Environmental Water Office's (CEWO) commitment to adaptive management.

Vegetation: Maintain the condition, growth and survival of riparian, in-channel, anabranch and wetland vegetation.

Waterbirds: Provide drought refuge for waterbirds and support waterbird habitat.

Native fish: Prevent loss of native fish species by supporting opportunities for movement, dispersal, reproduction, and recruitment, and providing in-channel refuge and aquatic habitat.

Other vertebrates: Support opportunities for the reproduction and recruitment of other native aquatic species, including frogs and turtles.

Connectivity: Support longitudinal connectivity, including with the Lower Namoi floodplain and the Barwon River, and lateral connectivity between the river and floodplain.

Processes/water quality/resilience: Support key ecosystem functions and promote productivity and nutrient cycling; maintain water quality in channels and pools; and maintain drought refuge habitat.

3.5.3 First Nations environmental objectives

Representatives of the First Nations peoples of the Namoi River valley have identified environmental objectives for their country for 2020–21 (Table 1). These objectives were developed through the First Nations Environmental Guidance project undertaken by the Northern Basin Aboriginal Nations organisation. Some of these objectives sit outside the scope of water for the environment to influence, while for others, the link between water for the environment and the site or species is not well understood.

The CEWO is committed to working with First Nations groups to better understand their objectives. The CEWO will use environmental flows to contribute to these objectives where possible and where this is consistent with the Commonwealth Environmental Water Holder's statutory responsibility of protecting and restoring environmental assets in the Basin.

Table 19: First Nations environmental objectives for the Namoi River system for 2020–21 (NBAN Ltd. 2020)

River flows and Connectivity
Priority sites: Narrabri is an important site for recreational activities; Namoi to flow at a certain level at all times.
Native Vegetation
Indicator species: Gidgee Gum[i], blue gum[i], bulrush, water lily, sedges, tea trees[i], sandalwood[i], iron bark (poplar box)[i].
Native Birds
Indicator species: Teal, crimson wing, storks, white long-legged heron.
Native Animals
Indicator species: Dhufish (eel tailed catfish), yellowbelly, codfish, black bream (silver perch).
Connecting with Country
To tell and share our stories, to be able to hunt and fish along the rivers, to gather at the river as a Nation to camp.

[i] Water for the environment targeting other environmental outcomes may influence this species or objective

3.5.4 Recent conditions and seasonal outlook

(a) Recent conditions and environmental water use

The Namoi catchment has experienced very hot and dry conditions since 2017–18, with lowest on record rainfall, and highest on record temperatures. Inflows to storage have been extremely low during this time, and no releases have been made from Keepit Dam since December 2018, with the exception of a 200 megalitres stock and domestic flow in March 2020.

With extreme drought conditions in the Namoi River Valley, general security allocations were zero during 2019–20 in both the Lower Namoi and Peel. Access to general security carryover water was also restricted in the Lower Namoi until this restriction was lifted on 25 February 2020. Carryover is not available in the Peel, and environmental accounts remain unavailable for use. No Commonwealth water for the environment was delivered in 2019–20 in either the Namoi or Peel rivers.

Ongoing very hot and dry conditions have affected the condition of the Namoi and Peel rivers. Extended cease to flow conditions in the Namoi River resulted in the drying of refuge pools and stressed riparian and floodplain vegetation. Flows below Dungowan on the Peel River were restricted from 30 November 2019, to help secure town water supply, resulting in very little flow downstream. A number of fish kills occurred over the summer in the Namoi and Peel rivers, which included native fish such as Murray cod, golden and silver perch, and freshwater catfish.

Increased rainfall began in February 2020, which provided much needed flows to parts of the Lower Namoi and Peel rivers. Inflows also resulted in some increase in storage levels in Keepit Dam, which was at 14.8 per cent capacity as of 30 June 2020 (up from less than 1 per cent at the end of January). As of 30 June, Chaffey Dam was at 15.1 per cent capacity. However, in the absence of further significant rainfall, there may be insufficient water available to meet system requirements in 2020–21. Around 34 gigalitres of inflows into Keepit Dam are required before any new allocations would be available in the Lower Namoi.

Details of previous Commonwealth environmental use in the Namoi River Valley are available at: http://www.environment.gov.au/water/cewo/catchment/namoi/history.

(b) Seasonal outlook

According to the Bureau of Meteorology outlook in July, above median rainfall is forecast across the Namoi River Valley from late winter into spring. While this forecast suggests that the recent severe dry conditions may ease somewhat, several months of above average rainfall are needed to see a recovery from the current severe drought. Stream flows may be less than expected during the recovery. However, wetter conditions can return suddenly in the northern Basin. Maximum temperatures are also forecast to remain above average over the coming months.

(c) Water availability

The volume of Commonwealth environmental water carried over in the Namoi River Valley for use in 2020–21 is 0.6 gigalitres. Further improvements in resource availability are required before any new allocations are expected in either the Namoi or Peel rivers.

Based on the expected available volume of water held by the Commonwealth and other water holders, as well as recent and forecast catchment conditions, it is expected that the overall resource availability will be very low to low in 2020–21.

(d) Environmental demands

Considering the prolonged drought and need to support recovery and avoid further damage to key assets, there are a number of environmental demands that require water urgently in 2020–21.

The environmental water demands for assets in the Namoi River Valley in 2020–21 are represented in **Error! Reference source not found.**. Note that the capacity to contribute to these environmental demands is contingent on a substantial improvement in water availability in the catchment.

Table 20: Environmental demands, priority for watering in 2020–21 and outlook for coming year in the Namoi River Valley

Environmental asset	Target values	Indicative demand (for <u>all sources of water</u> in the system)		Watering history	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution?	Likely environmental demand in 2021–22 if watering occurred as planned in 2020–21
Lower Namoi River channel: • **D/s Keepit Dam to Boggabri** • **Boggabri to Mollee** • **Mollee to Bugilbone** • **Bugilbone to Walgett** Native fish habitat, dispersal and spawning Instream aquatic ecosystems Riparian vegetation Threatened species e.g. silver perch, eel tailed catfish	Drought refuge habitat Water quality Fish maintenance and survival (all groups)	<u>Very low flows:</u> • 5–200 ML/day d/s Keepit Dam (min. 365 days) • 1–200 ML/day at Gunnedah (min. 365 days) • 1–150 ML/day at Boggabri (min. 356 days) • 1–200 ML/day at Mollee (min. 343 days) • 1–150 ML/day at Bugilbone (min. 336 days) • 1–25 ML/day at Goangra (min. 323 days)	Annually (can occur at any time of year)	Very low flows were last met in 2017–18 in the Namoi River between Keepit Dam and Mollee, and in 2016–17 between Mollee and Walgett. With prolonged periods of cease to flow conditions, very low flows were not achieved in the Lower Namoi River in any reach in 2019–20. Very low flows are required annually. Therefore, the demand for water in 2020–21 in the Lower Namoi River between Keepit and Walgett has been assessed as critical.	Critical	High priority for CEW under very low to low scenarios, subject to water availability. Would be met by other water in moderate to very high scenarios. The reaches between Mollee and Walgett may be a particularly important target for CEW.	High
	Water quality Habitat maintenance Connectivity Fish maintenance and survival (all groups) Fish recruitment (generalists + in-channel specialists)	<u>Baseflows:</u> • 200–500 ML/day d/s Keepit (min. 209 days for survival; 119 days for recruitment) • 200–600 ML/day at Gunnedah (min. 240 days for survival; 140 days for recruitment) • 150–300 ML/day at Boggabri (for a min. 274 days for survival; 154 days for recruitment) • 200–500 ML/day at Mollee (min. 267 days survival; 154 days recruitment) • 150–300 ML/day at Bugilbone (min. 277 days for survival; 158 days for recruitment) • 25–65 ML/day at Goangra (min. 335 days for survival; 195 days for recruitment) • 30–200 ML/day u/s of Walgett	1 in 1–2 years (Max interval 2 years for fish recruitment) (can occur at any time for native fish maintenance and survival, or Sept-Mar for native fish recruitment)	Baseflows have generally only been partially or not met in the Lower Namoi River over at least the past five years, except at Goangra, which was met in 2016–17. In 2019–20, prolonged periods of cease to flow conditions meant that baseflows were not achieved in the Lower Namoi River. River flows commencing in February were substantially shorter in duration than the minimum required, even in very dry years. Also, the maximum time between baseflow events and required frequency to support native fish have been exceeded. Considering baseflows are required once every 1–2 years, and they have not been adequately met for a number of years, the demand for these flows in 2020–21 has been assessed as critical.	Critical	High priority for CEW under very low to moderate scenarios, subject to water availability. May be met by other water in high/very high scenarios.	High
	Longitudinal connectivity Low level bank and bar wetting Pool maintenance Fish movement, productivity and condition Fish spawning (generalists + in-channel specialists)	<u>Small freshes:</u> • 500–1 400 ML/day d/s Keepit • 600–5 400 ML/day at Gunnedah • 350–3 600 ML/day at Boggabri • 500–6 000 ML/day at Mollee • 350–3 200 ML/day at Bugilbone • 65–1 000 ML/day at Goangra • 200–2 250 ML/day u/s of Walgett	Annually for fish dispersal and productivity/ condition (max interval 1 year); 1 in 1–2 years for fish spawning (max interval 2 years) (Ideally Oct–Apr for fish dispersal and condition/ productivity (but can occur any time) for a minimum of 10 days. Sept–Apr for fish spawning for a minimum of 14 days)	Small freshes have been met each year in the Namoi River between Keepit Dam and Mollee since at least 2015–16, except in 2019–20, when they were not met below Keepit Dam and only partially met at Gunnedah. Downstream of Mollee, small freshes have been less frequent, particularly at Bugilbone and upstream of Walgett. However, rainfall between February and April provided sufficient flows to achieve this demand from Boggabri down to Walgett. Small freshes are ideally met each year, particularly for native fish dispersal and condition. The maximum interval for these flows will be exceeded if water is not provided in 2020–21 downstream of Keepit Dam and at Gunnedah, and small freshes have not been consistently provided across years further downstream. Therefore, the demand for small freshes has been assessed as high (Boggabri to Walgett) to critical (downstream Keepit to Gunnedah).	High to Critical	High priority for CEW, particularly between Mollee and Walgett under low to high water resource scenarios, subject to water availability and being delivered in conjunction with other water. May be met by other water under a very high scenario.	High

Environmental asset	Target values	Indicative demand (for <u>all sources of water</u> in the system)		Watering history	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution?	Likely environmental demand in 2021–22 if watering occurred as planned in 2020–21
Lower Namoi River channel (ctd)	Longitudinal connectivity Increase ecosystem function Bench and bank wetting Access to habitat Nutrient cycling Fish dispersal and productivity/condition (all groups) Fish spawning (flow specialists)	<u>Large freshes:</u> • 1 400–3 500 ML/day d/s Keepit • 5 400–32 700 ML/day at Gunnedah • 3 600–17 750 ML/day at Boggabri • 6 000–18 750 ML/day at Mollee • 3 200–9 900 ML/day at Bugilbone • 1 000–5 800 ML/day at Goangra • 2 250–8 500 ML/day u/s Walgett	1 in 1–2 years for fish dispersal and productivity/condition (max interval 2 years); 1 in 2–3 years for fish spawning (max interval 4 years) (Ideally July–Sept for fish dispersal and productivity/condition (but can occur any time) for a minimum of 5 days. Oct–Apr for flow specialists spawning for a minimum of 5 days.)	The achievement of large freshes in the Lower Namoi River has been variable. Downstream of Keepit Dam, large freshes were last achieved in 2017–18. Between Gunnedah and Boggabri, large freshes have not been adequately met since 2013–14, or longer. However, rainfall resulted in sufficient river flows to achieve large freshes in February 2020 at Mollee, Bugilbone, Goangra and Walgett. Before that, large freshes had not been met since 2012–13 (Mollee and Bugilbone) and 2016–17 (Goangra and Walgett). Large freshes are required in 2020–21 downstream of Keepit Dam to Boggabri, particularly for native fish dispersal and condition, which is required once every 1–2 years. The demand at these locations has been assessed as critical. From Mollee to Walgett small freshes were met in 2019–20, however, had not been met for multiple years before that, so may require water again in 2020–21. Therefore, the demand at these locations has been assessed as moderate to high.	Critical (d/s Keepit to Boggabri) Moderate to High (Mollee to Walgett)	Possible use of CEW only if there is an increase in available water under high to very high water resource availability scenarios. Would need to be delivered in conjunction with other flows.	High to Critical
	Lateral and longitudinal connectivity Riparian vegetation in low commence to flow anabranch channels Increase ecosystem function Nutrient cycling Access to habitat Fish spawning (floodplain specialists) Fish dispersal and productivity/condition (all groups)	<u>Bankfull and overbank flows:</u> • 3 500–6 150+ ML/day d/s Keepit • 32 700–40 000+ ML/day at Gunnedah • 17 750–22 000+ ML/day at Boggabri • 18 750–21 750+ ML/day at Mollee • 9 900–13 400+ ML/day at Bugilbone • 5 800–8 200+ ML/day at Goangra • 8 500–10 600+ ML/day u/s Walgett	1 in 2 years for fish spawning (max interval 4 years); 1 in 3–5 years for fish dispersal and productivity/condition (max interval 5 years) (Oct–Apr for fish spawning (floodplain specialists) for a minimum of 10 days. Ideally Sept–Feb for fish dispersal and productivity/ condition (but can occur any time) for a minimum of 5 days.)	Bankfull and overbank flows have not been met in the Lower Namoi River between Keepit Dam and Walgett in the last three years, and during the past six years, have only been met at Goangra and Walgett in 2016–17. The maximum interval for these flows has been exceeded between Keepit Dam and Bugilbone for both spawning and dispersal/conditioning flows for native fish, and for fish spawning between Goangra and Walgett. Therefore, the demand for 2020–21 has been assessed as critical overall, particularly between Keepit and Bugilbone.	Critical	Commonwealth environmental water unlikely to contribute to this demand because of insufficient water and system constraints.	High to Critical

Environmental asset	Target values	Indicative demand (for <u>all sources of water</u> in the system)		Watering history	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution?	Likely environmental demand in 2021–22 if watering occurred as planned in 2020–21
Peel River channel[3] • **d/s Chaffey Dam to Piallamore** • **Piallamore to Carrol Gap** Native fish habitat and spawning Instream aquatic ecosystems Riparian vegetation	Drought refuge habitat Water quality Fish maintenance and survival (all groups)	<u>Very low flows:</u> • 1–100 ML/day d/s Chaffey Dam, and at Piallamore and Carrol Gap, for a minimum 365 days Very low flows may occur at any time.	Annually	Very low flows have been met in the Peel River downstream of Chaffey Dam to Carrol Gap in every year between 2012–13 and 2018–19. However, these flows were only partially met at Piallamore and Carrol Gap in 2019–20, with flows being <1 ML/day for part of the year. Because very low flows are required annually and were not fully met at all sites for all of 2019–20, the demand for water in 2020–21 has been assessed as high to critical.	High to Critical	High priority for CEW under very low and low water resource scenarios, subject to water availability. Expected to be met by other water under moderate to very high scenarios.	High
	Water quality Habitat maintenance Connectivity Fish maintenance and survival (all groups) Fish recruitment (generalists + in-channel specialists)	<u>Baseflows:</u> • 100–250 ML/day d/s Chaffey Dam (min. 60 days for survival; 29 days for recruitment) • 100–250 ML/day at Piallamore (min. 130 days for survival; 78 days for recruitment) • 100–300 ML/day at Carrol Gap (min. 241 days for survival; 152 days for recruitment)	1 in 1–2 years (Max interval 2 years for fish recruitment) (May occur at any time for native fish maintenance and survival, or Sept–Mar for native fish recruitment.)	Baseflows were not met in the Peel River in 2019–20. These flows were last met downstream of Chaffey and at Piallamore in 2018–19 but have not been sufficiently met for at least the past eight years at Carrol Gap (partially met in 2012–13 and 2016–17). These flows are required once in every 1–2 years, with a maximum interval of 2 years for native fish recruitment. Therefore, the demand for water in 2020–21 has been assessed as critical.	Critical	High priority for CEW (particularly to Piallamore and Carrol Gap) under very low to moderate water resource scenarios, subject to water availability. May be met by other water under high to very high scenarios.	High
	Longitudinal connectivity Low level bank and bar wetting Pool maintenance Fish movement, productivity and condition Fish spawning (generalists + in-channel specialists)	<u>Small freshes:</u> • 250–900 ML/day d/s Chaffey Dam • 250–1 350 ML/day at Piallamore • 300–3 900 ML/day at Carrol Gap	Annually for fish dispersal and productivity/ condition (max interval 1 year); 1 in 1–2 years for fish spawning (max interval 2 years) (Ideally Oct–Apr for fish dispersal and condition/productivity (but can occur any time) for a minimum of 10 days. Sept–Apr for fish spawning for a minimum of 14 days)	Small freshes were not met downstream of Chaffey and at Piallamore in 2019–20, however, a small fresh was achieved at Carrol Gap in February 2020. Before this, small freshes were last met at all three sites in 2016–17. These flows are required annually for native fish dispersal and condition, and the maximum interval has been exceeded downstream of Chaffey and Piallamore. Therefore, this demand for water in 2019–20 has been assessed as high to critical (high at Carrol Gap, and critical downstream of Chaffey and at Piallamore).	High to Critical	High priority for CEW in conjunction with other water under low to high scenarios. Would be met by other water in very high scenario.	High
	Longitudinal connectivity Increase ecosystem function Bench and bank wetting Access to habitat Nutrient cycling Fish dispersal and productivity/condition (all groups) Fish spawning (flow specialists)	<u>Large freshes:</u> • 900–2 900 ML/day d/s Chaffey Dam • 1 350–5 150 ML/day at Piallamore • 3 900–13 500 ML/day at Carrol Gap	1 in 1–2 years for fish dispersal and productivity/condition (max interval 2 years); 1 in 2–3 years for fish spawning (max interval 4 years) (Ideally July–Sept for fish dispersal and productivity/ condition (but can occur any time) for a minimum of 5 days.	Large freshes have not been achieved in the Peel River between Chaffey Dam and Carrol Gap in the period assessed since 2012–13. During that time, large freshes have only been partially met (for a dispersal flow) in 2016–17 at Piallamore and Carrol Gap, and have otherwise not been met. Large freshes are ideally required every 1–2 years for native fish dispersal and once in every 2–3 years for spawning. The maximum intervals for both flows have been exceeded in this reach. Therefore, the demand for water in 2020–21 has been assessed as critical.	Critical	Commonwealth environmental water unlikely to contribute to this demand because of insufficient water and system constraints.	Critical

Environmental asset	Target values	Indicative demand (for all sources of water in the system)		Watering history	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution?	Likely environmental demand in 2021–22 if watering occurred as planned in 2020–21
Peel River channel[3] (ctd)	Lateral and longitudinal connectivity Riparian vegetation in low commence to flow anabranch channels Increase ecosystem function Nutrient cycling Access to habitat Fish spawning (floodplain specialists) Fish dispersal and productivity/condition (all groups)	Bankfull and overbank flows: • 2 900–6 400+ ML/day d/s Chaffey Dam • 5 150–13 400+ ML/day at Piallamore • 13 500–40 000+ ML/day at Carrol Gap	1 in 2 years for fish spawning (max interval 4 years); 1 in 3–5 years for fish dispersal and productivity/ condition (max interval 5 years) (Oct–Apr for fish spawning (floodplain specialists) for a minimum of 10 days. Ideally Sept–Feb for fish dispersal and productivity/ condition (but can occur any time) for a minimum of 5 days.)	Bankfull and overbank flows have not been met in the Peel River between Chaffey Dam and Carrol Gap during the period assessed since 2012–13. These flows are ideally required 1 in 2 years for native fish flow spawning, and the maximum intervals for both spawning and dispersal flows have been exceeded. Therefore, this demand has been assessed as critical, with water being required in 2020–21.	Critical	Commonwealth environmental water unlikely to contribute to this demand because of insufficient water and system constraints.	Critical

Note: contributions to meet Barwon-Darling environmental requirements may be considered subject to water availability, antecedent conditions, and environmental demands. Refer to CEWO Water Management Plan 2020-21: Chapter 3.7 Barwon–Darling.

References

1. Sourced from information provided by Green et al. (2011), MDBA (2012), and previous environmental watering, with advice from NSW DPI – Fisheries (Anthony Townsend, pers. comm.)

2. Sourced from information provided by Green et al. (2011), MDBA (2012), NSW OEH (2019a and b), and Foster (1999), with advice from NSW DPI – Fisheries (Anthony Townsend, pers. comm.)

3. Sourced from information provided by Barma Water Resources et al. (2012), with advice from NSW DPI – Fisheries (Anthony Townsend, pers. comm.)

4. All watering history sourced from data from the following gauges (WaterNSW 2020):

- 419021: Namoi River at Bugilbone
- 419012: Namoi River at Boggabri
- 419059: Namoi River d/s Gunidgera Weir (Wee Waa)
- 419094: Namoi River d/s Duncan's Junction
- 419091: Upstream Walgett
- 422001: Dangar Bridge
- 419045: Peel River d/s Chaffey Dam

Key - potential watering in 2020-21

- High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)
- Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate - high water resource availability); or water demand likely to be met via other means
- Low priority for Commonwealth environmental watering (under high - very high water resource availability)
- Unable to provide Commonwealth water because of constraints or insufficient water

Key - environmental demands

- Critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
- High demand for water i.e. needed in that particular year
- Moderate demand for water i.e. water needed that particular year and/or next
- Low demand for water i.e. water generally not needed that particular year
- Very low demand for water i.e. water generally not needed that particular year or the following year

Note that demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime

3.5.5 Water delivery in 2020–21

Based on the demand for water for the environment, water availability (supply), and catchment conditions, the overall purpose for managing Commonwealth water for the environment in the Namoi River Valley in 2020–21 is to avoid damage and protect the health and resilience of aquatic ecosystems in the Lower Namoi and Peel rivers.

Subject to water availability, and consistent with the demands and purpose identified, the CEWO is considering supplying water for the environment to the following actions in 2020–21.

There is a critical demand to provide very low flows and baseflows in both the Lower Namoi and Peel rivers, where prolonged drought conditions have meant requirements for these flow components have not been adequately met. In particular, requirements for baseflows have generally not been adequately met for a number of years in the Lower Namoi River. Maintaining a very low flow (at minimum) and preferably a baseflow along as great a length of river as possible will be a high priority for 2020–21. These flows would help provide refuge habitat, improve water quality, increase connectivity, support native fish, and help to build resilience.

Should conditions improve, and more water becomes available, the priority would be to reassess demand and potentially deliver critical components, which may include extending the duration of baseflows, or providing small freshes, which currently have a high to critical demand for water. Providing small freshes in either the Lower Namoi River or Peel River would be dependent on delivering water for the environment in conjunction with other water. The highest priority reaches for delivering small freshes may be Keepit Dam to Gunnedah (especially downstream of Keepit to the Peel River junction) in the Lower Namoi River, and Chaffey Dam to Piallamore in the Peel River, where these flows were not met in 2019–20. Delivering small freshes would provide connectivity, maintain pools and water quality, support native fish movement and condition, and possibly provide opportunity for spawning of some species (flow generalists and in-channel specialists).

While there are also critical demands for water to achieve large freshes and bankfull flows in the Namoi and Peel rivers, the capacity to use Commonwealth environmental water to contribute to these demands is limited. In the Namoi, a significant increase in water availability would be required, and environmental water is unlikely to contribute to these flows in the Peel River because of the relatively small volumes available to meet demand, and system constraints.

As in previous years, the use of Commonwealth water for the environment in the Namoi River Valley will be adaptively managed throughout 2020–21, in response to changing water resource availability and environmental conditions and demands.

3.5.6 Monitoring and Lessons learned

(a) Monitoring

In the Namoi River Valley, monitoring is primarily undertaken by NSW agencies including NSW DPIE, (inundation and photo point monitoring), NSW DPI – Fisheries (native fish), and WaterNSW (hydrology and flow delivery data).

(b) Lessons learned

Outcomes from monitoring and lessons learned in previous years are a critical component for the effective and efficient use of Commonwealth water for the environment. These learnings are incorporated into the way environmental water is managed.

Key lessons and findings the 2017–18 and 2018–19 watering years and state agency monitoring results in the Namoi River Valley are summarised in Table 21.

Table 21: Key lessons learned in the Namoi River Valley

Theme	Lesson learned
Native fish	• Providing a small flow to the lower Namoi River during dry conditions can be beneficial for improving water quality and native fish survival, by increasing water depth and dissolved oxygen levels in refuge pools. • The number of small freshes has been substantially reduced by river regulation downstream of Chaffey Dam. Therefore, providing environmental water may be important for supporting native fish that depend on these flows to maintain healthy condition, and to support dispersal and recruitment, which is needed to maintain native fish populations.
Connectivity/ processes	• A pulse of 750 ML/day is more effective than 500 ML/day in wetting more low-level benches in the Peel River and providing greater depths for fish movement. • Flows of 750 ML/day can also result in some fine sediment movement/scouring, however, flows over 1 000 ML/day may be required to effectively mobilise sediment and algae that has accumulated downstream of Chaffey Dam.

3.5.7 Bibliography

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3.6 Macquarie River Valley

3.6.1 Region overview

(a) River valley

The Macquarie River forms above Bathurst in Central Western New South Wales (NSW), where the Campbells and Fish rivers join, and flows into Burrendong Dam, south east of Wellington (Figure 5). Below the dam, tributary flows are provided by the Bell, Little and Talbragar rivers, and Wambangalong and Coolbaggie creeks. As the land flattens further west of Dubbo, the Macquarie River provides flows to distributary creeks, wetlands and rich alluvial river flats associated with braided channels and can connect with the Barwon-Darling River.

Macquarie River flows are heavily influenced by large rainfall events in the upper catchment and flows in tributary systems. Two major storages, Windamere Dam (capacity 368 gigalitres) on the Cudgegong River, and Burrendong Dam on the Macquarie River (storage capacity of 1 188 gigalitres, with additional storage capacity of 489 gigalitres in the flood mitigation zone), regulate catchment water supplies.

(b) Traditional Owners

The rivers and wetlands of the Macquarie River Valley hold significant spiritual and cultural importance for Aboriginal people. In the upper and middle Macquarie valley, the Aboriginal people are the Wiradjuri, while on the plains the Bogan River forms the boundary between the Ngemba and Ngiyampaa Nations to the west and the Wayilwan Nation to the east. Wayilwan country includes most of the Castlereagh catchment, except the north-east corner, which is the traditional land of the Kamilaroi.

(c) Important sites and values

The valley includes the Macquarie Marshes complex on the lower reaches of the Macquarie River, of which, parts of the northern, southern and eastern Marshes are listed as a Wetland of International Importance under the Ramsar Convention. Parts of the Macquarie Marshes were recognised under the Ramsar Convention for being a unique example of a wetland type in the region in terms of their size and their diversity of wetland types, supporting species of conservation significance and biological diversity, providing refuge during adverse conditions, and regularly supporting large numbers of waterbirds. This includes those listed under international migratory agreements (JAMBA, ROKAMBA, CAMBA). The Ramsar site contains a range of habitats including core areas of semi-permanent wetlands, such as forests and woodlands, reed beds, marshes, rushlands and open lagoons. These vegetation types have been identified as critical components of the Ramsar site.

Other assets in the valley include the Macquarie River channel, the unregulated components of the lower Macquarie River and the distributary creek system to the west of the Marshes.

The Macquarie Marshes and Macquarie River support numerous species listed as endangered or vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999*, for example, the Australian painted snipe, Australasian bittern, Murray cod, trout cod and spike rush. The aquatic community of the Macquarie also forms part of the Lowland Darling River aquatic ecological community, which is listed as endangered under the *NSW Fisheries Management Act 1994*.

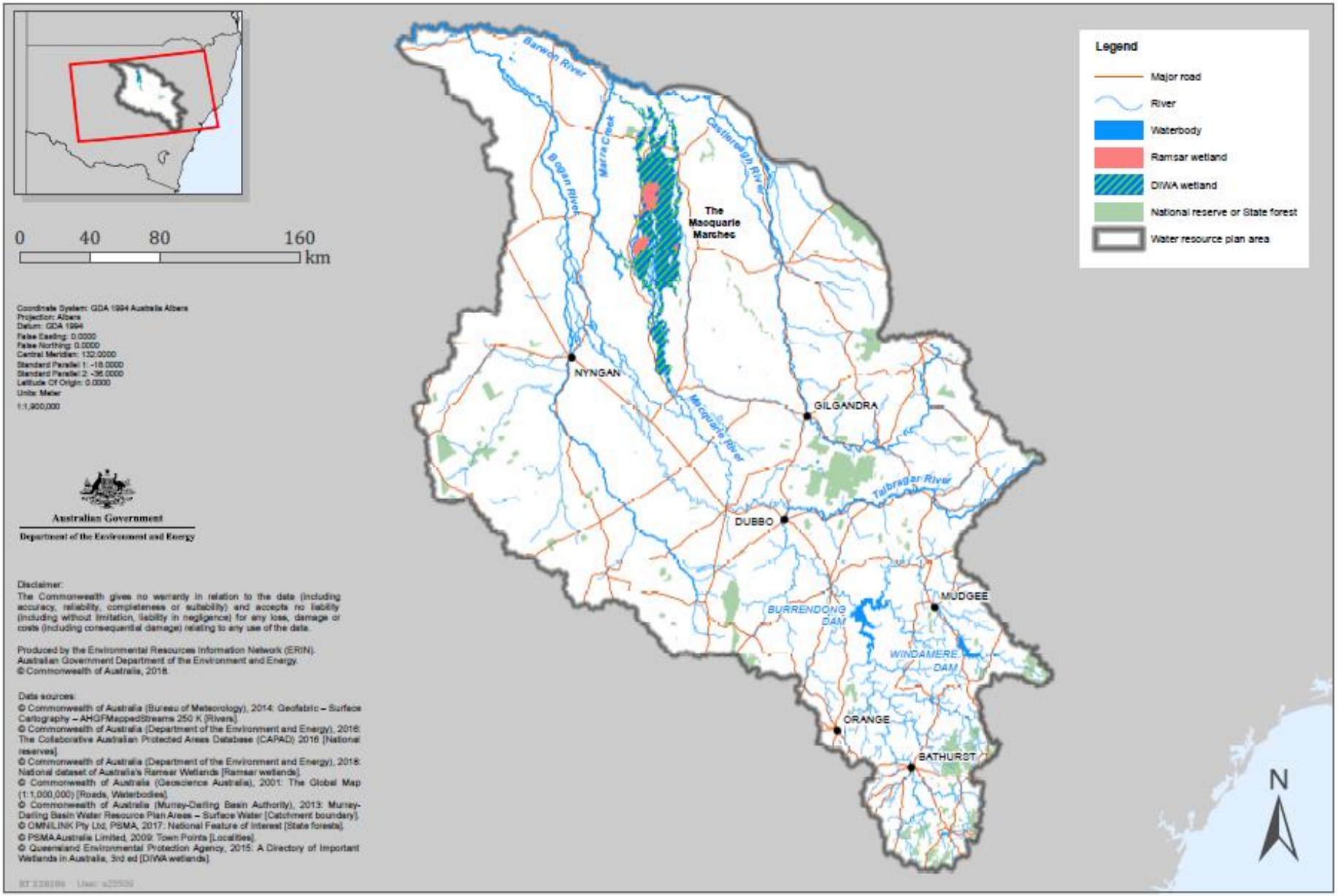


Figure 10: Map of the Macquarie River Valley (produced by the Department of the Environment and Energy, June 2018.)

(d) Stakeholder engagement

In the Macquarie River Valley, the planning, management, and delivery of Commonwealth water for the environment is undertaken in conjunction with a range of partners and stakeholder groups. Key stakeholders in the Macquarie include the NSW Department of Planning, Industry and Environment (DPIE), the Department of Primary Industries (DPI) – Fisheries, WaterNSW, and the Macquarie Cudgegong Environmental Flow Reference Group (EFRG), who provide advice to water managers on priorities for water use.

Local Engagement Officers from the Commonwealth Environmental Water Office (CEWO) also work with different stakeholders as part a broader program of engagement around the management of the Commonwealth environmental water entitlements. As part of this work, Local Engagement Officers have been engaging directly with members of the local Aboriginal community.

3.6.2 Environmental objectives

Based on long-term environmental objectives in the Basin Plan, draft state long-term watering plans, site management plans (including Ramsar site ecological character descriptions), and best available knowledge, the following objectives are relevant for environmental watering in the Macquarie River Valley.

The objectives targeted in a particular year may vary, depending on available water, catchment conditions, operational feasibility, and demand for environmental water. These objectives will continue to be revised as part of the CEWO's commitment to adaptive management.

Vegetation: Maintain the condition, growth and survival of riparian, in-channel, floodplain and wetland vegetation.

Waterbirds: Increase waterbird abundance and maintain species diversity by supporting naturally triggered breeding events, and maintaining suitable refuge, feeding and breeding habitat.

Native fish: Prevent loss of native fish species and improve population structure and distribution, by supporting opportunities for movement, dispersal, reproduction, and recruitment.

Other vertebrates: Support opportunities for the reproduction and recruitment of other native aquatic species, including frogs and turtles.

Connectivity: Support longitudinal connectivity, including with the Barwon River, and lateral connectivity between the river and floodplain.

Processes/water quality/resilience: Support key ecosystem functions and promote productivity; maintain water quality in channels and pools; and maintain drought refuge habitat.

3.6.3 First Nations environmental objectives

Representatives of the First Nations peoples of the Macquarie valley have identified environmental objectives for their country for 2020–21 (Table 22 and Table 23). These objectives were developed through the First Nations Environmental Guidance project undertaken by the Northern Basin Aboriginal Nations (NBAN) and the Murray Lower Darling Rivers Indigenous Nations (MLDRIN) organisations, as well as directly from local Ngiyampaa, Wayilwan and Wiradjuri Aboriginal community members.

Some of these objectives sit outside the scope of water for the environment to influence, while for others, the link between water for the environment and the site or issues is not well understood. The CEWO will use environmental flows to contribute to these objectives where possible and where this is consistent with the Commonwealth Environmental Water Holder's statutory responsibility of protecting and restoring environmental assets in the Basin.

The Commonwealth Environmental Water Holder is committed to continuing to work with the local Aboriginal community to better understand their objectives.

Table 22: First Nations environmental objectives for the Macquarie Valley for 2020–21 from NBAN (NBAN Ltd. 2020)

River flows and Connectivity
Priority sites: Macquarie River: needs to provide flow to the marshes at all times. Castlereagh River*: the flow that comes from rain needs to be protected. Other flows and connectivity: Macquarie and Castlereagh Rivers need to flow at all times to sustain cultural and heritage sites. Local advice is needed to inform this objective.
Native Vegetation
Indicator species: Redgum, bulrush, stringy bark[i], iron bark[i] are all important for culture. Redgum and bulrush are important for habitat, and bulrush for weaving.
Native Birds
Indicator species: Wood duck, kingfisher, black cockatoo[i]. Wood Duck are used for food. The kingfisher has cultural significance.
Native Animals
Indicator species: Cod, yellowbelly, turtles, Macquarie perch (missing). These are important for providing food.
Connecting with Country
Wayilwan people are and need to be connected with Country across the Wayilwan Nation.

[i] Water for the environment targeting other environmental outcomes may influence this species or objective

Table 23: First Nations environmental objectives for the Macquarie Valley for 2020–21 from MLDRIN (MLDRIN 2020)

Waterways and Places in Need of watering
Major rivers; Wetlands, Billabongs and Floodplains; Other places, parks, forests, islands; All on Country; Macquarie River; Macquarie Marshes
River Flows and Connectivity
Improve flows and quantity (rivers and general); Improve timing and seasonality of flows; Improve tributary flows; Improve water quality; Remove barriers and constraints.
Vegetation
Nardoo, phragmites, sheoaks[i].
Fish
Catfish, Murray cod, silver perch, yellowbelly,
Waterbirds
Darters, ducks, swan.
Other species
Platypus[i], cockatoos[i].

[i] Water for the environment targeting other environmental outcomes may influence this species or objective

* The Castlereagh River is currently out of scope for use of environmental water entitlements.

3.6.4 Recent conditions and seasonal outlook

(a) Recent conditions and environmental water use

The Macquarie River Valley has experienced very hot and dry conditions since 2017-18, with rainfall being well below average, and highest on record temperatures. Inflows to Burrendong Dam have been extremely low during this time, with the lowest inflows on record.

With new drought of record conditions in the Macquarie River Valley, access to general security and planned environmental water accounts was restricted to 70 per cent of the 1 July 2018 carryover balance. This limited the volume of NSW and Commonwealth water for the environment that was delivered to support wetland vegetation and native fish in 2018-19.

Further restrictions were put in place in 2019-20, with all allocations of water for the environment being held in a drought sub-account (along with other general security water). Consequently, no water for the environment was able to be delivered as the extreme drought continued.

The mid-Macquarie River was shut off downstream of Warren in late August 2019, resulting in cease to flow conditions, necessitating the rescue of native fish from drying refuge pools over summer. Ongoing very hot and dry conditions affected the condition of vegetation in the Macquarie Marshes. During the spring and summer large areas had little or no ground cover. A fire in spring 2019 also burnt large areas of the north marsh reedbed (part of the Ramsar site).

Late summer and autumn rainfall and flows provided much needed water to parts of the Macquarie Marshes. Commonwealth and NSW supplementary water entitlements were used to ensure some additional water was left instream to help support recovery in the Macquarie River and Marshes. Some areas of the Marshes such as the north marsh reedbed have responded well. However, areas that haven't received sufficient water are in poorer condition. A range of bird species such as spoonbills, magpie geese, ibis and whistling ducks have been observed in increasing numbers in the Marshes.

As of 29 June 2020, Burrendong Dam was at 23 per cent capacity, up from ~1.5 per cent in February. However, further significant inflows are required before there is sufficient water available to meet all system requirements in 2020–21 or announce any new allocations.

Details of previous Commonwealth environmental use in the Macquarie River Valley are available at: http://www.environment.gov.au/water/cewo/catchment/macquarie/history.

(b) Seasonal outlook

According to the Bureau of Meteorology outlook in July, above median rainfall is forecast across the Macquarie River Valley from late winter through spring. While this forecast suggests that the recent severe dry conditions may ease somewhat, several months of above average rainfall are needed to see a recovery from the current severe drought. Stream flows may be less than expected during the recovery. However, wetter conditions can return suddenly in the northern Basin. Maximum temperatures are also forecast to remain above average over the coming months.

(c) Water availability

The volume of Commonwealth environmental water carried over in the Macquarie River Valley for use in 2020–21 is 22.7 gigalitres. However, given current drought restrictions only 40 per cent of this volume (9.08 gigalitres) is available for use. The remaining volume continues to be quarantined in the drought sub-account until conditions improve further. No new allocations are expected unless resource availability significantly improves, and quarantined water has been made available.

Based on the expected available volume of water held by the Commonwealth and other water holders, as well as recent and forecast catchment conditions, it is expected that the overall resource availability will be very low to low in 2020–21.

(d) Environmental demands

Considering the prolonged drought and need to support recovery and avoid further damage to key assets, there are a number of environmental demands that require water urgently in 2020–21.

The environmental water demands for assets in the Macquarie River Valley in 2020–21 are represented in Table **24**. Note that the capacity to contribute to many of these environmental demands is contingent on a substantial improvement in water availability in the catchment.

Table 24: Environmental demands, priority for watering in 2020–21 and outlook for coming year in the Macquarie River Valley.

Environmental assets	Target values	Indicative demand (for all sources of water in the system)[6]		Watering history[7]	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Mid-Macquarie River (Burrendong – Marebone Weir) [1] Native fish habitat and spawning including threatened species such as Murray cod, freshwater catfish In-stream aquatic ecosystems Riparian vegetation	Fish refuge: all guilds Aquatic ecosystems	**Baseflows*:** small (>200 ML/d), very regular flows through to end of system, wetting waterholes and in-stream storages. Ideally depth >0.3 m above commence to flow level, to allow some movement and prevent pool stratification.	Ideally: continuous flow (Max interval: continuous flow)	Demand expected to be met by essential regulated supplies in all but the most extreme dry years. Minimum baseflows have been achieved in all years, other than in 2019–20 when extreme dry flow conditions meant that the Macquarie River was shut off downstream of Warren Weir in late August 2019 until tributary flows improved conditions in February 2020. Baseflows are ideally required continuously to maintain in-stream habitat, and will be required again in 2020–21, particularly in the river between Warren and Marebone where there were cease to flow conditions. Therefore, the environmental demand has been assessed as high to critical.	High to Critical	High priority for use of CEW under very low water availability scenario, subject to environmental water being available for delivery. However, there is a risk in 2020–21 that baseflows won't be met should extreme dry conditions continue. Expected to be met by essential regulated supplies under low to very high water resource availability scenarios.	High
	Fish spawning–flow generalists (e.g. Australian smelt, carp gudgeon) + in-channel specialists (e.g. Murray cod, freshwater catfish)	**Small freshes:** Small fresh 1(SF1) >500 ML/d anytime (but ideally Oct–Apr) for 10 days. Small fresh 2 (SF2) >500–6 000 ML/day for at least 14 days at Baroona in Sep–Apr (Sep–Dec for Murray cod spawning); and conditioning flow in winter (July to mid-August).	Ideally: SF1: annually (Max interval: 3 years for large-bodied generalists; 5 years in-channel specialists; 1 year for small-bodied) SF2: 5–10 years in 10	Small freshes were achieved between 2015–16 and 2018–19 but had only been partially met in 2019–20 as of mid-April 2020. SF1 and SF2 were likely met in February and April downstream of tributaries (Bell, Little rivers), but not upstream to Burrendong Dam. No winter priming flow was achieved. These flows are ideally provided annually, particularly for small bodied fish, so are required again in 2020–21. Therefore, the environmental demand has been assessed as high.	High	Potential use under low to high water resource availability scenarios, subject to natural tributary flows and water temperature.	Moderate to High
	Flow specialists guild movement and breeding[†]	**Priming flow:** >5 000 ML total flows at Baroona over 3 days with approx. 7 day recession (tributary pulse). **Spawning pulse:** initial peak ≥ 5 000 ML/day at Baroona for >2 days with event lasting for >7 days. (35–40 day total event) **Dispersal flow:** Initial pulse >3 000 ML total flows over 3 days at Baroona. Second pulse min. 2 000 ML/day peak with recession. Approx 10d duration total events. (Oct–March) Water temperature for all pulses ≥19°C.	Ideally: 3–5 years in 10 (up to twice per year) (Max interval: 4 years)	Flows for native fish flow specialists were likely last fully met in 2012–13 (Nov–Jan). Tributary flows to Baroona in February 2020 likely provided priming and spawning flows, followed by a dispersal flow in March. Another potential spawning pulse occurred in April 2020. However, this demand was not met to Marebone, and supplementary access, and channel breakouts/floodrunners and operation of creeks impacted on achievement of required flows. The maximum interval between events for these flows has been exceeded by three years. Also, in consideration of the extreme drought conditions, and recent fish kills, it is unlikely that the flows in 2019–20 were sufficient to support the longer-term recovery of native fish flow specialists in the mid-Macquarie River. Therefore, the environmental demand for water in 2020–21 has been assessed as critical.	Critical	Although the demand for water is very high, water available to meet this demand is insufficient under a very dry scenario. The capacity to target spawning pulses using regulated environmental water is also limited in most years. Possible use of CEW (e.g. supplementary) under moderate to high water resource availability scenarios to augment freshes and support movement. Subject to natural tributary flows, water temperature, and significant river rises that will cue movement and possibly spawning of flow specialists.	Critical
	Fish movement In stream + riparian vegetation	**Large freshes and bankfull:** 10 000–20 000 ML/day at Baroona for a minimum of 3 days (to drown out key weirs). (Gin Gin drowns out at 18 000 ML)	Ideally: 2 in 10 years (Max interval: 2–4 years)	Large freshes were last achieved in 2016–17, when flows >10 000 ML/day were achieved at Baroona on three occasions, for 6, 3 and 28 days respectively in Sept–Oct 2016, and in 2011–12 before that. These flows were partially met in 2019–20, having exceeded 10 000 ML/d at Baroona for 2 days in February and 3 days in April. However, these flow rates were not reached in other sections of the river, and supplementary access impacted on the achievement of this demand. To meet the desired frequency of these flows, water is required in 2020–21 or 2021–22. Therefore, the environmental demand has been assessed as moderate.	Moderate	A low priority for CEW in 2020–21 and only able to contribute to this demand when coordinated with major tributary flow event.	Moderate

* Very low flows in the mid-Macquarie River have the same flow rate and requirements as baseflows (>200 ML/day). Cease to flow events should be avoided because they no longer occur, and fish, plant and animal communities are dependent on regular flows.

† There are still knowledge gaps related to spawning requirements and hotspots in the Macquarie catchment for flow specialists.

Environmental assets	Target values	Indicative demand (for <u>all sources of water</u> in the system)[6]		Watering history[7]	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Macquarie Marshes[3,4‡] Includes areas of Ramsar listed wetlands[§] Nationally significant wetlands Waterbird breeding and habitat Habitat and breeding ground for frogs Native fish habitat	Blue and Purple inundation zones (4 000 to 9 000 ha)	30–60 GL at Marebone over 3 months between June and April to inundate reed beds, lagoons, mixed marsh, and water couch.	Ideally: annually (Max interval: 2 years)	Demand has been met in most parts of the Marshes in most years since 2012–13. This demand was likely met in the Northern and Southern Marshes in 2019–20, based on the flow volume, inundation extent and duration. Rainfall and supplementary events contributed flows (~132 GL of water was recorded at Marebone over three months to late April, with 106 GL being available to the Marshes). Approximately 49 GL reached Pillicawarrina and the Northern Marshes. However, in the Eastern Marshes, despite good rainfall, lower inflows were received. Overall, the demand for water in 2020–21 has been assessed as high, to support the recovery and growth of core wetland vegetation, and to provide habitat for a range of aquatic species. This is based on the annual need for water, the prolonged extreme dry conditions preceding inflows in autumn 2020, and inflows occurring later in the growing season when temperatures were cooler. Encroachment of dryland species and high grazing pressure also intensifies the need for water in 2020–21, to aid recovery of wetland vegetation.	High	A high priority for CEW under very low to high water resource availability scenarios.	High
	Pink inundation zone (19 000 ha)	100 GL at Marebone over 3 months between June and April to inundate reeds, water couch, mixed marsh, river red gum forest, river cooba.	Ideally: 8 in 10 years (Max interval: Groundcover – 2 years; trees 4–7 years)	Demand met in 2012–13, 2016–17 and again in 2017–18 in all areas of the Marshes, excluding the Eastern Marshes in 2017–18, which was not inundated for the target duration. Demand was either partially met or not met in years in between, including in 2019–20. Although ~132 GL of flow passed Marebone Weir over three months to the end of April, 106 GL of which was available to the Marshes, this demand has not yet been met. Extreme dry conditions preceding these flows has meant this volume has been insufficient to adequately support all vegetation types in the pink zone. Lateral connectivity has not been achieved between channels, beyond the reedbeds into areas of river red gum forest and river cooba. Inundation outside the prime growing season may also impact on the ability to fully meet these requirements. Low groundcover and high grazing pressure have also intensified the need for water to aid recovery. Requires water in 2020–21 to contribute to 8 in 10 year frequency, avoid damage, and to build resilience, including in Ramsar sites. Therefore, this environmental demand has been assessed as high.	High	A high priority for CEW under low to high water resource availability scenarios. Unlikely to have sufficient water to target this demand, unless there is a substantial improvement in water availability.	High
	Red inundation zone (50 000 ha)	250 GL at Marebone over 3– 5 months between June and April to inundate river red gum woodland, river cooba, inner coolibah woodland	Ideally: 1 in 3 years (Max interval: 4–7 years)	Demand met in 2016–17 and 2012–13 in all areas of the Marshes. However, as this flow has now not been met in the last three years (ideal frequency), water is needed in 2020–21. Therefore, the demand is considered high.	High	Possible use under high or very high water resource availability scenarios. Would require other water sources to meet.	High
	Orange and green inundation zones (81 000 to 145 000 ha)	400 to 700 GL at Marebone over 5 months between June and April to inundate outer river red gum (RRG) woodland, coolibah, and black box	Ideally: 1 in 4 years (RRG), or 1 in 8 years (other veg) (Max interval: 7 years (RRG) 20 years (other veg))	Demand last met in 2016–17 in all areas of the Marshes and previously in 2010–11. Some minor inundation occurred in 2011–12 and 2012–13. The condition of this area may be affected by low inflows and below average rainfall during extreme drought conditions. Demand is considered moderate to high, requiring water in 2020–21 or 2021–22, particularly to maintain river red gum woodland.	Moderate to High	Low priority for use of CEW in 2020–21 and only able to contribute to this demand when coordinated with major flow event.	Moderate to High

‡ Volume required to meet demands may vary depending on antecedent conditions.

§ Vegetation types/communities that are identified as critical components of the Ramsar site include water couch, river red gum forest and woodland, reed beds, cumbungi, mixed marsh, coolibah and blackbox woodland. By maintaining this wetland vegetation, other critical components of the Ramsar site may be supported, including frogs, fish, waterbird breeding and foraging habitat.

Environmental assets	Target values	Indicative demand (for <u>all sources of water</u> in the system)[6]		Watering history[7]	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Lower Macquarie River (Marshes – Barwon River)[1,2] Native fish habitat and dispersal Provides connectivity between Macquarie and Barwon catchments In-stream aquatic ecosystems and floodplain vegetation	In-stream aquatic ecosystems Fish Connectivity	In-channel flows: Minimum 20 ML/day at Bells Bridge for 45 days.	Ideally: annually (Max interval: 1–2 years)	Small in-channel flows were met in the lower Macquarie in each year between 2016–17 and 2018–19 (usually between Aug and Dec/Jan). However, cease to flow conditions have persisted in the lower Macquarie River in 2019–20, with the exception of small flows above 20 ML/d (S&D) in March, April and again in May 2020. These flows ideally occur annually and are required again in 2020–21. Therefore, the environmental demand has been assessed as high.	High	Possible use under low to moderate water resource availability scenarios, subject to tributary flows. Needs may be partially met by other flows (e.g. environmental water delivered to the Marshes).	High
	Fish Connectivity	System connectivity between the Macquarie and Barwon catchments: † for example in-channel flow targeting minimum rates of 140 ML/day at Bells Bridge (minimum depth of 50 cm) to connect the lower Macquarie River and the Barwon River for a minimum of 28 days.	Opportunistic (Max interval: 4 years)	Based on flows at Bells Bridge, suitable connection was achieved in spring 2016, autumn 2017, and again in spring/summer 2017. Note that these flows in 2016–17 occurred during wetter conditions and the autumn flow was specifically targeting connectivity to the Barwon River. However, flows in 2017–18 occurred in drier conditions and were likely subject to extraction downstream of Bells Bridge, meaning suitable connection may not have been achieved. This demand was also partially met in 2018–19, with environmental water providing a low flow connection to the Barwon River during spring 2018. Flows from the Castlereagh and Marthaguy provided good connectivity in the lower reaches in early 2020. However, cease to flow conditions persisted through much of 2019–20, and flows remained well below 140 ML/d at Bells Bridge. Therefore, this demand was not met and water required in 2020–21.	High	High priority for CEW under moderate to very high water resource availability scenarios only, subject to suitable conditions and operational feasibility.	Moderate to High
	Floodplain vegetation Connectivity	15–30 GL at Bells Bridge to inundate floodplain and lower reach of Macquarie River.	Ideally: 1 in 3 years (Max interval: 7 years)	Good connectivity was achieved with the lower reach and floodplain of the Macquarie River in 2016–17 and previously in 2012–13. ~15.3 GL of flow also passed Bells Bridge between July and mid-Dec 2017. However, this water was likely subject to unregulated flow extraction in the lower Macquarie, so this demand may not have been fully met since 2016–17. Therefore, the environmental demand has been assessed as high.	High	Unlikely to be a priority under continuing very dry conditions. Possible use under high to very high water resource availability scenarios only, subject to suitable conditions and operational feasibility.	High
Unregulated Distributary creeks[5] **(Marra Creek Lower Crooked Creek**[**]**)** Native fish habitat In-channel and riparian habitat Connectivity with Barwon–Darling catchment	Fish In channel and riparian vegetation Increased frequency and duration of connectivity to Barwon–Darling	Baseflows and freshes to Marra Creek and/or the lower Crooked Creek. Volumes required dependent on which creeks are targeted. Some connectivity may be provided by replenishment flows.	Required frequency unknown (1 in 1–3 years based on key vegetation)	Demand was met in 2016–17 and 2012–13, with stock and domestic replenishment flows partially contributing to demand in some creeks in years in between. Some flows were recorded in Crooked and Marra creeks following rainfall, tributary flows and delivery of stock and domestic water between February and April 2019–20. Marra Creek also connected with the Barwon. Following these flows, this demand is considered to have been met in Marra Creek (total 16 138 ML at the Carinda gauge Feb–Apr). However, flows only partially met this demand in Crooked Creek (total 5 350 ML at the Profile gauge Feb–Apr). Overall, water is required in the next 1–2 years, so the environmental demand has been assessed as moderate to high.	Moderate to High	Possible use under moderate to very high water resource availability scenarios, subject to suitable water availability and operational feasibility.	High

[**] Broader system connectivity may be achieved by other flows in the system and operational management of environmental/other water (e.g. via the Bogan River, Gunningbar Creek, the Castlereagh River, and Marthaguy Creek (including through the Gum Cowal)).

Environmental assets	Target values	Indicative demand (for all sources of water in the system)[6]		Watering history[7]	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Prioritised critical refuge habitat – various locations as required in exceptional circumstances Refuge habitat Native fish (e.g. olive perchlet), water rat and tortoise survival Water quality	Fish (all guilds) and other aquatic dependent biota refuge Aquatic ecosystems	Baseflows to replenish significant refuge pools at high risk of drying down in exceptionally dry circumstances. Volumes required are likely to be relatively small, but dependent on which refuge pools are targeted.	As required only during extremely dry conditions	Demand expected to be met by essential regulated supplies in all but the most extreme dry years. Environmental water was provided to two important refuge pools in 2018–19 (Lower Nyngan Weir Pool and at Methalibar Reserve on Ewenmar Creek) to help prevent them from drying out. Extreme dry conditions persisted for much of 2019–20, and generally no environmental water was available to deliver. Some native fish and turtles were rescued and relocated or moved to hatcheries to form insurance populations. However, tributary flows between February and April 2020 provided relief to refuge pools downstream of Warren Weir. Other refuge pools have been replenished by rainfall, stock and domestic and/or tributary flows. Considering the prolonged dry conditions, and overall decline in the condition of many refuge pools, the demand for water to maintain critical refuge habitat has been assessed as moderate to high. The urgency for water to maintain refuges in 2020–21 will depend on catchment conditions and water availability in the coming months.	Moderate to High	Expected to be met by essential regulated supplies. However, there is a risk in 2020–21 that some critical refuge habitat will dry out and decline in quality if conditions remain dry. Potential use under very low water availability scenario, subject to environmental water being available for delivery.	Variable depending on climatic conditions: If extreme dry conditions persist, demand may be Critical; Should conditions become significantly wetter, demand may reduce to Low or Very Low

Note: contributions to meet Barwon–Darling environmental requirements may be considered subject to water availability, antecedent conditions, and environmental demands. Refer to CEWO's Water Management Plan 2020-21 Chapter 3.7: Barwon–Darling.

References:

1. Sourced from information and advice provided by NSW DPI Fisheries (Sam Davis and Rod Price, pers. comm. 2015– 2020).

2. Sourced from Barma Water Resources et al. (2011).

3. Sourced from advice from NSW Department of Planning, Industry and Environment (Tim Hosking, Paul Keyte and Debbie Love, pers. comm. 2015–2020), NSW Department of Environment, Climate Change and Water (2010), and MDBA (2012).

4. Based on inundation zones as mapped by Thomas et al. (2015).

5. Sourced from Torrible et al. (2011).

6. Information on flow/volume and required frequency of indicative demands drawn from the draft Macquarie-Castlereagh Long Term Water Plan (NSW OEH 2018a and b), as appropriate.

7. All watering history sourced from advice from NSW Department of Planning, Industry and Environment (Tim Hosking, Paul Keyte and Debbie Love, pers. comm. 2015–2020), NSW DPIE Statement of annual environmental watering priorities, WaterNSW Water Balance Reports, and data from the following gauges (WaterNSW 2020):

421090: Macquarie River at d/s Marebone Weir

421001: Macquarie River at Dubbo (in the absence of available data at Wellington)

421147: Macquarie River at Pillicawarrina

421088: Marebone Break at d/s regulator

421107: Marra Creek at Billybongbone Bridge

421097: Marra Creek at Carinda Road

421146: Gum Cowal at Bifurcation

421907: Macquarie at Brewon

421127: Macquarie River at Baroona

421016: Crooked Creek at Profile

421012: Macquarie River at Carinda (Bells Bridge)

421022: Macquarie River at Oxley Station

421152: Gum Cowal at Oxley

Key - potential watering in 2020-21

- High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)
- Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate - high water resource availability); or water demand likely to be met via other means
- Low priority for Commonwealth environmental watering (under high - very high water resource availability)
- Unable to provide Commonwealth water because of constraints or insufficient water

Key - environmental demands

- Critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
- High demand for water i.e. needed in that particular year
- Moderate demand for water i.e. water needed that particular year and/or next
- Low demand for water i.e. water generally not needed that particular year
- Very low demand for water i.e. water generally not needed that particular year or the following year

Note that demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime

3.6.5 Water delivery in 2020–21

Based on the demand for water for the environment, water availability (supply), and catchment conditions, the overall purpose for managing Commonwealth water for the environment in the Macquarie River Valley in 2020–21 is to avoid damage and protect the health and resilience of aquatic ecosystems in the Macquarie River and Marshes, and other important sites in the valley as required.

Consistent with the demands and purpose identified, the CEWO is considering supplying water for the environment to the following actions in 2020–21.

Using water for the environment carried over into 2020–21, deliver water to the Macquarie Marshes to target the inundation of 4 000–9 000 ha (blue and purple inundation zones – Figure 11) of core wetland vegetation (reeds, water couch, lagoons and mixed marsh). Inundation of the core wetlands is required for 3–6 months over the warmer spring growing period, particularly for reedbeds and mixed marsh. Delivery of water for the environment at this time would help support wetland recovery and avoid irretrievable loss or damage in the Marshes.

To help prime the system ready for this delivery, tributary flows and NSW translucent water may be used, if available, to maintain moisture in the marshes over winter. This would build on the benefits of recent rainfall and flows and help boost the response to water delivered in spring.

Delivery of water for the environment to the Macquarie Marshes is scalable, depending on the volume of water available and catchment conditions. Should conditions and water availability improve, there may be opportunities to target the inundation of a larger area of the Marshes, although not at the expense of meeting the required duration target in core areas.

Depending on the volume of water available, delivering environmental water to the Macquarie Marshes may also:

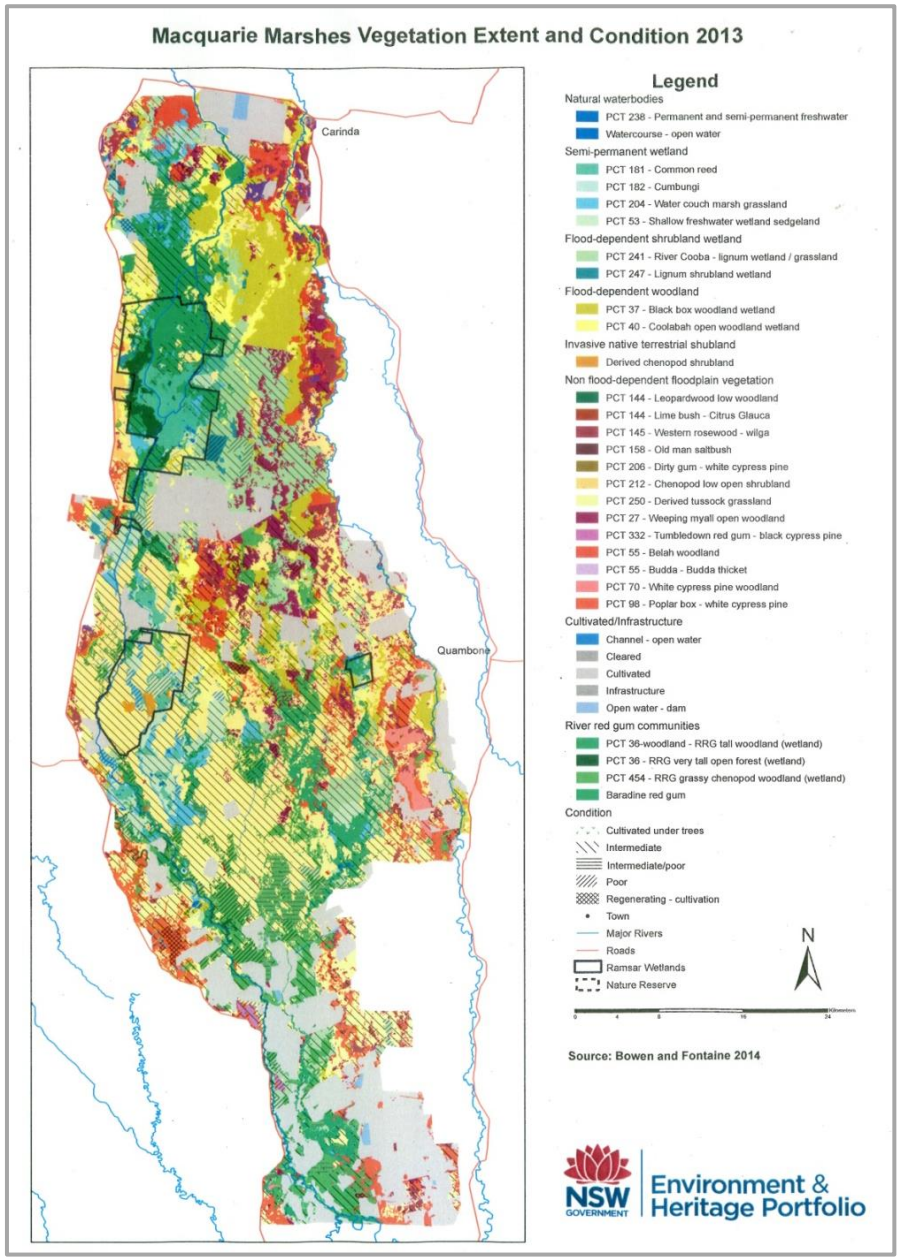
- meet baseflow and small fresh requirements in the mid-Macquarie River
- support native fish condition, movement and spawning opportunities in the mid-Macquarie River by managing the hydrograph to provide suitable flows
- support values of the Ramsar site within the Marshes as defined by its ecological character, such as maintaining core areas of semi-permanent wetlands (including reeds, water couch and red gum forest), providing habitat for migratory waterbirds and native fish, and promoting biological diversity.

Another priority is to provide a connection flow to the Barwon River via the Marshes and lower Macquarie River. A suitable connection flow has not occurred since 2016–17 and would provide an opportunity for native fish to move and disperse between the two systems. This may include juvenile golden perch observed moving in the Barwon–Darling system in autumn 2020. Delivering a native fish connection flow is dependent on sufficient water being available at a time best suited for fish to move and disperse.

There is a critical demand to provide flows to support native fish flow specialist movement and breeding in the mid-Macquarie River. Similarly, there is a high demand for water to inundate up to 50 000 ha of the Macquarie Marshes, and to support floodplain vegetation in the lower Macquarie. However, a significant increase in the availability of water for the environment (and other water sources) is required to support these demands. Meeting the demand for native fish flow specialists is also dependent on the occurrence of suitable tributary flows to cue movement and breeding.

As in previous years, the use of Commonwealth and NSW environmental water in the Macquarie River Valley will be adaptively managed together throughout 2020–21, in response to changing water resource availability and environmental conditions and demands.

a)



b)

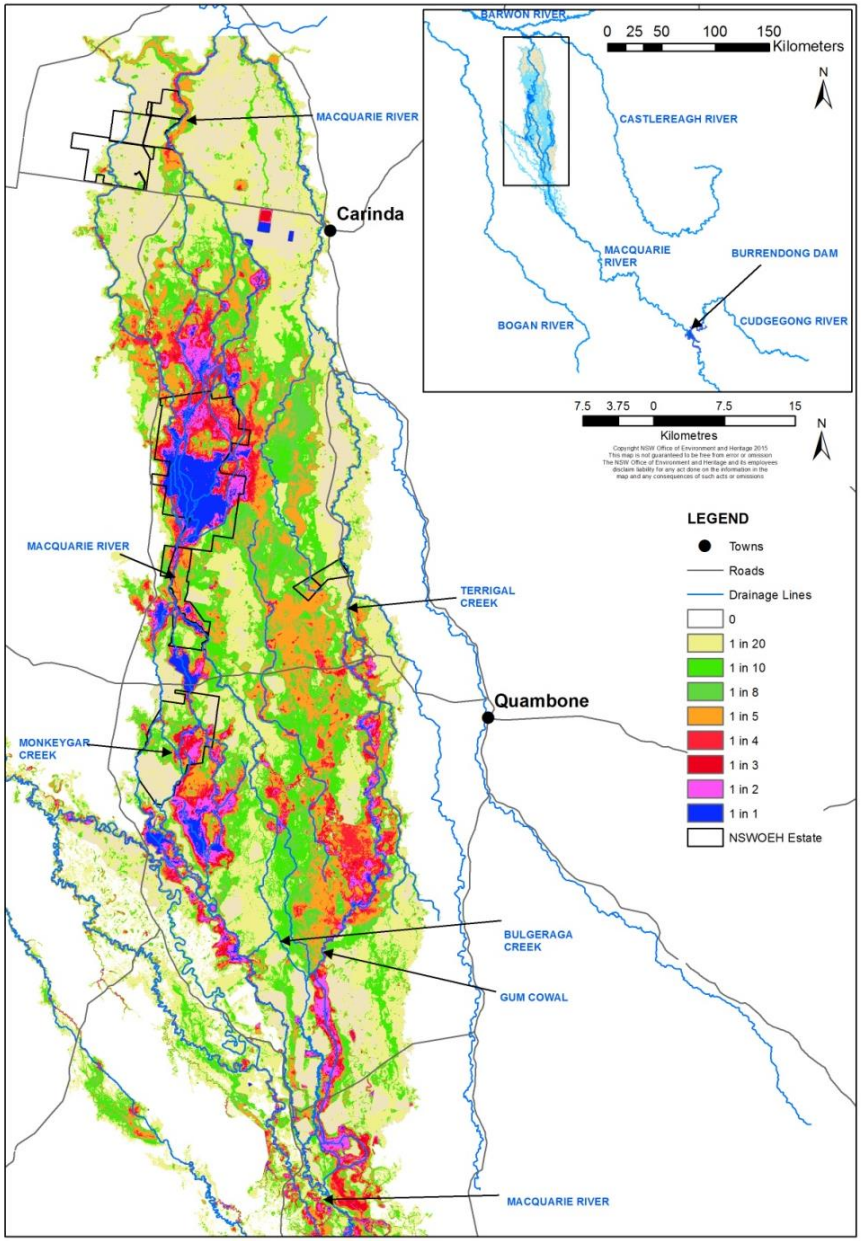


Figure 11: a) Macquarie Marshes vegetation mapping (Bowen & Fontaine 2014); b) Inundation frequencies: Macquarie Marshes 1988–2008 (Thomas et al. 2015)

3.6.6 Monitoring and Lessons learned

(a) Monitoring

In the Macquarie River Valley, monitoring is primarily undertaken by NSW agencies including NSW DPIE (vegetation, waterbirds and frogs), NSW DPI – Fisheries (native fish), and WaterNSW (hydrology and flow delivery data). The CEWO has also funded a number of short-term intervention monitoring projects to evaluate the environmental responses of native fish, waterbirds, and freshwater mussels.

Details of monitoring activities funded by the CEWO in the Macquarie River Valley can be found at: http://www.environment.gov.au/water/cewo/catchment/macquarie/monitoring

(b) Lessons learned

Outcomes from monitoring and lessons learned in previous years are a critical component for the effective and efficient use of Commonwealth water for the environment. These learnings are incorporated into the way environmental water is managed.

Key findings from fish[1], flow[2], frog[3] and waterbird[4] monitoring in the Macquarie River Valley are summarised in Table 25.

Table 25: Key lessons learned in the Macquarie River Valley

Theme	Lesson learned
Native fish	• Spring/early summer delivery has been associated with peaks in breeding of some small-bodied opportunistic fish species (e.g. Australian smelt, un-specked hardyhead, Murray-Darling rainbowfish), particularly on the receding tail of flows, or during sustained periods of increased flow. • Spring/early summer delivery is also likely to support recruitment of native species such as Murray cod and freshwater catfish, by increasing flows and boosting in-stream productivity in the river.
Frogs	• Local weather and inundation extent influence the activity of some species. Increased inundation increases the number of sites with conditions suitable for breeding, and the calling of flow-responsive species. • Flooding events are very important for increasing overall abundance of flow-responsive species, by supporting breeding and enabling frogs to move between wetlands. • Longer duration of inundation is important for frogs to complete metamorphosis. Maintaining water levels in the Marshes into late November increases frog recruitment.
Waterbirds	• Delivery in winter/spring (into summer if possible) provides suitable wetland habitat for nationally threatened and internationally recognised migratory species and coincides with warmer temperatures and peak activity for waterbirds and their food supplies. • A slow steady contraction of inundated area is preferable, particularly for wading species. • Delivery to parts of the Marshes during dry conditions helps support a diverse range of waterbirds and provides important feeding and refuge habitat.
Connectivity	• Connectivity between Macquarie and Barwon rivers can be achieved using water for the environment and is important for allowing the movement of native fish between rivers for spawning, dispersal and recruitment.

[1] Stocks et al. 2015, Davis et al. 2017
[2] WaterNSW 2017
[3] NSW OEH 2017, Ocock and Spencer 2017, NSW OEH 2019a
[4] Spencer et al. 2016, McGinness et al. 2017, Brandis 2017, NSW OEH 2019b

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3.7 Barwon-Darling River

3.7.1 Region overview

(a) River system

The Barwon River flows south-west through a relatively narrow floodplain with a tightly meandering channel. It has a highly variable channel capacity and flow pattern. Channel capacity increases downstream of Collarenebri, after the Little Weir, Boomi, Moonie, Gwydir and Mehi rivers have joined the Barwon.

Downstream of Collarenebri, the Barwon River continues south-west, and is joined by more creeks and rivers including the Namoi River. Beyond Walgett the river turns in a westerly direction and flows unrestricted across alluvial plains. Further downstream there are many anabranches and effluent channels, which split and re-join the major channel. Upstream of Bourke, the Culgoa and Barwon Rivers join to form the Darling River.

The Darling River flows south-west within a deeply incised channel towards Wilcannia. Below Wilcannia the Darling reaches the Menindee Lakes, at the artificial storage of Lake Wetherell.

There are no major public water storages along the Barwon–Darling system, although large headwater storages exist in several tributaries. There are also large private off river storages that store water diverted or pumped from the Barwon and Darling Rivers or harvested from floodplain run-off. There are also 14 major weirs along the main stem of the Barwon–Darling system from Mungindi to upstream of Menindee Lakes, which create a series of barriers for fish passage. Only the Brewarrina Weir contains an effective fishway.

(b) Traditional Owners

The rivers and waterholes of the Barwon–Darling system hold significant spiritual and cultural importance for Aboriginal people from several nations including the Barkandji, Murrawarri, Ngemba and Ngiyampaa peoples.

(c) Important sites and values

The Barwon–Darling River channel connects the rivers, lakes and wetlands in the northern Murray–Darling Basin as well as providing connectivity with the southern Basin. Connectivity of the Barwon–Darling has been listed in the Basin environmental watering priorities in recent years. The Barwon–Darling provides a critical dry period refuge and movement corridor for fish and waterbirds, as well as habitats for other aquatic species including turtles, mussels, river snail and shrimp. Connectivity along the length of the Barwon and Darling Rivers is particularly important for regional communities of native fish and other aquatic species.

Diverse in-stream habitats including channels, deep pools, riffles, benches, snags, gravel beds and aquatic and riparian vegetation support a significant native fish community. There are more than 1 100 refugial waterholes between Mungindi and Wilcannia.

The fish community within the Barwon–Darling system includes 15 native species which have been recorded or expected to occur along the system, and up to five non-native species. Silver perch is listed as critically endangered and Murray cod as vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. The system is likely to contain remnant populations of olive perchlet, purple spotted gudgeon and freshwater catfish, all of which are listed under relevant threatened species legislation within NSW. Other important species found in the Barwon–Darling that are not widely dispersed across the Basin include Rendahl's tandan, Hyrtl's tandan, spangled perch, Darling River hardyhead and desert rainbowfish.

The Barwon–Darling also supports several species of river mussels, including *Alathyria jacksoni*, which is highly responsive to changes in low and zero flows.

(d) Stakeholder engagement

The Commonwealth Environmental Water Office (CEWO) works with the following to collect and collate relevant monitoring information and evaluation results that facilitates adaptive management and changing our practices where needed:

the Murray–Darling Basin Authority

- state agencies in particular the Water and Environment, Energy and Science groups in the Department of Planning, Industry and Environment (DPIE)
- research organisations
- regional organisations, local groups and landholders.

This continual review of information and outcomes is helping to build knowledge about the best way to get positive outcomes across the Barwon–Darling system scale, based on what does and does not work across the system.

The CEWO funds a Monitoring, Evaluation and Research program, that includes a selected area at the junction of the Warrego and Darling rivers. This provides additional information to inform adaptive management.

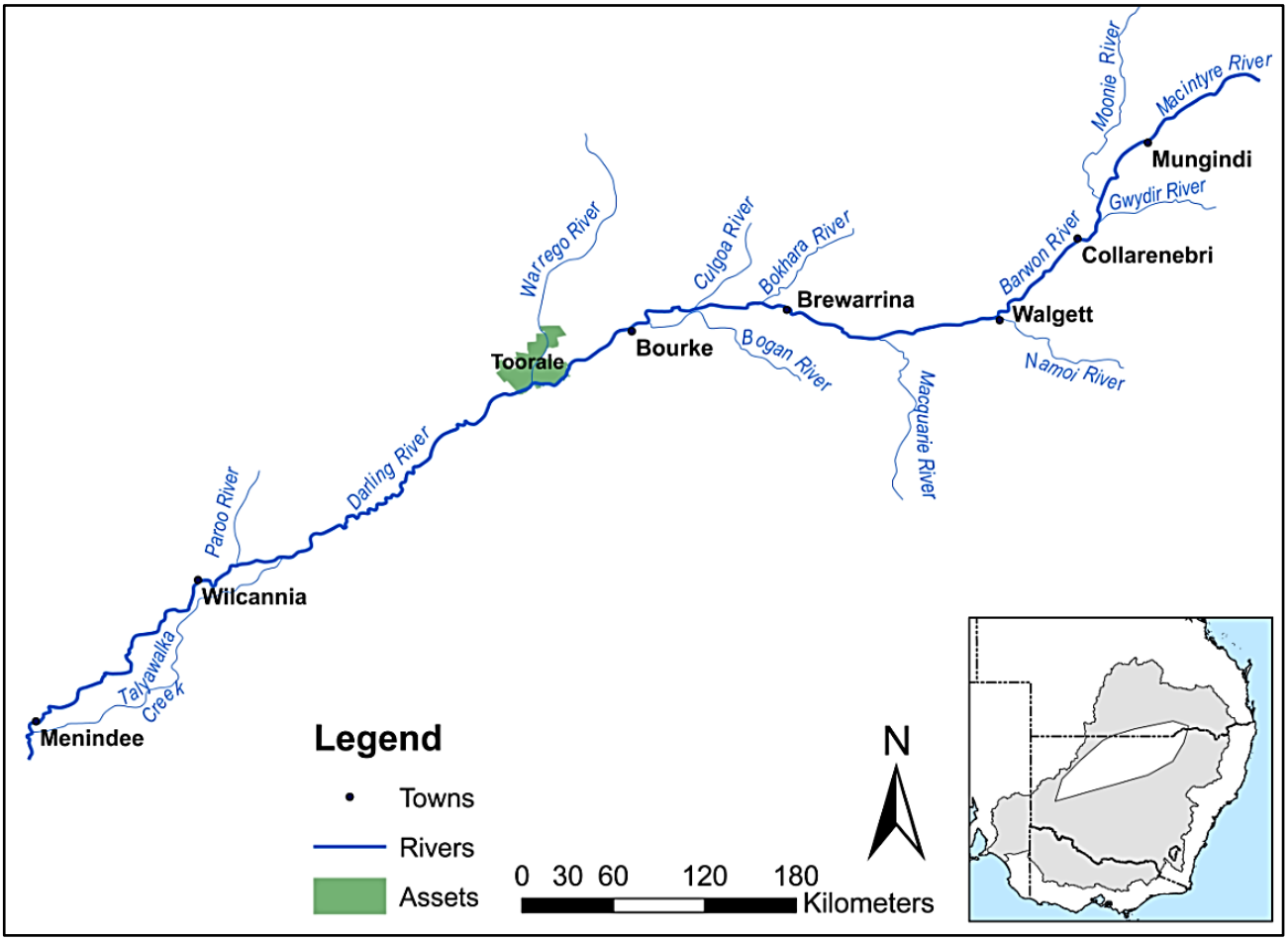

Figure 1: Map of the Barwon–Darling system.

3.7.2 Environmental objectives

Based on long-term environmental objectives in the Basin Plan, draft state long-term watering plans, site management plans, and best available knowledge, the following objectives are relevant for environmental watering in the Barwon–Darling system.

Because of the unregulated nature of the Barwon–Darling system, the objectives that can be achieved in a particular year may vary and are highly dependent on catchment conditions and rainfall events within the systems tributaries. These objectives will continue to be revised as part of the commitment of the CEWO to adaptive management.

Vegetation: Maintain the condition, growth and survival of riparian, in-channel, floodplain and wetland vegetation.

Waterbirds: Increase waterbird abundance and maintain species diversity by supporting naturally triggered breeding events, and maintaining suitable refuge, feeding and breeding habitat.

Native fish: Prevent loss of native fish species and improve population structure and distribution, by supporting opportunities for movement, dispersal, reproduction, and recruitment.

Other vertebrates: Support opportunities for the reproduction and recruitment of other native aquatic species, including frogs and turtles.

Connectivity: Support longitudinal connectivity, along the Barwon and Darling rivers, and lateral connectivity within the river network and between the rivers and their floodplains.

Processes/water quality/resilience: Support key ecosystem functions and promote productivity; maintain water quality in channels and pools; and maintain drought refuge habitat.

3.7.3 First Nations environmental objectives

Representatives of the First Nations peoples of the Barwon-Darling river system have identified environmental objectives for their country for 2020–21 (Table 26). These objectives were developed through the First Nations Environmental Guidance project undertaken by the Northern Basin Aboriginal Nations organisation.

Some of these objectives sit outside the scope of water for the environment to influence, while for others, the link between water for the environment and the site or species is not well understood.

The CEWO is committed to working with First Nations groups to better understand their objectives. The CEWO will use environmental flows to contribute to these objectives where possible and where this is consistent with the Commonwealth Environmental Water Holder's statutory responsibility of protecting and restoring environmental assets in the Basin.

Table 26: First Nations environmental objectives for the Barwon-Darling system for 2020–21 (NBAN Ltd. 2020)

River flows and Connectivity
Priority sites: The Big Warrambool.
Other flows and connectivity: Ensure there is flow at all times, which can then flow into smaller tributaries and rivers during flooding.
Native Vegetation
Indicator species: Lignum, river reed, quinine, river redgum, yam, dog wood, nardoo.
Native Birds
Indicator species: Pelican, duck, black swan, black shag, black cockatoo[i].
Native Animals
Indicator species: Cod, booglie, yellowbelly, emu[i], echidna[i], silver bream (silver perch).
Connecting with Country
A place to teach culture and stories. A place of gathering for men, and women. Fishing and hunting.

[i] Water for the environment targeting other environmental outcomes may influence this species or objective

3.7.4 Recent conditions and seasonal outlook

(a) Recent conditions and environmental water use

Like much of the northern Basin, the Barwon–Darling system experienced very hot and dry conditions between January 2018 and January 2020. Rainfall was well below average, with 2018 and 2019 recording the two highest annual average maximum temperatures at Brewarrina for the 83 years of record. Flows along the system during this period have also been generally low, with long reaches of the Barwon–Darling ceasing to flow for extended periods. The hot and dry conditions over the last two years resulted in the Darling River downstream of Bourke not flowing for over 430 days between September 2018 and November 2019. Other river reaches such as downstream of Collarenebri and upstream of Wilcannia experienced low or no flow periods of over 170 days and 200 days respectively. These long periods of low or no flow saw a reduction in the number and quality of refuge pools within the Barwon–Darling systems. The reduction in extent and quality of drought refuges is likely to have had a significant impact on the aquatic communities of the system. Exceptions to these dry conditions were:

- Small flow events moving through the system in autumn 2018, winter 2019 (river reaches downstream of the Warrego/Darling River junction to just downstream of Wilcannia), and late spring 2019.
- Environmental flows from the Northern Connectivity Event along both the Barwon and Darling rivers to the Menindee Lakes during autumn/winter 2018, and Northern Fish Flow moving along the Barwon River during winter 2019.

During late summer and early autumn 2020 widespread rainfall occurred across most of the northern Basin with the upper parts of northern Basin valleys recording more than 300 mm of rainfall during January and February. This rainfall generated significant flows in most Barwon–Darling tributaries and corresponding inflows into the Barwon and Darling rivers. The contribution each tributary made to flows along the Barwon and Darling rivers varied, with the Condamine-Balonne contributing the most (205 gigalitres as measured at the end of system gauges on the Culgoa and Bokhara rivers).

To address critical water needs along the Barwon–Darling systems, temporary water restrictions were put in place by the NSW Government using Section 324 of the NSW *Water Management Act 2000*. These restrictions commenced on 4 November 2019 and prevented unregulated river licence holders along the Barwon and Darling Rivers upstream of Menindee from extracting water from the natural flow events. The temporary restrictions were in place along the Barwon River until 27 February 2020, while along the Darling River upstream of Menindee Lakes the restrictions were in place until 6 March 2020.

Details of previous Commonwealth environmental use in the Barwon–Darling catchment are available at: https://www.environment.gov.au/water/cewo/catchment/northern-unregulated-rivers/history

(b) Seasonal outlook

According to the Bureau of Meteorology outlook on 2 July 2020, above median rainfall is forecast across the Barwon–Darling system from August to October. While this forecast suggests that recent severe dry conditions may continue to ease somewhat, follow up rain over the forthcoming summer is needed to ensure continued recovery from the drought. Wetter conditions can return suddenly in the northern Basin. Maximum temperatures are also forecast to remain above average over the coming months.

(c) Water availability

Unregulated held environmental water entitlements

Commonwealth holdings of water for the environment in the Barwon–Darling system are exclusively made up of unregulated entitlements. These entitlements can only be sourced as a share of an unregulated flow event, determined by entitlement conditions. The list of unregulated entitlements held along the Barwon–Darling is shown in Table 27.

Table 27: Unregulated Commonwealth environmental water entitlements in the Barwon-Darling system.

Water Access License (WAL)	Water Management Zone	Class	Long-term Average Annual Allocation (ML)
37810	Boomi River Confluence to Mogil Mogil Weir Pool	B	3 731
33619	Downstream of Mogil Mogil to Collarenebri	B	9 252
33798		C	6 963
37461	Boorooma to Brewarrina	B	323
33701	Bourke To Louth	A	51
33704		A	22
33784		B	1 566
35944		B	1 188
35943		C	5 535

Available water for the environment using unregulated entitlements within the Barwon–Darling system depends on the nature of flow events that occur. Unregulated entitlements provide opportunistic access to unregulated river flows and overland flows when water resource plan rules are triggered. Each entitlement will contribute to restoring in-stream flows reflecting its flow class, daily take rates and location.

On a long-term average basis 28 631 megalitres of Commonwealth water for the environment is available in the Barwon–Darling system. The amount of water available in each water varies, with above average volumes of Commonwealth water for the environment available in wet years and very small volumes available during dry times.

Environmental water entitlements held in tributary systems

In addition to holdings within the Barwon–Darling system, held water for the environment delivered from within tributary systems of the Barwon–Darling can be delivered to the Barwon and Darling systems to enhance environmental outcomes in the Barwon and Darling Rivers. Active management enables water for the environment to be protected from extraction so it can remain in-stream and be used for environmental purposes.

Regulated and supplementary entitlements of water for the environment held within tributary systems of the Barwon–Darling can be delivered to increase flows in the Barwon and Darling Rivers. The Northern Connectivity Event and Northern Fish Flow are examples of this type of use. In most regulated tributaries of the Barwon–Darling system account volumes for regulated entitlements held by the Commonwealth are currently low. This means use of regulated entitlements held by the Commonwealth to meet environmental outcomes in the Barwon–Darling is unlikely to occur during the 2020–21 water year.

Supporting Policies

To maximise environmental outcomes resulting from environmental water delivered from regulated tributaries as well as from the activation of unregulated entitlements along the Barwon–Darling will require water for the environment to be protected from downstream extraction.

Through implementation of the Water Reform Action Plan, the NSW Government is committed to improving the way in which water for the environment is managed in the NSW northern Murray–Darling Basin. As part of the Plan, the NSW Government is exploring changes to existing operational arrangements along the Barwon and Darling rivers to increase the level of management across the system. Known as active management, this will allow water for the environment to be protected from extraction and used instream for environmental purposes (referred to as active environmental water). Active management presents new but complex opportunities for managers of water for the environment.

(d) Environmental demands

The environmental water demands for assets in the Barwon–Darling for the 2020–21 water year are represented in Table 28. These demands have been drawn from material presented in the draft Long-Term Water Plan, prepared by the NSW Government for the Barwon–Darling system.

Table 28: Environmental demands, priority for watering in 2020–21 and outlook for coming year along the Barwon–Darling system.

Environmental assets	Target values	Indicative demand (for all sources of water in the system)		Watering history	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Refuge pools along the Barwon and Darling rivers Refuge habitat Native fish Water quality Aquatic invertebrate species	Critical drought refuge habitat Native fish maintenance and survival Maintenance and survival of key invertebrate fauna	Cease-to-flow Triggers 0 ML/d (Barwon River @ Beemery) for a maximum of 50 days during very dry conditions 0 ML/d (Darling River @ Bourke) for a maximum of 100 days during very dry conditions 0 ML/d (Darling River @ Louth) for a maximum of 110 days during very dry conditions 0 ML/d (Darling River @ Wilcannia) for a maximum of 120 days during very dry conditions	Cease to flow period should not exceed periods of 50–120 days	The Northern Connectivity Event in April–May 2018 assisted in replenishing refuge pools along the entire Barwon and Darling system. With extremely dry conditions during the 2018–19 water year, the Northern Fish Flow in April–June 2019 assisted in replenishing refuge pools along the Barwon River to just downstream of the Culgoa junction. Reflecting the extremely dry conditions that persisted through most of 2018–19 and 2019–20, cease-to-flow triggers were exceeded at Bourke, Louth and Wilcannia. Rainfall events during late summer/early Autumn have moved the system towards more moderate conditions. However, a return to below average rainfall patterns across the northern Basin during the summer of 2020–21 will see the system return to dry conditions and possibly the return of prolonged periods of no or low flows.	High	A high priority for CEW under dry to very dry conditions. Protection of natural flow events through activation of unregulated environmental water entitlements held along the Barwon and Darling systems is a high priority. Using regulated environmental water entitlements to respond to extended periods of no flow is not expected to be an option until account balances improve in key regulated systems.	High
		Very Low flows >95 ML/d for a total of 230 days in a year at Dangar's Bridge (near Walgett) on the Barwon River >105 ML/d for a total of 180 days in a year at Bourke on the Darling River >70 ML/d for a total of 180 days in a year at Louth on the Darling River >30 ML/d for a total of 175 days in a year at Wilcannia on the Darling River	Every year	These flows provide replenishment volumes to refuge pools along the Barwon–Darling system. Over the last 10 years the requirements for very low flows have been met around 6–7 times but have not been met since the 2017–18 water year. During dry years like the 2017–18 water years, held environmental water delivered from tributaries systems (through watering actions like the Northern Connectivity Event) can assist in achieving these environmental water requirements. Rainfall events during late summer/early Autumn 2020 have moved the system towards more moderate conditions. However, the extremely dry conditions that persisted for most of 2018–19 and 2019–20 mean the requirement for very low flows across the system remains a high priority.	High	A high priority for CEW under dry to moderate conditions. Protection of natural flow events through activation of unregulated environmental water entitlements held along the Barwon and Darling systems is a high priority. Using regulated environmental water entitlements to respond to extended periods of no or low flow dry is not expected to be an option until account balances improve in key regulated systems.	High
In-stream habitats (pools channels benches, snags, and gravel beds) along the Barwon and Darling Rivers Aquatic habitat Native fish Aquatic invertebrate species Water quality	Enabling native fish to access in-stream habitats Native fish movement Maintaining the condition/quality of in-stream habitat	Baseflows >320 ML/d for a total of 150 days in a year at Dangar Bridge (near Walgett) on the Barwon River >500 ML/d for a total of 135 days in a year at Bourke on the Darling River >450 ML/d for a total of 135 days in a year at Louth on the Darling River >350 ML/d for a total of 145 days in a year at Wilcannia on the Darling River	Every Year	These flows provide a flow depth to support movement for small and medium bodied fish as well as assist in managing water quality issues (destratification of waterholes and blue green algal blooms). During dry years like the 2017–18 water years, held environmental water delivered from tributaries systems (through watering actions like the Northern Connectivity Event) can assist in achieving these environmental water requirements. Active management of un-regulated environmental water entitlements held along the Barwon and Darling Rivers will also assist in achieving these environmental water requirements. Over the long term, baseflow requirements across the Barwon Darling system have been met 4–5 years in the last ten and more recently have not been met since the 2016–17 water year. Due to the extended dry period over the last 3 water years the need for Baseflows across the Barwon–Darling system is a high priority.	High	A high priority for CEW under moderate to dry conditions. Protection of natural flow events through activation of unregulated environmental water entitlements held along the Barwon and Darling systems is a high priority. Using regulated environmental water entitlements to respond to extended periods of no or low flow dry is not expected to be an option until account balances improve in key regulated systems.	High

Environmental assets	Target values	Indicative demand (for <u>all sources of water</u> in the system)		Watering history	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Native fish habitat and aquatic communities along the Barwon and Darling Rivers Aquatic habitat Aquatic invertebrate species Water quality Breeding opportunities for native fish	Providing native fish with spawning and recruitment opportunities	Small Freshes (SF1) >700 ML/d for at least 10 days on the Barwon at Dangar's Bridge near Walgett ideally in Oct–April (but can occur at any time). >1 500 ML/d for at least 10 days on the Darling at Louth ideally in Oct–April (but can occur at any time). >1 400 ML/d for at least 10 days on the Darling at Wilcannia ideally in Oct–April (but can occur at any time).	Annual	SF1 flows provide flow depths and velocities to support movement of large bodied fish. Small freshes, particularly along the Darling River need to be supported by natural flow events. Active management of unregulated environmental water entitlements held along the Barwon and Darling rivers will assist in achieving these environmental water requirements. SF1 flows along the Barwon River have occurred 7–9 out of the last 10 years, while along the Darling SF1 flows have occurred 5 out the last 10 years. Along the Darling River SF1 events have occurred only once (during the 2019–20 water year) over the last 3 water years. SF1 flows seek to provide opportunities for fish movement across each water year and are a high priority because of the infrequent movement opportunities for large bodied fish particularly along the Darling River over the last 3 years.	High	A high priority for CEW under dry to moderate conditions. Protection of natural flow events through activation of unregulated environmental water entitlements held along the Barwon and Darling systems is a high priority.	High
		Small Fresh (SF2) 700–6 500 ML/d for at least 14 days on the Barwon at Dangar's Bridge near Walgett in Oct–April. 1 500–15 000 ML/d for at least 14 days on the Darling at Bourke ideally in Oct–April.	5–10 years in 10 (overall 75% of years)	SF2 flows seek to support spawning opportunities for native fish - preferred temperature range for fish spawning, >20°C for most native fish and >18°C for Murray cod). Small freshes, particularly along the Darling River need to be supported by natural flow events. Active management of un-regulated environmental water entitlements held along the Barwon and Darling Rivers will assist in achieving these environmental water requirements. SF2 flows along the Barwon River have occurred 6–7 out of the last 10 years, while along the Darling River small fresh flows have occurred 5 out the last 10 years. Along the Darling River SF2 events have occurred only once (during the 2019–20 water year) over the last 3 water years. SF2 flows seek to provide spawning opportunities for native fish in most water years. Along the Barwon River, the frequency of SF2 events has been within the specified range. While the along the Darling River, SF2 events have occurred at the bottom end of specified frequency range – overall SF2 flows across the Barwon–Darling are a moderate priority.	Moderate	A moderate priority for CEW under all water resource availability scenarios. Protection of natural flow events through activation of unregulated environmental water entitlements held along the Barwon and Darling systems is a secondary priority.	Moderate

Key - potential watering in 2020-21

- High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)
- Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate - high water resource availability); or water demand likely to be met via other means
- Low priority for Commonwealth environmental watering (under high - very high water resource availability)
- Unable to provide Commonwealth water because of constraints or insufficient water

Key - environmental demands

- Critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
- High demand for water i.e. needed in that particular year
- Moderate demand for water i.e. water needed that particular year and/or next
- Low demand for water i.e. water generally not needed that particular year
- Very low demand for water i.e. water generally not needed that particular year or the following year

Note that demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime

3.7.5 Water delivery in 2020–21

Environmental water contained within unregulated flows is important in achieving ecological outcomes in the Barwon–Darling system. These natural flows (not delivered from dams) are particularly important for fish as they contain the natural cues and nutrients fish require for their lifecycles. Unregulated flows through the Barwon–Darling system can be enhanced using Commonwealth holdings both along the Barwon-Darling and within tributary systems.

The focus for Commonwealth environmental water use during the 2020-21 water year will be the protection and enhancement of unregulated flows along the Barwon–Darling to meet the following watering priorities:

- protection of dry spell breaking low flows along the Barwon-Darling to refresh refuge pools
- enhancing fresh pulses to maintain or improve water quality, enhance native fish condition, and support fish movement along the Barwon-Darling.

Low resource availability in regulated upstream storages will significantly constrain the ability for regulated releases to further enhance environmental outcomes in the Barwon–Darling for the 2020-21 watering year.

3.7.6 Monitoring and Lessons learned

(a) Monitoring

Operational monitoring is undertaken for all Commonwealth environmental watering actions and involves collecting on-ground data about environmental water delivery such as volumes delivered, impact on the river systems hydrograph, area of inundation and river levels. It can also include observations of environmental outcomes.

The Monitoring, Evaluation and Research (MER) Program (previously the Long-Term Intervention Monitoring Project 2014-2019) has the junction of the Darling and Warrego Rivers as a focus area. It aims to understand the environmental response from Commonwealth environmental watering with respect to the targeted objectives by carrying out monitoring of site condition over many years.

Information on the monitoring activities is available https://www.environment.gov.au/water/cewo/catchment/northern-unregulated-rivers/monitoring.

Monitoring information is also provided by state governments and other organisations throughout the Barwon-Darling system.

(b) Lessons learned

Outcomes from monitoring and lessons learned in previous years are a critical component for the effective and efficient use of Commonwealth water for the environment. These learnings are incorporated into the way environmental water is managed.

Key findings from monitoring undertaken across the Barwon–Darling system is summarised in Table 29.

Table 29: Key lessons learned in the Barwon–Darling system

Theme	Lesson learned
Native fish and other aquatic species	• Over the last several years, the University of New England (UNE) with NSW DPI – Fisheries have been monitoring native fish responses to flow as part of the CEWO's MER/LTIM Warrego-Darling selected area projects. • Preliminary results from monitoring undertaken in the 2019–20 water year have found juvenile golden perch in both the Warrego and Darling rivers, and several large Murray cod in the Darling River. Turtles were also common across most sites, with some larger specimens found at the confluence of the Warrego and Darling rivers.

Theme	Lesson learned
Connectivity	• Connectivity between the Barwon–Darling system and its tributaries can be enhanced using water for the environment. Connectivity is important for supporting native fish habitat and allowing the movement of native fish between rivers for spawning, dispersal and recruitment. • The Northern Connectivity Event and Northern Fish Flow delivered from the Gwydir and Border Rivers into the Barwon–Darling system during the 2017–18 and 2018–19 water years were critical actions. These events reconnected channel habitats and promoted fish movement. Protecting environmental water delivered in these events from extraction was essential for success. In the absence of appropriate protection, these watering actions would not have provided the same level of environmental outcomes. • Understanding the amount of water required to refill pools and wet up sections of river channel is a key element to estimating the environmental water requirements of the Barwon–Darling system during dry periods. • For the Northern Fish Flow, on a dry riverbed, the volume of water that passed Collarenebri was approximately 15 350 megalitres, of which 2 230 megalitres or about 15 per cent passed Brewarrina. This means about 5 000 megalitres per 100 river kilometres was used to fill pools and wet the dry river channel between Collarenebri and Brewarrina. • For the Northern Connectivity Event, where waterholes were full before the flow, the volume of water that passed Collarenebri was about 19 900 megalitres, of which approximately 15 700 megalitres or about 80 per cent passed Brewarrina. • This means that approximately three times as much water was used to refill pools and wet up sections of river channel between Collarenebri and Brewarrina during the Northern Fish Flow as compared to the Northern Connectivity Event.
Water Quality	• During summer months refuge pools located along the Barwon and Darling Rivers can stratify, reducing habitat quality. • The primary risk considered before the Northern Fish Flow (NFF) was the stratification of waterholes which may rapidly de-stratify when the NFF event arrived, resulting in deoxygenation of the waterholes and fish kills. Consultants (Ecological) were used to gather information about water quality risks. • Samples of dissolved oxygen were collected from refuge pools before, during and after the Northern Fish Flow. If dissolved oxygen falls below 4 mg/L then fish become stressed and may die. Before the Northern Fish Flow, dissolved oxygen concentrations at the Collarenebri Weir pool were found to be below 4 mg/L in places. Dissolved oxygen readings show that concentrations increased when the Northern Fish Flow passed. • The Northern Fish Flow was timed for the flows to reach the Barwon by late May and early June when temperature was significantly reduced, helping to reduce risks to water quality. • Commonwealth water for the environment delivered as part of natural flow events can improve water quality, nutrient cycling and provide access to in-channel habitats for other species. Additionally, Commonwealth water delivered as part of small flow events in the Barwon and Darling rivers may minimise algal productivity and the potential for blooms.

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3.8 Lower Darling River

3.8.1 Region overview

(a) River valley

Travelling approximately 700 km, the lower Darling River includes the river channel and adjacent billabongs and wetlands from the Menindee Lakes to the junction of the Murray and the Darling rivers at Wentworth (Figure 5). The catchment also includes the Great Darling Anabranch an ancestral path of the Darling River, including its lakes, floodplains and channel. The catchment is located on the semi-arid plains of south-western New South Wales.

The lower Darling valley relies on flows from rivers in southern Queensland and northern New South Wales, including ephemeral systems such as the Warrego, that flow into the Barwon-Darling River. Water is captured at the Menindee Lakes, a series of natural lakes that have been altered to improve water storage. Key storages include Menindee, Wetherell, Pamamaroo and Cawndilla. Water is released from lakes Menindee, Wetherell and Pamamaroo to provide flows into the Lower Darling River, while Lake Cawndilla can provide flows down the Great Darling Anabranch.

Of the 11 lakes that form the Menindee Lakes system, the two largest; lakes Menindee[1] and Cawndilla, as well as ~40 km of the lower Darling River and ~25 km of Great Darling Anabranch, are vested in the 44, 259 ha Kinchega National Park.

Land use in the catchment is largely based on pastoral industries, comprising mainly of sheep as well as rangeland goats and beef cattle production. There are also some small areas of lakebed cropping, and irrigated cropping, horticulture and viticulture. Tourism is vitally important to the local economy, with waterways and national parks supporting widespread recreational activities such as fishing and camping.

(b) Traditional Owners

The river and floodplains of the lower Darling River have long been important for sustenance and spirituality. In 2015, the Barkindji people received Native Title over much of the Darling River valley, extending from the South Australian border to Tilpa in the east, Wentworth in the south and north almost to Wanaaring. The lower Darling River flows through the traditional land of many other Aboriginal nations including the Maraura, Muthi Muthi, Nyeri Nyeri and Ngintait nations. The region contains many significant spiritual and cultural sites, including Lake Mungo in the Willandra Lakes Region and Menindee Lakes.

(c) Important sites and values

The Menindee Lakes are listed in the Directory of Important Wetlands in Australia as an exceptional example of the Ephemeral Deflation Basin Lakes (EDBL) wetland type within the bioregion. They provide important waterbird habitat with more than 30 species recorded on the main lakes, including threatened species such as freckled duck and migratory waders. It also provides critical habitat for native fish including golden perch and threatened species such as Murray cod, silver perch and freshwater catfish. The ephemeral nature of the large shallow lakes makes them very productive and support diverse food sources for fish at a range of life-stages. The Menindee Lakes also provide important refuge for wildlife during drought or adverse conditions.

[1] Half of Lake Menindee in Kinchega National Park

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) lists the Coolibah-Black Box community, Menindee nightshade, silver perch, Murray cod and 37 waterbirds as conservation dependent. Eighteen migratory bird species recorded at Menindee Lakes are listed under international agreements (JAMBA and CAMBA). The Lakes are listed by the Murray-Darling Basin Authority as key environmental assets and are used as hydrological indicator sites. The Menindee Lakes including Lakes Cawndilla and Menindee, lower Darling River and Great Darling Anabranch are listed by the *Fisheries Management Act NSW 1994* as an Endangered Ecological Community.

The Menindee Lakes and lower Darling River represents a large area of highly connected aquatic and riparian habitat which supports a diverse native fish community. The natural flow variability of the lower Darling River supports fish breeding (particularly by Murray cod and golden perch) and contributes to recruitment and dispersal of native fish throughout the Southern-connected Basin (Stuart and Sharpe 2020, Sharpe and Stuart 2018b, Zampatti and Leigh 2013). For example, up to 60 per cent of golden perch in the Edward-Wakool, Goulburn, lower and mid-Murray have been found to originate from recruitment events in the Menindee Lakes/lower Darling (Zampatti et al. 2015). This is the only EDBL floodplain lake system remaining in the entire Murray-Darling Basin that has been recorded to sustain mass golden perch recruitment events (Sharpe 2011, Sharpe and Stuart 2018a, Stuart and Sharpe 2020). The Menindee Lakes are considered among the last, functional EDBL golden perch nursery habitat remaining in the Murray-Darling Basin, hence listed in Directory of Important Wetlands in Australia (Sharpe 2011, Stuart and Sharpe 2020).

The Great Darling Anabranch is the ancestral path of the Darling and, together with its ephemeral lakes, is highly significant in terms of its contribution to terrestrial and biodiversity value through natural wetting and drying cycles and diverse habitats. The lakes also provide important refuge for wildlife during drought. For example, Lake Cawndilla is an important fish nursery habitat and previous environmental flows have demonstrated its significance as a dispersal pathway for native fish, such as golden perch.

Flows in the lower Darling also promote other environmental outcomes such as the transport of propagules and nutrients that drive and support food webs and fish communities in the Lower Murray. In recent decades, protracted cease-to-flow and low-flow conditions have significantly compromised these values, including fish deaths events in 2004, 2008, 2015-16 and more recently in 2018-19 (NSW DPI Fisheries 2020).

Both the lower Darling River and the Great Darling Anabranch are identified in the *Basin-wide environmental watering strategy* as wetlands of Basin significance for native fish and birds.

(d) Partners and stakeholder engagement

In the lower Darling, Commonwealth environmental water is managed in partnership with the NSW Department of Planning, Infrastructure and Environment- Environment, Energy and Science (DPIE-EES). It is coordinated with other sources of water, including environmental water available through The Living Murray program, and operational flows managed by WaterNSW and/or the Murray-Darling Basin Authority (depending on who has operational control of Menindee Lakes at the time in accordance with the *Murray-Darling Basin Agreement*).

In addition to the above agencies, advice is regularly received from the NSW Department of Primary Industries (DPI) – Fisheries, the Lower Darling Technical Advisory Group and the Lower Darling Regional Operations Stakeholder Consultation Committee (LD ROSCCo), who provide advice to water managers to address stakeholder concerns and share river operation information. The Commonwealth Environmental Water Office (CEWO) also seeks guidance from representatives of the Barkindji Traditional Owners, Murray Lower Darling Rivers Indigenous Nations (MLDRIN), recreational fishers, landholders and irrigators.

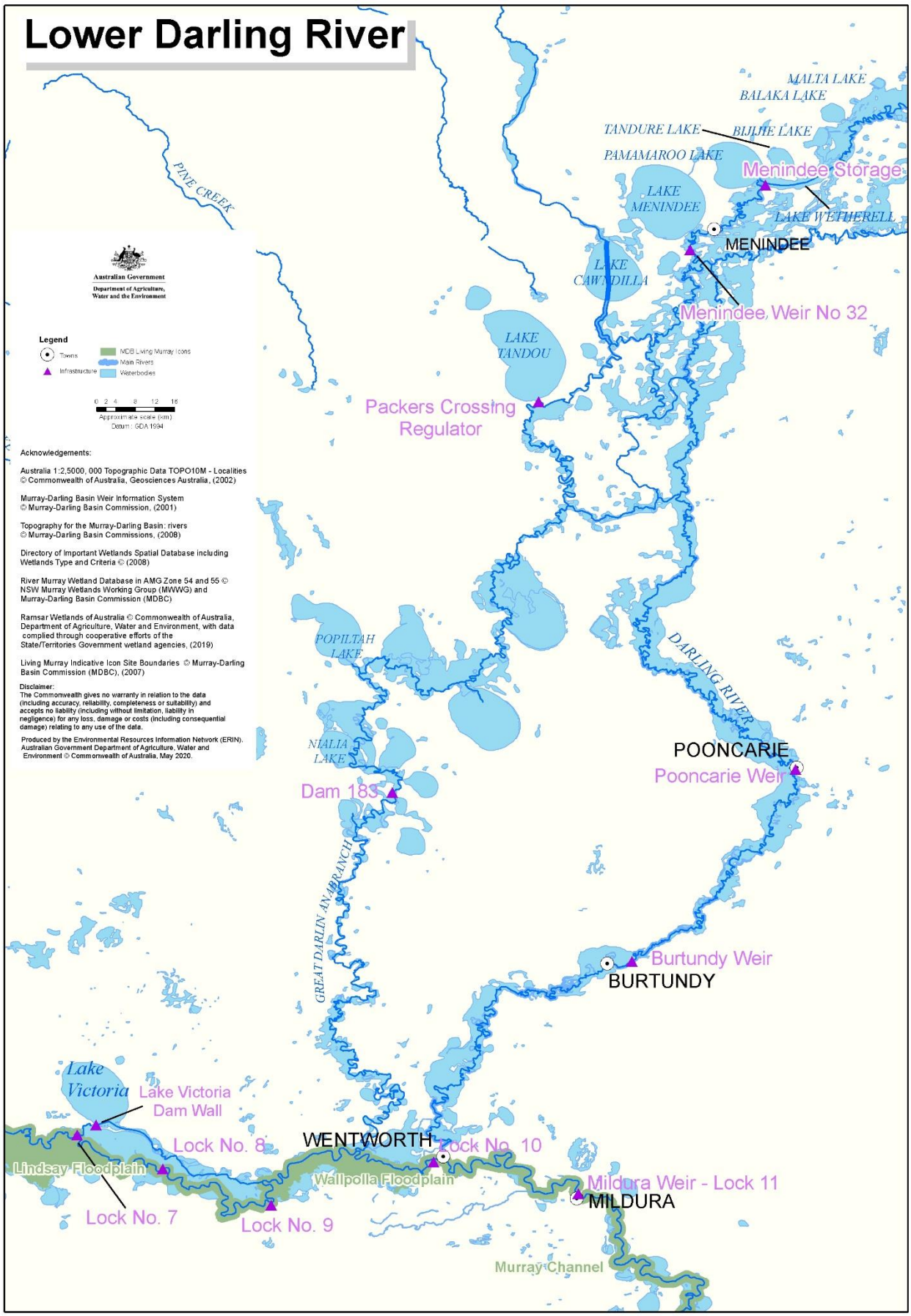

Figure 12: Map of the lower Darling River

3.8.2 Environmental objectives

Based on long-term environmental objectives in the Basin Plan, draft state long-term watering plans, site management plans (including Ramsar site ecological character descriptions), and best available knowledge, the following objectives have been developed for environmental water planning in the lower Darling River region.

The objectives targeted in a particular year may vary depending on available water, catchment conditions, operational feasibility, and demand for environmental water. These objectives will continue to be revised as part of the Commonwealth Environmental Water Office's commitment to adaptive management.

Vegetation: Maintain riparian and in-channel vegetation condition. Increase periods of growth for non-woody vegetation communities that closely fringe or occur within river channels.

Waterbirds: Provide habitat and food sources to support waterbird survival and recruitment and maintain condition and current species diversity.

Native fish: Provide flows to support habitat and food resources and promote increased movement, recruitment and survival/condition of native fish.

Invertebrates: Provide habitat to support increased microinvertebrate and macroinvertebrate survival, diversity, abundance and condition.

Other vertebrates: Provide habitat to support survival, maintain condition and provide recruitment opportunities for frogs and turtles.

Connectivity: Maintain longitudinal connectivity along the lower Darling and with the Murray river, to support important environmental functions (see next objective).

Processes/water quality/resilience: Increase primary productivity, nutrient and carbon cycling, biotic dispersal and movement. Maintain suitable water quality for native plants and animals and provide refuge from adverse water quality events (e.g. hypoxic blackwater in the Murray). Maintain drought refuge habitat and maintenance/condition of native biota (e.g. fish and other aquatic fauna).

3.8.3 First Nations environmental objectives

Advice on environmental water objectives in the Lower Darling valley has been provided by the Murray Lower Darling Rivers Indigenous Nations (MLDRIN) through the First Nations Environmental Water Guidance project. Table **30** includes just some of the common objectives for the Lower Darling catchment, selected as they were raised by 2 or more participating Nations for the region. It is important to note these objectives are not fully representative nor do they represent the detail, depth and complexity of Nations' localised water-related objectives.

Some of these objectives sit outside the scope of water for the environment to influence, while for others, the link between water for the environment and the site or issues is not well understood. Environmental flows will aim to contribute to identified objectives, where possible. The Commonwealth Environmental Water Holder (CEWH) is committed to continuing to strengthen engagement with all Southern Basin First Nations to support those Nations to articulate objectives for water management.

Whilst not all Traditional Owner groups participated in the project, the importance of the Baaka (Darling River) was not lost. Many participating Nations noted the Baaka as a priority for watering, despite the fact that this river is not part of their Traditional Country. This highlights the interconnectedness of cultural outcomes and the importance of a whole-of-system perspective. First Nations understand that cultural responsibility for sustaining river health, and the outcomes of custodianship, extend beyond the boundaries of one Nation's Country. Declining river health and low flows in the Baaka affects outcomes across the whole Southern Basin. It should be noted that the spelling of Baaka is being consulted on by the NSW Geographical Names Board for dual naming, and there are other spellings and pronunciations. Through place naming, communities have the opportunity to unlock past stories, preserve traditions, reawaken language and

provide a sense of belonging and identity. Barkindji were not provided full opportunity to input into the plan for 2020-21, and the CEWO aims to do better in working with Barkindji in our planning for future years.

Table 30: First Nations environmental water objectives for the Lower Darling for 2020-21 (MLDRIN, 2020)

Waterways and Places in Need of watering
Wetlands, Billabongs and Floodplains, Creeks, Major rivers, Other places, parks, forests, islands, Baaka.
River Flows and Connectivity
Improve water quality, Restore flows in degraded rivers, Improve timing and seasonality of flows, Improve tributary flows, Remove barriers and constraints.
Vegetation
Grasses, Lignum, Old Man Weed, Black Box, Reeds and Rushes.
Fish
Catfish, Murray Cod, Yellowbelly.
Waterbirds
Pelican, Birds, Swan, Ducks, Sea eagle[i].
Other species
Frogs, Shrimp, Turtles, Mussels, Platypus, Yabbies, Emu[i], Kangaroo[i].

[i] Water for the environment targeting other environmental outcomes may influence this species or objective

3.8.4 Recent conditions and seasonal outlook

(a) Recent conditions and environmental water use

For the past 20 years, the lower Darling River has experienced increased frequency and duration of low-flow (most recently in 2014-15, 2018) or cease-to-flow (most recently 2015-16, 2019-20) conditions (DPI Fisheries 2020). The exception being between September 2016 to the start of December 2017, when environmental and consumptive flows provided welcome relief to both the lower Darling and the Great Darling Anabranch.

In the lower Darling River, environmental flows in spring of 2016 and 2017 supported Murray cod spawning and recruitment. A population census in winter 2018 found that the resulting cohorts comprised 28 per cent of the overall population structure, with 14 per cent from each cohort (Sharpe and Stuart 2018a). Subsequent water releases from the Menindee Lakes and down the Lower Darling in 2017 to meet consumptive needs were 'shaped' by ecologists and environmental water managers in collaboration with the river operators to promote the spawning and dispersal of other large-bodied native fish species such as golden perch and silver perch.

In the Great Darling Anabranch, environmental water releases contributed to positive responses in river red gum and black box vegetation communities fringing the anabranch, and facilitated the successful dispersal of native fish, particularly golden perch juveniles, from Lake Cawndilla, down the anabranch and ultimately to the River Murray (Sharpe and Stuart 2018a).

Details of these and other Commonwealth environmental water actions in the lower Darling River catchment are available at: https://www.environment.gov.au/water/cewo/catchment/lower-murray-darling/history.

The return of dry conditions in early 2018 had catastrophic impacts on the local ecology. Mass deaths of millions of fish occurred in the Darling River adjacent to the town of Menindee in in December 2018 and January 2019. As the lower Darling contracted to disconnected pools through 2019, many thousands more fish perished. Small remnant fish populations were supported through intervention such as relocation to more secure waters and deployment of mechanical aerators at 10 locations in the Lower Darling and Menindee Lakes region.

Following rainfall across the northern Basin in early 2020, water again flowed to the Menindee Lakes. This provided an opportunity to 'restart' the lower Darling River, with a pulsed flow to reconnect with the River Murray in March/April 2020. This flow, along with subsequent provision of baseflows, has provided relief and improved conditions for remnant fish populations. As of 15 June 2020, the Menindee Lakes system collectively held approximately 27 per cent of active capacity. For the latest storage and release details for the lower Darling valley, visit: https://www.waternsw.com.au/supply/regional-nsw/availability.

(b) Seasonal outlook

According to the Bureau of Meteorology outlook (BoM 2020) there is an 75-80 per cent chance of above median rainfall in the lower Darling River valley between July and September 2020. Across the northern catchments that provide inflows to the lower Darling system, there is a 65 to 80 percent chance of above median rainfall - noting that inflows to Menindee Lakes can vary within and between seasons.

While this forecast indicates that the severe dry conditions are somewhat eased, several months of above average rainfall are needed to see a recovery from the current long-term drought. Additionally, maximum temperatures are likely to remain average over the coming months.

(c) Water availability

The volume of Commonwealth environmental water to be carried over in the lower Darling for use in 2020-21 is approximately 10.8 gigalitres.

Water resource availability remains low, with the potential for any improvement reliant on further inflows to the Menindee Lakes system from the northern Basin. As at 1 July 2020, full (100 per cent) allocation has been provided for high security entitlements and 30 per cent allocation has been provided for general security entitlements (DPIE-Water 2020), which adds an additional 10.7 gigalitres available against the Commonwealth's entitlements for use in 2020-21. A total of 21.5 gigalitres is available as at 1 July 2020.

(d) Environmental demands

The environmental water demands for assets in the lower Darling River valley in 2020-21 are represented in Table 31. Note that the capacity to contribute to some of these environmental demands is contingent on a substantial improvement in water availability in the catchment.

Table 31: Environmental demands, priority for watering in 2020–21 and outlook for coming year in the lower Darling River valley.

Environmental assets	Indicative demand (for <u>all sources of water</u> in the system)[1]		Watering history	2020–21		Implications for future demands
	Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Menindee Lakes[1] · Native fish: survival, dispersal & recruitment of flow pulse specialists in Lakes and dispersal downstream · Vegetation: non-woody wetland, lignum, fringing river red gum, low-lying black box and coolibah · Waterbirds: maintain habitat, potential breeding · Ecosystems: refuge, productivity	**Lake Menindee**: 60 GL (1.5 m, 56 m AHD) **Lake Cawndilla**: 50 GL (1.5 m, 53.8 m AHD) Timing: anytime of year, filling to be triggered by upstream flows in the Barwon-Darling River system Min duration: 3-5 months Max duration: 3 years	6-8 years in 10 (Menindee: 2 years, very important to have a refill event before it dries again) (Cawndilla: 3 years)	The lakes last refilled in 2016-17 (total storage ~1 730 GL). Forecast storage in 2020 is ~580 GL (i.e. < 35%).	Critical	Lake levels primarily rely on upstream inflows and larger natural events. Commonwealth environmental water deliveries will consider environmental needs in both the Lakes and lower Darling River system and will look to where the most effective use of available environmental water.	Critical
	Lake Menindee: 116 GL (1.8 m, 56.5 m AHD) **Lake Cawndilla**: 84 GL (2.2 m, 54.5 m AHD) Timing: anytime of year, filling to be triggered by upstream flows in the Barwon-Darling River system Min duration: 3-5 months Max duration: 1-2 years	3-5 years in 10 (4 years)		Moderate		Moderate
	Lake Menindee: 57.5 m AHD **Lake Cawndilla**: 57.5 m AHD Timing: anytime of year, filling to be triggered by upstream flows in the Barwon-Darling River system Min duration: 3-5 months Max duration: 1 year	1.5 year in 10 (8 years)		Moderate		Moderate
Lower Darling River[1] · Native fish: spawning, nesting and recruitment (riverine specialists, generalists). · Ecosystem functions: longitudinal connectivity, refuge habitat, small-scale productivity	Elevated baseflows above minimum releases through to River Murray for water quality and fish habitat requirements (400 ML/d at Weir 32).	Continuous (if limited water, focus on baseflows during spring and summer).	Very low and cease-to-flow conditions in 2014-15 and 2015-16. Small to moderate spring pulse was achieved in 2016-17 and, to a lesser extent, in 2017-18. Cease-to-flow conditions commenced in 2018–19 and persisted for most of 2019-20. Resumption of flows in late 2020 peaking at 3 500 ML for a few weeks in March and April 2020 with a return to baseflows of at least 200-400 ML/day expected for at least 12 months.	Critical	A high priority for Commonwealth environmental watering 2020-21 (likely to receive water even under low water resource availability)	High
	Small to moderate river pulse (up to 800 ML/d at Weir 32 in spring and summer).	1-2 in 5 years (max interval unknown)		Critical	A high priority for Commonwealth environmental watering 2020-21 subject to water resource availability	
	Small fresh (up to 2 000 ML/d at Weir 32 for ~60 days in summer) for Murray cod breeding.	2-4 years in 10 (5 years)		High	Option to be considered under a moderate to high water resource availability	
Floodrunners and fringing lakes[1] · Native fish: spawning (flow pulse specialists), dispersal (all species), · Waterbirds: foraging habitat, support natural breeding events · Ecosystem functions: lateral connectivity, dispersal of biota, channel maintenance, productivity, nutrient/carbon exchange · Other: frog habitat and breeding	10 000 – 12 000 ML/d at Weir 32, ideally August-October or January-April (or anytime) for a minimum of 14 days (to achieve 2-6 months of wetland inundation)	5-8 years in 10* (2 years) * annual event for 2-3 consecutive years for recovery of wetland vegetation	Small overbank flow in 2011-12.	Moderate	Reliant on large, unregulated flows.	Moderate

Environmental assets	Indicative demand (for all sources of water in the system)[1]		Watering history	2020–21		Implications for future demands
	Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Great Darling Anabranch[1] · Native fish: recruitment and dispersal of flow pulse specialists · Native vegetation: non-woody, fringing river red gum, black box, lignum · Waterbirds: habitat and potential breeding · Ecosystem functions: refuge; productivity	> 800 ML/day (800-2 000 ML/day) from Menindee Lakes for minimum 21 days.	2-3 in 10 years (4 years)	Environmental water in-channel flows in spring 2013 to reconnect residual pools, supporting recovery of riverine and wetland communities through dispersal opportunities and improving riparian vegetation. A significant e-water action occurred in summer of 2017, allowing for dispersal of large bodied native fish and improved water quality and vegetation condition. No flows have been provided down the Anabranch since then.	Moderate	Lower priority for Commonwealth environmental water. Lower Darling is a higher priority, particularly given a very low to low resource availability forecast for 2020-21.	Moderate

References:

1. Information on flow/volume and required frequency of indicative demands drawn from the draft Murray-Lower Darling Long Term Water Plan (DPIE-Water 2019), as appropriate.

Key - potential watering in 2020-21

- High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)
- Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate - high water resource availability); or water demand likely to be met via other means
- Low priority for Commonwealth environmental watering (under high - very high water resource availability)
- Unable to provide Commonwealth water because of constraints or insufficient water

Key - environmental demands

- Critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
- High demand for water i.e. needed in that particular year
- Moderate demand for water i.e. water needed that particular year and/or next
- Low demand for water i.e. water generally not needed that particular year
- Very low demand for water i.e. water generally not needed that particular year or the following year

Note that demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime

3.8.5 Water delivery in 2020–21

Based on the demand for water for the environment, water availability (supply), and catchment conditions, the overall purpose for managing Commonwealth water for the environment in the lower Darling River valley in 2020-21 is to avoid further damage or decline to environmental assets and support recovery of the system if water availability improves.

The highest priority will be to provide elevated baseflows in spring to support Murray cod breeding and recovery of a variety of other aquatic biota (e.g. mussels and snails). The magnitude of the flow will depend on water availability. A small spring fresh of up to 2 000 ML/day to target both Murray cod and golden perch recruitment may be considered if water availability significantly improves.

Golden perch spawning has also been recorded upstream in response to flow in the Barwon-Darling and its tributaries. Young fish have been recorded dispersing with these flows to the Menindee Lakes nursery habitat (Sharpe and Stuart, 2018a) and delivery of environmental water will provide an opportunity for some of these to ultimately disperse further into the lower Darling and potentially into the River Murray.

Deliveries to the Great Darling Anabranch will only be considered if water availability significantly improves and there is sufficient inflow into Lake Cawndilla.

Environmental flows will be designed with native fish ecologists and in close consultation with the local community, including First Nations people. Consideration will also be given on water levels in the Menindee Lakes and its associated environmental values.

3.8.6 Monitoring and Lessons learned

(a) Monitoring

In the lower Darling River, monitoring is primarily undertaken by NSW agencies including NSW DPIE (vegetation, waterbirds and frogs), NSW DPI – Fisheries (native fish), and WaterNSW (hydrology and flow delivery data).

Several short-term intervention monitoring projects were conducted to assess the success of environmental flows in 2016-17 and 2017-18. The projects both demonstrated the success of the flows in achieving the desired outcome and informing real-time adaptive management of the flows.

Technical reports from short term monitoring projects in the lower Darling can be found at:

https://www.environment.gov.au/water/cewo/publications/assessment-murray-cod-recruitment-lower-darling-river-flows-2016-18 (Sharpe and Stuart 2018a).

https://www.environment.gov.au/water/cewo/publications/environmental-flows-darling-river-fish-2016-17 (Sharpe and Stuart 2018b).

https://www.environment.gov.au/water/cewo/publications/environmental-flows-support-murray-cod-spawning-lower-darling-river-2017 (Sharpe 2019).

A monitoring program drafted to assess environmental flows delivered in 2020-21 will be scoped early in the water year.

(b) Lessons learned

Outcomes from monitoring in previous years are critical in our commitment to the effective and efficient use of Commonwealth water for the environment.

Monitoring in the lower Darling River (2016-17 and 2017-18) and the Great Darling Anabranch (2016-17) showed environmental flows were successful in supporting tangible and significant multi-species outcomes for native fish. Where possible, maintaining the function of the Menindee Lakes and lower Darling River is critical for Murray cod spawning and recruitment, the dispersal and recruitment of golden perch from their nursery grounds in the Menindee Lakes, and spawning of golden perch and the nationally threatened silver perch in the lower Darling River channel (Sharpe and Stuart 2018a and b, Stuart and Sharpe 2020).

3.8.7 Bibliography

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3.9 Lachlan River

3.9.1 Region overview

(a) The Lachlan Valley

The Lachlan River (Figure 5) is the fourth longest river in Australia at 1 448 kilometres with a catchment of around 90 000 square kilometres. Flow attenuation in the system is high due to the low gradient of the system and it can take 90 days for a flow event from Wyangala Dam to reach the end of the river system at The Great Cumbung (Barma Water Resources 2011). Many anabranches and distributary creeks in the Lachlan terminate in wetlands. Not all environmental water is sourced from dam releases – unregulated tributary inflows can be ordered and accounted for as environmental water and allowed to reach assets by bypassing regulating storages. The harvesting of water for consumptive purposes has significantly modified the flow of the Lachlan River (Higgisson et al, 2019).

(b) Traditional Owners

The Lachlan River flows through the lands of the Nari Nari, Ngiyampaa, Wiradjuri and Yita Yita Nations, and the Commonwealth Environvmental Water Office (CEWO) respectfully acknowledge these people, their Elders past, present and future, as the Traditional Owners of the land on which this chapter is focused.

(c) Important sites and values

The draft Long Term Water Plan for the Lachlan Catchment (OEH 2018a and b) provides greater detail on the environmental assets found in the Lachlan Catchment and their watering requirements. The Commonwealth works with NSW agencies to deliver flows to priority sites that are identified from year to year and as conditions change during the year. During 2019-20 sites such as Booberoi Creek, Yarrabandai Lagoon, the river channel, Brewster Weir pool and a number of lower Lachlan wetlands, including the core reed beds of The Great Cumbung (Figure 14) were watered to create a mosaic of drought refuge sites throughout the Lachlan riverine system.

(d) Stakeholder engagement

The CEWO continues to work with NSW Department of Planning, Industry and Environment (NSW DPIE-ESS) in reviewing, coordinating and managing environmental watering actions in the Lachlan Catchment. This work is done in conjunction with the CEWO's Monitoring, Evaluating and Research (MER) Program provider, the University of Canberra, the river operator WaterNSW and the Lachlan Environmental Water Advisory Group (EWAG). This work is further complemented by regular landholder visits and discussion.

Legend

Zone A Zone B

0 35 70
Kilometers

Planning Units

1. Belubula River
2. Upper Lachlan River
3. Lachlan River - Forbes to Condobolin
4. Upper and Mid Lachlan floodplains
5. Mid Lachlan anabranches
6. Lachlan River - Condobolin to Lake Cargelligo
7. Booberoi Creek
8. Lachlan River - Lake Cargelligo to Willandra Weir
9. Lake Cargelligo
10. Lake Brewster
11. Willandra Creek
12. Merrowie Creek
13. Merrimajeel Creek
14. Lower Lachlan watercourse
15. Muggabah Creek
16. Western Lachlan watercourse
17. Abercrombie River
18. Crookwell River
19. Lachlan River above Reids Flat
20. Belubula River above Carcoar
21. Belubula River Tributaries
22. Waugoola Creek
23. Boorowa River
24. Crowther Creek
25. Burrangong Creek
26. Tyagong Creek
27. Goonigal & Kangarooby Creeks
28. Mandagery Creek
29. Goobang & Billabong Creeks
30. Lake Forbes & Back Yamma Creek
31. Ooma Creek & Tributaries
32. Western Bland Creek
33. Bogandillon & Manna Creeks
34. Humbug Creek
35. Mid Lachlan Unregulated
36. Gunningbland & Yarrabandai
37. Mount Hope Area
38. Naradhan Area
39. Unregulated Effluent Creeks

Figure 13: The Lachlan valley showing the division of planning units into Zone A and B as used in the draft Long Term Water Plan for the Lachlan Catchment (NSW OEH 2018a)

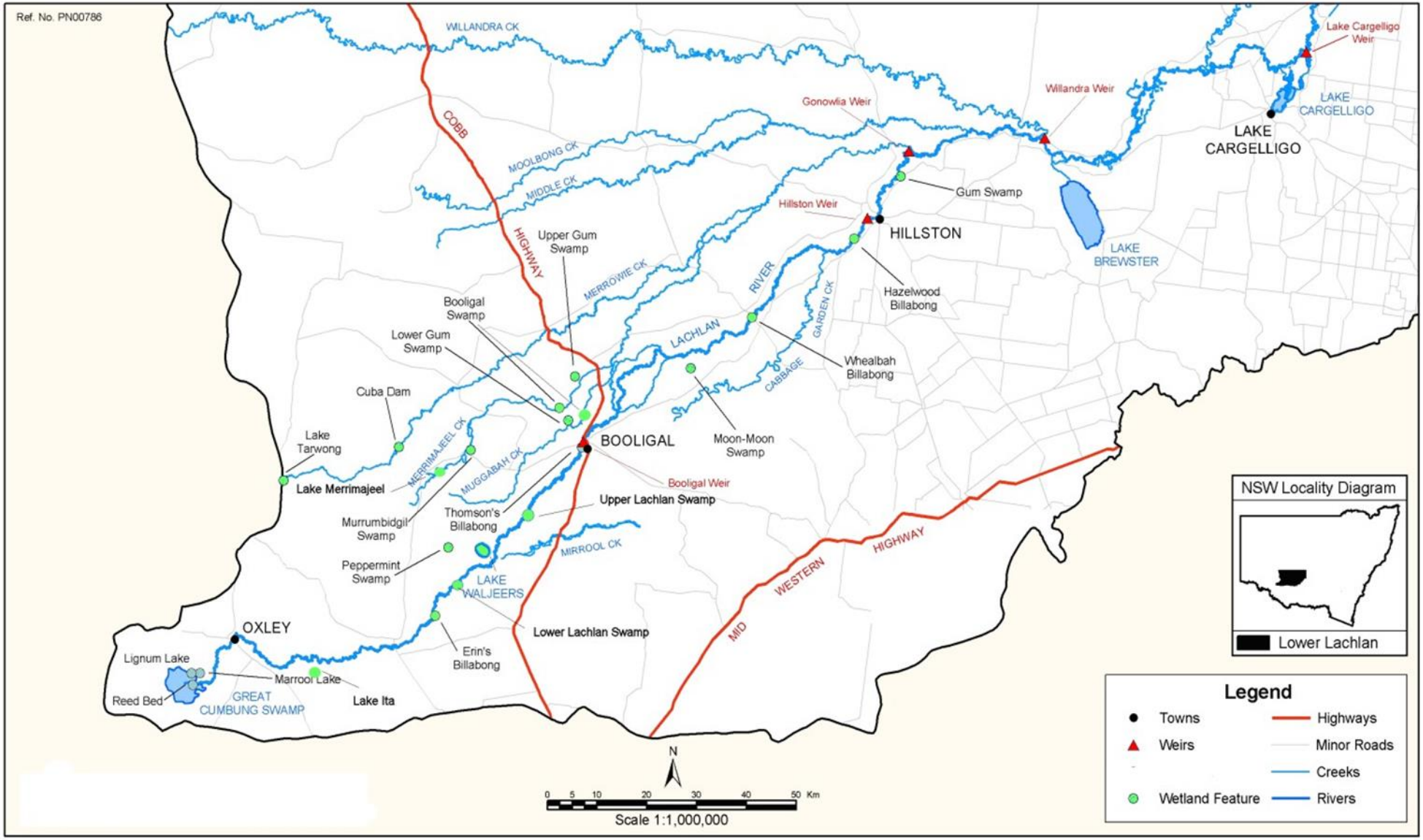

Figure 14: Map of the Lower Lachlan Catchment (Driver et al 2003)

3.9.2 Environmental objectives

Table 32 sets out the objectives for environmental watering in the Lachlan River catchment, based on long-term environmental objectives in the Basin Plan, draft state Long-Term Water Plans (LTWP), site management plans, and best available knowledge.

The objectives that are targeted in a particular year may vary, depending on available water, catchment conditions, operational feasibility, and demand for environmental water. These objectives will continue to be revised as part of the CEWO's commitment to adaptive management.

Table 32: Summary of objectives for environmental watering in the Lachlan River catchment.

Basin-Wide Matters	In-Channel Assets	Off-Channel Assets
Vegetation	1. Maintain riparian and in channel vegetation condition. 2. Increase periods of growth for nonwoody vegetation communities that closely fringe or occur within river corridors.	3. Maintain the current extent of floodplain vegetation near river channels and on low-lying areas of the floodplain. 4. Maintain the condition of black box, river red gum and lignum shrublands. 5. Maintain and improve condition of wetland vegetation.
Waterbirds	6. Provide habitat and food sources to support waterbird survival and recruitment and maintain condition and current species diversity.	7. Support naturally triggered bird breeding events that may be in danger of failing due to falling water levels. 8. Provide habitat and food sources for migratory birds
Native Fish	9. Provide flows to support habitat and food sources and promote increased movement, recruitment and survival/condition of native fish.	10. Provide flow cues to promote increased movement, recruitment and survival/condition of native fish (particularly for floodplain specialists).
Invertebrates	11. Provide habitat to support increased invertebrate survival, diversity, abundance and condition.	
Other vertebrates	12. Provide habitat to support survival, maintain condition and provide recruitment opportunities for rakali (native water rat), frogs and turtles.	
Connectivity	13. Maintain longitudinal & lateral connectivity through contributing to an increase in the frequency of freshes.	14. Maintain latitudinal connectivity (within constraints) to wetlands, floodplains, creeks and anabranches by contributing an increase in the frequency of lowland floodplain flows.
Process **Water quality** **Resilience**	15. Increase primary productivity, nutrient and carbon cycling, biotic dispersal and movement. Increase transport of organic matter and nutrients downstream. 16. Maintain water quality and provide refuge habitat from adverse water quality events. 17. Provide drought refuge habitat and maintenance/condition of native biota.	

3.9.3 First Nations Environmental Objectives

Advice on environmental water objectives in the Lachlan Catchment has been provided by the Murray Lower Darling Rivers Indigenous Nations (MLDRIN) and the Northern Basin Aboriginal Nations (NBAN) through the First Nations Environmental Water Guidance project. Table 33 includes just some of the common objectives for the Lachlan Catchment, provided by MLDRIN, selected as they were raised by two or more participating Nations for the region. It is important to note these objectives do not represent the detail, depth and complexity of Nations' localised water-related objectives. Table 34 shows the First Nations environmental water objectives provided by NBAN for the Lachlan Catchment.

Some of these objectives sit outside the scope of water for the environment to influence, while for others, the link between water for the environment and the site or issues is not well understood. Environmental flows will aim to contribute to identified objectives, where possible. The Commonwealth Environmental Water Holder (CEWH) is committed to continuing to strengthen engagement with all Southern Basin First Nations to support those Nations to articulate objectives for water management.

Eel-tailed Catfish

"The eel-tailed catfish on Ngiyampaa Country, can only be found in Booberoi Creek. We grew up fishing and eating them. When we were young, we'd wade through the creek to find the catfish breeding sites, amongst the bulrush and river weed. The catfish(es) would thrash around and cut up our legs, trying to protect their nest and their eggs when we got too close. Once we found the nests, we would protect it, by making sure no one would go into that area of the creek. Later on, we would then put in a line further downstream, and fish for them when they have bred up. They were good tucker. We would protect the breeding of the catfish, so we can always have catfish to eat. With the drought, there's only a few little ones left, but they will come back when there is water." – Peter Harris, Ngiyampaa Nation

Figure 9. Happy times at Murrin Bridge when water was plenty and healthy (1950s).

Figure 15: Eel-tailed Catfish story (NBAN, 2020)

Table 33: First Nations environmental objectives for the Lachlan Catchment 2020-21 provided by MLDRIN (MLDRIN 2020)

Waterways and Places in Need of watering
Billabongs (general), All on Country, Murrumbidgee, Lachlan
River Flows and Connectivity
Improve water quality, Improve timing and seasonality of flows, Improve flows and quantity (rivers and general), Remove barriers and constraints.
Vegetation
Lignum, River Red Gum.
Fish
Murray Cod, Yellowbelly (Golden Perch, Callop), Catfish, Silver perch .
Waterbirds
Ducks (general), Pelican, Swan (general)
Other species
Murray Cray

Table 34: First Nations environmental objectives for the Lachlan system for 2020-21 provided by NBAN (NBAN Ltd 2020)

River flows and Connectivity
Priority sites: Lachlan River needs to flow at all times, Booberoi Creek.
Native Vegetation
Indicator species: River Red Gum, Black Box[i], Bulrush, Ribbon Weed, Pinrush.
Native Birds
Indicator species: Black Duck, Emu[i], White Cockatoo[i], Black Swan, Kookaburra[i].
Native Animals
Indicator species: Water Rats, Turtles, Yellowbelly, Catfish, Frogs.
Connecting with Country
Flows from the Lachlan River at all times, to flow into Booberoi Creek and Willandra Creek for Ngiyampaa Wangaaypuwan People to Connect with Country at the waterways

[i] Water for the environment targeting other environmental outcomes may influence this species or objective

3.9.4 Recent conditions and seasonal outlook

(a) Recent conditions and environmental water use

As noted by Dyer et al. (2015-2019) and Higgisson et al. (2019) the Lachlan Catchment can experience highly variable rainfall and related flow conditions. In 2016-17, the catchment experienced widescale flooding due to heavy rainfall. This was beneficial to wetland and floodplain vegetation and waterbird populations. However, the widescale flooding also caused a significant hypoxic blackwater event that negatively impacted on large bodied native fish like Murray cod. During 2017-18 to 2018-19, the use of Commonwealth environmental water in the Lachlan River system included a focus on the recovery of Murray cod populations.

Drought conditions deepened in many NSW catchments during 2018-19. By the start of 2019-20 the Lachlan Catchment was being managed under Stage 3 of the NSW Extreme Event Policy (NSW Department of Industry 2018). The use of Commonwealth environmental water in the Lachlan River during 2019-20 focused on building resilience and maintaining drought refugia at key sites across the catchment.

Details of previous Commonwealth environmental use in the Lachlan catchment are available at: http://www.environment.gov.au/water/cewo/catchment/lachlan

(b) Seasonal outlook

NSW Department of Planning, Industry and Environment (2020a) notes that the Lachlan catchment will continue to be managed under the NSW Extreme Event Policy for the foreseeable future and may escalate from Stage 3 to Stage 4 (extreme drought) if there is no significant improvement in the system. The Bureau of Meteorology *(*2020) suggests there is largely a 70-75 per cent chance of above median rainfall across the Lachlan River catchment between July and September 2020.While this forecast indicates that the severe dry conditions may ease, as of May 2020, a total of 315 gigalitres of inflows into storages in the Lachlan catchment would be required before new general security allocations could be made NSW Department of Planning, Industry and Environment, (2020a).

(c) Water availability

On 1 July 2020, the NSW Department of Planning, Industry and Environment (2020b) announced 70 per cent allocation against high security entitlements and no new allocation to general security allocations. The restriction of accessing 43 per cent of the 1 July 2019 general account balance remains and a further 50 per cent restriction has been applied for 2020-21 on the active general security account balance as at 30 June 2020 (NSW DPIE 2020b). Based on this, as at 1 July 2020 the CEWO has around 650 megalitres of water, with 16 gigalitres still held in the WaterNSW Drought Account.

The CEWO will continue to monitor catchment conditions, inflows and changes to water availability and will undertake watering actions should additional water become available (either through the release of water from the Drought Account or increased water allocations following large rain events).

(d) Environmental demands

Environmental demands, and need to avoid further damage to key assets, remain high as a result of drought conditions across the catchment. The environmental water demands for assets in the Lachlan River catchment in 2020-21 are represented in Table 35. Note that the capacity to contribute to these environmental demands is contingent on a substantial improvement in water availability in the catchment.

Table 35: Environmental demands, priority for watering in 2020–21 and outlook for coming year in the Lachlan River catchment.

Environmental assets and Long Term Water Plan unit (PU) reference number (see Figure 1 and more detailed description at bottom of table)	Indicative demand (for all sources of water in the system)		Watering history	2020–21		Implications for future demands
	Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Lachlan River (PU 2, 3, 6, 8, 14, 16) Protect tributary inflows (natural trigger) or deliver upon environmental triggers (e.g. timing or temperature) being reached, to target native fish, in-stream productivity, native vegetation and connectivity along the river channel	>600 ML/d, based on conceptual hydrographs (Ellis et al. 2016), other flow objectives and available water allocations.	5–10 years in 10 (Annual for the maintenance of drought refuge)	From 2018-2020 a pulse and minimum flow period in spring has been provided	High	High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)	High
Yarrabandai Lagoon (formerly known as Burrawang West, PU 3) (see note 1) Provide off-channel drouth refuge habitat for native frogs and waterbirds	400-800 ML in total	5–10 years in 10 (Annual for the maintenance of drought refuge)	Previously watered by NSW. Watered since 2018-19 and received high natural flows in winter 2020.	Moderate	Priority for Commonwealth environmental watering (likely to receive water even under low water resource availability), subject to site assessment	Moderate
Brewster Weir Pool (PU 8) Help maintain weir pool height to maintain olive perchlet habitat	Up to 5 GL dependant on the operational level and management requirements of the weir	5–10 years in 10 (Annual for the maintenance of drought refuge)	Watered since 2017-18 and received variable flows in May 2020 as operational water was moved into Lake Brewster	High	High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)	High
Mid-Lachlan anabranches (PU 5) Provide lateral connectivity to anabranch systems, maintain native vegetation and native fish outcomes	Nerathong and Wallamundry Creek >30ML/day, Wallaroi Creek >70ML/day for 10 days min annually, Oct to April	Annual	These systems receive water from annual consumptive demand and replenishment flows.	Low	Option to be considered under moderate- high water resource availability.	Low
Booberoi Creek (PU 7) Maintain populations of native fish, aquatic plants and connectivity to the Lachlan River.	Up to 100 ML/day at Booberoi Offtake with return flows at Booberoi Creek return monitored.	5–10 years in 10. (Annual for the maintenance of drought refuge)	Watered every year since 2017.	High	High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)	High
Lake Brewster (PU 10) Habitat for breeding pelican colony. Wetland vegetation support water quality outcomes	Flows are managed where possible to avoid inundation of nests if pelican breeding has occurred	As required	Watered in 2016 and 2017 for pelican and aquatic vegetation outcomes. Operational inflows into the lake commenced in May 2020.	Contingency	Option to be considered under all water resource availabilities if breeding event is triggered, however more likely to occur under moderate or high water resource availability	Contingency
Willandra Creek (PU 11) Lateral connectivity to major distributary and native vegetation	>70 ML/d	5–10 years in 10.	Distributary receives stock and domestic flows. Demand is usually met annual by operational flows.	Low	A low priority for environmental water. Asset receives more water under regulated conditions than would have occurred naturally	Low
Merrowie Creek (PU 12) Lateral connectivity to major distributaries, foraging and nesting habitat for waterbirds	>160 ML/d for 30 days	5-7 years in 10	This demand was partial met in three of the previous four years, including delivery to Murphy's Lake	Moderate	Option to be considered under moderate- high water resource availability.	Moderate
	>150 ML/d for 45 days	5-7 years in 10	Wetland inundation targets last achieved in 2016 flood.	Moderate	Option to be considered under moderate-high water resource availability.	Moderate

Environmental assets and Long Term Water Plan unit (PU) reference number (see Figure 1 and more detailed description at bottom of table)	Indicative demand (for all sources of water in the system)		Watering history	2020–21		Implications for future demands
	Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Merrimajeel Creek (PU 13) Provide lateral connectivity to major distributaries, foraging and nesting habitat for waterbirds and maintain wetland vegetation	Small wetland inundation: >300-650 ML/d for 30 days minimum	7-8 years in 10	Wetland inundation targets last achieved in 2016 flood. In 2019-20 some flows were delivered to Murrumbidgil Swamp.	Moderate	Option to be considered under moderate-high water resource availability.	Moderate
	Large wetland inundation >850 ML/d for 60 days minimum	3-5 years in 10	Wetland inundation targets last achieved in 2016 flood	Moderate	Option to be considered under high water resource availability.	Moderate
Merrimajeel Creek (PU 13) Where extensive natural flooding provides foraging areas and habitat for food resources to support a successful breeding event, provide flows to support breeding events once they have established.	Variable and seeks to provide at least 0.8 metres of depth below nests until chicks have fledged	As required	Water provided during breeding events in 2012, 2015 and 2016.	High	Watering required, if feasible. Option is associated with moderate to high water resource availability (wet conditions).	High
Muggabah Creek (PU15) Where extensive natural flooding provides foraging areas and habitat for food resources to support a successful breeding event, provide flows to support breeding events once they have established.	Variable and seeks to provide at least 0.8 metres of depth below nests until chicks have fledged	As required	Water provided during breeding events in 2012, 2015 and 2016.	High	Watering required, if feasible. Option is associated with moderate to high water resource availability (wet conditions).	High
Lachlan Swamps (PU 16) Provide connectivity to major distributaries, foraging and nesting habitat for waterbirds and maintain wetland vegetation	Small wetland inundation:	7-8 years in 10	This demand was last met in 2016.	Moderate	Option to be considered under moderate- high water resource availability.	Moderate
	Large wetland inundation: >1,200 ML/d for 60 days minimum	3-5 years in 10	This demand was last met in 2016.	Moderate	Option to be considered under high water resource availability.	Moderate
Great Cumbung Swamp (PU 16) Provide drought refuge, longitudinal connectivity, foraging and nesting habitat for waterbirds and maintain wetland vegetation. Compliments landscape scale outcomes in Murrumbidgee wetlands	Small fresh event >150 ML/d for 10 days minimum	Annual	Has been met in 5 of the last 5 years	High	High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)	High
	Small wetland inundation: >650 ML/d for 30 days minimum	7-8 years in 10	This demand was last met in 2016.	Moderate	Option to be considered under moderate- high water resource availability.	Moderate
	Large wetland inundation: >1,200 ML/d for 60 days minimum	3-5 years in 10	This demand was last met in 2016.	Moderate	Option to be considered under high water resource availability.	Moderate

Environmental assets and Long Term Water Plan unit (PU) reference number (see Figure 1 and more detailed description at bottom of table)	Indicative demand (for all sources of water in the system)		Watering history	2020–21		Implications for future demands
	Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Lake Cowal (PU 4) and other lake systems within the catchment Provide habitat for native fish and colonial nesting waterbirds	Demand yet to be assessed	Various and may be linked to delivery of operational flows	Various. Systems may receive natural inflows and be a source of floodwater returning to the Lachlan River.	Various - may have limited capacity to deliver Commonwealth environmental water to some assets		

Planning Unit (PU) naming as per Lachlan Long Term Water Plan Part B: Lachlan planning units (Draft for exhibition):

PU1: Belubula River

PU2: Upper Lachlan River

PU3: Lachlan River - Forbes to Condobolin (Lachlan River, Horseshoe Lagoon, Bumbuggan Creek)

PU4: Upper and Mid Lachlan floodplain (Thurumbidgee Lagoon, Bundaburra Creek, Lake Cowal)

PU5: Mid Lachlan anabranches (Island, Wallamundry, Wallaroi and Narrathong Creeks)

PU6: Lachlan River - Condobolin to Lake Cargelligo (Lachlan River, Borapine & Kiagathur Creeks, Yarnel Lagoon)

PU7: Booberoi Creek

PU8: Lachlan River - Lake Cargelligo to Willandra Weir (Lachlan River, Box Creek)

PU9: Lake Cargelligo

PU10: Lake Brewster

PU11: Willandra Creek

PU12: Merrowie Creek (Cuba Dam, Chillichil swamp, Merrowie Creek wetlands, Box Creek)

PU13: Merrimajeel Creek (Merrimajeel Creek, Booligal Wetlands, Lake Merrimajeel, Murrumbidgil Swamp)

PU14: Lower Lachlan watercourse (Lachlan River, Moon Moon Lake)

PU15: Muggabah Creek

PU16: Western Lachlan watercourse including The Great Cumbung Swamp (Lachlan River, Great Cumbung Swamp, Lake Waljeers, Pimpara Creek, Lachlan swamp, Baconian swamp, Lake Ita)

Key - potential watering in 2020-21

- High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)
- Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate - high water resource availability); or water demand likely to be met via other means
- Low priority for Commonwealth environmental watering (under high - very high water resource availability)
- Unable to provide Commonwealth water because of constraints or insufficient water

Key - environmental demands

- Critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
- High demand for water i.e. needed in that particular year
- Moderate demand for water i.e. water needed that particular year and/or next
- Low demand for water i.e. water generally not needed that particular year
- Very low demand for water i.e. water generally not needed that particular year or the following year

Note that demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime

3.9.5 Water delivery in 2020-21

Based on the demand for water for the environment, water availability (supply), and catchment conditions, the overall purpose for managing Commonwealth water for the environment in the Lachlan catchment in 2020-21 is to avoid damage and protect the health and resilience of aquatic ecosystems and wetland areas.

The planning of watering actions is undertaken in partnership with NSW agencies. A range of scenarios, from very dry to very wet conditions, are planned for so that environmental water managers can respond quickly to changing catchment conditions during the year.

Very low water availability, ongoing dry conditions and related restrictions on water use are likely to limit the ability to delivery environmental flows in the Lachlan River catchment during 2020-21. With the anticipated volumes for the start of 2020-21, Commonwealth environmental water is proposed to be used in a joint watering action with NSW to delivery a flow down Booberoi Creek (Booberoi Weir has been closed since March to allow the Booberoi off-take channel to dry down ahead of de-silting works by WaterNSW). This action will re-start the system after the completion of de-silting works and will provide a flushing pulse in September-October to coincide with fish movement back into the creek once the off-take is reopened, and should provide an end of system return flow. This actioin will help maintain Booberoi Creek as an important drought refugia site in the Lachlan system.

Should there be substantial rainfall and a significant increase in water availability during 2020-21, watering actions will be scaled up accordingly. This may enable drought refugia to be consolidated for another year. Alternatively, under very wet conditions, watering actions may seek to compliment other flows in the system to maintain the health of floodplain vegetation, maintain water quality where feasible to do so and/or the need to support waterbird breeding events.

3.9.6 Monitoring and Lessons Learned

(a) Monitoring

The CEWO Monitoring, Evaluation and Research (MER) Program (2019-20 to 2021-22) integrates and replaces monitoring and research activities under the Long-Term Intervention Monitoring (LTIM) and Environmental Water Knowledge and Research (EWKR) projects.

The University of Canberra is the lead agency, contracted by the CEWO, to undertake the Lachlan MER project. A detailed MER Plan has been developed by the University of Canberra for the Lachlan River which sets out the schedule of activities to be undertaken to June 2022. Further information about the Lachlan MER project is available from http://www.environment.gov.au/water/cewo/catchment/lachlan/monitoring.

Additional monitoring is also undertaken by NSW agencies. Landholders and community members play a critical role in providing real-time, onground advice and observations of conditions in the catchment, including the progress and outcomes from the use of environmental water.

(b) Lessons learned

Outcomes from monitoring and lessons learned in previous years are a critical component for the effective and efficient use of Commonwealth water for the environment. These learnings are incorporated into the way environmental water is managed.

Key findings in the Lachlan Catchment are summarised in Table 36.

Table 36: Key lessons learned in the Lachlan Catchment

Monitoring Indicator	Lesson learned
Hydrology (River)	• The spring pulse from Wyangala (2016-2018) has demonstrated its value in enabling a number of watering actions to be efficiently and effectively delivered as part of a larger flow event (Dyer et al. 2019), including all of the main river channel, Yarrabandai Lagoon, Booberoi Creek, Brewster Weir pool, Noonamah and the Great Cumbung. • Dyer et al. (2019) also notes the increasing influence and importance of these watering actions have as they move downstream. For example, in 2018-19 these flows contributed 4 per cent of the flow in the mid-Lachlan (at Forbes). In the lower Lachlan (at Booligal) these flows contributed 24 per cent of the flow, doubled the number of freshes that exceeded 200 ML/day and provided the only fresh to reach 500 ML/day for the watering year. • Based on Sentinel monitoring, the combination of multiple pulses delivered at Booligal in May-June may achieve a greater spread into the Great Cumbung when compared to a spring pulse. Depending on the objectives to be targeted and catchment conditions, the use of water in autumn-winter, delivered to Booligal, may be a more efficient at watering the Great Cumbung region than delivery during spring. Winter-autumn would take advantage of lower temperatures and possible winter rain. However, spring may remain a preferred time in terms of response from the core reed beds and upstream in-channel outcomes. Proposed research under MER will inform these decisions into the future. • Consistently reviewing the planned annual hydrograph can enable water saving to be made during the year (e.g. the dispersal pulse as end of fish nesting period may not be required if operational flows can achieve this).
Native fish (River Community and Larvae)	• Dyer et al. (2019) notes evidence that a remnant adult population of Murray cod persists in the lower Lachlan below Lake Brewster after the 2016 hypoxic water event. Monitoring has shown this population to be spawning and will be the most likely recovery pathway for this species. It will be important for future water delivery to continue to provide breeding opportunities, by facilitating the movement of pre-spawning fish and maintaining spawning habitat during nesting periods to prevent rapid water level drops and nest abandonment or desiccation. • The provision of a 'minimum flow' targets during the spawning season for nesting fish species may also be river reach specific. The decision in 2018-19 to not include a minimum flow target at Hillston (lower Lachlan) appears to have had no impact on cod larvae response in that year. This would suggest that nesting fish species are (a) nesting at sites lower than existing low flow levels, and/or (b) that flows delivered to the upper Lachlan continued to provide benefit to the lower Lachlan in addition to operational base flows. These flows would be better informed/targeted if incorporated with habitat mapping undertaken by NSW and fish movement monitoring (yet to be undertaken in the Lachlan) (Dyer et al. 2019). • Watts et al. (2019) note the learning from the 2015-16 watering action that targeted, but failed to detect, golden perch spawning in the Lachlan River (Dyer et al. 2016). Future watering actions targeting golden perch spawning as an objective, will need to be undertaken in a year of high water availability to be able to provide increasing flows over several days combined with increasing water

Monitoring Indicator	Lesson learned
	temperatures (above 23°C). Under such catchment conditions consideration will also have to be given to the likelihood that golden perch may have spawned on earlier high flows (translucent releases or flood flows). • The integration of eDNA metabarcoding in the 2018-19 monitoring efforts resulted in more robust species richness data for the lower Lachlan River through the detection of freshwater catfish and silver perch. • Monitoring coordinated by NSW continues to show the importance of off-channel habitat, such as Booberoi Creek, to a range of native fish including Freshwater catfish. Monitoring has also shown that Olive perchlet are continuing to persist in Brewster Weir pool (McGrath 2020). • Linked to the theme of stream metabolism below, CEWO (2017) notes the difficulty in the timely provision of water for native fish refuge flows during hypoxic water quality events. Long travel times for the delivery of flows can mean that it is not possible to provide refuge flows in time to prevent or minimise the impacts of fish kills, especially in the lower Lachlan. The recent installation of dissolved oxygen loggers on NSW gauges in the system will help with earlier detection of hypoxic water conditions.
Vegetation condition and diversity	• There is a challenge for environmental water managers in maintaining the health of floodplain vegetation, especially at sites that are easier to provide water to (Higgisson et al. 2019). These sites may be prone to river redgum encroachment. Planning of events for vegetation outcomes must include and trial not only the timing of flow events but also the duration and depth of flows to match what is required for the vegetation outcomes being targeted at individual sites. • Dyer et al. (2019) found that frequently watered sites, such as Nooran Lake, have the greatest number of native amphibious species present and can frequently replenish soil seedbanks. Maintaining flows to these sites may help reduce the number of terrestrial plant species that would be able to invade these sites in the absence of regular watering. A comparison of approaches and results with watering similar wetland sites for vegetation outcomes in the Murrumbidgee Catchment (Wassens 2020) may also help inform such an approach in the Lachlan Catchment.
Stream metabolism	• Dyer et al. (2019) suggest that pulses at the warmer time of year may improve the ability of flows to provide a boost in productivity to the river system. Planning of flows for spring-early summer will take the following points into consideration: o the other objectives that may also be targeted with the use of water o where those objectives may be met as the water moves down the river channel o how best to use environmental water with other water, such as the Lachlan Water Quality Allowance, also being delivered in the system, identifying and filling gaps in key component of the hydrograph where required. o minimising the risk of generating hypoxic events by providing pulses into the river when water temperatures begin to exceed 16 degrees C.

Monitoring Indicator	Lesson learned
Waterbirds	• Brandis (2016) concluded that even with the provision of flows, the abandonment of Booligal wetland nesting sites by straw necked ibis during June-^{Oc}tober 2015 was in response to a combination of factors relating to hotter temperatures, declines in flows and water levels, reduction in foraging habitat and better habitat being available in other catchments. • Brandis and Lyons (2016) notes the response of straw necked ibis during the August- November 2016 breeding event where the colony exceeded 200 000 nests at its peak. This work also showed the effectiveness of the use of drones to assist with monitoring waterbird outcomes. Dyer et al. (2017) notes that this response highlights the importance of regional weather patterns, and the value of extensive flooding to provide foraging areas and habitat for food resources to thrive in a successful breeding event. The strategy of using flows to support breeding events once they have established (rather than trying to trigger a breeding event) is therefore sound. The management of water levels at the second waterbird colony site in the Booligal Wetlands in 2016-17 demonstrates the value of this approach.
Frogs	• At sites like the Booligal Wetlands and The Great Cumbung, there is a need for standing water to be present in the landscape to enable summer breeding frog species to be able to complete their life cycle Dyer et al. (2016). The provision of flows during warmer months of the year needs to include consideration of the potential to contribute to the breeding of carp in the same areas where frog outcomes may be sought. Carp exclusion/management activities may be required on a site-by-site basis prior to flows being delivered in summer for frog outcomes.

3.9.7 Bibliography

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3.10 Murrumbidgee River Valley

3.10.1 Region overview

(a) River valley

The Murrumbidgee River Valley (Figure 5) covers 84 000 square kilometres of southern New South Wales. It is bordered by the Great Dividing Range to the east, the Lachlan River Valley to the north and the River Murray Valley to the south (Green et al. 2011). The river originates in the alpine area of Kosciuszko National Park and flows through the Monaro High Plains and the low-lying plains of the western Riverina, joining the River Murray south of Balranald.

Most of the flow in the Murrumbidgee River comes from the upper portion of the catchment (gaining stream) and is delivered by the main tributary rivers: Cotter, Yass, Molonglo, Queanbeyan, Bredbo, Numeralla, Goodradigbee and Tumut (Kingsford and Thomas 2001). Several tributaries located immediately downstream of the dams contribute significant inflows, including Adelong, Adjungbilly, Gilmore, Hillas, Tarcutta, Kyeamba, Jugiong, Muttama, Billabong and Houlaghans Creeks, and Goobarragandra River (SKM 2011). The middle and lower portions of the catchment do not contribute significant inflows (losing stream).

Regulated water is provided by two major headwater storages, Burrinjuck Dam on the Murrumbidgee River and Blowering Dam on the Tumut River. Collectively these storages have a capacity of 2 654 gigalitres. Blowering Dam and Tantangara Reservoir catchments are also affected by the operation of the Snowy Mountains Hydro Electricity scheme.

(b) Traditional Owners

The rivers and wetlands of the Murrumbidgee River Valley hold significant spiritual and cultural importance for Aboriginal people. The Wiradjuri are the largest Aboriginal nation in the Murrumbidgee River valley, with their nation extending from the River Murray in the south to beyond Dubbo in the north, and west to Balranald. At the western end of the catchment are the traditional land of the Barapa Barapa, Muthi Muthi, Nari Nari, Nyeri Nyeri, Wadi Wadi, Wamba Wamba, Weki Weki, and Wolgalu nations. The mountains at the eastern end of the Murrumbidgee River Valley are the country of the Ngunawal and Ngarigo nations. (MDBA 2019).

(c) Important sites and values

Supporting a complex range of natural ecosystems, the Murrumbidgee River Valley contains many significant in-channel and wetland habitats which provide important habitat for a range of aquatic and terrestrial species including frogs, fish and waterbirds.

Commonwealth water for the environment is delivered to a number of important regions in the Murrumbidgee River Valley, including but not limited to the mid-Murrumbidgee wetlands, Yanco Creek system, Lowbidgee floodplain and Murrumbidgee River. These regions provide critical habitat for a range of water dependent animals, including internationally listed migratory waterbirds and a range of threatened species including the southern bell frog, Australasian bittern, trout cod, Murray cod, silver perch, native catfish, fishing bat; and freckled and blue-billed ducks.

Murrumbidgee River

The Murrumbidgee River spans approximately 1 600 km (Frazier et al. 2005) and is heavily regulated with 26 dams, weirs and irrigation channels (SKM 2011). The lowland section of River between Gandagai and Balranald consists of meandering channels and wide floodplains, providing a range of aquatic habitats (Green et al. 2011) which play a critical role in the life cycles of a variety of species (MDBA 2012).

River regulation has affected the frequency and duration of floodplain inundation, with the magnitude of small to medium floods on the Murrumbidgee River having significantly reduced (Frazier et al. 1995). This has had a significant impact on the river system and the plants and animals that depend on it. It has also altered the natural seasonal flow patterns, with higher flows now occurring in summer and early autumn to meet irrigation demand and lower flows occurring during winter and spring when inflows are captured in the dam (CSIRO 2008, Frazier et al. 2005). River regulation has significantly contributed to native fish declines in the Murrumbidgee, with the native riverine fish communities remaining in poor condition (Wassens et al. 2020a, Davies et al. 2008), as part of the Sustainable Rivers Audit, found the overall condition and ecosystem health of the Murrumbidgee Valley to be very poor.

Mid-Murrumbidgee Wetlands

The mid-Murrumbidgee wetlands are located on the Murrumbidgee River floodplain between Wagga Wagga and Carrathool and consist of hundreds of lagoons and billabongs (MDBA 2012a), with several listed as nationally significant in the Directory of Important Wetlands of Australia (EA 2001). The mid-Murrumbidgee wetlands are also part of the Natural Drainage System of the Lower Murray River Management Catchment aquatic endangered ecological community listed under the NSW *Fisheries Management Act 1994*.

The mid-Murrumbidgee wetlands system is characterised by river red gum forests with marginal black box woodlands, and open water habitat of permanent to semi-permanent wetlands with aquatic plants such as spike rush, garland lily and spike rush (NSW OEH 2019a, MDBA 2012a, CSIRO 2008). Many of these wetlands rely on higher flows in the Murrumbidgee River to fill (Murray 2008). However, due to river regulation, inundation frequency and duration has significantly reduced, resulting in the overall poor condition of the mid-Murrumbidgee wetlands. Whilst the use of pumping infrastructure to deliver water for the environment has helped to improve or maintain the condition of a small number of wetlands in the mid-Murrumbidgee, it is not as ecologically effective as filling wetlands with a reconnecting river flow. As such, a high priority for environmental watering is reconnecting these wetlands to help the recovery of aquatic vegetation and improve the health of the river by enabling nutrients and animals to flow back to the river.

Murrumbidgee Irrigation Area wetlands

A number of significant wetlands occur in the Murrumbidgee Irrigation Area and require the use of irrigation infrastructure to receive environmental water. This includes Fivebough and Tuckerbil Swamps which are listed as wetlands of international importance under the Ramsar Convention. Both of these wetlands support a high abundance and diversity of waterbirds, including migratory waterbirds listed under international agreements (JAMBA, ROKAMBA, CAMBA, Bonn Convention) and threatened species, including the endangered Australasian bittern and Australian painted snipe (EPBC Act). They also provide significant breeding habitat for waterbirds including egrets and brolgas (White 2011).

Yanco Creek System

The Yanco Creek system consists of four major creeks, the Yanco, Billabong, Colombo and Forest creeks, and receives a majority of infows from the Murrumbidgee River but also catchment inflows from the unregulated Billabong Creek. The system discharges into the Edward River which is an effluent of the River Murray (Alluvium 2013). This system is known to provide important native fish habitat, including for the threatened trout cod and freshwater (eel-tailed) catfish (Alluvium 2013). Floodplain wetlands occur throughout the Yanco Creek system providing important habitat for a range of species, this includes Wanganella Swamp which is a significant waterbird breeding site located in the Forest Creek system.

Lower Murrumbidgee (Lowbidgee) Floodplain

The Lowbidgee floodplain is located between upstream of Maude and Balranald and is listed on the Directory of Important Wetlands in Australia (EA 2001) and forms part of the Natural Drainage System of the Lower Murray River Catchment aquatic endangered ecological community listed under the *NSW Fisheries Management Act 1994*. The Lowbidgee floodplain contains the third largest river red gum forest in Australia (Murrumbidgee CMA 2009), some of the largest lignum wetlands in New South Wales (CSIRO 2008) and also has significant black box and reed bed communities (Murrumbidgee CMA 2009). Some of the Murray-Darling Basin's largest breeding sites for colonial nesting waterbirds and migratory waterbird species listed under bilateral agreements occur on the Lowbidgee floodplain (Wassens et al. 2019a).

The Lowbidgee floodplain can be inundated through controlled diversions from Maude and Redbank weirs or via overbank flooding from the river. The Lowbidgee floodplain can be divided into three wetland systems based on distinctive hydrological and ecological characteristics and are Gayini Nimmie-Caira, Fiddlers-Uara and Redbank systems. Gayini Nimmie-Caira supports extensive areas of lignum shrubland that provides important waterbird breeding habitat and important habitat for the threatened southern bell frog. Fiddlers-Uara creeks are the most upstream major distributaries on the Lowbidgee and support black box woodlands with lignum, nitre goosefoot and river cooba understory (MDBA 2012b, SKM 2011, NSW OEH 2019a). The Redbank system consists of North and South (Yanga National Park) Redbank and is dominated by river red gum forests and woodlands with marginal black box woodlands (CSIRO 2008), and a high proportion of open water and semi-permanent wetland communities, including aquatic herbs and spike rush sedgelands (MDBA 2012b, NSW OEH 2019a). This area also provides important waterbird breeding habitat.

At the western edge of the Lowbidgee is the Western Lakes, which is a complex of ephemeral lakes, wetlands and connecting waterways. The Western Lakes were disconnected from the Murrumbidgee River in the early 1900's due to the construction diversion structures on the floodplain (Kingsford and Thomas 2001, NSW OEH 2012) and remained isolated until flow diversion works enabled the delivery of water for the environment in 2011 (NSW OEH 2012). This area provides habitat for a diverse range of waterbirds.

Junction Wetlands

The Junction Wetlands lie between Balranald and the confluence of the Murrumbidgee and Murray rivers. This area consists of a number of creeks, lagoons and areas of river red gum forest, black box and mallee (SKM 2011).

(d) Stakeholder engagement

In the Murrumbidgee River Valley, the planning, management and delivery of Commonwealth water for the environment is undertaken in conjunction with a range of partners and stakeholder groups. Key stakeholders include the New South Wales Department of Planning, Industry and Environment (DPIE) – Biodiversity and Conservation, NSW Department of Primary Industries (DPI) - Fisheries, WaterNSW, Nari Nari Tribal Council, scientists from Charles Sturt University engaged in monitoring the outcomes of Commonwealth environmental water use, Murray-Darling Wetlands Working Group, The Nature Conservancy and the Murrumbidgee Environmental Water Advisory Group (EWAG).

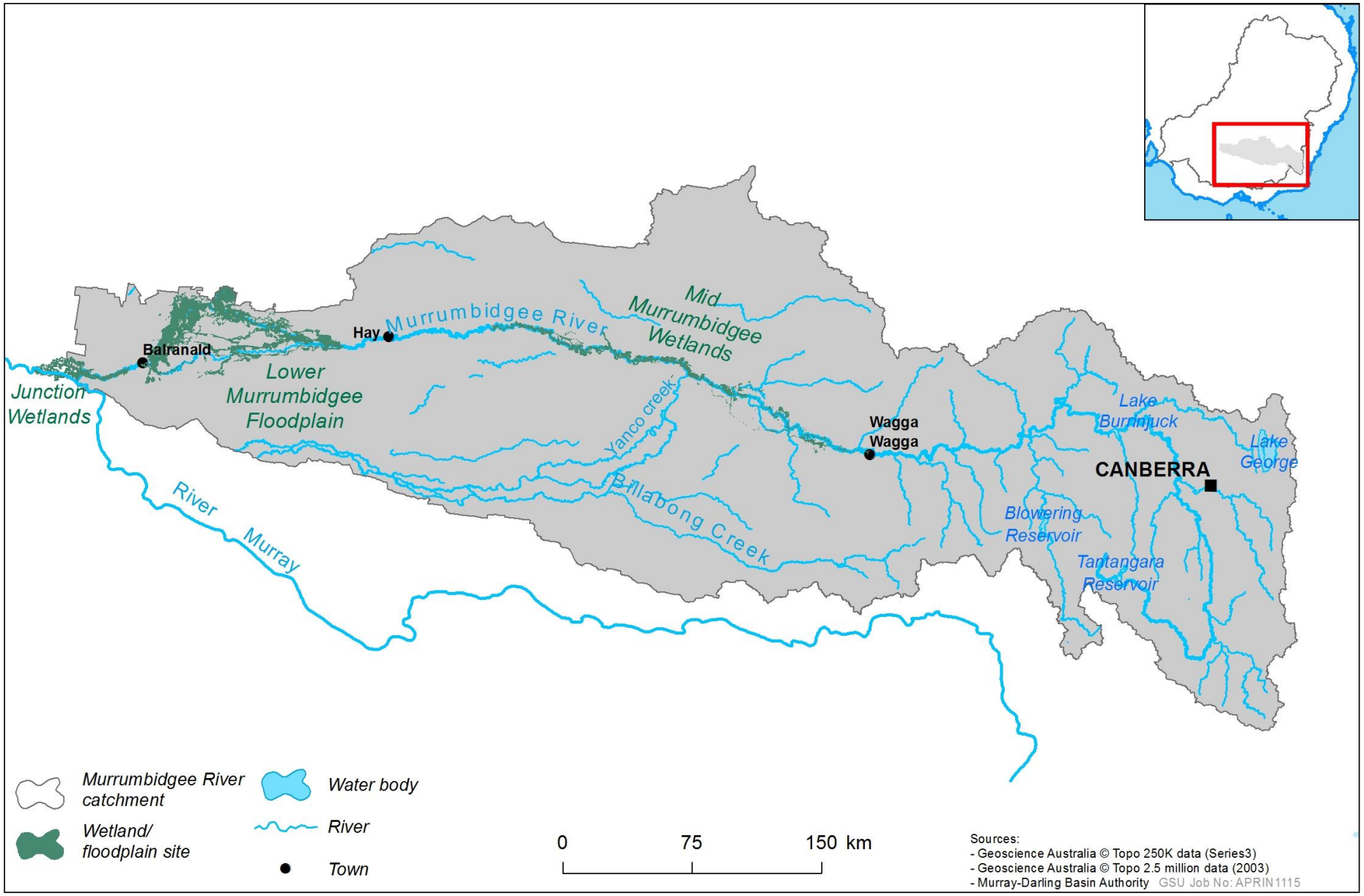

Figure 16: Map of the Murrumbidgee catchment including major towns and headwater storage (courtesy of the Murray-Darling Basin Authority).

3.10.2 Environmental objectives

Objectives for environmental water delivery in the Murrumbidgee River Valley are based on long-term environmental objectives in the Basin Plan, draft state long-term watering plans, the Ramsar site ecological character description for Fivebough and Tuckerbil swamps and best available ecological knowledge.

The objectives that are targeted in a particular year may vary, depending on available water, catchment conditions, operational feasibility, and demand for environmental water. These objectives will continue to be revised as part of the Commonwealth Environmental Water Office's (CEWO) commitment to adaptive management.

Vegetation: Maintain or improve the condition, and maintain or increase the extent, of native riparian, in-channel, floodplain and wetland vegetation.

Waterbirds: Increase waterbird abundance and maintain species diversity by supporting naturally triggered breeding events, and maintaining suitable refuge, feeding and breeding habitat.

Native fish: Prevent loss of native fish species and improve population structure, distribution, and species abundance by supporting opportunities for movement, dispersal, reproduction, and recruitment.

Other vertebrates: Provide habitat to support survival of other native aquatic species, including frogs and turtles; and support opportunities for reproduction and recruitment.

Invertebrates: Provide habitat to support increased microinvertebrate and invertebrate survival, diversity, abundance and condition.

Connectivity: Support longitudinal connectivity, including with the Murray River, and lateral connectivity (within constraints) between the river and floodplain and wetlands.

Processes/water quality/resilience: Support in-stream and floodplain productivity; support nutrient, carbon and sediment transport; provide movement and dispersal opportunities for biota; create quality instream, floodplain and wetland habitat (i.e. including supporting water quality); and maintain or provide a diversity of drought refuge habitat across the landscape.

3.10.3 First Nations Environmental Objectives

Advice on environmental water objectives in the Murrumbidgee catchment has been provided by the Murray Lower Darling Rivers Indigenous Nations (MLDRIN) through the First Nations Environmental Water Guidance project. Table 1 includes just some of the common objectives for the Murrumbidgee catchment selected as they were raised by 2 or more participating Nations for the region. It is important to note these objectives do not represent the detail, depth and complexity of Nations' localised water-related objectives.

Some of these objectives sit outside the scope of water for the environment to influence, while for others, the link between water for the environment and the site or issues is not well understood. Environmental flows will aim to contribute to identified objectives, where possible. The Commonwealth Environmental Water Holder is committed to continuing to strengthen engagement with all Southern Basin First Nations to support those Nations to articulate objectives for water management.

Table 37: First Nations environmental water objectives for the Murrumbidgee system for 2020-21 (MLDRIN 2020).

Waterways and Places in Need of watering
Murrumbidgee, Dry Lake, Yanga Lake, Billabong Creek, Baaka (Darling), Wetlands, Billabongs, Floodplains, Creeks, Other places – parks, forests, islands, Major rivers, Tributaries, Ramsar-listed wetlands.
River Flows and Connectivity
Improve water quality, Improve timing and seasonality of flows, Restore flows in degraded rivers, Remove barriers and constraints, Improve flows and quantity (rivers and general), Restore wetland hydrology, Improve river and or floodplain connectivity, Improve tributary flows

Vegetation
Old Man Weed, Cumbungi, Black Box, Lignum, River Red Gum, Grasses
Fish
Murray Cod, Yellowbelly, Catfish, Native fish
Waterbirds
Swan, Pelican, Ducks, Eastern Bittern, Sea eagle [i], Black Swan.
Other species
Turtles, Frogs, Murray Cray, Shrimp, Mussels, Platypus, Yabbies, Water Rat (Rakali), Macroinvertebrates, Emu [i], Kangaroo [i], Birds.

[i] Water for the environment targeting other environmental outcomes may influence this species or objective

3.10.4 Recent conditions and seasonal outlook

(a) Recent conditions and environmental water use

The Murrumbidgee Valley has experienced dry conditions from early 2017 up until early 2020 when wetter conditions prevailed, contributing to the dry conditions easing (BOM 2020). However, by March 2020 inflows into catchment dams and the Murrumbidgee River had been limited owing to the severity of the dry conditions experienced over the previous three years. Further rainfall in late April 2020 did contribute to an improvement to water resources in Murrumbidgee valley storages, resulting in an increase to general security allocation (NSW DPIE 2020a).

The NSW Department of Planning, Industry and Environment reported in their mid-May 2020 water allocation statement that the Murrumbidgee Valley has averaged 95th percentile conditions in 2019-20, which means only five years out of 100 years of historical record experience drier conditions.

In 2019-20, given the hot, dry conditions and low water resource availability in the Valley, the primary focus of Commonwealth environmental watering was to deliver flows to maintain critical refuge habitats at sites throughout the Murrumbidgee catchment, including:

- Gayini Nimmie-Caira
- North Redbank
- Yanga National Park
- Toogimbie Indigenous Protected Area
- Murrumbidgee Irrigation Area, including Ramsar listed Tuckerbil Swamp
- selected mid-Murrumbidgee and Junction wetlands via pumping.

Delivery of Commonwealth and NSW water for the environment successfully maintained refuge habitat which supported:

- native vegetation communities, including growth of aquatic plant species such as spike rush, spiny mud grass, cumbungi and nardoo
- a high diversity of native fish, including carp gudgeon, Australian smelt, Murray-Darling rainbow fish, flathead gudgeon, golden perch, bony bream and Murray cod
- all three Murrumbidgee turtle species (broad shelled, eastern long-necked and Macquarie River turtles)
- six species of frogs (barking and spotted marsh frogs, Peron's tree frog, plains froglet, inland banjo frog and the threatened southern bell frog)

- a diverse range of waterbirds including threatened species (such as Australasian bittern, blue-billed and freckled ducks) and migratory shorebirds (such as wood sandpiper, sharp-tailed sandpipers, mash sandpiper, curlew sandpiper and long-toed stint) (CSU 2020; Bourke et al. 2019)
- breeding of frogs, including the threatened southern bell frog; and waterbirds, including royal spoonbills, darters, cormorants, white ibis, nankeen night heron and potentially Australasian bitterns (which were heard calling (James Maguire, NSW DPIE, pers. comms 11 March 2020)).

Flows targeting the northern section of Yanga National Park, however, were suspended part way through delivery due to meter failure at the offtake regulator, resulting in less area inundated than planned. Whilst not achieving inundation of all targeted areas in the northern section of the Yanga National Park, inundated areas supported growth of wetland vegetation and provided habitat for native fish, frogs (including tadpoles), turtles and waterbirds (CSU 2020). The meter at the offtake regulator was repaired in early 2020 and therefore is not anticipated to affect planned delivery of water for the environment into Yanga National Park in 2020-21.

A key environmental water objective of the refuge habitat maintenance flow in Gayini Nimmie-Caira through to Tala Lake and associated creek systems in Yanga National Park was to top up Tala Lake and Tala and Talpee creeks, to support golden perch following the successful spawning and recruitment of this species in 2017-18 and 2018-19. These flows provided refuge habitat throughout Gayini-Nimmie Caira, however, due to flow rates through new Gayini-Nimmie-Caira infrastructure works being lower than expected, flows topped up Talpee Creek but did not reach Tala Lake and Creek in Yanga National Park as planned. Top-up flows of Tala Lake and associated deep creek systems will remain a priority for Commonwealth water for the environment in 2020-21. The identification of this restricted flow rate has been taken into consideration during the planning process to mitigate the risk of flows not reaching these sites.

Commonwealth water for the environment was also delivered to specifically target breeding of southern bell frogs at key sites in Gayini-Nimmie Caira, such as Eulimbah Swamp, where populations had declined and were at risk of local extinction. Commonwealth, in conjunction with NSW water for the environment, successfully supported southern bell frog breeding, with tadpoles followed by metamoprhs and juveniles having been observed (CSU 2020). The 2019-20 watering, coupled with future watering, will contribute to maintaining these populations in Gayini-Nimmie Caira.

Commonwealth water for the environment was delivered for the first time using pumping infrastructure to Wanganella Swamp in the Yanco Creek System and to Sunshower Lagoon in the mid-Murrumbidgee to prevent loss of aquatic vegetation from the lack of higher natural flows and to provide habitat for water dependent animals. Monitoring at Sunshower Lagoon provided evidence of a significant increase in aquatic vegetation species diversity compared to previous years (CSU 2020; Bruni, J. et al. 2020) and recorded five species of frogs, including the threatened southern bell frog, tadpoles, eastern long-necked turtles and waterbirds (CSU 2020, Bourke et al. 2020). In response to environmental watering at Wanganella Swamp, NSW DPIE staff, Yanco Creek and Tributaries Advisory Council Environmental Manager and local field naturalists reported sighting the re-establishment of aquatic vegetation, including with significant cumbungi and culturally significant nardoo, turtles, frogs and over 25 species of waterbirds including brolga, red-necked avocet (the first observed in the district since 2010), red-kneed dotterel, white-necked heron, freckled duck, sharp-tailed sandpiper and Latham's snipe.

Details of previous Commonwealth environmental use in the Murrumbidgee River Valley are available at: https://www.environment.gov.au/water/cewo/catchment/murrumbidgee/history.

(b) Seasonal outlook

According to the Bureau of Meteorology outlook, across the Murrumbidgee River Valley there is a greater than 80 per cent chance of above median rainfall for the periods of June to August and July to September 2020 (BOM 2020). Additionally, the chance of exceeding maximum temperatures over the coming months is variable across the Murrumbidgee River Valley, ranging from high in the eastern end of the valley reducing to low at the western end of the valley (BOM 2020).

While this forecast indicates that the dry conditions are likely to ease, several months of above average rainfall are needed to see a recovery from the current long-term drought.

(c) Water availability

The volume of Commonwealth environmental water carried over in Murrumbidgee River Valley for use in 2020-21 is 62 gigalitres.

Allocations against Commonwealth water entitlements in the Murrumbidgee River Valley are determined by state governments and will vary depending on inflows. On 1 July 2020, the NSW Department of Planning, Industry and Environment (2020b) announced full opening allocations to high security (i.e. 95 per cent allocation) and conveyance entitlements as per the valley's water sharing plan, and 10 per cent allocation to general security entitlements. Based on this, approximately 137 GL of Commonwealth environmental water is available for use in the Murrumbidgee River Valley as at 1 July 2020.

Based on the expected available volume of water held by the Commonwealth and other water holders (including carryover and forecast allocations), as well as recent and forecast catchment conditions, it is expected that the overall resource availability will be low to moderate in 2020–21. High to very high resource scenarios are only possible if conditions become substantially wetter.

(d) Environmental demands

The environmental water demands for assets in the Murrumbidgee River Valley in 2020–21 are represented in Table 38. The capacity to contribute to some of these environmental demands are contingent on a substantial improvement in water availability in the catchment. For example, a low-level mid-Murrumbidgee reconnection is a high priority under all water resource scenarios, however, under a low water resource availability, there would be insufficient environmental water for this action to proceed.

Table 38: Environmental demands, priority for watering in 2020-21 and outlook for coming year in the Murrumbidgee River Valley.

Environmental assets and Long Term Water Plan planning units (PU) (see description at bottom of table)	Indicative demand (for <u>all sources of water</u> in the system)*		Watering history	2020-21		Implications for future demands
	Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020-2021
Mid-Murrumbidgee Wetlands† (includes pumping to Toogimbie Indigenous Protected Area) (PU 4, 5, 6, 9 and may also contribute flows in PU 7, 8, 10, 11, 12, 13)	Infrastructure assisted delivery to individual high priority wetland assets targeting provision of refuge habitat and maintenance of wetland vegetation (minimum of 4 GL required under a very low inflow scenario to support critical refuge requirements) (PU 6)	8 in every 10 years – annual (2 years)	Demand met or partially met over the last 5 years	HIGH to CRITICAL To provide refuge habitat for aquatic animals and maintain established aquatic habitat. However overbank connection is preferred	High Potential for water use under Very Low to Moderate inflow scenarios Up to 16 GL (volume contributed will be dependent on resource availability/antecedent conditions, with a minimum of 4.5 GL required under a Very Low inflow scenario)	HIGH TO CRITICAL
	Tombullen storage releases to augment flows over 13 GL/day at Darlington Point (PU 6, 7, 8)	7–8 in every 10 years (2 years)	Demand partially met over the last 3 years	HIGH The condition of the mid-Murrumbidgee wetlands is generally poor due to a lack of inundation.	High Potential for water use under Moderate to High inflow scenarios subject to natural flow event triggers Up to 10 GL per event	HIGH
	Minimum of 15.5 GL/day @ Darlington Point for up to 6 days plus a gradual recession targeting low-lying wetland vegetation and aquatic habitat up to 180 GL (multiple PU's)	7–8 in every 10 years (2 years)	Demand met 2 out of the last 5 years, last met 2017-18.	HIGH The condition of the mid-Murrumbidgee wetlands is generally poor due to a lack of inundation.	Up to 150 GL under Moderate to High inflow scenarios planned for autumn/winter 2021 subject to available allocations	HIGH
Murrumbidgee Irrigation (MI) Area Ramsar sites (Fivebough and Tuckerbil wetlands) and includes other important wetlands in MI Area (PU 14)	Fivebough 500 ML to inundate 60% of wetland. Tuckerbil 500 ML to fill	Fivebough: Shallow water 9 in every 10 years. Fill Tuckerbil 4 of every 10 years	Fivebough: Required frequency met over the last 6 years Tuckerbil: Required frequency met over last 5 years.	HIGH Required to maintain ecological character under Ramsar	High Potential for water use minimum of 2 GL under a Very Low inflow scenario Moderate to High Potential for water use. Up to 4 GL under Low inflow scenario	HIGH
Yanco Creek System (PU 12)	Up to 20 GL, targeting up to 1 400 ML/day @ Yanco Creek off-take targeting low-lying wetland vegetation and aquatic habitat and native fish	3 in every 10 years (3 years)	Demand met or partially met in 2 of the last 5 years, however watering required to maintain condition of wetland-floodplain vegetation	MODERATE Watering, required to maintain the good condition of wetland-floodplain vegetation	Low to Moderate Potential for water use Up to 10 GL under Moderate to High inflow scenarios. Supplementary use prioritised if available.	MODERATE, subject to natural cues
Yanco Creek System – Wanganella Swamp (PU13)	Pumping of 1.5 GL to prevent loss of aquatic vegetation species	7–8 in every 10 years (2 years)	Demand met 2 out of the last 5 years	CRITICAL to prevent loss of aquatic vegetation species (cumbungi rhizomes)	High Potential for water use Up to 1.5 GL under Very Low to Moderate inflow scenarios	HIGH
Yanco Creek System – Wanganella Swamp and Forest Creek (PU13)	Up to 6 GL targeting wetland and black box vegetation communities	3 in every 10 years (3 years)	Demand met or partially met in 2 of the last 5 years	MODERATE Watering following natural cues to maintain condition of wetland-floodplain vegetation	Moderate Potential for water use up to 3 GL if natural flow event triggers an opportunity under Moderate to High inflow scenario. Supplementary use prioritised if available.	LOW, subject to natural cues

* Volumes may be limited by current channel constraints. Roberts and Marston (2011), Hardwick and Maguire (2012), Alluvium (2013)

† Note: Difference in filling height (i.e. flows required to fill a wetland) vary among the lagoons that make up the mid-Murrumbidgee wetlands, and so their condition and watering requirements vary accordingly

Environmental assets and Long Term Water Plan planning units (PU) (see description at bottom of table)	Indicative demand (for all sources of water in the system)*		Watering history	2020-21		Implications for future demands
	Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020-2021
Lowbidgee - Core refuge and permanent aquatic habitat sites (PU7)	Up to 74 GL targeting critical refuge habitat requirements (minimum of 8.5 GL is required under a Very Low inflow scenario to meet these needs)	Annual	Demand met over the last 5 years	HIGH to CRITICAL Annual watering required for critical habitat requirements	High Potential for critical/permanent habitats. Volume contributed will be dependent on resource availability/antecedent conditions, with a minimum of 4.5 GL required under a Very Low inflow scenario increasing to 41 GL under Moderate inflow scenarios	HIGH to CRITICAL
Lowbidgee – Rookery sites (PU7)	Up to 30 GL in the event of naturally triggered colonial waterbird breeding	As required in response to naturally triggered colonial bird breeding event	As required	HIGH to CRITICAL to support successful completion of waterbird breeding events	Low Potential, unless colonial waterbird breeding is naturally triggered under Moderate to Very High inflow scenario	HIGH to CRITICAL
Lowbidgee - North Redbank (PU7)	Up to 40 GL‡ targeting wetland vegetation and habitat for native fish, frogs, turtles and waterbirds	River red gum forest and spike rush wetlands 1-3 years (3 years)	Met or partially met over the last 5 years	MODERATE Watering following natural cues, to maintain the good condition of wetland-floodplain vegetation	Moderate Potential for wetland inundation Up to 20 GL under Moderate to High inflow scenarios	LOW, subject to natural cues
Lowbidgee - Yanga National Park (PU7)	Up to 50 GL‡ targeting wetland vegetation and habitat for native fish, frogs, turtles and waterbirds	River red gum forest and spike rush wetlands 1-3 years (3 years)	Met or partially met over the last 5 years	HIGH Watering required to maintain deep creek fish refuges and condition of wetland-floodplain vegetation	High Potential for wetland inundation Up to 25 GL under Moderate to High inflow scenarios	MODERATE, subject to natural cues
Lowbidgee - Gayini Nimmie-Caira (PU7)	Up to 50 GL§ targeting wetland vegetation and habitat for native fish, frogs, turtles and waterbirds	Refuge habitat annual Lignum dominated wetlands 1 to 5 years, with duration of up to 7 months	Met or partially met over the last 5 years	HIGH Watering following natural cues to maintain the good condition of wetland-floodplain vegetation	High Potential for wetland inundation Up to 25 GL under Moderate to High inflow scenarios	MODERATE, subject to natural cues
Lowbidgee - Fiddlers-Uara (PU7)	Up to 20 GL targeting wetland vegetation and habitat for native fish, frogs, turtles and waterbirds	Black box and lignum wetlands every 3 to 7 years	Met 2 out of the last 6 years	LOW Watering following natural cues to maintain the good condition of wetland-floodplain vegetation	Low Potential for wetland inundation Up to 10 GL under High inflow scenarios	LOW, subject to natural cues

‡ Cumulative volume - includes volume allocated for this asset under Lowbidgee Core refuge and permanent aquatic habitat
§ Cumulative volume - includes volume allocated for this asset under Lowbidgee Core refuge and permanent aquatic habitat

Environmental assets and Long Term Water Plan planning units (PU) (see description at bottom of table)	Indicative demand (for all sources of water in the system)*		Watering history	2020-21		Implications for future demands
	Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020-2021
Lowbidgee - Western Lakes (PU7)	Up to 30 GL to maintain open water habitats and floodplain vegetation	Wetland habitats and open water, black box and lignum wetlands every 3 to 7 years	Met or partially met over the last 5 years	MODERATE Watering following natural cues, to maintain open water bodies and good condition of wetland-floodplain vegetation	Moderate Potential Up to 15 GL under Moderate to High inflow scenario	LOW
Lowbidgee full system watering (PU7)	Up to 180 GL** for Basin-wide waterbird habitat and future population recovery. Improve overall condition of the floodplain. Prioritise use of up to 393 GL of Lowbidgee supplementary allocations if made available.	Opportunistic based on natural occurring rain and flow events	Met or partially met over the last 5 year	HIGH Improve the complexity and health of priority waterbird habitat to maintain species richness and aid future population recovery	Low Potential Up to 90 GL under High inflow scenario. Up to 393 GL of Lowbidgee supplementary allocations will be prioritised if made available under High to Very High inflow scenarios.	HIGH
Murrumbidgee River channel, distributaries and anabranches (PU 6, 7, 8, 9, 10, 11, 12, 13)	Contribute up to 10 GL from Tombullen storage to higher river flows (freshes) in spring-summer to support native fish spawning, recruitment, movement and dispersal.	7 in every 10 years	Met 2 out of the last 6 years	MODERATE Watering following natural cues, required to continue recovery of native fish populations.	Moderate Potential Up to 5 GL if natural flow event triggers an opportunity under Moderate to High inflow scenario.	LOW
	Moderate in-channel pulse targeting native fish movement and recruitment, productivity and in-stream vegetation (flows >3 500 ML/day at Balranald) up to 50 GL	7 in every 10 years	Met 2 out of the last 5 years	MODERATE Native fish populations in the lower Murrumbidgee River are in poor condition. Water required for improved fish passage and connectivity, aquatic habitat and riverine productivity	Moderate Potential Up to 25 GL under Moderate to High inflow scenarios	MODERATE
	Distributary and anabranch freshes to restore flow components most impacted by river regulation and support native fish up to 15 GL	7 in every 10 years to annual	Demand met 2 out of the last 5 years	MODERATE Watering following natural cues to maintain the good condition of wetland-floodplain vegetation	Moderate Potential subject to natural cues up to 7.5 GL	MODERATE, subject to natural cues
	Contribute to managing water quality issues within in-stream and wetland environments across the Murrumbidgee Catchment	Contingency in response to poor water quality	As required	CRITICAL Provide refuge habitat for aquatic animals due to poor water quality, including potential hypoxic conditions.	Contingency in response to poor water quality/aquatic habitat availability. This may include up to 15 GL contingency under very low to low inflows, in the absence of IVT (Lower Murrumbidgee weir pool stratification, high risk fish kills).	CRITICAL (Contingency)

** Cumulative volume – includes volumes of all Lowbidgee wetland actions listed above.

Environmental assets and Long Term Water Plan planning units (PU) (see description at bottom of table)	Indicative demand (for all sources of water in the system)*		Watering history	2020-21		Implications for future demands
	Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020-2021
Junction Wetlands (PU8)	Flows greater than 5 GL/day @ d/s Balranald Weir and >10 GL/day on the Murray@ Murrumbidgee confluence targeting wetland vegetation and habitat for native fish, frogs, turtles and waterbirds	5 in every 10 years	Demand met in 2 of the last 5 years	HIGH The condition of the Junction Wetland is generally poor due to a lack of inundation	Low Potential under low inflows. Likely to be achieved by other environmental watering actions and also through Lowbidgee Supplementary allocations under Moderate to High inflow scenarios	HIGH
	Flows greater than 7 GL/day @ d/s Balranald Weir targeting wetland vegetation and habitat for native fish, frogs, turtles and waterbirds	5 in every 10 years	Demand met in 1 of the last 5 years	HIGH The condition of the Junction Wetland is generally poor due to a lack of inundation	Low Potential under low inflows. Likely to be achieved by other environmental watering actions and also through Lowbidgee Supplementary allocations under Moderate to High inflow scenarios	HIGH
	Pumping to individual high priority wetland assets targeting wetland vegetation and refuge habitat for native fish, frogs, turtles and waterbirds	7–8 in every 10 years (2 years)	Demand met in 4 of the last 5 years	HIGH TO CRITICAL To support continued recovery of wetland vegetation and provide refuge habitat	HIGH Potential for water use up to 4 GL under Very Low to Moderate inflow scenarios (volume contributed will be dependent on resource availability/antecedent conditions, with a minimum of 1.5 GL required under a Very Low inflow scenario)	HIGH

Planning Units (PU) 4 – 14. Identified in the Murrumbidgee Long Term Water Plan Part B: Murrumbidgee planning units (draft for exhibition) (NSW OEH 2019b).

PU4: Murrumbidgee River – Tumut River Junction to Berembed Weir
PU5: Murrumbidgee River – Berembed Weir to Gogeldrie Weir
PU6: Murrumbidgee River – Gogeldrie Weir to Maude Weir
PU7: Lower Murrumbidgee Floodplain
PU8: Murrumbidgee River – Balranald to Murray
PU9: Beavers and Old Man's Creek
PU10: Upper Yanco Creek
PU11: Colombo & Billabong Creeks
PU12: Lower Yanco Creek to Lower Billabong Creek
PU13: Lower Billabong and Intersecting Streams
PU14: Murrumbidgee Infrastructure Dependent Floodplain Wetlands

Key - potential watering in 2020-21

- High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)
- Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate - high water resource availability); or water demand likely to be met via other means
- Low priority for Commonwealth environmental watering (under high - very high water resource availability)
- Unable to provide Commonwealth water because of constraints or insufficient water

Key - environmental demands

- Critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
- High demand for water i.e. needed in that particular year
- Moderate demand for water i.e. water needed that particular year and/or next
- Low demand for water i.e. water generally not needed that particular year
- Very low demand for water i.e. water generally not needed that particular year or the following year

Note that demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime

3.10.5 Water delivery in 2020–21

Based on the demand for water for the environment, water availability (supply), and catchment conditions, the overall purpose for managing Commonwealth water for the environment in the Murrumbidgee River Valley in 2020-21 is to maintain, and where possible improve the health and resilience of aquatic ecosystems including to restore ecologically significant flow components impacted by river regulation under wetter scenarios. Specifically, for the mid-Murrumbidgee wetlands the purpose is to maintain and ensure their ecological capacity for recovery and remains a priority under all resource scenarios subject to available allocations.

Planning for water delivery in the Murrumbidgee River Valley considers all water resource availability scenarios from extreme dry to wet, thereby enabling water managers to efficiently and effectively respond to changing conditions. Delivery of water for the environment to many sites and landscapes in the Murrumbidgee River Valley is scalable (i.e. increase the area, volume delivered, and number sites inundated on the floodplain), depending on the volume of water available and catchment conditions. For instance, should climatic conditions and water availability improve there may be opportunities to increase the number of sites inundated on a floodplain, including sites that require substantial volumes of water to fill.

In the Murrumbidgee Valley, the availability of water for the environment forecast at the beginning of 2020-21 will enable water managers to undertake environmental watering actions planned under all dry resource scenarios, including very high priority action identified under a moderate resource scenario. Most of these managed environmental watering actions will initially focus on maintaining key refuge habitats for waterbirds, native fish, frogs, turtles and other water dependent animals and viability of wetland vegetation in the mid-Murrumbidgee, Murrumbidgee Irrigation Area, Lowbidgee, Junction wetlands and Yanco Creek system. This includes delivery of water to Ramsar listed Fivebough and Tuckerbil Wetlands in the Murrumbidgee Irrigation Area to maintain habitat condition to support threatened waterbird species and waterbirds listed under international migratory agreements. Maintaining refuge habitat with water for the environment, particularly in dry conditions, is critical for the survival of waterbirds, native fish, frogs and turtles (Wassens et al. 2019b). These actions also aim to maintain and prevent loss of threatened southern bell frog populations by supporting breeding and recruitment of these short-lived species.

Other important wetland habitats on the Lowbidgee floodplain, such as the southern section of North Redbank, Paika Lake (Western Lakes) and Kia Lake and Swamp (Gayini Nimmie-Caira) which have not received water for the environment since a managed reconnection in 2017 or large scale natural flooding in 2016, are also targeted to maintain or improve the ecological condition of native vegetation communities, and provide habitat for water dependent animals.

The volume of environmental water expected to be available for use in early 2020-21 will also enable water managers to undertake a full system watering of the northern section of South Yanga (moderate resource scenario action). The primary objective of this action is to top-up Tala Creek and Lake to maintain refuge for golden perch and other native fish, including those recruited on the floodplain in 2017-18 and 2018-19 (Kopf et al. 2019; Bourke et al. 2019). It will also maintain or improve the condition of native vegetation communities and provide habitat and recruitment opportunities for water dependent animals.

Under moderate and wet conditions, further larger scale wetland and floodplain inundation including river-floodplain connection will be targeted to restore components of natural flow regime. These flows aim to disperse essential nutrients, plants and animals, and support reproduction and improve condition of native plants, waterbirds, native fish, frogs, turtles and other water dependent animals. These broader scale watering actions will help to improve the condition and resilience of important sites in the Murrumbidgee River Valley. Building resilience into the system to help sites to maintain condition and function in dry years, and to help cope with climate change. The scale of watering will be informed by prevailing climatic conditions and subject to water availability. River-floodplain connectivity in the lower Murrumbidgee may also be supported by in-channel flows targeting native fish movement and recruitment and in-channel productivity.

Note that under wet conditions, unregulated flows are likely to meet many of the Murrumbidgee River Valley's environmental demands. However, water for the environment may be used to extend the duration

of unregulated flows or undertake follow-up watering to achieve environmental watering objectives, subject to constraints and third-party impacts.

If a decline in water quality of in-stream or wetland environments across the Murrumbidgee catchment occurs due to low inflows and dry conditions, or very wet conditions, water for the environment will target protecting refuge habitat for aquatic animals, including for native fish, subject to available allocations.

A key priority for Commonwealth environmental water remains a managed low-level mid-Murrumbidgee wetlands reconnection action, which is generally in poor condition due to lack of repeated inundation. Ideally, a low-level wetlands reconnection with the Murrumbidgee River is required annually to enable the recovery of wetland vegetation. Low-level wetlands were last inundated by the Murrumbidgee River through a managed reconnection in winter 2017. Based on the forecast water resource availability for 2020-21 there is insufficient environmental water holdings for this action to proceed in winter 2020. Should conditions become wetter and environmental water availability improve throughout 2020-21, a managed low-level reconnection may be possible in autumn-winter 2021 (if this priority is not met, by natural, unregulated flows). The aim is to contribute to river flows and inundation of fringing wetlands to continue improvement and promote recovery of wetland vegetation communities, as well as maintain habitat and provide movement opportunities for waterbirds and native aquatic species (including fish, turtles, frogs and invertebrates). The action is subject to water availability, dam release capacities and assessment of potential third-party impacts. The watering action would also contribute to downstream demands, including Yanco Creek, the Lowbidgee floodplain including the Junction Wetlands and potentially the lower Murray. The refinement of arrangements to provide for return flows of environmental water from the Murrumbidgee to the Murray (a “pre-requisite policy measure” in place from 1 July 2019 under the Basin Plan) will enable Commonwealth environmental water used in the Murrumbidgee River to be credited for further environmental use downstream in the River Murray.

Should a managed reconnection not be able to proceed or if mid-Murrumbidgee wetlands are inundated by unregulated flows during 2020-21, maximising carryover volume into 2021-22 is likely to be targeted for a potential managed low-level mid-Murrumbidgee reconnection action in 2021-22.

Additional environmental demands may also be identified during the water year as new information becomes available. Note, under certain levels of water availability, watering actions may not be pursued for a variety of reasons. For example, this may be due to the environmental demand being met by unregulated flows or the ability to deliver environmental water may be limited by constraints or infrastructure works and/or risks.

As in previous years, the use of Commonwealth and NSW water for the environment in the Murrumbidgee River Valley will be adaptively managed throughout 2020-21 in response to changing water availability, and environmental conditions and demands.

3.10.6 Monitoring and Lessons learned

(a) Monitoring

Operational monitoring is undertaken for all Commonwealth environmental watering actions and involves collecting on-ground data with regard to environmental water delivery such as volumes delivered, impact on the river systems hydrograph, area of inundation and river levels. It can also include observations of environmental outcomes.

The Monitoring, Evaluation and Research (MER) Program (previously the Long-Term Intervention Monitoring Project 2014-2019) has sites in the mid-Murrumbidgee Wetlands, Lowbidgee Floodplain and Murrumbidgee River as focus areas. It aims to understand the environmental response from Commonwealth environmental watering with respect to the targeted objectives by carrying out monitoring of site condition over many years.

Details of monitoring activities funded by the CEWO in the Murrumbidgee River Valley can be found at: https://www.environment.gov.au/water/cewo/catchment/murrumbidgee/monitoring.

Monitoring information is also provided by state governments and The Living Murray program.

(b) Lessons learned

Outcomes from monitoring and lessons learned in previous years are a critical component for the effective and efficient use of Commonwealth water for the environment. These learnings are incorporated into the way environmental water is managed.

Key findings and recommendations from short term intervention monitoring projects (Baldwin 2019) and the five year (2014-19) Long-term intervention monitoring (Wassens et al. 2020 a and b, Kopf et al. 2019, Wassens et al. 2019 b and c) in the Murrumbidgee River Valley is summarised in Table 39.

Table 39: Key lessons learned in the Murrumbidgee River Valley

Theme	Lesson learned
Native fish	• Spawning and recruitment of native fish species, such as golden perch, can occur from within the floodplain system. Spawning of golden perch on the floodplain can be triggered using environmental flows, as demonstrated by monitoring in 2018. • Floodplain habitats may be critical for golden perch spawning, growth and recruitment, and importantly provide rare refuges of high-quality habitat and productivity during extreme drought conditions. Management decisions to deliver environmental water to inundate and maintain Lowbidgee floodplain habitats during spring and summer are important to maintain viable native fish populations, and to provide food and habitat for resident populations of fish, frogs and a diverse assemblage of waterbirds. • Spawning of golden or silver perch in the Murrumbidgee River does not appear to be translating to recruitment for either of these species. As stocking of silver perch does not occur in the Murrumbidgee and golden perch stocking is thought to contribute to ~14 per cent of the golden perch population the Narrandera zone, it can be assumed that the population is comprised of wild adults that spawned and recruited locally. Poor young of year recruitment response has also been exhibited by Murray cod, with abundance of juveniles being considerably lower in 2018-19 compared with 2014-15 and 2015-16, but similar to those recorded in 2016-17. The drivers of successful recruitment, the key locations which support juveniles and the causes for the recent failures in recruitment remain unknown. • Since monitoring commenced in 2014, there has been little evidence to suggest that managing discrete flow peaks within the monitored reaches of the mid-Murrumbidgee influenced native fish spawning. This might be in part due to the already higher water flows occurring in the mid-Murrumbidgee compared to other parts of the river, with irrigation deliveries creating conditions suitable for spawning throughout the breeding season. • Wetland native fish species diversity was highest in wetlands that have an area of permanent water, including Avalon swamp, Telephone Creek and Waugorah Lagoon.
Frogs	• Breeding of many frog species, including the southern bell frog (EPBC Act vulnerable), is triggered by rising water levels in wetlands during October and November. Therefore, watering actions in early spring are important to enhance frog breeding activity and recruitment.

Theme	Lesson learned
	• Southern bell frog numbers, particularly in the Lowbidgee wetlands, have increased steadily in response to environmental water actions over the Murrumbidgee Selected Area since monitoring commenced. Nap Nap and Eulimbah swamps are key refuge habitats for the threatened southern bell frog and maintaining these sites is important for the long-term recovery of this species.
Turtles	• Maintaining the availability of permanent water holes, particularly at Telephone Creek and Wagourah Lagoon, is important to support high turtle numbers.
Waterbirds	• Higher waterbird species richness and abundance has been observed at sites that were inundated by water for the environment in the last five years compared to wetlands that were dry for extended periods. • Where possible, Commonwealth environmental water should be prioritised to provide annual seasonally-inundated habitat (spring-summer) for waterbirds in the Lowbidgee floodplain and mid-Murrumbidgee wetlands. • Most waterbirds commence breeding in spring, however, the stimuli for breeding is usually a combination of season, rainfall and flooding. • When breeding occurs, water levels in active sites need to be maintained into summer months to ensure the successful fledging of young birds. • In the years following large-sale flooding events, provision of environmental water is likely to be extremely important in creating feeding habitat to support survival of young birds. • When there is limited natural overbank flooding, inundating floodplain habitat to create foraging habitat would benefit waterbird populations in the Murray-Darling Basin by promoting the survival of juvenile and adult waterbirds.
Vegetation	• Despite the wide range of hydrological regimes and geomorphologies of wetlands in the Murrumbidgee, there is a clear trend that wetlands which have received environmental water more frequently over the past five years support higher species richness of water dependent vegetation species and lower numbers of exotic species. • River red gum encroachment remains a concern in the mid-Murrumbidgee wetlands, particularly at McKennas Lagoon. Given the current level of river red gum at this and other wetlands, mechanical removal coupled with repeat inundation over several years may be required for restoration.
Microinvertebrates	• Higher river levels and cooler temperatures in the Narrandera zone may impact the development of a productive and diverse microinvertebrate community. Environmental flows that inundate dried sediments without creating stable high flows or colder water temperature may be important for maintaining high levels or riverine microinvertebrate density. • Watering actions that allow key wetlands to drawn down and temporarily dry out will contribute to maintaining microinvertebrate densities.
Processes Connectivity	• Rates of metabolism have remained relatively stable over the past five years despite considerable variability in flow volume. There seems to be little capacity for Commonwealth environmental water to have a significant influence on the rates of stream metabolism and nutrient availability via manipulation of water levels in the Murrumbidgee River within existing

Theme	Lesson learned
	capacity constraints under normal flow conditions. However, previous work has shown that managed return flows do have the capacity to influence riverine nutrient availability at local scales, as was the case of the Redbank return flows undertaken in 2014-15. • Broad-scale wetland reconnections and periods of low flow are necessary to promote resources for river food webs. Future planning of watering actions that allow for wetland reconnections either via managed return flows or by generating peaks in river height may assist with the mobilisation of carbon and nutrients from the floodplain to the river.
Water Quality	• Monitoring of weir pool stratification (the establishment of a thermocline, with warmer, oxygenated water above and cooler, low dissolved oxygen below) and hypoxic water management in the Lower Murrumbidgee River in 2019 showed that high temperatures and low flow conditions have the potential to adversely affect water quality. Mixing of the hypoxic bottom water with oxygenated surface water can result in low dissolved oxygen concentrations throughout the water column thereby potentially causing fish kills. Water quality can be improved and fish kills mitigated against by: ○ steadily increasing in-channel flows and gradually releasing hypoxic water from weirs, and ○ exporting hypoxic water from weirs onto the floodplain using existing regulators. • In the absence of Inter Valley Transfers during Summer, target end-of-system flow rates alone (under the Murrumbidgee Water Sharing Plan) are inadequate to maintain acceptable water quality thresholds for aquatic biota under extreme climatic conditions
Hydrology	• Water for the environment is the primary driver of ecological responses for water dependent species in the mid and lower Murrumbidgee floodplains. Maintaining core permanent refuge habitats and providing foraging opportunities for resident species should be a priority in all water years. In years of moderate and high water availability, inundation of larger, continuous areas of floodplain habitats that support breeding opportunities should continue to be a priority.
Operational	• During the delivery of water for the environment in Gayini Nimmie-Caira in 2019-20, it was identified that a section of the newly constructed water delivery infrastructure was unable to deliver flows at the expected rate modelled. As a result, the duration of flows needs to be extended (due to lower flow rates) to reach and inundate targeted sites downstream of this point. This will be considered when planning future deliveries using this infrastructure. • Removal of carp from a wetland prior to pumping, either through physical removal and/or short-term drying of the wetland, have shown to have positive benefits for frogs and vegetation. It is recommended that this management intervention be implemented when carp numbers increase and declines in vegetation and tadpole diversity become apparent.

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3.11 Victorian Rivers

3.11.1 Region overview

(a) River system

The Victorian rivers in the Murray-Darling Basin include the Goulburn-Broken, Campaspe, Loddon, Ovens and Wimmera catchments (Figure 5 and Figure 18). The northern Victorian rivers, particularly the Ovens and Goulburn-Broken, contribute significantly to the water resources of the River Murray, and 11.5 per cent of the Basin's stream flow originates in the Goulburn-Broken. Lake Eildon on the Goulburn River is one of the Basin's major water storages. The Wimmera River in central-west Victoria flows into a series of terminal lakes, including Hindmarsh and Albacutya and does not connect to the River Murray. The Victorian rivers region has a highly developed agricultural sector and a population of almost half a million people (DEPI 2015).

(b) Traditional Owners

Aboriginal people have had a long association with the river valleys of northern and central Victoria (MDBA 2020):

- The Ovens River catchment falls in the traditional lands of the Bangerang nation and neighbouring Taungurung and Yorta Yorta nations, to the south and west, respectively. The Waywurru nation is also located within the Ovens River valley.
- The Aboriginal people of the northern plains of the Goulburn and Broken catchments are the Yorta Yorta and Bangerang Nations. The Taungurung is the main Nation of people in the Broken River Valley and upper Goulburn Valley.
- West of the Campaspe River is the traditional land of the Dja Dja Wurrung Nation and east is the land of the Taungurung Nation. On the plains north of Rochester, the area is the traditional land of the Yorta Yorta and Bangerang Nations.
- Most of the Loddon catchment and the Avoca catchment is the traditional land of the Dja Dja Wurrung Aboriginal nation. On the floodplains, around Kerang and Kow Swamp, is the traditional land of the Barapa Barapa nation.
- The Wimmera catchment is large and diverse, and covers the traditional country of several Aboriginal Nations, including the Dja Dja Wurrung, Wotjobaluk and Wergaia in the mid and lower catchment. The north of the catchment, towards the River Murray, is the traditional lands of the Latji Latji, Tatti Tatti and Wamba Wamba Nations.

(c) Important sites and values

The northern Victorian Rivers are identified in the Basin-wide environmental watering strategy (MDBA 2019) as being important Basin environmental assets for native fish, including supporting threatened native fish species, high fish diversity, and as a fish refuge during dry periods. They create key native fish movement corridors and are recognised as priority sites for improving the core range of silver perch.

These rivers also support species and communities listed under the *Environment Protection and Biodiversity Conservation Act 1999*. Faunal species include Murray cod, Macquarie perch, trout cod, silver perch, Australasian bittern, swift parrot and the growling grass frog; vegetation includes rigid water milfoil and box-dominated grassy woodland communities.

The river system also supports bird species listed under international migratory species agreements (such as those agreements with Japan, China and the Republic of Korea, and the Bonn Convention), including the Caspian tern, glossy ibis and Latham's snipe.

Located at the terminus of the Wimmera system, Lake Albacutya Ramsar wetland represents the only internationally listed wetland along the northern Victorian river reaches, but only receives water in exceptionally wet years. Further, the Kerang Wetlands Ramsar site is located at the junction of three major floodplains associated with the Avoca, Loddon and Murray rivers, and is hydrologically linked to the Loddon River. Several sites are listed in the Directory of Important Wetlands in Australia including the Broken River, Upper Broken Creek, Lower Ovens River, Wimmera River, Lake Hindmarsh and Moodie Swamp.

The delivery of environmental water to the northern Victorian rivers also supports ecological values and outcomes in the River Murray valley. This can include Ramsar-listed wetlands such as Barmah Forest, Gunbower Forest, Hattah Lakes, and the Coorong, Lower Lakes and Murray Mouth.

(d) Partners and Stakeholder engagement

The planning, management and delivery of Commonwealth water for the environment throughout the northern Victorian valleys is undertaken in collaboration with a range of partners and stakeholder groups.

The implementation of watering actions within the Victorian rivers is coordinated by the Victorian Environmental Water Holder (VEWH) and managed by regional waterway managers including the Goulburn-Broken Catchment Management Authority (GBCMA), North Central Catchment Management Authority (NCCMA), North East Catchment Management Authority (NECMA) and Wimmera Catchment Management Authority (WCMA). Goulburn Murray Water (GMW) is the principal storage and water supply manager in northern Victorian catchments and is responsible for the day to day delivery of water (including environmental water) throughout its river systems and irrigation supply network. Grampians Wimmera Mallee Water (GWMW) is the storage and water supply manager for the Wimmera catchment.

Early input to the potential watering actions for 2020–21 was received via the Environmental Watering Advisory Group meetings organised and chaired by the North Central and Goulburn Broken Catchment Management Authorities. In addition to relevant government agencies, membership includes local land holders, irrigators and community members. The Yorta Yorta, Taungurung and Dja Dja Wurrung Nations are invited to contribute to the development of these actions, to embed cultural values and Traditional Owners ecological knowledge into environmental water management. Delivery partners and the Catchment Management Authorities attended workshops to review the 2019–20 watering events, including to identify any risks that arose, and discuss mitigating actions going into 2020–21. Feedback on draft versions of the plan was provided by the Victorian Environmental Water Holder and the Catchment Management Authorities and incorporated into the final version.

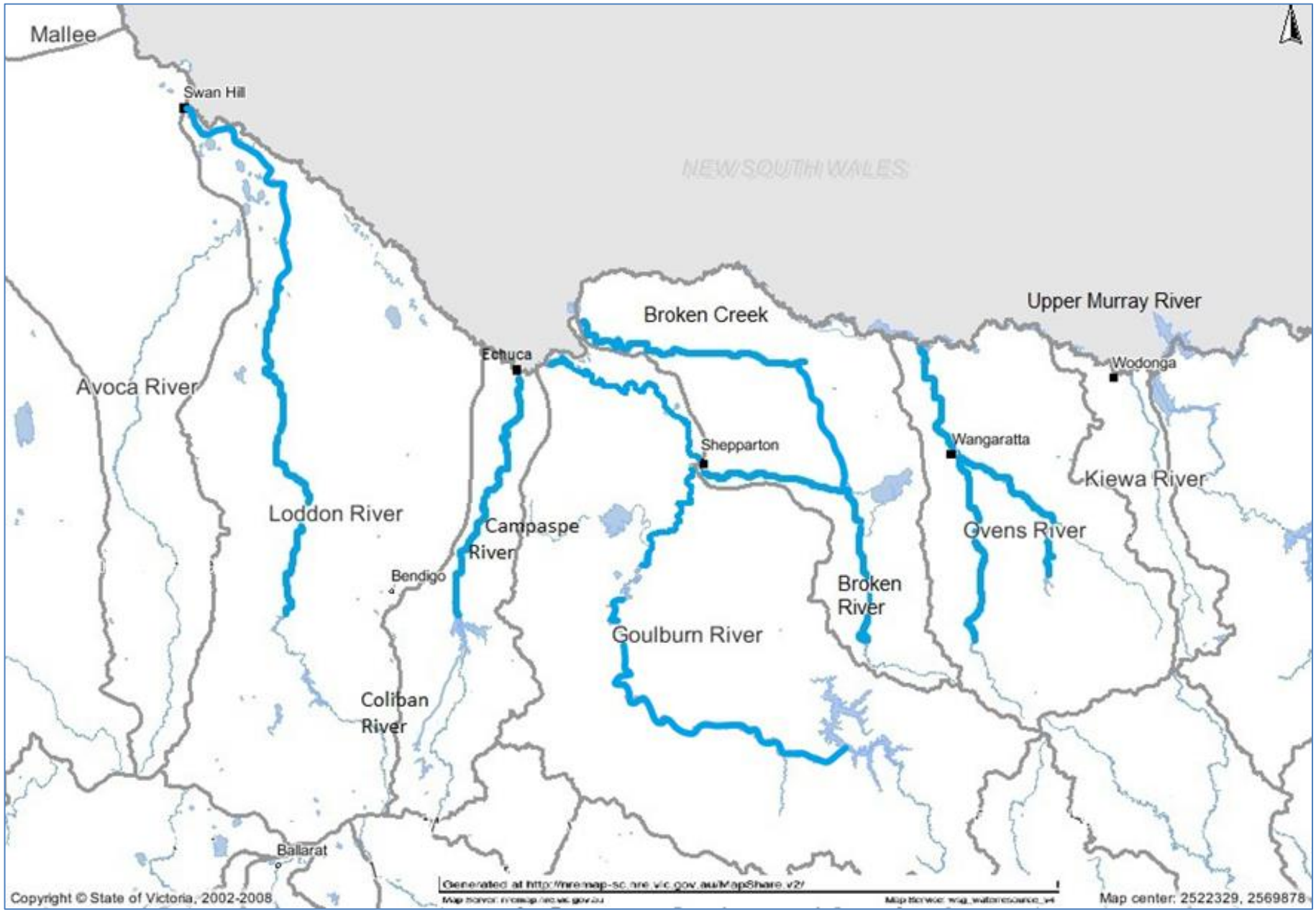

Figure 17: Map of the northern Victorian rivers described in this plan that flow to the River Murray.

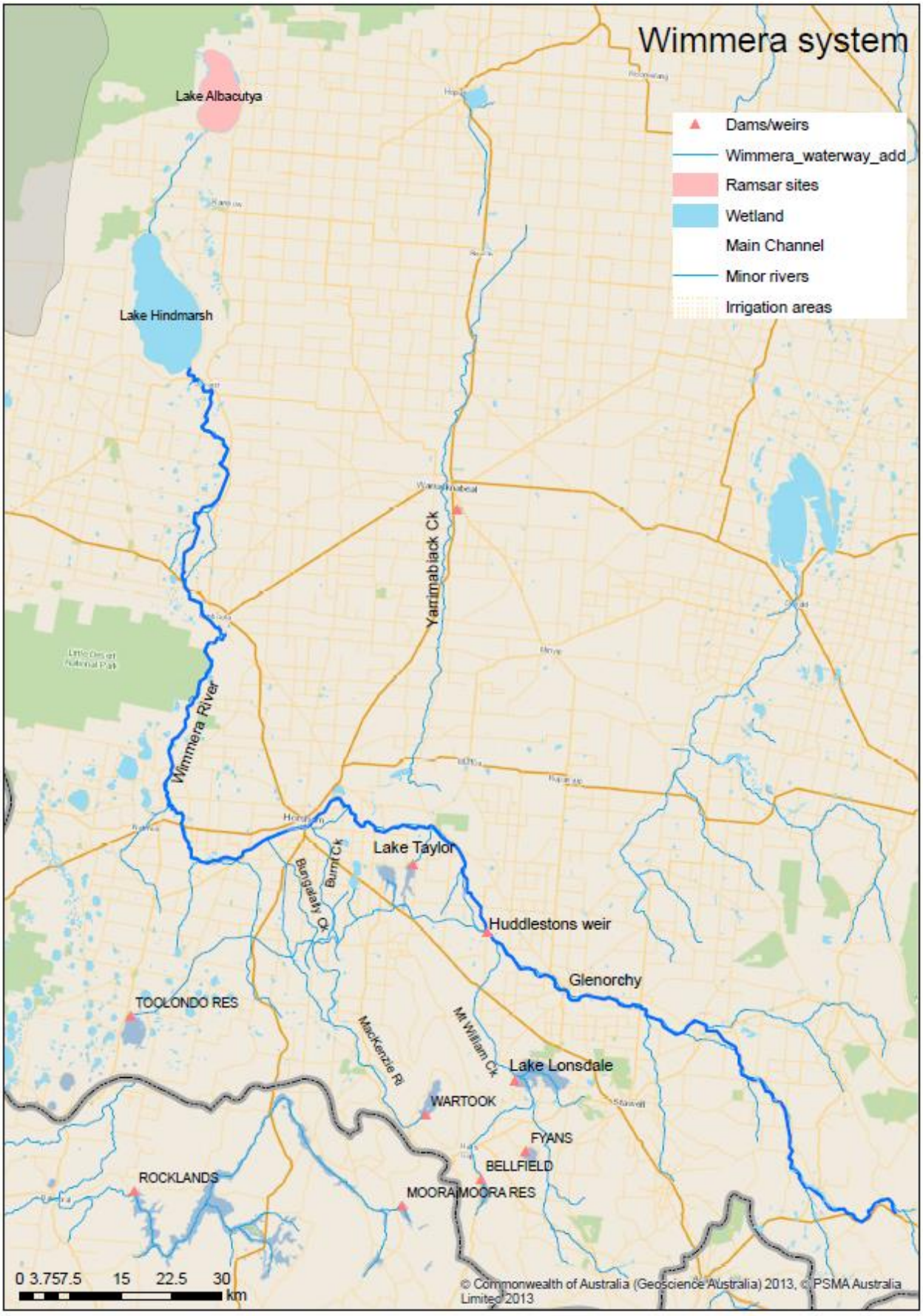

Figure 18: Map of the Victorian Wimmera System

3.11.2 Environmental objectives

The following objectives in Table 40 are relevant for environmental watering in Victorian Rivers. They are based on long-term environmental objectives in the Basin Plan, Victorian state government long-term watering plans for northern Victorian catchments, site management plans, and best available knowledge.

The objectives that are targeted in a particular year may vary, depending on available water, catchment conditions, operational feasibility, and demand for environmental water. These objectives will continue to be revised as part of the Commonwealth Environmental Water Office's (CEWO) commitment to adaptive management.

Table 40: Summary of objectives being targeted by environmental watering in the Victorian rivers

	In-Channel Assets Goulburn (lower and middle reaches), Broken, Campaspe, Loddon, Ovens and Wimmera rivers; Upper and lower Broken Creek	**Off-Channel Assets** Goulburn River wetlands; Lower Broken wetlands; Upper Broken Creek wetlands (Moodie Swamp); Ovens wetlands (Mullinmur Billabong)
Basin-wide Matters		
Vegetation	Maintain and improve riparian and in-channel vegetation cover, extent, condition and diversity. Increase periods of growth for inundation tolerant vegetation communities that closely fringe or occur within river channels.	Maintain the current extent, condition and diversity of water-dependent vegetation. Improve condition of black box, river red gum and lignum shrublands. Improve recruitment of trees within black box and river red gum communities.
Waterbirds	Provide habitat and food sources to support waterbird breeding, survival and recruitment, and maintain condition and current species diversity.	
		Support waterbird breeding, including brolga in Moodie Swamp
Fish	Provide flows to support habitat and food sources to promote increased movement, breeding, recruitment and survival of native fish. Improve abundance and maintain species richness. Provide native fish passage through fishways.	Provide flow cues to support habitat and food sources and promote increased movement, recruitment and survival of native fish (particularly for floodplain specialists).
Invertebrates	Provide habitat to support increased microinvertebrate and macroinvertebrate survival, diversity, abundance and condition.	
Other Vertebrates	Provide habitat and food sources to support survival, maintain condition and provide recruitment opportunities for frogs, turtles, platypus and native water rats (Rakali).	

	In-Channel Assets Goulburn (lower and middle reaches), Broken, Campaspe, Loddon, Ovens and Wimmera rivers; Upper and lower Broken Creek	Off-Channel Assets Goulburn River wetlands; Lower Broken wetlands; Upper Broken Creek wetlands (Moodie Swamp); Ovens wetlands (Mullinmur Billabong)
Basin-wide Matters		
Connectivity	Support longitudinal connectivity along Victorian rivers and to the River Murray for environmental functions such as nutrient and sediment transport, organism dispersal and water quality. Support lateral connectivity to low-lying wetlands and anabranches adjacent to river channel by increasing the frequency of freshes.	Support lateral connectivity (within operational limits) to wetlands and floodplains by contributing to an increase in the frequency of lowland floodplain flows.
Processes	Support primary productivity, sediment, nutrient and carbon transport and cycling; biotic dispersal/movement; and channel maintenance.	
Water Quality	Maintain water quality and provide refuge habitat from adverse water quality events (e.g. low dissolved oxygen, hypoxic blackwater and hypersalinity), including minimising accumulation of Azolla (aquatic plant) in lower Broken Creek to help maintain DO levels.	Support the transport of nutrients and carbon off the floodplain and into the river channel and downstream.
Resilience	Provide drought refuge habitat.	

3.11.3 First Nations Environmental Objectives

Advice on environmental water objectives in the Victorian Rivers has been provided by the Murray Lower Darling Rivers Indigenous Nations (MLDRIN) through the First Nations Environmental Water Guidance project.

Table **41** includes just some of the common objectives for the Victorian River catchments, selected as they were raised by two or more participating Nations for the region. It is important to note these objectives do not represent the detail, depth and complexity of Nations' localised water-related objectives.

Some of these objectives sit outside the scope of water for the environment to influence, while for others, the link between water for the environment and the site or issues is not well understood. Environmental flows will aim to contribute to identified objectives, where possible. The Commonwealth Environmental Water Office is committed to continuing to strengthen engagement with all Southern Basin First Nations to support those Nations to articulate objectives for water management.

Table 41: First Nations environmental water objectives for Victorian Rivers for 2020-21 (MLDRIN 2020)

Waterways and Places in Need of watering
Wetlands, Billabongs, Floodplains, Creeks, Major rivers, Campaspe River, Ramsar-listed wetlands, Baaka, Murray.
River Flows and Connectivity
Improve water quality, improve timing and seasonality of flows, Restore wetland hydrology, Improve river and or floodplain connectivity, Improve flows and quantity (rivers and general), Remove barriers and constraints, Improve tributary flows, Restore flows in degraded rivers.
Vegetation
Cumbungi, Medicinal plants (general)[i], Old Man Weed, River Red Gum, Black Box, Black Wattle[i]
Fish
Native fish (all), Murray Cod, Catfish, Yellowbelly, Blackfish, Macquarie Perch, Silver perch
Waterbirds
Brolga, Birds, Pelican
Other species
Turtles, Yabbies, Frogs (general), Platypus, Water Rat (Rakali), Murray Cray, Shrimp, Emu[i], Macroinvertebrates.

[i] Water for the environment targeting other environmental outcomes may influence this species or objective

3.11.4 Recent conditions and seasonal outlook

(a) Recent conditions and environmental water use

The health of the Victorian rivers in the Murray-Darling Basin reflect the climate conditions of the past 20 years. During this period there was prolonged drought conditions between 1997 and 2010. Since the Millennium Drought, three natural high river flow events have occurred (2010-11, 2012-13 and 2016-17) which provided overbank flooding and large flow volumes for many northern Victorian catchments. The years between the floods, and since the 2016 flood, have been moderate or dry. Environmental watering in northern Victoria has focused on supporting year-round baseflows along with higher in-channel flows (such as freshes) in winter and spring. This has contributed to positive ecological outcomes such as maintaining vegetation condition along riverbanks and riparian zones, improved water quality and providing habitat for water bugs and native fish. However, in the last three years large volumes of operational water have been delivered over the summer months in the Campaspe and Goulburn Rivers to meet the need of downstream users (known as inter-valley transfers). This has caused some erosion and damage to vegetation on the lower parts of the riverbanks in these catchments.

Ongoing dry conditions across the northern Victorian catchments mean that many of the sites continue to require water for the environment to maintain the ecological health of the waterways and have high demand, as outlined in Table 42.

Details of previous Commonwealth environmental use in Victorian Rivers are available at: http://www.environment.gov.au/water/cewo/catchment/northern-victorian-rivers/history.

(b) Seasonal outlook

According to the Bureau of Meteorology outlook (BoM 2020), across northern Victoria there is largely a 60-80 per cent chance of above median rainfall from June to August 2020.

While this forecast indicates that the severe dry conditions may ease somewhat, several months of above average rainfall are needed to see a recovery from the current long-term drought. Additionally, maximum temperatures are likely to remain slightly below average from June to August.

(c) Water availability

Allocations against Commonwealth water entitlements in the Victorian rivers are determined by the Victorian Government and will vary depending on inflows. The following forecasts in Table 42 are based on the best available information including state forecasts and historical inflow scenarios.

Table 42: Carryover and forecast allocation of Commonwealth environmental water for Victorian rivers in 2020-21

Valley	Carryover from 2019-20 (GL)	Forecasts of Commonwealth water allocations (including carryover) in 2020–21 (GL)	
		Very dry	Very wet
Goulburn	55.2	198.8	372.8
Upper Broken Creek and Broken River	0.1	0.1	0.5
Campaspe	0.4	0.7	7
Loddon	0	1.1	3.4
Ovens	0	0.1	0.1
Wimmera	0	0	0
Total – Southern-connected Basin[1]	267	821	1 829

(d) Environmental demands

Not all environmental demands can and will be met using held environmental water. Some demands are met by regulated water deliveries for consumptive purposes and inter-valley transfers, while others are met by large unregulated/natural flow events or are beyond what can be delivered within current operational limits. There may be opportunities for Basin State governments to relax these limits, which will improve the efficiency and/or effectiveness of environmental watering.

The environmental water demands for assets in Victorian Rivers in 2020-21 are represented in **Table 43**. Note that the capacity to contribute to these environmental demands is contingent on a substantial improvement in water availability in the catchment.

[1] Southern-connected Basin is the network of rivers that feed into the Murray River between the Hume Dam and the sea. This includes the Murray, Murrumbidgee, Lower Darling, Ovens, Goulburn-Broken, Campaspe and Loddon valleys.

Table 43: Environmental demands, priority for watering in 2020-21 and outlook for coming year in Victorian Rivers.

For northern Victorian Rivers a flow range is provided for each potential watering action. This allows for flexibility of delivery across the year depending on water availability which can range between Very Low, Low, Moderate, High and Very High. For example, volumes at the lower end of range and/or shorter duration during dry conditions and an increased magnitude and/or duration and/or additional freshes as resource availability increases. In all rivers it is aimed to have some flow all year-round, with no cease flow experienced.

The information in this table is consistent with the draft VEWH Seasonal Watering Plan (VEWH 2020) and the relevant CMA Seasonal Watering Proposals (GBCMA a-d 2020; NCCMA a, b 2020; NECMA 2020; WCMA 2020).

Environmental assets	Indicative demand (for all sources of water in the system		Watering History (from all sources of water)	2020-21		Implications for future demands
	Flow/Volume	Required Frequency (maximum dry interval)		Environmental demand for water	Potential Commonwealth environmental water contribution	Likely environmental demand in 2021-22 if watering occurred as planned in 2020-21
Goulburn River *reach 4 Goulburn Weir to Loch Garry; and reach 5 Loch Garry to the River Murray* • Native fish - Murray cod, trout cod, Macquarie perch, golden perch and fresh water catfish • Bank vegetation, especially littoral vegetation and river red gum trees that shade the river and provide: habitat for animals including the squirrel glider; carbon from fallen leaves; habitat for birds such as egrets, herons and cormorants. • Frogs also benefit from inundated vegetation at the edge of the river channel. • Waterbugs During the past two years very high volumes of intervalley transfer water has impacted on the planned deliver of e-water and this may continue during 2020-21 if dry conditions continue.	Low flow (all year) 500-940 ML/day to: provide slow shallow habitat for small-bodied fish and deep water habitat for large-bodied fish; submerge snags to provide habitat for fish, waterbugs and biofilm growth; maintain aquatic vegetation and water the root zone of vegetation on the lower bank; encourage the production of plankton for food; and disrupt biofilms and maintain water quality.	Annually with all levels of water availability	Minimum low flows have been delivered every year since the Millennium drought.	High	High priority for Commonwealth environmental water. However likely to be met by other water sources such as natural or operational flows for large parts of the year.	High
	At least one winter/spring fresh (July-Oct) >6 600 ML/day for 14 days for lower bank vegetation establishment and maintenance. Deliver using tributary flows where possible, rather than releases from Eildon. If there is no natural event then deliver as a managed event in Sept/Oct to inundate vegetation on benches and the lower banks to facilitate recruitment, sustain growth, and encourage flowering, seed development and distribution.	Annually except	An early spring flow was delivered in 2012-13, not delivered in 2013-14 and partially met during 2014-15 and 2015-16. Since then, LTIM has identified the early spring fresh as important to deliver each year. This demand has been met every year since 2016-17, including in 2019-20.	High	High priority for Commonwealth environmental water (likely to receive water even under a very low water resource availability)	High
	Spring/summer low flow (after a spring fresh) <1 000 ML/day for 5–6 weeks to allow newly grown plants to establish, provide bank stability and provide habitat for small-bodied fish and waterbugs.	Annually with all levels of water availability	This was partially achieved in 2019-20, the first year it was included as a flow requirement. IVT flows commenced four weeks into this period and exceeded the recommended flow.	This is a demand to not provide water above a given flow rate		High due to vegetation damage caused by prolonged IVT flows in previous years
	Spring/summer fresh (Nov/Dec) When possible, >6 600 for 1 day for native fish spawning. This will not be delivered if the spring/summer 5-6 weeks low flow for vegetation has not been achieved.	When conditions are suitable except with Very Low water availability	A late spring fresh was delivered from 2012–13 to 2014–15 but with dry conditions in 2015–16 it was not delivered. In 2016–17 fish spawning objectives were met by natural flows so the fresh was not delivered to protect low bank vegetation after prolonged periods of high natural flows. It was delivered in 2017–18 but not in 2018–19 and 2019–20 due to the need for a drying phase for bank vegetation ahead of expected higher summer operational flows.	High if a decision is made for the action to be delivered	High priority for Commonwealth environmental water if a decision is made for the action to be delivered	High

Environmental assets	Indicative demand (for all sources of water in the system		Watering History (from all sources of water)	2020-21		Implications for future demands
	Flow/Volume	Required Frequency (maximum dry interval)		Environmental demand for water	Potential Commonwealth environmental water contribution	Likely environmental demand in 2021-22 if watering occurred as planned in 2020-21
Goulburn River continued *(reaches 4 and 5)*	Summer/autumn low flows between pulses. Flows are not to exceed 1 000 ML/day for more than 20 consecutive days, with a minimum of 7 days between pulses. This is to maintain vegetation for more than one season, to provide bank stability and to ensure habitat for small-bodied fish and waterbugs. This flow is a trigger for the delivery of an autumn fresh – i.e. if this flow objective is not met, the autumn fresh) will not be delivered.	Annually with all levels of water availability	This objective has not been met since 2016.	This is a demand to not provide water above a given flow rate		High
	Autumn fresh (March/April) When possible >5 600 ML/day for 2 days to: encourage seed germination; reduce turbidity and mix water to improve water quality; flush fine sediment to encourage biofilm growth; and improve food and habitat for waterbugs. Note that delivery of the summer/autumn low flows between pulses is a trigger for this action.	Annually when possible and with all levels of water availability	This autumn fresh was delivered from 2012–13 to 2015–16. It was not delivered in 2016–17 or 2017–18 following the earlier fish attractant flow action in those years. This fresh was not delivered in 2018–19 due to the already high volumes delivered as intervalley transfers and in 2019–20 due to dry conditions and low water availability.	Moderate – this demand is only triggered under certain scenarios	Option to be considered only under certain conditions	Moderate
	Winter fresh (June/July 2021) Up to 15 000 ML/day* with more than 14 days above 6 600 ML/day †o: encourage bank vegetation; provide carbon (e.g. leaf litter) to the channel; and improve water quality and waterbug habitat. The winter fresh also has direct benefit for lamprey migration in South Australia if deliver to the Lower Lakes during July and/or August.	Annually except with Very Low water availability	The winter fresh was first delivered in 2014–15, then not delivered in 2015–16 due to low water availability. It was delivered in each year between 2016–17 and 2018–19 but not in 2019–20 due to low water availability.	Moderate	High priority for Commonwealth Environmental water, however this action may be met/partially met by natural flows	High
	Following natural flows (all year) Provide water for a slower recession or add pulses following natural cues/unregulated flows to minimise the risk of bank erosion and hypoxic blackwater. Recession flows are releases from Goulburn Weir to prevent damage to the lower bank for 3 000 ML/day and below in Summer/Autumn and 6 000 ML/day in Winter/Spring	When required	The delivery of environmental water to slow a recession occurred twice in 2019–20.	High when required	High priority for Commonwealth environmental water if triggered from natural inflow events – this could occur under any scenario	High when required
Goulburn River *reach 1 Lake Eildon to Goulburn Weir* • Native fish - Macquarie perch Only receives water when it is released from Lake Eildon	Spring/autumn/winter low flows (July–Sept and April–June). 400 ML/day at Eildon to maintain and improve the habitat of small bodied native fish and maintain existing aquatic vegetation and invertebrate communities.	Annually during the non-irrigation month with all levels of water availability	This low flow was delivered during the non-irrigation period each year between 2017–18 and 2019–2.	High	High priority for Commonwealth environmental water (likely to receive water even under a very low water resource availability)	High

* Note the peak flow achievable with environmental water under current operating rules is approximately 9 500 ML/d in the lower Goulburn. The full target flow of 15 000 ML/d can however be met with unregulated tributary inflows.

Environmental assets	Indicative demand (for all sources of water in the system		Watering History (from all sources of water)	2020-21		Implications for future demands
	Flow/Volume	Required Frequency (maximum dry interval)		Environmental demand for water	Potential Commonwealth environmental water contribution	Likely environmental demand in 2021-22 if watering occurred as planned in 2020-21
Lower Broken Creek *reach 4 Nathalia Weir to River Murray with en route benefit to reach 1 (Boosey Creek to Nine Mile Creek), reach 2 (Nine Mile Creek) and reach 3 (Broken Creek confluence with Nine Mile Creek to Nathalia Weir).* • Native fish – Murray cod, golden perch, silver perch, unspecked hardyhead and Murray-Darling rainbow fish • Platypus, turtles, water rat (Rakali) • Vegetation – box-dominated grassy woodland communities, river swamp wallaby-grass • Birds – Australian Bittern • Environmental demand requires water in addition to irrigation supply • Source of return flows for use downstream in the River Murray During the past two years very high volumes of intervalley transfer water has impacted on the planned delivery of environmental water and this may continue during 2020–21 if dry conditions continue.	Year-round low flow A minimum of 40 ML/day to allow fish ladders to remain open, enable native fish movement and provide minimum levels of habitat for platypus, water rat (rakali), fish, plants, waterbugs and turtles.	Annually with all levels of water availability	The year-round flow of 40 ML/day is considered the minimum requirement and has been met or partially achieved since 2011-12. Environmental water has been the main water source used to provide minimum low flows during the non-irrigation season, especially in dry years.	High	High during the non-irrigation season. Likely to be met by operational deliveries during the irrigation season.	High
	Year-round (during irrigation season) higher flows 300–450 ML/day delivered when required for operational purposes. These levels are not expected to cause negative ecological outcomes.		This flow has been partially achieved each year since 2011-12. In recent years, Inter-Valley Transfers and Murray Bypass flows have been the main water source contributing to higher flows during the irrigation season.	Moderate	Option to be considered for Commonwealth environmental water under a moderate to high water resource availability.	Moderate
	Year-round (during irrigation season) extended high flow (July to May) 100–250 ML/day 250 ML/day over spring and summer to help prevent Azolla accumulation and maintain dissolved oxygen (DO) levels, and reduced flow at other times to maintain instream habitat for native fish spawning and movement.	Annually if required with all levels of water availability	Extended high flows have been met or partially achieved since 2011-12 through a combination of environmental water and consumptive deliveries. In recent years, Inter-Valley Transfers and Murray Bypass flows have significantly contributed to the provision of extended high flows.	High	High priority for Commonwealth Environmental water, however this action may be partially met by operational flows	High
	Winter/spring freshes (July–Sept) Up to 3 actions of 300-450 ML/day for 1 to 2 weeks to flush Azolla blooms (if any) and to provide cues to trigger fish migration, spawning and dispersal.	Annually if required with all levels of resource availability water	Freshes have been met in most years since 2011-12 and partially achieved in others. Environmental water deliveries have contributed significantly to the provision of spring freshes. A late winter/spring fresh through environmental water delivery was not required in 2019-20 as Azolla levels remained low.	High when required	High priority for Commonwealth Environmental water, however this action may be met/partially met by natural flows	High
Goulburn-Broken catchment wetlands (Moodie Swamp) *Accessed via Gearys channel from reach 2; Waggarandall Weir to Reillys Weir* • Birds – Brolga • Native vegetation - cane grass and rigid water milfoil	Spring – a top-up if required to support bird breeding and plant growth/flowering Autumn – fill Delivery is to promote growth of cane grass to provide habitat for brolga nesting and for rigid water milfoil germination and growth.	Moodie Swamp maximum dry interval is 1 year for waterbirds and 3 years for vegetation	Environmental water has been delivered to Moodie Swamp each year between 2013–14 and 2017–18. No water was required in 2018–19 in 2019–20 natural flows partially filled the wetland.	High	High priority for Commonwealth Environmental water provided sufficient allocations available	Moderate

Environmental assets	Indicative demand (for all sources of water in the system		Watering History (from all sources of water)	2020-21		Implications for future demands
	Flow/Volume	Required Frequency (maximum dry interval)		Environmental demand for water	Potential Commonwealth environmental water contribution	Likely environmental demand in 2021-22 if watering occurred as planned in 2020-21
Upper Broken Creek *reach 1 Casey's Weir to Waggarandall Weir* • Native fish – carp gudgeon, Murray cod, golden perch, Murray-Darling rainbow fish • Vegetation – box riparian vegetation, remnant plains grassy woodland, buloke trees and rigid water milfoil • Platypus • Common long-necked turtle • Birds – brolga, Australasian bittern	Winter/spring low flows (June–Nov) Flows of 5 to 15 ML/day for around 30–70 days to maintain: pool habitat for native fish and waterbugs; access to food and habitat for platypus; and in-stream vegetation.	Annually with all levels of water availability	This flow was not met in 2013–14 and was partially met between 2014-15 and 2018-19. The flow was not met in 2019-20	High	High priority for Commonwealth environmental water (likely to receive water even under a very low water resource availability)	High
	Summer/autumn fresh (Dec–May) Up to 100 ML/day for around 10 days to maintain water quality, particularly dissolved oxygen levels in refuge pools.	Annually with all levels of water availability except Very Dry	No historic information is available. In 2018–19 and 2019–20 no water quality issues were identified that required the delivery of this fresh.	High	High priority for Commonwealth environmental water if required	High
	Summer/autumn low flows (Dec–May) Flow of 1–8 ML/day for around 60–120 days to maintain: pool habitat for native fish and waterbugs; access to food and habitat for platypus; and in-stream vegetation.	Annually with all levels of water availability	This flow was not met in 2013–14 and was partially met between 2014-15 and 2017–18. The flow was not met in 2018-19 and 2019-20.	High	High priority for Commonwealth environmental water (likely to receive water even under a very low water resource availability)	High
Broken River **Reach 1** • Native fish - Murray cod, golden perch, silver perch, Murray-Darling rainbow fish, Macquarie perch, river black fish and mountain galaxias • Vegetation – eel grass, common reed and water ribbon	Baseflow (all year) Flows of 5-25 ML/day for around 40–100 days to provide diverse habitat (riffles, slackwater, pools) for native fish, aquatic plants, platypus and waterbugs; support in-stream and fringing aquatic plants; and prevent terrestrial plants growing on the river bed.	Annually with all levels of water availability	Natural flows and consumptive water have met/partially met this flow target since 2010-11, except in 2019–20 when banked water was used in addition to operational flows. In accordance with the Broken System BE, between May and December 2019 the GB CMA and GMW agreed to reduce the passing flow requirement below Lake Nillahcootie from 30 ML/day or natural to 15 ML/day or natural and banked inflows above 15 ML/day. This action was undertaken to ensure sufficient water was available to maintain minimum baseflow requirements in the Broken River throughout the season. A total of 1425 ML of water was banked.	Moderate	May be met by other means	Moderate
	Summer/autumn fresh (Dec–May). 400–500 ML/day for 2 to 5 days with rates of rise and fall and a base flow of 30 ML/day to: maintain aquatic vegetation; provide native fish passage; scour sediments from hard surfaces to increase productivity and biofilms; and provide flow cues for native fish breeding and migration.	Annually with all levels of water availability except Very Dry	This target had not been met until 2017–18 when it was achieved by natural flows. In 2018-19 it as partially met when VEWH water was added to operational flows. This demand was partially met in 2019–20 from unregulated flows	Moderate	May be met by other means	Moderate

Environmental assets	Indicative demand (for all sources of water in the system		Watering History (from all sources of water)	2020-21		Implications for future demands
	Flow/Volume	Required Frequency (maximum dry interval)		Environmental demand for water	Potential Commonwealth environmental water contribution	Likely environmental demand in 2021-22 if watering occurred as planned in 2020-21
Ovens River *reach 1 immediately below Lake Buffalo on the Ovens River; reach 2 immediately below Lake William Hovell on the King River; reach 4 Ovens River from the confluence of the Buffalo River to the confluence of the King River; reach 5 Ovens River downstream of the confluence of the King River to the Murray River; and Mullinmur wetland downstream of Wangaratta.* • Native fish – Murray cod, trout cod, golden perch, Macquarie perch and eel tailed catfish • Frogs – giant bullfrog and growling grass frog • Waterbirds – egrets, herons, cormorants and bitterns • Vegetation – river red gum forests and woodlands	Up to the total Commonwealth environmental water entitlement of 103 ML per year (50 ML from Lake William Hovell and 53 ML from Lake Buffalo) to contribute to in-stream flows within the Ovens, Kings and Buffalo rivers, for example: • Pulsed autumn fresh in conjunction with a bulk water transfer from Lake Buffalo to scour biofilms and maintain macroinvertebrate assemblage. • Increased summer/autumn baseflows if bulk water transfer is not available to improve flow variability and ensure connectivity between pools and riffles.	Annually with all levels of water availability	In 2014–15, 2015–16, 2017–18 and 2018–19 Commonwealth environmental water was released to supplement in-stream baseflows in the Buffalo and Ovens River. In all years Commonwealth environmental water was released to supplement in-stream baseflows in the King River. In 2011-12, 2012–13, 2013–14, 2016–17 and 2019-20 environmental water was delivered as part of a bulk release drawdown provided by Goulburn-Murray Water.	Moderate	High priority for Commonwealth environmental water, with releases to combine with natural or operational deliveries	Moderate
	Autumn fresh (March/April) >430 ML/day for 3 days in reaches 1 and 4, and 130–260 ML/day in reach 5 to: achieve connectivity between pools and stimulate native fish movement; improve water quality by mixing pools; provide small variations in river levels and flow to flush sediment from hard surfaces and scour biofilm; and maintain waterbug habitat.					
	Summer/autumn low flow (Dec–May) Provide a small increase in flow variability to support water quality, provide connections between pools and the maintenance of waterbug habitat.					
	Up to a total of 20 ML (from Lake Buffalo) of Commonwealth environmental water to contribute to Mullinmur wetland summer top-up (pumping) (Nov–Feb) Delivery to maintain water level, and to support aquatic vegetation and habitat for native eel-tailed catfish.	Annually with all levels of water availability except in a wet scenario	In 2019–20, 20 ML of Commonwealth environmental water was delivered to Mullinmur wetland. This supported the translocation of native eel-tailed catfish	Moderate	High priority for Commonwealth environmental water (likely to receive water even under a very low water resource availability)	Moderate

Environmental assets	Indicative demand (for <u>all sources of water</u> in the system		Watering History (from all sources of water)	2020-21		Implications for future demands
	Flow/Volume	Required Frequency (maximum dry interval)		Environmental demand for water	Potential Commonwealth environmental water contribution	Likely environmental demand in 2021-22 if watering occurred as planned in 2020-21
Campaspe River *reach 2 Eppalock to Campaspe Weir; reach 3 Campaspe Weir to Campaspe Siphon at Rochester; and reach 4 Campaspe Siphon to River Murray)* • Native fish - Murray cod, silver perch, golden perch, Murray-Darling rainbow fish and flat headed gudgeon • Platypus, native water rats (rakali), turtles and frogs • Bank and instream vegetation, especially mature river red gum trees that support terrestrial fauna, including the swift parrot and squirrel glider. • During the past three years very high volumes of intervalley transfer water has impacted on the planned deliver of environmental water and this may continue during 2020–21 if dry conditions continue.	Summer/autumn low flow (Dec-May) 10–50 ML/day to: maintain slackwater habitat for zooplankton and native fish; promote the growth of biofilms for water bugs and native fish; maintain water quality in deep pools; allow platypus to move between pools; and maintain in-stream vegetation along the channel edges.	Annually with all levels of water availability	These flow components have been delivered every year since 2012–13. During dry conditions all flows are delivered at the lower end of the flow ranges. Since 2017–18, annual intervalley transfers have exceeded the recommended summer low flows and freshes.	High	May be met by other means	High
	Winter/spring reduced low flow (June-Nov) 20–40 ML/day to maintain water quality and connectivity between pool refuges to: allow fish movement, facilitate male platypus movement during the breeding season; and provide habitat and food for female platypus prior to breeding.	Annually only in an extremely dry scenario		High	May be met by other means	High
	Winter/spring fresh (June-Nov) Up to 2 actions of 1 100–1 600 ML/day to maintain habitat connectivity for fish movement and possibly spawning; flush leaf litter to reduce the risk of blackwater events in summer; and maintain soil moisture for river red gum and woody shrubs	Annually, however with low water availability in extreme dry-dry scenarios the action is of lower priority		Moderate	High priority for Commonwealth environmental water (likely to receive water even under a very low water resource availability)	Moderate
	Winter/spring increased low flow (June–Nov) 70–200 ML/day to achieve the same objectives as for winter/spring low flows but with additional vegetation objectives. These include to: prevent terrestrial plants colonising lower sections of the banks; maintain soil water in the banks for river red gum and woody shrubs; and to help establish littoral vegetation.	Annually, however with low water availability in extreme dry-dry scenarios the action is of lower priority		Moderate	High priority for Commonwealth environmental water (likely to receive water even under a very low water resource availability)	Moderate
	Summer/autumn fresh (Dec-May) Up to 3 freshes of 100–200 ML/day to: promote local movement of adult fish to access new habitat; wet submerged wood and flush fine silt and old biofilm to promote new biofilm growth and increase waterbug mass; and encourage movement of juvenile platypus to find other habitat. When conditions are favourable, a fish attraction flow may also be delivered.	Annually, however with low water availability in extreme dry-dry scenarios the action is of lower priority		Moderate	May be met by other means	Moderate

Environmental assets	Indicative demand (for all sources of water in the system		Watering History (from all sources of water)	2020-21		Implications for future demands
	Flow/Volume	Required Frequency (maximum dry interval)		Environmental demand for water	Potential Commonwealth environmental water contribution	Likely environmental demand in 2021-22 if watering occurred as planned in 2020-21
Loddon River reach 4 Loddon Weir to Kerang Weir with en route benefit to reaches 1 to 3 storage reservoirs to Loddon Weir and to reach 5 downstream Kerang Weir. • Native fish - river blackfish, Murray-Darling rainbow fish and golden perch • vegetation – cane grass, tangled lignum, black box and river red gum • platypus • Water rat (rakali)	Winter/spring low flow (continuous June–Nov) 50–100 ML/day to: increase water depth for habitat and dispersal of fish; platypus and native water rat; prevent fine sediment settling on hard surfaces; and prevent terrestrial plant growth in the river channel.	Annually with all levels of water availability	The winter low flow has been delivered in every year since 2012–13 except for 2016–17 when it was partially achieved due to natural flooding causing water to be delivered at a higher rate and longer duration.	Moderate	May be met by other means	High
	Winter/spring high flow (Aug–Nov) 450- 750 ML/day for 6–10 days once a year to: provide flows through flood runners; trigger native fish movement and breeding; flush organic matter from banks and benches to increase productivity and reduce the risk of hypoxic blackwater in summer; scour accumulated sediment in pools; and increase wetted area for growth of bank vegetation.	Annually with all levels of water availability	The winter fresh was delivered in 2012–13 and between 2016–17 and 2019–20; it was partially delivered in 2013–14 and 2015–16.	High	High priority for Commonwealth environmental water (likely to receive water even under a very low water resource availability)	Moderate
	Summer/autumn low flows (continuous Dec–May) 25–50 ML/day to: maintain pool depth for waterbugs, fish, native water rats and aquatic plants; and provide continuous flows for water quality and bank vegetation.	Annually with all levels of water availability	The summer low flows have been delivered in every year since 2012–13.	High	May be met by other means	High
	Summer/autumn freshes (Dec-May) 50–100 ML/day for 3–4 days, up to 3 times/year to: flush fine sediment from hard surfaces; promote growth of fringing vegetation; reduce risk of hypoxic black water; and enable connectivity for fish and platypus movement.	Annually with all levels of water availability	The summer freshes have been delivered in every year since 2012–13, except in 2018–19 when it was partially achieved.	Moderate	High priority for Commonwealth environmental water (likely to receive water even under a very low water resource availability)	Moderate
	Autumn high flow (March–May) 400 ML/day for 6–10 days, once a year, to trigger and facilitate upstream movement of golden perch, silver perch and Murray cod over one year of age and facilitate platypus dispersal.	Biannually with all levels of water availability except an extreme dry scenario	The autumn fresh has been partially achieved since 2013–14 and was fully delivered every year from 2017–18 and 2019–20.	Low	May be met by other means	Low

Environmental assets	Indicative demand (for all sources of water in the system		Watering History (from all sources of water)	2020-21		Implications for future demands
	Flow/Volume	Required Frequency (maximum dry interval)		Environmental demand for water	Potential Commonwealth environmental water contribution	Likely environmental demand in 2021-22 if watering occurred as planned in 2020-21
Serpentine Creek	Winter/spring low flow (June–Nov) 20–30 ML/day to: ensure depth to maintain biofilms and flow variability for bank vegetation; inundate exposed debris and vegetation to provide habitat for aquatic animals; maintain water quality by re-oxygenating pools; and maintain spawning habitat for native fish.	Annually with all levels of water availability	This flow was partially delivered in 2017–18 and not achieved in 2018–19 or 2019-20.	High	May be met by other means	High
	Winter/spring fresh (Aug–Nov) 40 ML/day for 2 days or 120-150 ML for 1 day once a year to: provide connectivity for fish and waterbug habitat; transport accumulated organic matter; and scour pools.	Annually with all levels of water availability	This fresh has been delivered every year since 2017–18.	Moderate	High priority for Commonwealth environmental water (likely to receive water even under a very low water resource availability)	Moderate
	Summer/autumn low flows (Dec–May) 10–20 ML/day to: provide flow variability and prevent notching; ensure connectivity between pools for fish; re-oxygenate pools to maintain water quality; maintain platypus habitat; and maintain aquatic environment for instream aquatic vegetation.	Annually with all levels of water availability	This flow was not delivered in 2017–18 and 2018–19; It was fully delivered in 2019-20.	High	High priority for Commonwealth environmental water (likely to receive water even under a very low water resource availability)	High
	Summer/autumn fresh (Dec–May) 30–40 ML/day for 1-3 days up to 4 times a year to: transport accumulated organic matter; maintain fringing vegetation and biofilms; and provide water to inundate benches and flush fine sediment.	Annually with all levels of water availability	These freshes were partially delivered in 2017–18 and 2018–19 and fully delivered in 2019-20.	Moderate	High priority for Commonwealth environmental water (likely to receive water even under a very low water resource availability)	Moderate
Wimmera System	Up to the total Commonwealth entitlement of 28 000 ML (low reliability water share) per year to contribute toward instream flows within the Wimmera River (baseflow and freshes), to support native riparian vegetation, native fish and waterbugs, and improve connectivity and water quality.	Annual	In 2016–17 the Commonwealth received its first and only allocation of 14 280 ML against this entitlement. Through careful management and carryover this water was progressively used (alongside VEWH water) throughout 2017 to early 2020 to support baseflows in the Wimmera system.	Critical	Low. The Commonwealth has no allocations or carryover currently available in the Wimmera. It will take significant inflows under a wet or very wet scenario before water becomes available to use	Critical

Key - potential watering in 2020-21

- High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)
- Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate - high water resource availability); or water demand likely to be met via other means
- Low priority for Commonwealth environmental watering (under high - very high water resource availability)
- Unable to provide Commonwealth water because of constraints or insufficient water

Key - environmental demands

- Critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
- High demand for water i.e. needed in that particular year
- Moderate demand for water i.e. water needed that particular year and/or next
- Low demand for water i.e. water generally not needed that particular year
- Very low demand for water i.e. water generally not needed that particular year or the following year

Note that demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime

3.11.5 Water delivery in 2020–21

In the northern Victorian rivers, the delivery of water for the environment in 2020-21 is contingent upon the volume of holdings and the available allocations for each catchment. Consistent with the demands and purpose identified in Table 3, and as water for the environment becomes available, the CEWO is considering supplying water for the environment to contribute to:

- baseflows and freshes in each river, as well as off channel wetland actions that support a range of environmental outcomes for plants and animals
- flows that are coordinated across the Southern-connected Basin, when conditions are conducive, to achieve identified ecological outcomes, for example, golden and silver perch migration
- enhancing ecological benefit from natural flows and when possible, intervalley transfer flows, for example, adding water to the peak or during the recession of the flow.

As in previous years, the use of Commonwealth, Victorian and The Living Murray water will be adaptively managed together throughout 2020-21, in response to changing water resource availability and environmental conditions and demands.

3.11.6 Monitoring and Lessons learned

(a) Monitoring

The CEWO's Long Term Intervention Monitoring Project (LTIM) in the Goulburn River has identified a number of key environmental outcomes associated with the use of environmental water in the Goulburn River over the period 2014-15 to 2018-19. This work is being continued through the CEWO's Monitoring, Evaluation and Research (MER) program from 2019-20 to 2021-22. Both LTIM and MER complement the Victorian Environmental Flow Monitoring Assessment Program (VEFMAP), which examines the effect of water for the environment along 13 Victorian Rivers.

(b) Lessons learned

Outcomes from monitoring and lessons learned in previous years are a critical component for the effective and efficient use of Commonwealth water for the environment. These learnings are incorporated into the way environmental water is managed. Key findings from the LTIM (Webb et al. 2020) and VEFMAP (VEFMAP 2018) projects are summarised in **Table 44**.

Table 44: Key outcomes and lessons learned in Victorian Rivers

Theme	Outcomes and lesson learned
Native fish	*Goulburn River* • Improved habitat for larger native fish by providing flows that increase the depth and area of the larger pools where they live. • Golden perch spawning may occur after higher flows when water temperature is over 18°C. • Improved habitat for small-bodied fish with flows that increase areas of slow-flowing water. • Higher autumn flows can support upstream movement of golden and silver perch from the Murray River into the Goulburn and Campaspe Rivers. • Spawning by endangered trout cod in the last three years (2017–2019), shows that breeding populations exist in the river. • Although recruitment for golden perch is low, the Goulburn River is a source of fish for the Murray River.

Theme	Outcomes and lesson learned
	Campaspe • Murray River rainbow fish, previously thought lost to the Campaspe system, observed at many sites and in abundance downstream of Elmore in reach 2. • Good numbers of Murray cod young-of-year. This may be a result of the 2019 winter high flow event, or reduced impact of intervalley transfers, due to smaller magnitude compared to previous years. *Loddon* • Combined Pyramid-Loddon spring fresh enhanced fish movement and populations in the Loddon River and Pyramid Creek. *Wimmera* • Fish monitoring in autumn 2018 showed that populations of small-bodied native fish have been maintained in all reaches of the Wimmera catchment that received environmental flows. *Lower Broken Creek* • the delivery of minimum low flows during the off-irrigation season provided habitat and instream refuge areas, especially important for young-of-year fish and for fish movement when fish ladders can remain open.
Macroinvertebrates	*Goulburn* • Improved habitat for large water bugs (insects, snails, shrimp) with flows that increase areas of slow-flowing water. • Increased habitat for populations of prawns during high winter flows, providing food for fish during spring.
Connectivity	*Goulburn* • Increased food (organic carbon) availability for fish and large water bugs by providing high flows in winter and spring that maintain a healthy balance between the organic carbon that is produced and consumed in the river. • Stream metabolism (the amounts of carbon created and consumed each day) increases with increasing in-channel flows up to around 4 000 ML/d. This represents a benefit to the total food resources produced for fish and other organisms, especially at small flow increases. However, it is still suggested that larger flows that inundate flood runners and parts of the floodplain would provide even greater benefits.
Vegetation	*Goulburn* • Increased plant cover on the river bank by providing flows that increase soil moisture, reduce erosion, and provide areas of low flow that favour seed and sediment deposition and plant establishment. • Renewal of bank and in-channel vegetation following deposition of sediment and seed when river banks are submerged during high flows over winter. • Very high intervalley transfer flows affected the presence of shallow water near the banks, potentially reducing the availability of suitable habitat for juvenile fish; it can also drown lower bank vegetation.

Theme	Outcomes and lesson learned
	Lower Broken Creek • the minimum low flows over winter retained water in the main creek channel and inundated the instream aquatic plants present.
Bank condition	*Goulburn* • Current environmental flows do not cause more erosion than would occur under natural flows • Notching of the lower bank has been observed where high IVT flows were delivered at constant levels over summer.

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3.12 River Murray Valley

3.12.1 Region overview

(a) River valley

The River Murray is Australia's longest river, running a course of 2,500 km from near Mount Kosciuszko in the Australian Alps to the Southern Ocean at Goolwa, in South Australia. A mountain stream in its upper reaches, the river turns into a meandering river lined with magnificent river red gum forests and woodlands, before ending its journey flowing through the vast Lower Lakes and northern edges of the Coorong, and out through the small Murray Mouth. Many creeks and anabranches flow in and out of the River Murray, the largest being the Edward/Kolety-Wakool River system.

Water for the environment, managed by the Commonwealth can be ordered for delivery to sites downstream of Hume Dam, near Albury, with water also supplied from Lake Victoria (west of Wentworth) and from its various tributaries, including from the Goulburn, Ovens, Kiewa, Loddon and Campaspe rivers in Victoria, and by the Murrumbidgee and Darling rivers in NSW. (Figures 1 and 2). The Ovens and Kiewa Rivers are particularly valuable to the ecology of the River Murray given their limited regulation, which means they provide natural inflows into the River Murray.

(b) Traditional Owners

The River Murray flows through the traditional land of many First Nations and the river and its floodplains have long been important for sustenance and spirituality (MDBA 2020).

The upper Murray catchment includes the traditional land of the Dhudhuroa, Djilamatang, Ngarigo, Walgalu and Yaitmathang Aboriginal Nations.

The Aboriginal Nations associated with the mid-Murray planning area include the Wiradjuri, extending from the River Murray to the Macquarie River in the north, and west to Balranald. The east, from the Murray and south into the Great Dividing Range, is the traditional land of the Dhudhuroa and Waywurru Nations. The region centred on Echuca, is the traditional land of the Barapa Barapa/Perepa Perepa, Wamba Wamba/Wemba Wemba and Yorta Yorta Nations. The lower stretch of the central Murray catchment includes the traditional land of the Barkindji, Maraura, Muthi Muthi, Nyeri Nyeri, Tati Tati, Wadi Wadi and Weki Weki Nations.

The Aboriginal Nations associated with land around the confluence of the Darling and Murray rivers include the Barkindji, Maraura, Muthi Muthi and Nyeri Nyeri. Upstream of the confluence of the Darling and Murray includes the land of the Barkindji and Maraura nations. Along the River Murray, from about Mildura and into South Australia is also the traditional land of the Ngintait Nation. The land of the lower reaches of the Murray, the Lakes and the Coorong is the traditional land of the Ngarrindjeri nation. The land west of the river and including the Mount Lofty Ranges, includes the country of the Kaurna and Peramanok Nations.

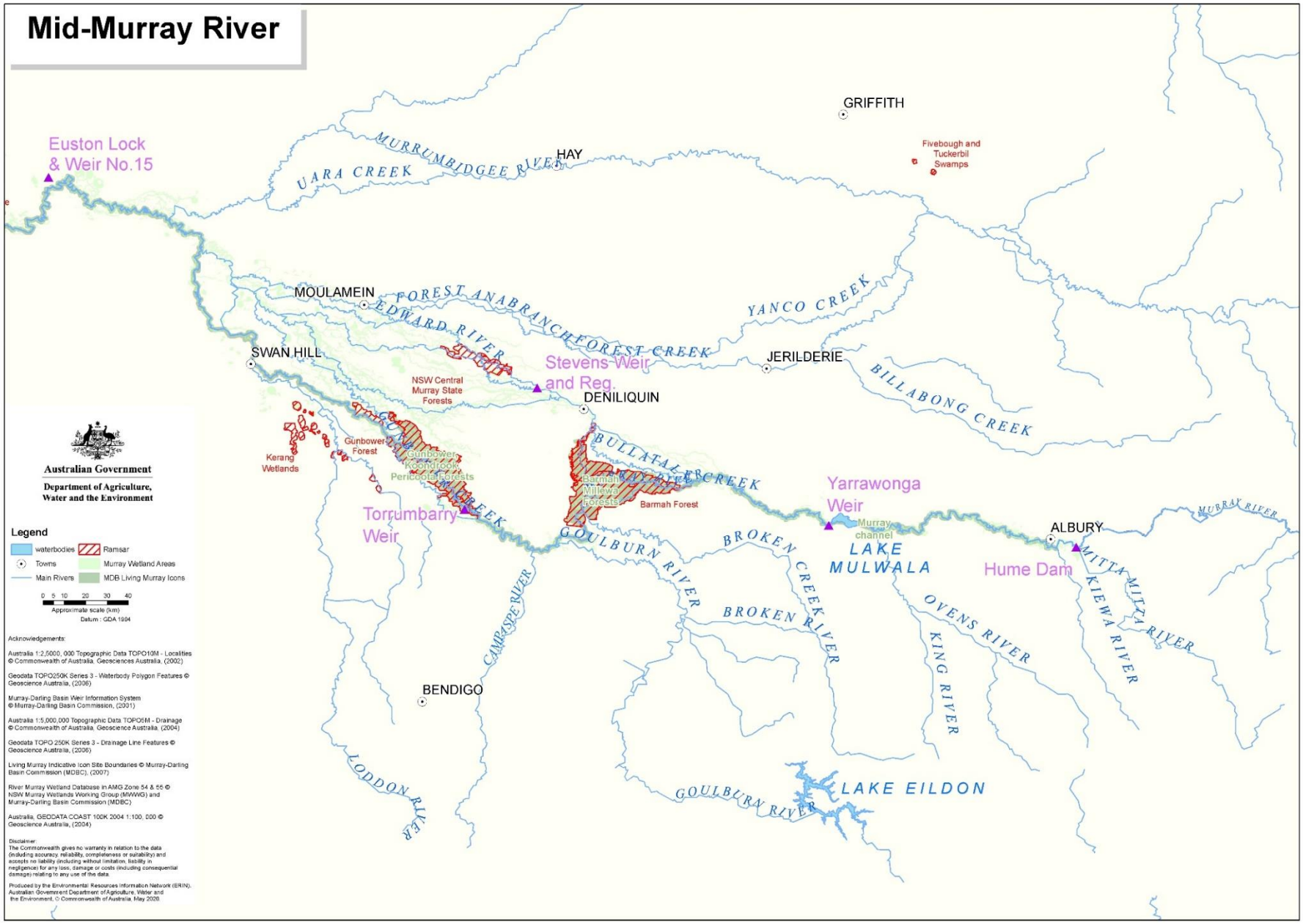

Figure 19: Map of the mid-Murray River valley, including the Edward/Kolety-Wakool river system.

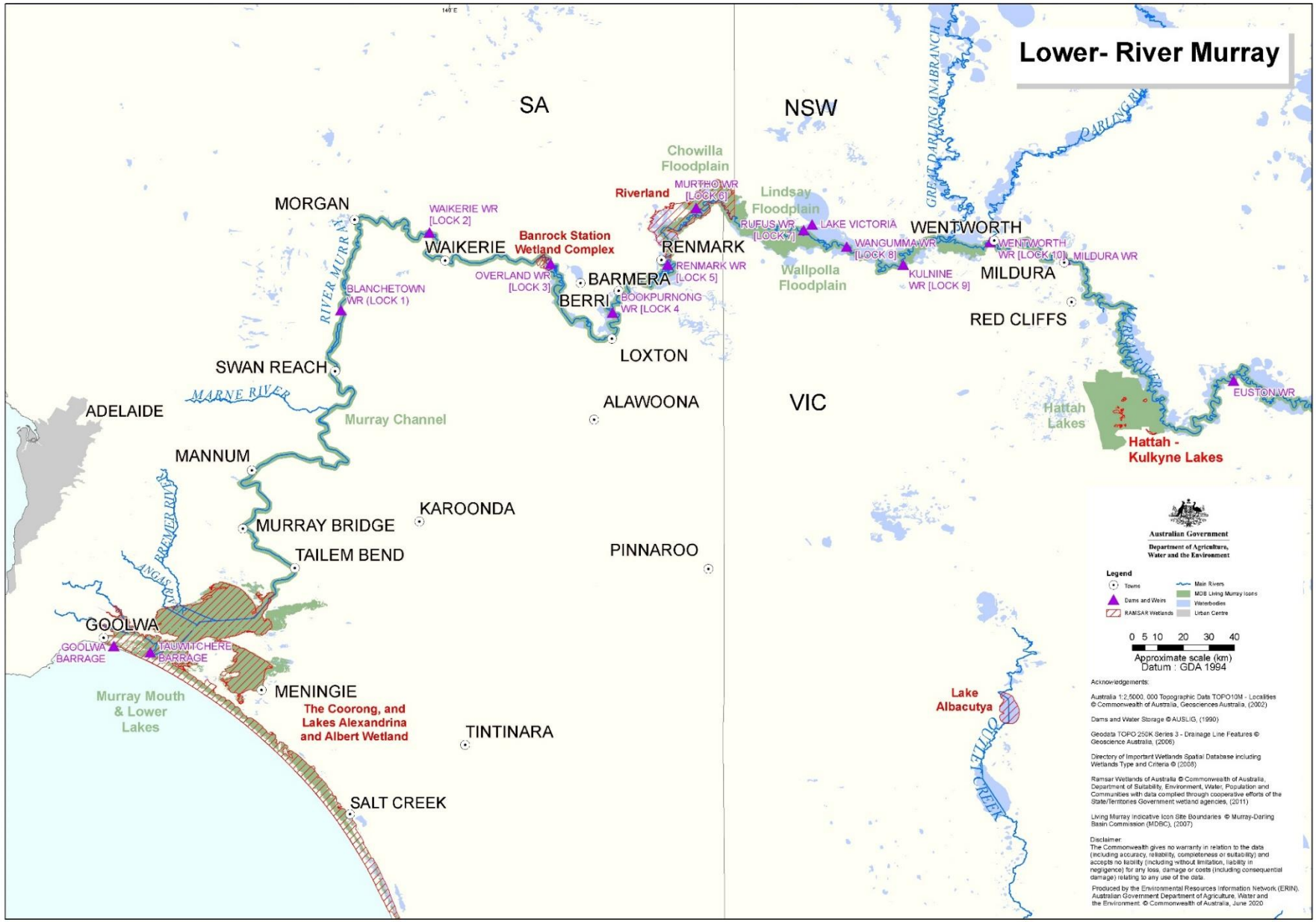

Figure 20: Map of the Lower-River Murray valley

(c) Important sites and values

The River Murray valley supports a range of environmental values of local, regional, national and international significance. Examples include:

Vegetation

Over 90 000 ha of river red gum and over 40 000 ha of black box and extensive lignum shrublands, including the vast river red gum forests of the Mid-Murray (Barmah-Millewa, Gunbower, Koondrook-Perricoota and Werai Forests). Together these comprise the largest complex of tree dominated floodplain wetlands in southern Australia and Australia's largest parcel of river red gum forests). The mid-Murray also comprises the woodlands of the Lower Murray (Hattah-Kulkyne Lakes, Lindsay-Mulcra-Chowilla Floodplain) and lignum shrublands. There are also important non-woody vegetation communities including the Moira grasslands in the Barmah-Millewa Forest and *Ruppia tuberosa* in the Coorong.

Native Fish

The River Murray, along with its anabranches, creeks and wetlands, provide habitat for a suite of native fish, including nationally listed threatened species, such as Murray cod, trout cod, silver perch and Murray hardyhead. The creeks through Barmah-Millewa Forest, the Edward/Kolety-Wakool system and Gunbower Creek (in the Mid-Murray) and the Lindsay-Mullaroo Creek system, Chowilla floodplain, Katarapko and Pike creeks and anabranches (in the Lower Murray) are also important habitat for native fish. Several small wetlands in the Lower Murray, along with the Lower Lakes, support some of the last remaining wild populations of threatened small-bodied native fish, such as Southern purple-spotted gudgeon, Southern pygmy perch and Murray hardyhead.

The connection between the Murray Mouth, the Coorong and the Lower Lakes is a hot spot for native fish diversity, supporting marine, estuarine, freshwater and diadromous (live in both salt and freshwater) fish. This includes a range of recreational and commercial fish species such as black bream, greenback flounder, yellow-eye mullet, golden perch, and mulloway. Species like sandy sprat and small-mouthed hardyhead are also essential food sources for predatory fish and waterbirds in the region.

Birds

Floodplain ecosystems of the Murray-Darling Basin support a high diversity of migratory shore birds and waterbirds, as well as 108 species of floodplain dependent woodland birds. There are several wetlands for waterbirds recognised as having Basin-wide significance importance for waterbirds. These include the River Murray, Barmah-Millewa Forest (which includes wetlands that are significant to the nationally endangered Australasian Bittern), Gunbower-Koondrook-Pericoota Forest, Hattah Lakes, Chowilla-Lindsay-Wallpolla, Noora evaporation Basin, Pyap Lagoon, and the Lower Lakes and Coorong. The Coorong and Lakes Albert and Alexandrina comprise the most important site in the Basin for shorebirds and the seventh most important site in Australia. They also support the greatest waterbird species richness of the Murray–Darling Basin. In addition to waterbirds, the River Murray floodplain between Robinvale and Swan Reach has also been identified as highly important to the nationally vulnerable regent parrot.

Ramsar Wetlands

The River Murray region contains several internationally important Ramsar listed wetlands: Barmah Forest, Gunbower Forest, New South Wales Central Murray Forests (consisting of Millewa, Koondrook-Pericoota and Werai forests), Hattah-Kulkyne Lakes, the Riverland (including Chowilla floodplain), Banrock Station Wetland Complex and The Coorong, Lakes Alexandrina and Albert Wetland. These sites are recognised for their unique and diverse wetlands, support of species of conservation significance and biological diversity, their role in providing refuge during adverse conditions, and regularly supporting large numbers of waterbirds. This includes those listed under international migratory agreements. The significance of these sites is documented in the ecological character descriptions (http://www.environment.gov.au/cgi-bin/wetlands/alphablist.pl).

(d) Partners and Stakeholder engagement

Delivery Partners

The planning, management and delivery of Commonwealth water for the environment throughout the Murray valley is undertaken in collaboration with a range of partners and stakeholder groups.

All Commonwealth environmental water is coordinated with other government environmental water holders: NSW Department of Planning, Industry and Environment - Environment, Energy and Science (DPIE-EES), the Victorian Environmental Water Holder (VEWH), the South Australian Department of Environment and Water (SA DEW), and the Murray Darling Basin Authority (MDBA) in its role in coordinating The Living Murray programs. In most cases, the Commonwealth environmental water is transferred to these agencies, who are responsible for ordering this water for delivery. The primary coordination body is the Southern Connected Basin Environmental Watering Committee (SCBEWC), which includes representatives from each of the federal and state government environmental water holders, as well as representatives from the Murray Lower Darling Rivers Indigenous Nations. Managers of The Living Murray (TLM) icon sites provide annual watering proposals that are considered by the committee in planning and delivering water for the environment. As part of this process, the Indigenous Partnerships Program supports First Nations contribution to the planning and management of key sites and environmental watering activities.

In addition to the above organisations, the delivery of environmental water is also supported by and coordinated with:

- river operators (MDBA, WaterNSW, Goulburn-Murray Water, SA Water)
- irrigation corporations (Murray Irrigation Limited, Renmark Irrigation Trust)
- regional natural resource management agencies (North Central Catchment Management Authority, Goulburn-Broken Catchment Management Authority, North East Catchment Management Authority, Mallee Catchment Management Authority, NSW Murray Local Land Services, South Australian Murray-Darling Basin Natural Resource Management Board), NSW DPI Fisheries
- land managers (such as Parks Victoria, NSW National Parks and Wildlife Service and Forestry Corporation NSW)
- private organisations (Nature Foundation SA, Murray-Darling Wetlands Working Group, Banrock Station/Accolade Wines, Calperum Station/Australian Landscape Trust).

Stakeholder engagement

The Commonwealth Environmental Water Office (CEWO) plans for the use of water with input from and/or consultation from many partners. These include the delivery partners listed above, scientists engaged in monitoring the outcomes of Commonwealth environmental water use and various community groups and individuals.

There are several advisory groups that draw on the expertise and experience of community members to help inform our work. Advisory groups may include water managers, recreational fishers, landholders, First Nations groups, independent scientists, local government representatives and a variety of partner agencies. Key stakeholder advisory groups include:

- The CEWO's Edward-Wakool Environmental Water Reference Group
- The New South Wales Murray-Lower Darling Environmental Water Advisory Group
- Victorian Environmental Water Advisory Groups
- The Coorong, Lower Lakes and Murray Mouth Community Advisory Panel.

3.12.2 Environmental objectives

Table 45 sets out the objectives for environmental watering in the River Murray valley, based on long-term environmental objectives in the Basin Plan, draft state long-term watering plans, site management plans (including Ramsar site ecological character descriptions), and best available knowledge.

The objectives targeted in a particular year may vary depending on available water, catchment conditions, operational feasibility and demand for environmental water. These objectives will continue to be revised as part of the Commonwealth Environmental Water Office's commitment to adaptive management.

Table 45. Summary of objectives for environmental watering in the River Murray valley.

Basin-wide Matters	In-Channel Assets	Off-Channel Assets	End of System
Vegetation	• Maintain riparian and in channel vegetation condition. • Increase periods of growth for nonwoody vegetation communities that closely fringe or occur within river corridors.	• Maintain the current extent of floodplain vegetation near river channels and on low-lying areas of the floodplain, including Moira grass. • Improve condition of black box, river red gum and lignum shrublands. • Improve recruitment of trees within black box and river red gum communities. • Maintain and improve condition of wetland vegetation.	• Ensure survival and promote growth and recruitment of *Ruppia tuberosa* in the south lagoon of the Coorong. • Maintain or improve the diversity, condition and extent of aquatic and littoral vegetation at the Lower Lakes.
Waterbirds	• Provide habitat and food resources to support waterbird survival and recruitment and maintain condition and current species diversity.	• Provide habitat and food resources to support waterbird survival and recruitment and maintain condition and current species diversity. • Complete seasonally appropriate bird breeding events that are in danger of failing due to drying. • Support naturally triggered bird breeding events. • Provide habitat for migratory birds.	• Maintain habitat and food sources to support waterbird condition and populations within the Lower Lakes and Coorong lagoons (including curlew sandpiper, greenshank, red-necked stint and sharptailed sandpiper). • Complete seasonally appropriate colonial bird breeding events that are in danger of failing due to drying.

Basin-wide Matters	In-Channel Assets	Off-Channel Assets	End of System
Native Fish	• Provide flows to support habitat and food sources and promote increased movement, recruitment and survival/condition of native fish.	• Provide flow cues to promote increased movement, recruitment and survival/condition of native fish (particularly for floodplain specialists).	• Maintain or improve diversity, condition and population for fish populations (including estuarine-dependent and diadromous fish) through providing suitable habitat conditions within the Coorong lagoons and maintaining migration pathways that supports species recruitment and survival/condition. • Provide flow cues to promote increased movement, recruitment and survival/condition of native fish.
Invertebrates	• Provide habitat to support increased microinvertebrate and macroinvertebrate survival, diversity, abundance and condition.		
Other vertebrates	• Provide habitat to support survival, maintain condition and provide recruitment opportunities for frogs and turtles.		
Connectivity	• Maintain baseflows and increase overall flows in the River Murray. • Maintain longitudinal & lateral connectivity through contributing to an increase in the frequency of freshes, bankfull and lowland floodplain flows.	• Maintain latitudinal connectivity (within constraints) to wetlands, floodplains, creeks and anabranches by contributing an increase in the frequency of lowland floodplain flows.	• Improve the connection of the River Murray to the Coorong and the sea, through supporting increased barrage flows and Murray Mouth openness.
Processes **Water quality** **Resilience**	• Increase primary productivity, nutrient and carbon cycling, biotic dispersal and movement. Increase transport of organic matter, salt and nutrients downstream. • Maintain water quality and provide refuge habitat from adverse water quality events. Increase mobilisation and export of salt from the River Murray system. • Provide drought refuge habitat and maintenance/condition of native biota.		

Information sourced from: MDBA (2019); Department of the Environment (2011a and b); MDBA (2012a-i); DELWP (2015); Department of Environment, Water and Natural Resources (2015)

3.12.3 First Nations Environmental Objectives

Advice on environmental water objectives in the Murray River valley has been provided by the Murray Lower Darling Rivers Indigenous Nations (MLDRIN) through the First Nations Environmental Water Guidance project. Table **46**2 includes just some of the common objectives for the Murray River valley, selected as they were raised by 2 or more participating Nations for the region. It is important to note these objectives do not represent the detail, depth and complexity of Nations' localised water-related objectives.

Some of these objectives sit outside the scope of water for the environment to influence, while for others, the link between water for the environment and the site or issues is not well understood. Environmental flows will aim to contribute to identified objectives, where possible. The Commonwealth Environmental Water Holder is committed to continuing to strengthen engagement with all Southern Basin First Nations to support those Nations to articulate objectives for water management.

Table 46: First Nations environmental water objectives for the River Murray valley for 2020-21 (MLDRIN, 2020)

Waterways and Places in Need of watering
Wetlands, Billabongs, Floodplains, Other places - parks, forests, islands, Creeks, Major rivers, Tributaries, Baaka (Darling), Reedy Creek, Werai Forest, Billabong Creek, Edward River, Murray, Wakool River, Billabongs, Floodplains, Ramsar-listed wetlands.
River Flows and Connectivity
Improve water quality, Improve timing and seasonality of flows, Improve flows and quantity, Restore wetland hydrology, Remove barriers and constraints, Improve tributary flows, Restore flows in degraded rivers, Improve river and or floodplain connectivity.
Vegetation
Old Man Weed, Cumbungi, Lignum, Black Box, Grasses, Medicinal plants [i], Reeds and Rushes, Nardoo, River Red Gum.
Fish
Murray Cod, Catfish, Yellowbelly, Native fish (general)
Waterbirds
Pelican, Swan, Birds, Ducks, Sea eagle [i], Darters.
Other species
Turtles, Yabbies, Frogs, Shrimp, Platypus, Mussels, Water Rat, Murray Cray, Kangaroo[i], Emu[i], Macroinvertebrates.

[i] Water for the environment targeting other environmental outcomes may influence this species or objective

3.12.4 Recent conditions and seasonal outlook

(a) Recent conditions and environmental water use

The health of rivers, wetlands and floodplains, and the plants and animals they support, can be influenced by flows and conditions in the past. In some cases, this can date back many years, with parts of the environment still showing the effects of the Millennium Drought along with the more recent 2017–2020 drought.

Flows

Since the large-scale flooding of 2016-17, the River Murray has experienced three consecutive years of well-below average inflows. In 2019-20, River Murray inflows were less than half the long-term average of 8 870 gigalitres and within the driest 12 per cent of years since 1891. Without water for the environment, several critical off-channel waterways would have otherwise remained dry over this three-year period. Water

for the environment has supported variable flows in the River Murray, particularly in winter and spring, which are of critical importance to native fish populations. End-of-system flows have been solely dependent on water for the environment, which has accounted for 100 per cent of flows through the barrages since January 2018, and prevented the Lower Lakes dropping below the critical threshold of 0.4 m (a trigger for the planning phase of the Drought Emergency Framework).

The dry conditions since 2016-17 have been followed by above average rainfall over large parts of the southern Basin during early 2020. This was particularly evident during April and early May, with high rainfall in the catchments resulting in a rise in streamflow through the Mid-Murray region.

Vegetation

- Floodplain forests and woodlands:
    - The condition of river red gum forests at low elevation in the Mid-Murray (e.g. Barmah-Millewa and Gunbower Forests) has largely been maintained since the 2016-17 flood. Excellent red gum (and to a lesser extent, black box) tree canopy responding positively to environmental water delivery has been recorded (GB CMA 2020b, North Central CMA 2020). Due to dry conditions, woodlands at higher elevation and throughout Koondrook-Perricoota Forest, have shown declining health since the 2016-17 floods (New South Wales Forests 2020).
    - The internationally important Moira grass plains of Barmah-Millewa Forest have seen excellent growth during periods where water has been delivered and grazing pressure has been managed. Overall, the Moira grass plains are in good condition with the extent of coverage expected to increase with the addition of four new grazing exclusion fences in February 2020 (GB CMA 2020a).
    - Aquatic vegetation in wetlands that have received sufficient water is generally in good condition throughout the length of the River Murray. Instream aquatic native plants are slowly recovering in the Edward/Kolety-Wakool system after the 2016 flood (Watts et al. 2019). Similarly, the increased variability of weir pool levels has provided benefits for vegetation fringing the main river channel, anabranches and low-lying wetlands for several reaches of the River Murray (Ye et al. 2020, Gehrig 2018). Wetland vegetation condition in other locations, such as those more exposed to drought conditions, heat stress or grazing pressure, is poorer.
    - Further downstream, the condition of river red gum and black box woodlands such as at Hattah Lakes and Chowilla Floodplain has largely been maintained in areas where infrastructure has enabled the delivery of water (Mallee CMA 2020). In higher elevation sites where water has not been delivered, particularly at Chowilla, black box is showing signs of stress following three years of dry conditions (MDBA 2019).
- Coorong and Lower Lakes:
    - Fringing vegetation in Lower Lakes has become more diverse and the abundance of key taxa has increased over the past 3 years. This represents ongoing recovery from the millennium drought as the lakeside vegetation community re-establishes. Improvements have likely been driven by seasonally appropriate water levels varying between higher levels in spring (~0.85 m) and lower levels in autumn (~0.5 m) (Nicol et al. 2019, Nicol pers. comm.).
    - While monitoring indicates there has been little to no improvement in Ruppia distribution and abundance in the Coorong South Lagoon, some local community members are reporting that Ruppia abundance and distribution has increased in the southern part of Coorong North Lagoon and in certain areas in the South Lagoon (Glen Hill pers. comm., Jarrod Eaton, pers. comm.).

Native Fish

The 2016-17 flood was beneficial to wetland and floodplain vegetation and waterbird populations in many areas. However, the natural floods also generated a significant hypoxic blackwater event as organic material, accumulated by the lack of frequent, natural, flushing flows, was washed off the floodplain. While environmental flows were used to mitigate the impacts on native fish populations in some localities, the hypoxic blackwater still resulted in large-scale fish kills throughout the Mid-Murray and through parts of the

Lower Murray. There have since been mixed outcomes for fish species across the Murray system, however achieving sustained breeding success across the various key fish species remains a challenge.

- Fish species that occupy flowing river habitats and breed independently of particular flow events are perhaps the best faring native species across the Murray. Murray cod and trout cod have bred successfully in the Mid-Murray river channel during the spring and summer of most recent years (ARI, in prep., GB CMA 2020a, Raymond 2018). The Edward/Kolety-Wakool River systems continue to be a nursery area for Murray cod, with the species' population slowly recovering since the 2016 flood (Watts et al., 2018 and 2019). Similarly, in the Lower River Murray, Murray cod have successfully bred for six consecutive years following an extended period of unsuccessful breeding, considerably improving the structure of the Murray cod population in the Lower Murray (Ye et al. 2020).
- Iconic fish species that are dependent on a distinct flow 'pulse' during warmer spring or summer months for their breeding success, such as golden and silver perch, have bred in the Mid Murray (Raymond et al. in prep., GB CMA 2020a). In the Edward/Kolety-Wakool River systems, silver perch are benefitting from nursery habitat and winter flows that allow movement throughout the year (Watts et al. 2019). However, there has been a sustained lack of breeding success for golden perch in both the Edward/Kolety-Wakool and Lower River Murray areas for several years (Ye et al. 2020, Watts et al. 2019), which is a concerning trend.
- The condition of species that occupy floodplain wetland sites is variable, dependent on location. Overall this category of fish species has been heavily affected by reduced flows to floodplain wetland sites and introduced species, such as carp. For example, monitoring of the Lower Lakes in late 2018 failed to detect Yarra pygmy perch, which is now considered likely to be extinct in the Murray-Darling Basin (Wedderburn et al. 2019). However, there have been some success stories as a result of providing water for the environment.
    - Populations of the nationally endangered Murray hardyhead have been maintained at several locations, with two new populations established in recent years.
    - Increased variability in water levels in the Lower Lakes has benefited fringing and submergent vegetation (Nicol et al. 2019). In turn, small-bodied fish species have also demonstrated positive responses. Murray hardyhead have become more abundant and expanded in range after successful spawning and recruitment in the Lower Lakes in 2018-19 and 2019-20. For southern pygmy perch, high spring lake levels and improved submergent vegetation habitat have favoured spawning and some additional populations have been observed, however consecutive years with lake levels dropping to 0.5m have not supported strong recruitment or population recovery as preferred habitat is reduced at minimum (Wedderburn et al. 2019).
- Diadromous fish species spend portions of their life cycles partially in fresh water and partially in salt water. Water for the environment has been solely responsible for maintaining the connection between the River Murray and its estuary, the Coorong, for extended periods since the Millennium drought. This connection is having clear benefits for diadromous fish species.
    - For example, monitoring undertaken in the Lower Lakes in late spring 2019 recorded the native congolli as the most abundant fish species for the first time since surveys began in the mid 2000's. Congolli are a key part of the Coorong and Lower Lakes food web as a major prey item for larger predators including mulloway, pelicans, cormorants and golden perch, thus the high abundance of congolli is a strong positive indicator of available food resources for other species (DEW 2020).
    - Pouched lamprey has also been detected moving upstream during winter/spring for several consecutive years, and for the last two years short-headed lamprey were detected for the first time since 2006-07, suggesting that numbers of both species are gradually recovering (Bice et al. 2020).
- Outcomes for estuarine fish species in the Coorong have been variable, influenced by both the continuous connection between the lakes and the Coorong and low flows in ongoing drought conditions. Sustained connection has supported increasing abundances of congolli and common galaxias, which need connection but are not particularly flow dependent. On the other hand, while black bream spawned and recruited in early 2018 during a small flow pulse, barrage flows in late spring/summer 2018-19 and 2019-20 were comparatively low and recruitment has not been detected. (Ye et al. 2019, Ye pers. comm.

2020). Autumn 'pulsing' of flows from the barrages in line with tide and storm conditions has been linked to improvements in range and condition in commercial Coorong fish such as Coorong mullet (Glen Hill pers. comm. 2020).

Waterbirds

Basin scale monitoring of waterbirds in the Murray-Darling Basin indicates waterbird numbers are declining over the long term (since the 1980s). Waterbird breeding has generally been limited across the Murray system for several consecutive years. This may be due to a lack of natural breeding cues resulting from below average rainfall conditions through most of winter and spring, as well as limited foraging and nesting habitat availability and condition. Aerial waterbird surveys indicate a significant proportion of the waterbird breeding in the past two years in the Murray valley (and more broadly) has occurred at the Coorong and Lower Lakes (Kingsford et al. 2019).

Other notable points in relation to waterbirds in the Murray valley include:

- Barmah-Millewa Forest continues to provide a haven for bitterns, a species where survival is threatened by habitat loss, drought and fire (pers comms NSW NPWS, 2019). Up to twenty five percent of the estimated remaining population are thought to rely on use of the Barmah-Millewa wetlands (Belcher et al. 2018).
- The nationally vulnerable regent parrot has experienced a 12 per cent population decline in recent years due to a decline in river red gum health. Survey results from 2019-20 have shown a further decrease in nesting, but there are some indications that birds are moving into areas that are receiving environmental water as this is helping to maintain or restore tree condition (SA Regent Parrot Recovery Team, pers. comm.).
- The annual summer census of waterbirds in the Coorong and Lower Lakes observed low numbers of shorebirds including migratory waders, with many species having abundances below their long-term medians. Birds that were present were spending up to 80 percent of their time foraging, highlighting low food abundance within the mudflats, a consistent observation in recent years (Adrienne Rumbelow pers. comm. 2020, Paton et al. 2018).

Details of previous Commonwealth environmental use in the River Murray are available at:
http://www.environment.gov.au/water/cewo/catchment/mid-murray/history

http://www.environment.gov.au/water/cewo/catchment/lower-murray-darling/history

(b) Seasonal outlook

According to the Bureau of Meteorology outlook (BoM 2020), across the Murray River valley there is a 60 to 75 per cent chance of above median rainfall between July and September 2020.

While this forecast indicates that the severe dry conditions may ease somewhat, several months of above average rainfall are needed to see a recovery from the current long-term drought. Additionally, maximum temperatures are likely to remain slightly below average over the coming months.

(c) Water availability

The volume of Commonwealth environmental to be carried over in the River Murray valley for use in 2020-21 is 138 gigalitres. Total carryover in the Southern-connected Basin[1] is 267 gigalitres.

Allocations will vary depending on conditions. In the Murray, allocations against Commonwealth entitlements in 2020-21 could range from 498 gigalitres under very dry conditions, to 1 068 gigalitres in very wet conditions.

[1] Southern-connected Basin is the network of rivers that feed into the Murray River between the Hume Dam and the sea. This includes the Murray, Murrumbidgee, Lower Darling, Ovens, Goulburn-Broken, Campaspe and Loddon valleys.

(d) Environmental demands

While current and forecast conditions may signal improving conditions, years of drought conditions have had a significant impact on the environment. However, due to drought conditions in preceding years, there are several environmental demands that require water urgently in 2020-21. Without future significant rainfall and inflows to the system there is a need to avoid further damage to key assets through application of environmental water.

The environmental water demands for assets in the River Murray in 2020-21 are represented in Table 47, Table 48 and Table 49 below. Note that the capacity to contribute to many of these environmental demands is contingent on a substantial improvement in water availability in the catchment.

Looking across the demands for the Murray valley (identified in Table 4), they can be summarised as following:

- Critical environmental demand for water have been identified for ameliorating hypoxic conditions in the Edward/Kolety Wakool System, which has suffered from multiple hypoxic events in recent years.
- Critical environmental water demand for low level floodplain wetlands in South Australia that are suffering significant tree canopy cover loss and at risk of irretrievable damage.
- High environmental demands for water are generally related to sites/reaches that require frequent watering (an annual or biannual flow regime), for medium to high elevation floodplain wetlands that require larger but less often watering and end of system environments.
- Moderate environmental demands for water have been identified for both in-channel (large fresh) and floodplain wetlands that have recently had their requirements met through either natural floods or managed environmental deliveries.
- Low environmental demands for water were identified at floodplain wetlands sites that can be easily watered via environmental watering infrastructure (as these sites have been able to be watered in recent years).

Table 47. Environmental demands, priority for watering in 2020–21 and outlook for coming year in the Mid-Murray.

Environmental asset	Indicative demand (for all sources of water in the system)		Watering history	2020–21		Implications for future demands
	Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution?	Likely environmental demand in 2021–22 if watering occurred as planned in 2020–21
River Murray from Hume Dam to Euston and Barmah-Millewa Forest	2 000-5 000 ML/day at Yarrawonga Weir throughout the year for native fish habitat to improve recruitment and population structures, and water quality in main river channel and Barmah-Millewa creeks.	Annual	Continuous requirement, therefore the environmental demands has been assessed as High.	High	High priority for Commonwealth environmental watering (likely to receive water even under a very low water resource availability)	High
	Variable flows between 5 000 and 9 500ML/day at Yarrawonga Weir from July to November for fish condition, spawning, dispersal, in-channel non-woody vegetation and ecosystem function/productivity.	Annual	In-channel variability in 2018-19 was limited due to operational deliveries. Partially met in 2019-20.	High	High priority for Commonwealth environmental watering (likely to receive water even under a very low water resource availability)	Moderate
	Freshes 12 000-18 000 ML/day variable flow rate for at least 5 days, measured d/s Yarrawonga Weir during the period July to November for native fish habitat to improve recruitment and population structures (in-channel outcomes and anabranches) and for core wetlands, including Australasian bittern habitat. Would also provide carbon/productivity benefits to Edward/Kolety-Wakool system during the cooler time of the year.	5-10 in 10 years (2 years)	Has been met in 5 of the last 7 years. Therefore, the environmental demand has been assessed as Moderate.	Moderate	Option to be considered under a low to high water resource availability.	Moderate
	Small overbank of 12 000-15 000 ML/day for a minimum of 45 days measured d/s Yarrawonga between August to November, to improve recruitment and population structures (in-channel outcomes and giant rush wetlands). Would also provide carbon/productivity benefits to Edward/Kolety-Wakool system during the cooler time of the year.	4-8 in 10 years (2 years)	Has been met or partially met in 4 of the last 7 years. Therefore, the environmental demands have been assessed as Moderate.	Moderate	Option to be considered under a moderate to high water resource availability.	Moderate
	> 25 000 ML/day at Yarrawonga Weir (unregulated flow) for at least 7 days (river red gum forest) and followed by flows of up to 18 000 ML/day or greater for three to five months targeting Moira grassland.	6-8 in 10 years (2-3 years) Annual (2 years) for Moira grass.	For river red gum, the target has been met or partially met 2 in 6 years. For Moira grass the target has been met fully 2 in 6 years. Not met since spring 2016. Therefore, the environmental demand has been assessed as High.	High	Reliant on large, unregulated flows. Commonwealth environmental water may extend the depth and duration of natural floods within current constraints (i.e. < 15 000 ML/day), subject to ecological need, water availability and assessment of risk and potential, adverse third-party impacts.	High
Gunbower Creek	Winter low flow and summer ramp down to support juvenile fish and maintain habitat connectivity during off-irrigation season: · Winter base flows (200 ML/day for 5 months).	Annually (1 year).	Met or partially met every year in the last 5 years. Watering required on an annual basis therefore the environmental demand has been assessed as High.	High	Priority for Commonwealth environmental watering (likely to receive water even under low water resource availability, subject to flow constraints)	High
	Spring pulse and stable summer flows for fish breeding: · Small fresh up to 400 ML/day in spring, reducing to 300 ML/day in summer.	Fish spawning fresh 2 in 3 years.	Met or partially met every year in the last 5 years. The environmental demand has been assessed as Moderate.	Moderate	Priority for Commonwealth environmental watering (likely to receive water even under low water resource availability, subject to flow constraints)	Moderate

Environmental asset	Indicative demand (for <u>all sources of water</u> in the system)			Watering history	2020–21		Implications for future demands
	Flow/Volume		Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution?	Likely environmental demand in 2021–22 if watering occurred as planned in 2020–21
Gunbower Forest	Small-moderate actions (~100-1 000 ML/day in late winter/early spring – duration dependant on inflow rate) targeting permanent and semi-permanent wetlands, or targeted infrastructure use at the sites.	Up to 2 500 ha via Gunbower Forest infrastructure.	6-9 in 10 years (2 years)	Significant watering action in 2014-15 and 2015-16 and natural flood event in 2016-17 inundated various parts of the Forest. Drying phase in 2017-18, with the exception of high value permanent wetlands. Watering action in 2018-19. Small throughflow event to targeted wetlands in 2019-20. Environmental demand has been assessed as High.	High	It is anticipated that demands in Gunbower Forest will be met by other water holders in 2020-21.	High
	Infrastructure delivery to Gunbower Forest targeting river red gum forest (~1 600 ML/day for 90 days in winter/spring)	Up to 4 700 ha via Gunbower Forest infrastructure.	6-7 in 10 years (3 years)	Met or partially met in 5 of the past 6 years. The environmental demand has been assessed as Moderate.	Moderate	It is anticipated that demands in Gunbower Forest will be met by other water holders in 2020-21.	High
Mid-Murray Off-Channel Wetlands and ephemeral creeks Hume to Euston	Infrastructure delivery targeting permanent off-channel wetlands.		Annually	Annual requirement therefore the environmental demand has been assessed as High.	High	High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)	High
	Infrastructure delivery targeting semi-permanent off-channel wetlands.		3-7 in 10 years (5 years).	Variable across sites with last natural watering event in 2016. Therefore, the environmental demand has been assessed as Moderate.	Moderate	Option to be considered under a moderate to high water resource availability.	High
	Infrastructure delivery targeting ephemeral off-channel wetlands.		1 in 5 years.	Variable across sites with last natural watering event in 2016. Therefore the environmental demand is Low overall.	Low	Option to be considered under a moderate to high water resource availability.	Moderate

Key - potential watering in 2020-21

- High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)
- Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate - high water resource availability); or water demand likely to be met via other means
- Low priority for Commonwealth environmental watering (under high - very high water resource availability)
- Unable to provide Commonwealth water because of constraints or insufficient water

Key - environmental demands

- Critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
- High demand for water i.e. needed in that particular year
- Moderate demand for water i.e. water needed that particular year and/or next
- Low demand for water i.e. water generally not needed that particular year
- Very low demand for water i.e. water generally not needed that particular year or the following year

Note that demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime

References for Table 47:

Murray and Barmah-Millewa Forest indicators adapted from Department of the Environment (2011b), MDBA (2012c).
Gunbower Creek indicators sourced from North Central CMA (2013; 2014b; 2015b; 2016b; 2017).
Gunbower-Koondrook-Perricoota Forest indicators adapted from MDBA (2012a), MDBA (2012 h and i) and Department of the Environment (2011a).
Mid Murray Off-Channel Wetlands and ephemeral creek indicators sourced from North Central CMA (2014a; 2015a; 2016a).

Table 48. Environmental demands, priority for watering in 2020–21 and outlook for coming year in the Edward/Kolety-Wakool River system. The majority of flows listed below will be synchronised with flows in the River Murray (Table 47 above).

Environmental assets	Indicative demand (for all sources of water in the system)		Watering history	2020-21		Implications for future demands
	Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution?	Likely environmental demand in 2021–22 if watering occurred as planned in 2020-21
Yallakool - Wakool Maintenance of native fish habitat and instream aquatic vegetation Longitudinal connectivity Fish spawning, recruitment and movement Nutrient cycling Water quality	~200 ML/day base flow for ~304 days during late winter to late Autumn (~61 GL). Note: winter base flows are a separate flow component and is included below.	Annual	Has been met 5 out of the past 5 years	Low	Likely to be met by operational flows except in a very dry year when CEW may be use to prevent system from being cut off subject to NSW Extreme Events Policy	Low
	~600 ML/day peak for 4 days pulse/fresh over 20 days in spring with gradual recession (~10 GL, includes ~200 ML/day base flow).	Annual	Has been met 5 out of the past 5 years	High	Priority for Commonwealth environmental water to continue ecosystem recovery	High
	~430 ML/day for 41 days to maintain minimum flow for fish nesting habitat, and inundation for aquatic vegetation growth (~17 GL in total, includes ~200 ML/day base flow)	Annual	Has been met 5 out of the past 5 years	High	Priority for Commonwealth environmental water to continue ecosystem recovery	High
	~600 ML/day peak for 4 days undertaken 1-3 times in late spring/early summer with a gradual recession at end of fish nesting period (~10.61 GL, includes ~200 ML/day base flow).	Annual	Has been met 2 out of the past 5 years	Moderate	Option to be considered under a moderate to high water resource availability.	Moderate
	~470 ML/day peak for 3 days over 25 days pulse/fresh in autumn with a gradual recession (~7.3 GL, includes ~200 ML/day base flow).	2 in 3 years (2 years)	Has been met 2 out of the past 5 years	Moderate	Option to be considered under a moderate to high water resource availability.	Moderate
	~170 ML/day winter base flow from early-May (irrigation shut down) until last week of July (system restarts) (~10 GL). Needs minimum of 4,000 ML/day at Yarrawonga to meet all Edward/Kolety system winter base flow requirements.	Annual	Has been met 2 out of the past 5 years.	High	Priority for Commonwealth environmental water to continue ecosystem recovery.	High
Colligen - Niemur As per Yallakool-Wakool above	The potential flow components for the Colligen-Niemur during 2020-21, and related assessment of demands & urgency of demands are like the flow components outlined for the Yallakool-Wakool above. The primary difference is that the flows planned for the Colligen-Niemur have been scaled to fit within its constraint for environmental flows of up to 450 ML/day.					
Edward/Kolety River downstream of Stevens Weir	Up to 2 700 ML/day (constraint downstream of Stevens Weir) spring-pulse (~15 GL). Will need to align with delivery of flows into Yallakool-Wakool and Colligen-Nimeur systems.	Annual	Has been met 5 out of the past 5 years.	Low	Likely to be met by operational flows	Low
Tuppal Creek	Spring pulse with variability flows during the year (~3 GL of CEW + ~3 GL NSW).	Annual	Has been met 5 out of the past 5 years	Moderate	Priority for Commonwealth environmental water to maintain ecosystem health - undertaken in partnership with NSW.	Moderate
Merran Creek	~ 460 ML/day preferably in spring and comprised of: Merran Creek at Franklings Bridge (~250 ML/day), Waddy Cutting (~150 ML/day) and St Helena Creek (~60 ML/day).	Annual	Has been met 5 out of the past 5 years	High	Priority for Commonwealth environmental water to continue ecosystem recovery.	High
Jimaringle, Cochrans and **Gwynnes Creeks**	Total flow of ~3 000 ML deliverable preferably in spring. May also require high flows in receiving Niemur system to dilute potential poor water quality outflows from these systems.	1 in 2 years (2 years)	Last significant flow was the 2016 flood event.	Moderate	Use of CEW in these systems suspended pending further advice from NSW re acid sulphate soils and salinity issues.	Moderate
Werai Forest	Flows greater than ~2 100 ML/day downstream of Stevens Weir (with forest regulators open) in late autumn-early spring when water temp is below 16 degrees (~15 GL). Will need to align with delivery of flows into Yallakool-Wakool and Colligen-Nimeur systems.	2-3 in 5 years (2 years)	Has been met 5 out of the past 5 years	Moderate	Use of CEW, including pumping, could be considered subject to stakeholder support, operational delivery infrastructure, third party impacts and accounting being addressed.	Moderate

Environmental assets	Indicative demand (for all sources of water in the system)		Watering history	2020-21		Implications for future demands
	Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution?	Likely environmental demand in 2021–22 if watering occurred as planned in 2020-21
Koondrook-Perricoota Forest	Annual watering proposals for this site are developed by Forestry NSW and can be contributed to by a number of water holders. Flow objectives may include maintaining habitat for aquatic vegetation, stimulate wetland vegetation response and the provision of carbon (productivity) during cooler times of the year.	2-3 in 5 years (2 years)	Has been met 1 in 5 years (minimum flow provided in 2019-20, similar to 2014-15 commissioning event).	High	Commonwealth environmental water could be considered in future years, subject to stakeholder support, third party impacts and return flows being addressed.	Hig-
Pollack Swamp	~2 GL per year watering proposals for pumping to this site during late spring and summer developed by Forestry NSW and DPIE. Flow objectives may include provide water to water stressed red gums, encourage the recruitment of terrestrial species (i.e. red gums and benefits to waterbirds and frogs) and aquatic flora (i.e. amphibious and mudflat).	Annual	Has been met 5 out of the past 5 years	High	Priority for Commonwealth environmental water to maintain ecosystem health - undertaken in partnership with NSW.	High
Edward/Kolety Wakool System – Recession Flows Maintenance of instream aquatic vegetation and native fish habitat	~15 GL within constraints to provide more natural recession flows off rain rejection and unregulated events in the system.	As required - usually triggered via advice from NSW agencies re anticipated flow rates in the system.	Has been met when required	Moderate	Commonwealth environmental water may be used to manage flow recessions associated with natural or rain-rejection events.	Moderate
Edward/Kolety Wakool System - Refuge Flows Habitat flows Water quality Provision of refuges for native fish	~30-120 GL a year to manage hypoxic water quality events and other critical habitat needs.	As required - usually triggered once dissolved oxygen levels reach 4.0 mg/l in line with Basin Plan water quality requirements.	Has been met when required	Critical once trigger is met	High priority for Commonwealth environmental water to abate the impact of potential fish kills if triggers are met.	Critical once trigger is met

Key - potential watering in 2020-21

- High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)
- Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate - high water resource availability); or water demand likely to be met via other means
- Low priority for Commonwealth environmental watering (under high - very high water resource availability)
- Unable to provide Commonwealth water because of constraints or insufficient water

Key - environmental demands

- Critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
- High demand for water i.e. needed in that particular year
- Moderate demand for water i.e. water needed that particular year and/or next
- Low demand for water i.e. water generally not needed that particular year
- Very low demand for water i.e. water generally not needed that particular year or the following year

Note that demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime

References for Table 48:

Edward-Wakool indicators compiled from multiple sources (Hale & SKM 2011; Watts et al. 2013; Watts et al. 2014; Watts et al. 2015; Watts et al. 2016; Watts et al. 2017; Webster 2010). Previous watering actions and their outcomes have also been used for all indicators.

Table 49. Environmental demands, priority for watering in 2020–21 and outlook for coming year in the Lower Murray.

Environmental assets	Indicative demand (for all sources of water in the system)		Watering history	2020-21		Implications for future demands
	Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution?	Likely environmental demand in 2021–22 if watering occurred as planned in 2020-21
River Murray from Euston to Lower Lakes, including pool level wetlands	Elevated river baseflow of at least 10 000 ML/d at SA Border for up to 60 days in spring/summer for in-channel aquatic vegetation, fish and water quality.	9 in 10 years (2 years)	All indicators met in 2010-11, 2011-12, 2012-13 and 2016-17 (high flow years during the last decade). 2013-14 and 2017-18 also saw high baseflows and moderate freshes. The drier years (2014-15, 2015-16, 2018-19 and 2019-20) saw contributions to the baseflows and a moderate fresh in 2019–20 of 15 000 ML/day but only for a short duration All indicators have a high demand for 2020-21	High	A very high priority for watering in 2020-21, even in low resource availability.	High
	Moderate fresh of 15 000-25 000 ML/day at SA Border for up to 90 days in spring/summer for perch spawning and survival and other ecological benefits.	2 in 3 years (2 years)		High	A very high priority for watering in 2020-21, noting that at least moderate resource availability (and potentially multiple water holder contributions) would be required and extended duration may be challenging.	High
	Large fresh of 25 000-35 000 ML/day at SA Border for up to 60 days in spring/summer for fish populations and other in-channel biota.	1 in 2 years (3 years)		High	High resource availability and tributary inflows would be required to deliver flows of this magnitude	Moderate
Hattah Lakes	Small action targeting temporary wetlands (inundation to 42-43 m AHD in winter/spring) - up to 22 000 ML via infrastructure equivalent to natural event of 40 000-50 000 ML/day at Euston for 26-60 days.	1 in 2-3 years (4 years)	All indicators met in 2016-17 (flood). Environmental water also delivered to 44.85 m AHD in 2017-18. No additional water has been provided since then (with the exception of a small watering event at Lake Kramen in 2019-20).	Moderate	Environmental needs likely to be met by other sources of environmental water.	Moderate
	Moderate action targeting wetlands and fringing river red gums (inundation to 43.5 m AHD for 90 days in winter/spring) - up to 40 000 ML via infrastructure equivalent to natural event of 85 000 ML/day at Euston for 7-30 days.	1 in 3 years (7 years)		Moderate	Only likely to be delivered under moderate to high water resource availability	Moderate
	Large event targeting wetland and river red gum/black box woodlands on floodplain (inundation to 45 m AHD for 90 days) - up to 120 000 ML via infrastructure equivalent to natural event of 150 000 ML/day at Euston for 7 days anytime in the year.	1 in 8 years (12 years)		Low	Only likely to be delivered after a large natural overbank flow	Low
Floodplain and wetlands from Euston to South Australian border	30 000 ML/day at Lock 8 for 30-60 days targeting low lying wetlands and anabranches, or priority areas via infrastructure.	2 in 5 years (4 years)	All indicators met in 2016-17 (flood). Environmental water delivered to targeted wetland sites in 2017-18, 2018-19 and (to a lesser extent) 2019-20 across a range of floodplain elevation levels. However, the majority of sites have not received water since 2016-17 Therefore the environmental water demand has been assessed as high for small to medium overbank flows and moderate for larger overbank flows.	High	Commonwealth environmental water is able to contribute to overbank flows only in high resource availability years with significant tributary inflows. Water is likely to be delivered to priority wetland sites via infrastructure.	Moderate
	50 000-60 000 ML/day at Lock 8 for 60-120 days targeting river red gum forest, lignum shrubland and associated wetlands, or priority areas via infrastructure.	1 in 5 years (5 years)		Moderate		Low

Environmental assets	Indicative demand (for <u>all sources of water</u> in the system)		Watering history	2020-21		Implications for future demands
	Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution?	Likely environmental demand in 2021–22 if watering occurred as planned in 2020-21
Floodplain and wetlands from South Australian border to Lower Lakes	Small overbank flow of 40 000-50 000 ML/day at SA border for at least 30 days targeting river red gum forest, tea tree, lignum, river cooba and associated wetlands, or priority areas via infrastructure	1 in 2 years (3 years)	Indicators were last met in 2016-17, with small overbank flow also achieved via 2011-12 and 2012-13 natural flows. Environmental water has also been delivered to some priority wetland sites each year, across all floodplain elevation levels. The broader floodplain however is in poor condition with significant tree canopy loss. There is a critical to high demand for overbank flows in 2020-21.	Critical	Water use will be limited to delivery via infrastructure to priority wetland sites, in the absence of overbank flows. Commonwealth water can only contribute to overbank flows in high resource availability years with significant tributary inflows.	High
	Moderate overbank flow of 50 000-60 000 ML/day at SA border for at least 30 days targeting river red gum forest, tea tree, lignum, river cooba and associated wetlands, or priority areas via infrastructure	1 in 2 years (5 years)		Critical		High
	Infrastructure delivery to a priority area equivalent to 60 000-70 000 ML/day at SA border unless met by unregulated flows, targeting black box, cooba, lignum and chenopod and associated wetlands	1 in 3 years (4 years)		High	Water is likely to be delivered to priority wetland sites via infrastructure. Commonwealth environmental water can contribute to overbank flows only in high resource availability years with significant tributary inflows.	Low
Coorong, Lower Lakes and Murray Mouth	Minimum barrage flow of 650 GL/yr (and lake water levels maintained above 0.4 m AHD) to provide suitable conditions and refuge habitat in the lakes and north lagoon for native fish, plants and internationally important migratory birds.	1 in 1 year	Lower Lakes and Coorong north lagoon in generally good condition, with some signs of stress in the north lagoon due to three successive low-flow years (invertebrate deaths, localised algae outbreaks). Minimum flow (1 in 1 year) was not met in 2015-16 or 2018-19.	High	A very high priority for watering in 2020–21, even in low resource availability.	High
	Barrage flows of 2 000 GL/yr required to provide suitable conditions and refuge habitat for native fish, plants and internationally important migratory birds.	Rolling three-year average		High	A high priority for watering in 2020–21, even in low resource availability, noting that due to low outflows in 2018-19 and 2019-20, ~1000GL would be required to meet this target in 2020-21. Commonwealth water likely to contribute significantly, however target cannot be met by Commonwealth water alone.	Moderate
	Barrage flows of 6 000 GL every three to five years to maintain and improve habitat conditions within the Coorong. Lake water level range between 0.4 and 0.83 m AHD to maintain healthy lake ecology.	1 in 3 years (5 years)	Coorong south lagoon still in poor health. While Commonwealth environmental water can help to minimise further damage, strong recovery in the Coorong South Lagoon requires significant volumes of water and will likely only occur in high resource availability years. Large flow events in the last decade include 2010-11 (15,000+ GL), 2012-13 (6797 GL) and 2016-17 (6484 GL).	Moderate (met in 2016-17)	Commonwealth water will contribute to meeting this demand, however the targets cannot be met by Commonwealth water alone and will depend upon unregulated flow event(s).	Low
	Barrage flows of 10 000 GL every seven to seventeen years to improve habitat conditions within the Coorong. Lake water level range between 0.4 and 0.9 m AHD to maintain healthy lake ecology.	1 in 7 years (17 years)		Moderate (met in 2010-11)		Low

Key - potential watering in 2020-21

- High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)
- Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate - high water resource availability); or water demand likely to be met via other means
- Low priority for Commonwealth environmental watering (under high - very high water resource availability)
- Unable to provide Commonwealth water because of constraints or insufficient water

Key - environmental demands

- Critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
- High demand for water i.e. needed in that particular year
- Moderate demand for water i.e. water needed that particular year and/or next
- Low demand for water i.e. water generally not needed that particular year
- Very low demand for water i.e. water generally not needed that particular year or the following year

Note that demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime

References for Table 49

River Murray Channel indicators sourced from Wallace et al. (2014), Ecological Associates (2015), Ecological Associates (2010), DEWNR (2015) and MDBA (2012g)
Hattah Lakes indicators sourced from MDBA (2012f), (2012g); Roberts and Marston (2011).
Floodplain from Euston to SA indicators sourced from MDBA (2012b): 40 000 ML/day for 45-60 days or 50 000 ML/day for 26-45 days. Total duration of natural flows can include multiple discreet flow pulses above 40-50 000 ML/day with a minimum duration of individual pulses of 7 days.
Floodplain from SA to Lower Lakes indicators sourced from MDBA (2014b), MDBA (2012d) and DEWNR (2015)
Coorong, Lower Lakes and Murray Mouth indicators sourced from MDBA (2012e) and DEWNR (2015)

3.12.5 Water delivery in 2020–21

The use of water for the environment will be responsive to prevailing conditions, water availability, and any emergent opportunities or risks. As such, our plans are flexible (as opposed to being prescriptive) and we may deviate from them in order to maximise the achievement of environmental outcomes throughout the Basin.

Where possible, water for the environment will be managed to benefit multiple sites enroute and will be coordinated with other sources of water. This will include other environmental water portfolios (such as The Living Murray program), consumptive and operational deliveries, natural flows and inflows from key tributaries such as the Ovens and Kiewa Rivers.

The following summary indicates how we may manage Commonwealth environmental water deliveries under various scenarios.

Very Dry (a year that is in the driest 10 per cent of years, in terms of inflows)

- Maintain baseflows to support in-channel species (including native fish), provide drought refuge, maintain water quality and riverine functions:
    - in the main river channel in winter (4 000 ML/day at Yarrawonga), spring (8 000 ML/day at Yarrawonga) and summer (6 000 ML/day at the South Australian border)
    - through the creeks and key wetlands of Barmah-Millewa Forest over spring
    - through Gunbower Creek
    - through the Edward/Kolety-Wakool River system, including the Yallakool-Wakool and Colligen-Niemur Creek systems (subject decisions made by NSW agencies under the NSW Extreme Events Policy
    - provide continuous connection through the Lower Lakes and into the Coorong and maintain water levels in the Lower Lakes above 0.4 m (to avoid the risk of acidification).
- Use infrastructure, pumps and/or weir pool manipulation to provide water to key wetlands throughout the valley that provide refuge habitat or are at risk of suffering irretrievable damage
- Respond to poor water quality events that may result from low flows

Dry to Moderate (a year that is in the driest 25-50 per cent of years)

As per very dry (above), with following additional events in scope:

- Provide a spring fresh down the River Murray to support a broad range of environmental outcomes.
    - The timing, size and duration will be dependent water availability. Under drier scenarios, the fresh is likely to be of lower height and delivered later in spring to early summer. With increasing water availability, the targeted flow height and duration is likely to increase and may start earlier in spring. Even under a dry scenario, this may see flows travel through Barmah-Millewa Forest (reflecting the frequency in which this forest would naturally receive low-level flows).
- Provide spring fresh to Gunbower Creek.
- In the Edward/Kolety-Wakool River system provide a spring fresh and minimum flow target during fish nesting period, followed by increase flow variability in summer and autumn and winter flows from May- August 2021.
- Target minimum end-of-system flow targets to support salt export and improve conditions in the Coorong and the Lower Lakes for native fish and waterbirds.
- Increased scope (number of sites and volumes) of infrastructure-assisted water delivery to wetlands (including autumn watering).

Natural bankfull or overbank flows

- Extend the duration and recession of natural overbank flows.

Wet (a year that is in the wettest 25 per cent of years)

- Extend the duration and recession of natural overbank flows, including with 'top-up' watering for wetlands in autumn.
- Provide refuge flows in response to hypoxic blackwater events.
- Support elevated end-of-system flows.

3.12.6 Monitoring and Lessons learned

(a) Monitoring

Operational monitoring is undertaken for all Commonwealth environmental watering actions. It involves collecting on-ground data on environmental water delivery such as volumes delivered, impact on the river systems hydrograph, area of inundation and river levels. It can also include observations of environmental outcomes. The Commonwealth Environmental Water Monitoring, Evaluation and Research program has the Lower Murray and Edward/Kolety-Wakool region as focus areas. It aims to understand the environmental response from Commonwealth environmental watering with respect to the targeted objectives by carrying out monitoring of site condition and ecological response over many years.

Information on the Commonwealth Environmental Water Office's monitoring activities is available at: http://www.environment.gov.au/water/cewo/catchment/mid-murray/monitoring

https://www.environment.gov.au/water/cewo/catchment/lower-murray-darling/monitoring

This monitoring is complemented by that undertaken through The Living Murray program, focussed on Barmah-Millewa Forest, Koondrook-Perricoota Forest, Gunbower Forest, Hattah Lakes, Chowilla-Lindsay–Wallpolla Floodplain, the Lower Lakes and Coorong, and the River Murray channel itself.

Monitoring results from The Living Murray icon sites are available at:

https://www.mdba.gov.au/managing-water/water-for-environment/progress-outcomes

(b) Lessons learned

Outcomes from monitoring and lessons learned in previous years are a critical component for the effective and efficient use of Commonwealth water for the environment.

Environmental water delivery is still a relatively new practice, which means trialling and learning by doing from various events and outcomes. These learnings continue to be incorporated into the way environmental water is managed. While there are many learnings relating to particular locations, types of watering actions or subsets of the Murray's ecology (some are described in Table 50), key learnings that apply throughout the River Murray valley are summarised as follows.

Environmental water coordination

- Coordinating releases of water for the environmental across multiple river systems is complex. Factors such as delivery constraints, notification requirements and site-specific environmental demands or risks make it challenging to align releases of water in multiple tributaries to achieve coordinated flows downstream, however progress is being made. In spring 2019, the 'Southern Spring Flow' provided extensive environmental benefit along the River Murray, from Hume Dam to the Coorong in South Australia, enhanced by its timing aligning with a spring fresh in the Goulburn River. Full details, including environmental outcomes, are described in the 'Southern Spring Flow Wrap-up' (CEWO 2020a).

- The 2019 Southern Spring Flow, along with previous coordinated flow events and associated monitoring activities, has shown the benefits of flows moving through the length of the river system. However, the experience has also shown that until delivery constraints are relaxed, either natural flows or environmental releases from additional tributaries (such as the Murrumbidgee or Lower Darling Rivers) are required to achieve particular flow targets. For example:
    - At a maximum flow rate of 15 000 ML/day downstream of Yarrawonga, satellite images show that only 25 per cent of Barmah-Millewa Forest was wet as a result of the Southern Spring Flow (CEWO 2020a). Benefits from this extent of inundation are significant. For example, Moira grass growth, flowering and seed-set, river red gum condition, and generation of food for native fish in watercourses downstream of the forest as far as South Australia (CEWO 2020a, GB CMA 2020a). However, additional benefits such as to vegetation in the remaining majority of Barmah-Millewa Forest, remains unattainable with water for the environment alone.
    - The combined Murray and Goulburn releases achieved a peak flow at the South Australian border of around 15 000 ML/day. This flow threshold has been shown to be important for shifting a noticeable proportion of the Lower River Murray from still water to flowing water habitat, which benefits native plants and animals that are adapted to a riverine environment (Ye et al. 2020). This type of flow cue, along with warmth triggers, is understood to in turn trigger spawning of golden perch. However, golden perch did not breed in the Lower River Murray in spring 2019, continuing a trend that has occurred over past 7 consecutive years (Ye et al. 2020). This result is a concern for the population health of the iconic golden perch. Experience suggests that aligning environmental releases from the Murray and Goulburn Rivers alone does not provide a flow pulse large enough, or for long enough, to allow golden perch to breed in the Lower Murray. Environmental releases will need to be coordinated with additional tributaries, or added to natural flow events, in order to achieve breeding success.

End of system flows

The importance of delivering water for end of system flows is significant and remains amongst the highest priorities in the River Murray. Recent benefits of flows to the end of the River Murray, including new approaches to managing this water within the Lower Lakes and as it is released into the Coorong estuary, are as follows:

- Flows through the barrages to the Coorong have been almost continuous since the Millennium Drought (Ye et al. 2020). Without water for the environment, barrages would need to have been closed for extended periods, effectively disconnecting the River Murray from its estuary. Connection to the estuary and sea is vitally important for many fish species to move between fresh and saltwater habitats to successfully reproduce, and for providing suitable food and habitat for migratory shorebirds.
- Environmental flows substantially increased salt export out of the Basin, reduced salt import into the Coorong and reduced salinity concentrations in the Coorong. Flows have prevented 20 million tonnes of salt building up in the Coorong from 2014 to 2019, avoiding catastrophic impacts that would have been reminiscent of those experienced during the Millennium Drought (Ye et al. 2020). In some years, environmental water has contributed to over 500 000 tonnes of salt being exported from the river and out the Murray Mouth (Ye et al. 2018). This is the equivalent of 25 000 semi-trailers each carrying a full load of salt (around 20 tonnes). Reducing salinity levels has benefits for native plants and animals, as well as for stock, domestic and irrigation purposes.
- Without water for the environment water, water levels in the Lower Lakes would have dropped to levels that are ecologically devastating without water for the environment several times since the Millennium Drought. Environmental water stored temporarily in the Lower Lakes, prior to its release into the Coorong, has provided significant benefits to the health of the Lower Lakes. This is through provision of increased variability in the water levels of the Lower Lakes. Benefits have included improved diversity and extent of fringing and submergent vegetation, improved populations of some small-bodied native fish species and increased habitat for waterbirds and migratory shorebirds (SA DEW, 2020).

- While large volumes of freshwater are required to manage the health of the entire Coorong, new approaches to managing small releases of water through the barrages to the Coorong can have significant benefits. For example:
    - Strategically releasing pulses of water through Tauwitchere barrages to coincide with favourable wind, tide and swell conditions has proven effective in reducing Coorong salinity levels along the full length of the North Lagoon (CEWO 2020b).
    - Water delivered to the Coorong estuary in spring and summer 2017-18 for black bream breeding was successful, with 100 young-of-year black bream detected in autumn 2018, and good numbers of age 1+ black bream subsequently reported in autumn 2019. Recent research suggests that successful black bream cohorts are associated with low to moderate barrage flows during spring and early summer (Ye et al. 2019).
    - Lamprey have been detected migrating even under low flow conditions (e.g. 2018). As such they remain a legitimate objective in similar conditions during winter/early spring, though more moderate flows are likely to enhance attraction to barrages and passage upstream (Bice et al. 2020).

The value of flows all year round

Environmental flows have moved in scope from being solely delivered to specific sites at specific times (during drought times and when environmental water holdings were relatively small). Water for the environment is now also being delivered in a manner that aims to provide benefits through the length of the river system, as discussed above. Recent experience has also demonstrated the benefit of delivering water through the entire year, particularly when ecological needs would otherwise not be met due to limited demand for operational flow resulting in flows ceasing unnaturally. For example:

- Several consecutive years of stable winter flows in Gunbower Creek, along with a spring rise, are considered to have been key to the observed improvement in the structure of Murray cod populations (Bloink et al. 2019).
- Winter flows, supported by water for the environment, in the Edward/Kolety-Wakool River system have prevented cease to flow conditions (caused by the winter shut down of the irrigation season) This has resulted in in over a hundred kilometres of instream habitat throughout Yallakool Creek-Wakool River and Colligen Creek-Niemur River systems. The provision of winter flows has assisted with the movement of native fish, such as silver perch, throughout the system (Watts et. al., 2019). It is also expected that winter flows into the Edward/Kolety-Wakool River system will protect aquatic plants from frost damage and improve their rate of recovery in the following spring, however, will take more time to observe over multiple seasons (Watts et al. 2018).
- Further downstream, flows in winter enabling releases over the barrages and through fishways to the Coorong are essential for allowing pouched lamprey to complete their life cycle. Peak migration for pouched lamprey is understood to occur in August (Bice et al. 2020).
- In late summer and autumn, at a time when the majority of flow in the river is used for consumptive purposes, limited flows reach the end of system., Providing environmental water for the end of system during this period is highly important, however at times, system constraints have made this difficult to achieve. Environmental flow at this time of year has been critical in maintaining Lower Lakes water levels above 0.5 m AHD while still providing some connectivity to the Coorong through fishway flows. A sharp drop in lake levels over summer and autumn 2020 may have limited recruitment and health of small bodied fish in the Lower Lakes, which had spawned strongly during the 2019 spring pulse (Scott Wedderburn pers. comm. 2020).

Additional key findings that are specific to locations in the River Murray are summarised in Table 50.

Table 50: Key lessons learned in the Murray River

Theme	Lesson learned
Native fish	• The results of Murray cod movement and survival, in response to the natural flooding event and associated hypoxic conditions in November and December 2016, has provided strong evidence for the importance of providing connectivity between the River Murray and its anabranch systems (Watts et al. 2019). Specifically, it is vital that connectivity is maintained prior to, during and after these events to allow fish to disperse and seek refuge and then return to the anabranch after the event has passed (Watts et al. 2019). • Despite necessary reductions in the large body native fish hydrograph in Gunbower Creek due to constraints in the system, monitoring in winter 2018 indicated that a reduced flow rate of 200 ML/day still provided adequate habitat and connectivity for Murray cod (NCCMA, 2020). This reduced flow rate will be targeted again in 2020-21 hydrograph. • Water for the environment has been successfully delivered to stimulating native fish spawning in several river systems, including in the River Murray valley. In the Mid-Murray, excellent recruitment has been observed across several native species over multiple years (Raymond et al. 2018). However, evidence of recruitment is more limited in other areas that are less permanently flowing (Watts et al. 2019, Ye et al. 2020). This has implications for increasing efforts to coordinate flows to achieve flow cues required to stimulate successful breeding in other areas, such as for golden perch in the Lower River Murray. • In the Edward/Kolety-Wakool River system, a slow recovery of the Murray cod population appears to be underway after the 2016 flood and related fish kills. This system also appears to provide a nursery area for silver perch, with periods of high flow in summer seeming to trigger spawning (Watts et. al., 2018). Concerns remain about the lack of golden perch spawning or recruitment in this system over the past six years (particularly if a natural blackwater event similar to summer 2016 were to occur), highlighting the importance of golden perch migration into this system from the Darling and/or the Murray systems (Watts et al. 2019). • Monitoring of lamprey in winter-spring of 2019 has demonstrated that the migration season for lampreys is longer than previously understood, extending into late spring with peak migrations of short headed lamprey in September and October and August for pouched lamprey (Bice et al. 2020). During periods of limited water availability, releases through Goolwa and Mundoo barrages may elicit greater outcomes in relation to lamprey migrations compared to Tauwitchere, given the proximity of these barrages to the Murray Mouth and fresher environment downstream of these barrages (Bice et al. 2020). • Successful spawning of black bream is known to occur in summer (late December to early February) with barrage releases between 600-5 000 ML/day and temperature of 18-25 degrees Celsius, 1-2 weeks after a ~10 000-20 000 ML/day pulse out the barrages. • Flows of greater than 20 000 ML/day at the SA border are found to be required to create a flowing river in the lower Murray, requiring coordination of Murray and tributary flows in dry years.

Theme	Lesson learned

Native Vegetation	• Areas of floodplain and wetland vegetation that have been able to be inundated for several consecutive years are showing benefit.
	  ○ In Barmah Forest, low-level overbank spring flows have resulted in exceptionally good Moira grass growth and flowering was (particularly within grazing exclusion zones) during 2018-19 and 2019-20 (GB CMA 2020a).
	  ○ Wetland vegetation cover and diversity of species within wetlands in Gunbower Forest, indicates that environmental water delivery has provided an opportunity for wetland plants to germinate, flower and set seed (NCCMA 2020).
	  ○ River red gums that have received water following the 2016-17 flood have healthier canopies than those red gums in areas that remained dry (Mallee CMA 2020, North Central CMA 2020).
	• Vegetation located at higher elevation floodplain and wetlands, or vegetation that has not been able to have follow-up water delivered, are more stressed. These results demonstrate the importance of consecutive watering events to consolidate the outcomes from natural floods to see sustained improvements in vegetation condition.
	• Providing a slow rate of recession to flows enables native water plants to avoid being stranded and drying out prior to completing their life-cycle (Watts et al. 2015).
	• The duration and extent of the 2016 flood wiped out many areas of in-stream aquatic plants (Watts et al. 2018). This highlights the importance of understanding the impact of duration and depth of flows on aquatic plant communities as noted in other MER monitoring sites (Dyer et al. 2018).

Waterbirds	• During dry and moderate years water for the environment can assist in maintaining foraging and breeding habitat and support localised bird breeding events. Recent research indicates that regular small-scale breeding events are likely to be key in maintaining populations. While unlikely to be contributing to population growth, they are important in maintaining genetic diversity in the population and providing some new recruits each year (McGinness et al. 2019). It is likely that large scale breeding events will only occur in wetter years where more broader landscape cues apply.
Water quality	• High flows through Millewa Forest have been demonstrated to provide a productivity boost into the Edward/Kolety-Wakool River system (Watts et al. 2016). If delivered at a cooler time of year to avoid poor water quality, the NSW Mid-Murray forests can play a role in providing food resources to the adjacent rivers and creeks. • Refuge flows during floods can also be effective in mitigating the risk of hypoxic water conditions caused by heatwave conditions during summer (Watts et al. 2019), particularly in the Niemur Creek and Wakool River systems. Similarly, water for the environment maintained oxygen levels in the Rufus River (flows into the River Murray from Lake Victoria), during a period of low oxygen in the water during natural flood in 2016-17 (Ye et al. 2018). Maintaining oxygen levels in localised areas can provide refuge habitats for aquatic organisms. • Pulsing water through Tauwitchere barrages to opportunistically coincide with favourable wind and swell conditions has demonstrated to be effective in providing freshwater flow into the Coorong and reducing salinity levels albeit briefly.

Theme	Lesson learned
	• Maintaining flow through the fishway at the barrages for extended periods (e.g. 3 months during 2019-20 summer) are insufficient to prevent Coorong salinities increasing to 45 grams per litre. This represents a management threshold with levels above becoming lethal for some estuarine plants and animals (Taylor 2010). • Following three consecutive years of low barrage flows (average ~650 GL/year), South Lagoon salinities rose well above the 100 grams per litre management threshold during the 2019-20 summer, indicating that significantly more barrage flows are required to maintain a healthy South Lagoon.
Connectivity and water delivery	• Monitoring results from the Southern Spring Flow in 2019-20 indicated environmental watering resulted in a significant generation of carbon and nutrients from Barmah-Millewa floodplain and an increase in zooplankton abundance downstream of forest and in the Lower River Murray (CEWO 2020a). Reducing the carbon load on the floodplain will also reduce the risk of black water events during future flows. • A trial in the Yallakool Creek-Wakool River system during August-September 2018 (trialled delivery of flow at 800 ML/day instead of the existing limit of 600 ML/day) highlighted: o the importance of having a long lead in time for planning such an event with local land holders, agencies, community members and monitoring providers o the need to have access to alternative delivery arrangements (such as the Murray Irrigation network) to deliver target flow rates in the event that WaterNSW infrastructure is unable to meet those flow rates o the flow inundated one low level bridge in the Bookit Island area in the mid Wakool River and one creek crossing on Black Dog Creek, but this did not limit landholders access to their properties o the flow trial increased lateral connectivity within the river system, increasing the wetted area by an average of 10.2 per cent (Watts et al. 2018). • Where water availability allows and there are suitable natural triggers, early season delivery of environmental water assists in avoiding delivery constraints that arise during the irrigation season (spring-summer). • Fishways at the barrages (rock ramp and trapezoidal) continued to operate when Lower Lake levels fell below 0.6 m AHD, when previously thought to become non-functional. This provides future option of managing water levels below 0.6 m while continuing releases through the fishways. • Particularly in dry years, environmental water is critically important in supporting continuous flows through the barrages to the Coorong throughout the year, maintaining a connection between the river and the Coorong estuary to support a functioning river system.

3.12.7 Bibliography

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