Seasonal Watering Plan 2019-20

VICTORIAN ENVIRONMENTAL WATER HOLDER

VICTORIA State Government

Acknowledgement of Traditional Owners

The VEWH proudly acknowledges Victoria's Aboriginal communities and their rich culture and pays respect to their Elders past and present.

We acknowledge Aboriginal people as Australia's first peoples and as Traditional Owners and custodians of the land and water on which we rely. We recognise the intrinsic connection of Traditional Owners to Country, and we value their ongoing contribution to managing Victoria's landscapes. We also recognise and value the contribution of Aboriginal people and communities to Victorian life and how this enriches us.

The VEWH recognises the intersection between environmental flow objectives and outcomes for Traditional Owners and Aboriginal Victorians. We acknowledge the ongoing contribution that Aboriginal people are making to planning and managing water for the environment and the benefits that have resulted from these partnerships. The contribution of Traditional Owners to this year's seasonal watering plan is detailed in the regional introductions.

For tens of thousands of years, Aboriginal people have occupied Australia. There have been very different clan and Nation boundaries to those that exist today, often embodying deep cultural relationships with the land and waterways. In this seasonal watering plan, the VEWH has endeavoured, using the best-available information, to name the Traditional Owner groups and their Nations that lived in the area we now call Victoria, and who continue to maintain and enhance long-standing culture and tradition. We have also sought and, in some regions, have provided some background on local Aboriginal names for waterways.

We acknowledge that the Traditional Owner groups and their associations with particular areas are not definitive, and there may be multiple names for the waterways covered by the seasonal watering plan. The VEWH does not claim this information to be exact. We provide such information in the spirit of acknowledgement of Traditional Owners past and present and their long-standing connection to Country.

The VEWH embraces the spirit of reconciliation, working towards equity and an equal voice for Traditional Owners.

Section 1 : Introduction

Section 2 : Gippsland region

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Foreword

I'm pleased to introduce the Victorian Environmental Water Holder's (VEWH's) *Seasonal Watering Plan 2019–20*, which outlines the scope of where and when water for the environment may be delivered in the next 12 months.

The plan communicates how the VEWH and its program partners plan to use the water available for the environment to achieve positive ecological outcomes in a range of climate scenarios: from drought to dry and average to wet.

It has been eight years since the VEWH published its inaugural seasonal watering plan, and I noted then that our aim was to work closely with waterway managers and their partners to optimise environmental benefits.

This year's seasonal watering plan demonstrates how those relationships have strengthened. The watering actions in the plan are based on an ever-building bank of rigorous science, and also increasingly on targeted local knowledge gained from key stakeholder groups through the engagement networks of our catchment management authority and Melbourne Water partners.

This pairing of evidence-based decision-making and local experience in the Gippsland, central, western and northern regions aims to achieve the best possible outcomes with water for the environment.

Local knowledge together with river and wetland studies help show us where water for the environment should be prioritised and how it should be used in each waterway system, to get the best ecological benefits we can under prevailing conditions.

Tapping into local knowledge also helps us optimise shared benefits: 95 percent of us enjoy waterways for activities like camping, birdwatching, swimming, boating and fishing.

Increasingly, as our relationships with Traditional Owners build, water for the environment can also help deliver cultural outcomes.

When I welcomed the first VEWH seasonal watering plan in 2011–12, we had been experiencing rainfall and high-flow conditions in the previous 12 months. Now, some eight years on, it is a different climatic story, with the entire state experiencing extended dry conditions. Across Victoria, 2019 has commenced with a very dry autumn and warmer-than-average conditions. Overall, it was Victoria's warmest summer on record. This brings challenges to all water managers, farmers and communities and emphasises how important it is for water for the environment to be efficient, effective and adaptable.

Since its inception, the VEWH has carefully managed its Water Holdings in the Environmental Water Reserve, using the full suite of tools offered to us as an entitlement holder – including trade, carryover and investment – with the aim of optimising environmental outcomes for enduring benefit under all seasonal conditions. We are now able to demonstrate local outcomes from water for the environment.

We are evolving our decision-making about when to trade water, when to supplement watering with complementary actions and how to work with partners to optimise the efficiency of water for the environment within an integrated catchment management framework.

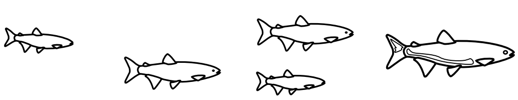
Water for the environment provides significant benefits for Victorian communities and is an integral part of protecting and improving the health of waterways.

Denis Flett
Chairperson, Victorian Environmental Water Holder

SECTION 1

Introduction

Werribee River, by Melbourne Water



1.1 The Victorian environmental watering program

The Victorian environmental watering program is the ongoing collaborative management of water for the environment used to improve the health of Victoria's rivers and wetlands and the native plants and animals that depend on them.

This seasonal watering plan previews all the potential watering actions that may be delivered across Victoria in 2019–20.

In this section ...

- **Why do we need an environmental watering program?**
- **What do we aim to achieve with water for the environment?**
- **Who is involved in the Victorian environmental watering program?**
- **What is the role of the Victorian Environmental Water Holder?**
- **How does the Victorian environmental watering program fit within broader integrated catchment and waterway management?**
- **How does the environmental watering program consider climate change?**
- **How do we know the environmental watering program is successful?**
- **Where can I find more information about the Victorian environmental watering program?**

1.1.1 Why do we need an environmental watering program?

As Victoria's population has grown, many of its rivers and wetlands have been significantly modified through the construction of dams, weirs and channels to provide water for communities to grow and thrive. In some rivers, up to half of the water that would have naturally flowed in them is removed each year to provide water for homes, farms and industry. As a result, these waterways are not able to function as they would naturally.

Reduced river flows and less frequent wetland inundation have disrupted breeding cycles for native fish, frogs, waterbirds, platypus and other animals; restricted the growth and recruitment of native plants; and reduced the overall productivity of waterways. Our waterways still support a range of native species, but the total abundance of native plants and animals has substantially declined and the aesthetic value and ecosystem services those waterways provide have diminished.

Healthy waterways are essential for the plants and animals that live in them and for the people and industries that rely on clean water and the ecosystem services that waterways provide. Many rivers and wetlands with altered water regimes cannot survive without help. It is necessary to actively manage how water flows through them, to protect their health and support the plants that grow in them and the native animals that live, feed and breed in them.

Water that is managed to improve water regimes to achieve specific environmental outcomes is called 'water for the environment', 'environmental flows' or 'environmental water'. Water for the environment is set aside in storages and released into rivers and wetlands.

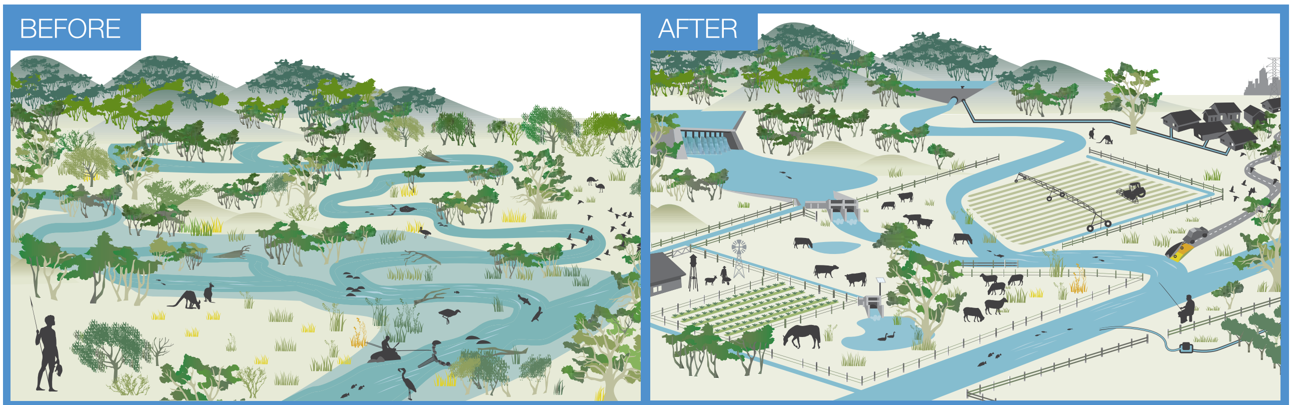
The Victorian environmental watering program seeks to collaboratively manage environmental flows to improve the health of river and wetland systems including their biodiversity, ecological function, water quality and other uses that depend on environmental condition.

By improving the health of rivers, wetlands and floodplains, environmental flows also provide benefits to communities.

Healthy rivers and wetlands support vibrant and healthy communities. They sustain people by supplying water for towns, farms and businesses. They also contribute to local agriculture, fishing, real estate, recreation and tourism activity.

Healthy rivers and wetlands make cities and towns more liveable and support the physical and mental wellbeing of communities. Most of Victoria's towns are located near a river or lake that the community identify with, and many people travel to their favourite waterways for holidays and to pursue recreational activities. Rivers and wetlands provide places for people to play, relax and connect with nature, and they sustain healthy Country for Aboriginal communities.

Figure 1.1.1. A typical Victorian river catchment before and after the development of dams, weirs and channels



Before and after the development of dams, weirs and channels

Many of Victoria's rivers and wetlands have been highly modified compared to how they were managed by Traditional Owners for tens of thousands of years. Water now flows very differently through the landscape – it is captured in dams and weirs, diverted by pipelines, pumps, drains, levees and constructed channels to support towns, cities, industry and farming.

Some of our rivers give up more than a third, and sometimes half, of their water for farms, homes and businesses. Instead of flowing naturally, with high flows in winter and low flows in the hotter summer months, many rivers now run higher when water needs to be delivered for farming and urban use.

Such significant changes have affected water quality and interrupted many of the natural river and wetland processes native plants and animals need to survive, feed and breed. Water for the environment is now needed to help mitigate some of these impacts.

1.1.2 What do we aim to achieve with water for the environment?

Water for the environment is released into rivers to mimic some of the flows that would have occurred naturally, before the construction of dams, weirs and channels. This is vital for maintaining the physical, chemical and biological health of rivers.

Managers of environmental flows generally focus on returning some of the small- and medium-sized river flows that are essential in the life cycles of native plants and animals. These flows can move sediment and nutrients through river systems, connect habitats and improve water quality.

The timing, duration and volume of water delivery is designed to support the plants and animals that rely on those flows. For example, fish such as the Australian grayling rely on an increase in river flow in autumn to signal them to migrate downstream for spawning (when fish release eggs). Breeding waterbirds require wetlands to retain water for long enough to allow their chicks to grow and fledge, and floodplain forests require inundation every few years to ensure the survival and recruitment of iconic tree species such as river red gums and black box.

Many wetlands are now either disconnected from the rivers that used to naturally fill them or are permanently connected to rivers or channels. This means that some wetlands do not get enough water, and others get too much.

In wetlands, managers of environmental flows focus on providing the wetting and drying cycles that plants and animals depend on for survival, reproduction and long-term resilience. For example, where wetlands and floodplains have been cut off from natural river flows, environmental watering can reconnect these areas, sometimes via irrigation infrastructure (such as pumps, channels and regulators).

1.1.3 Who is involved in the Victorian environmental watering program?

The Victorian environmental watering program involves a range of groups and organisations. Relationships between local communities, waterway managers, storage managers, land managers, environmental water holders and scientists are the foundation of the program. The program is overseen by the Victorian Minister for Water through the Department of Environment, Land, Water and Planning (DELWP).

Many public authorities collaborate to deliver the program. These authorities are referred to as program partners. Waterway managers (catchment management authorities [CMAs] and Melbourne Water) are the regional planning and delivery arm of the program. In consultation with local communities, waterway managers develop proposals for environmental watering in rivers and wetlands in their region. Waterway managers also order water for the environment from storage managers and monitor the outcomes.

Storage managers (designated water corporations) deliver water for all water users including waterway managers and environmental water holders.

The VEWH makes decisions about where available water for the environment is used, carried over or traded, to get maximum benefit for the state's waterways. In northern Victoria, the VEWH also works with the Commonwealth Environmental Water Office, the Murray-Darling Basin Authority (MDBA) and with the New South Wales and South Australian governments to prioritise how and where water is used and to ensure use of water for the environment is coordinated to optimise the health of the connected waterways of the Murray-Darling Basin.

Public land managers (such as Parks Victoria, DELWP and Traditional Owner land management boards) are closely involved in planning and delivering water for the environment on public land (such as state forests and national parks). Their responsibilities include controlling infrastructure (such as pumps, outlets, gates and channels) and public signage. Some environmental watering also occurs on private land, in partnership with landholders or corporations.

To effectively manage water for the environment, it is important to understand the environmental values of Victoria's rivers and wetlands. This understanding draws on the knowledge of local communities and scientists.

Local communities, including Traditional Owners, help identify the important environmental values in each region and help monitor the success of environmental watering. Local communities are often actively interacting with local rivers and wetlands and bring important cultural, economic, recreational, social and Traditional Owner perspectives to the program.

Scientists provide indispensable advice about how water for the environment will support native plants and animals in the short and long term and work with waterway managers to monitor, evaluate and report on the outcomes of environmental watering.

Citizen scientists are increasingly monitoring the outcomes of environmental watering. In some regions, Birdlife Australia volunteers help monitor environmental watering outcomes at wetlands, and Waterwatch volunteers collect water quality information to inform management decisions for some rivers.

Traditional Owners' connection to Country is central to their sense of identity and cultural continuity. Victoria's waterways are an important part of Country and have been managed successfully by Traditional Owners for thousands of years. We are now increasingly looking to incorporate Traditional Owners' knowledge in how we manage our waterways. For instance, in the western region, Budj Bim and Barengi Gadjin Land Council Aboriginal Corporation rangers are monitoring environmental watering outcomes including the presence of platypus, in the Glenelg River. In the north, Barapa Barapa Traditional Owners are monitoring environmental watering outcomes in Gunbower Forest.

How are Traditional Owners engaged in the environmental watering program?

Traditional Owners and their Nations in Victoria have a deep and enduring connection to Victoria's rivers, wetlands and floodplains, spanning tens of thousands of years. The VEWH and its environmental watering program partners recognise the intersection between environmental flow objectives and Aboriginal environmental outcomes and acknowledge the benefit of genuine, enduring partnerships with Aboriginal people in planning and managing water for the environment.

In many regions of Victoria, Traditional Owner Nations have strong relationships with environmental watering program partners, and they are working to better realise Aboriginal Victorians' aspirations and incorporate Traditional Owners and their objectives and knowledge into environmental flows management. These initiatives and ongoing contributions to the program are highlighted in the regional overviews in this seasonal watering plan.

A small number of potential watering actions have been identified in seasonal watering proposals as involving Traditional Owners in both the planning and potential delivery of the watering action. This objective has been recognised for those watering actions with the following icon:

Watering is planned to be delivered in partnership with Traditional Owners and achieve Aboriginal environmental outcomes

This is the first year that the VEWH has identified watering objectives in this way, and it expects to refine this approach in future years to better capture the environmental watering partnerships of Traditional Owners and environmental watering program partners.

There are certainly more opportunities for the VEWH and its partners to develop enduring partnerships with Traditional Owners who want to participate in the management of water for the environment. The VEWH and its program partners will continue to look for these opportunities and endeavour to develop enduring partnerships with Traditional Owner Nations. The VEWH is funding some projects to help waterway managers and Traditional Owners identify opportunities to better align environmental watering objectives and actions with Aboriginal objectives and to participate in managing water for the environment.

1.1.4 What is the role of the Victorian Environmental Water Holder?

The VEWH is a statutory authority, established by the Victorian Government in 2011. It is responsible for managing Victoria's water for the environment. Set up under the *Water Act 1989*, the VEWH manages environmental entitlements — a legal right to access a share of water available at a location — to improve the environmental values and health of Victoria's rivers, wetlands and floodplains, and the plants and animals that rely on them.

The role of the VEWH is to:

- make decisions about the most effective use of the environmental entitlements including for use, carryover and trade (see subsection 1.4.2)
- commit water and authorise waterway managers to implement watering decisions (see subsection 1.3.2)
- work with storage managers, waterway managers and other environmental water holders to coordinate and optimise environmental outcomes from the delivery of all water (see section 1.4)
- commission targeted projects to demonstrate the ecological outcomes of environmental flows at key sites and to help improve the management of water for the environment
- publicly communicate environmental watering decisions and outcomes
- invest in complementary works and measures, knowledge, monitoring, research and other priority activities in collaboration with DELWP where it improves the ability to manage water for the environment and the performance of the environmental watering program.

The VEWH consists of four part-time commissioners, supported by a small team.

The commissioners in place at the time this seasonal watering plan was published are Denis Flett (Chairperson), Geoff Hocking (Deputy Chairperson), Chris Chesterfield (Commissioner) and Rueben Berg (Commissioner). Commissioners are appointed by the Governor in Council on the recommendation of the Minister for Water.

1.1.5 How does the Victorian environmental watering program fit within broader integrated catchment and waterway management?

The environmental watering program fits within broader Victorian Government policies for integrated catchment management: it is a holistic way of managing land, water and biodiversity from the top to the bottom of our catchments. The Victorian environmental watering program forms part of the Victorian Government's record investment of $222 million over four years to improve the health of our waterways and catchments.

Key policy documents influencing the VEWH from a Victorian context include *Water for Victoria*, the *Victorian Waterway Management Strategy* and regional sustainable water strategies. Regional waterway strategies also determine priority waterways, in consultation with local communities, and outline integrated waterway management actions.

Water for Victoria is a plan for a future with less water as Victoria responds to the impact of climate change and a growing population. The actions in the plan support a healthy environment, a prosperous economy with growing agricultural production and thriving communities. Implementing the actions in the plan will improve the operation of the water and catchment management sector including the VEWH. *Water for Victoria* recognises that protecting and improving waterway health is a long-term commitment needing coordinated action. The full benefits of strategic, long-term investments in waterway health may not be realised for 30 years or more. *Water for Victoria* identifies 36 priority waterways for large-scale projects over this timeframe and environmental flows are planned for many of these waterways in this seasonal watering plan.

Complementary catchment management activities are often needed to achieve environmental watering outcomes. These include invasive species control, riparian (streamside) land management, sustainable agriculture, sustainable land use planning and development, integrated urban water management and other waterway management activities (such as providing fish passage and improved in-stream habitat, for example through large woody habitat). A lack of fish passage due to dams and weirs continues to be a problem in some Victorian rivers where environmental flows aim to increase the breeding success and recruitment of native fish. Figure 1.1.2 shows examples of complementary waterway management activities in Victorian waterways that receive water for the environment.

In most systems, environmental flows are delivered using existing infrastructure (such as dam outlet gates and water supply channels) built for and still used for the supply of water for agriculture, industry and communities. Permanent and temporary pumps are sometimes also used to deliver water for the environment to wetlands. Capacity limits with these types of infrastructure and the need to avoid flooding private land restrict the size and timing of deliveries of water for the environment. In some systems, these limitations mean only a fraction of the required environmental flows can be delivered to waterways, which significantly reduces the environmental outcomes that can be achieved.

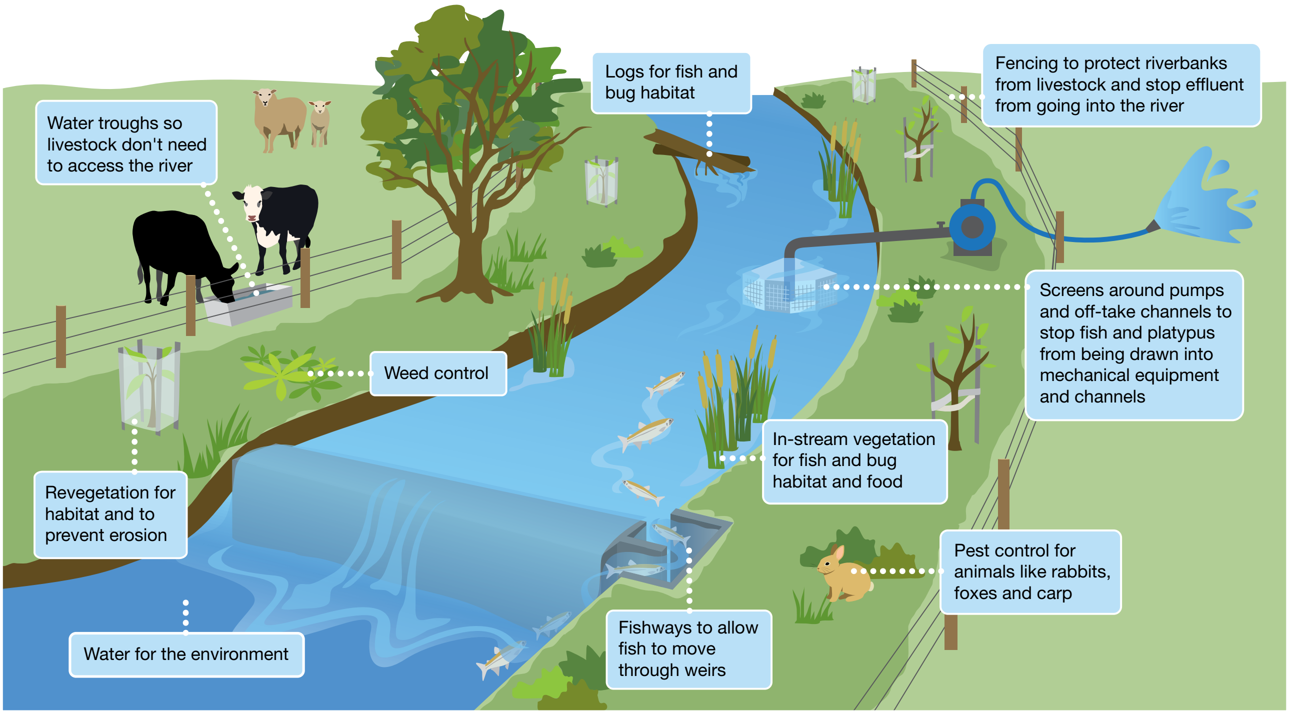
Victoria's environmental watering program is integral to the success of the following three strategies and plans.

Our Catchments, Our Communities is Victoria's first statewide strategy for integrated catchment management. Its aims are more effective community engagement, better connections between different levels of planning and stronger regional catchment strategies. The strategy also aims to clarify roles, strengthen accountabilities and coordination and improve monitoring, evaluation and reporting. Under this strategy, CMAs will lead 10 new integrated catchment management projects across the state, in collaboration with catchment management partners. The Caring for Campaspe and Living Moorabool projects are two which involve environmental watering actions.

Protecting Victoria's Environment – Biodiversity 2037 aims to ensure Victoria has a modern and effective approach to protecting and managing Victoria's biodiversity. Providing water for the environment is essential to supporting Victoria's biodiversity. The plan will be implemented together with the outcomes of reviews of the *Flora and Fauna Guarantee Act 1988* and Victoria's native vegetation clearing regulations.

The *Basin Plan 2012* for the Murray-Darling Basin is another key reform influencing the VEWH's operations, particularly its planning and reporting framework in northern and western Victorian systems which form part of the basin. The VEWH continues to work closely with the Victorian Government and other agencies to implement the Basin Plan.

Figure 1.1.2 Examples of complementary management actions



1.1.6 How does the environmental watering program consider climate change?

Victoria's climate has seen a drying and warming trend over the last two decades, and it is predicted this trend will continue in the future. Climate modelling[1] indicates there will be more extreme events including droughts, floods and heatwaves, and there are expected be more bushfires. Seasonal shifts in rainfall are expected to continue, with proportionally less rain in the cooler months. Average streamflow is predicted to decline across all parts of Victoria, with some of the greatest declines expected in the south-west and parts of the central and northern regions, as Figure 1.1.3 shows. These predicted changes have significant implications for waterway health, through reduced availability of water for the environment, increased water quality and algal bloom risks. There will also be impacts on the plants and animals that live in and around waterways and rely on well-established flow patterns for successful feeding, breeding and movement through the landscape.

Action 3.5 of *Water for Victoria* focuses on improving the management of environmental flows in a changing climate. It states the Victorian Government's commitment to continue to invest in environmental works and measures for priority environmental watering sites, which will allow better use of the VEWH's existing water. In some instances, the VEWH may be able to opportunistically complement this investment using water-trade revenue, where this optimises environmental outcomes. Action 3.5 also reaffirms commitments to recover water for the environment in the Thomson, Barwon, Moorabool, Werribee and Maribyrnong systems. As these commitments are delivered and resulting environmental entitlements created, this water will be managed by the VEWH and its partners to optimise future environmental outcomes in the face of climate change.

The VEWH and its program partners are addressing the challenges of climate change in the following ways.

1 *Timbal, B. et al. (2016) Climate change science and Victoria. Victoria Climate Change Initiative (VicCI) report. Bureau of Meteorology, Australia. Bureau Research Report 14, pp 94.*

Setting environmental watering objectives that describe the environmental outcomes that can be achieved under future climatic conditions

Environmental flow studies and environmental water management plans are revised periodically to update environmental watering objectives and their required water regimes. These reviews specifically consider how climate change will affect current environmental values and the types of outcomes that can be achieved in the future. Waterway managers also alter environmental watering objectives for individual systems to include the latest scientific information as it becomes available. The seasonal watering plan presents the most up-to-date environmental watering objectives and the watering actions required to achieve them.

Strengthening decisions about where and how water for the environment is used

During prolonged dry periods (which are more likely in the future), there is not enough water available to meet the needs of all waterways. Rigorous decisions need to be made about where and how to use the available water to optimise environmental outcomes for enduring benefit. Most high-priority environmental watering objectives rely on ecosystem processes that operate beyond individual rivers or wetlands. Therefore, in prioritising sites for environmental watering, decisions are increasingly considering the combination of waterways that need to be watered, to optimise outcomes. Portfolios of waterways are being managed in a coordinated way to support high-value species as well as critical ecosystem services.

For example, coordinated releases from Hume Reservoir, the Goulburn River and Campaspe River have been used to trigger the movement of young golden perch and silver perch throughout northern Victorian waterways. The VEWH and its program partners are also working together to identify the most important refuge habitats to water during critically dry periods.

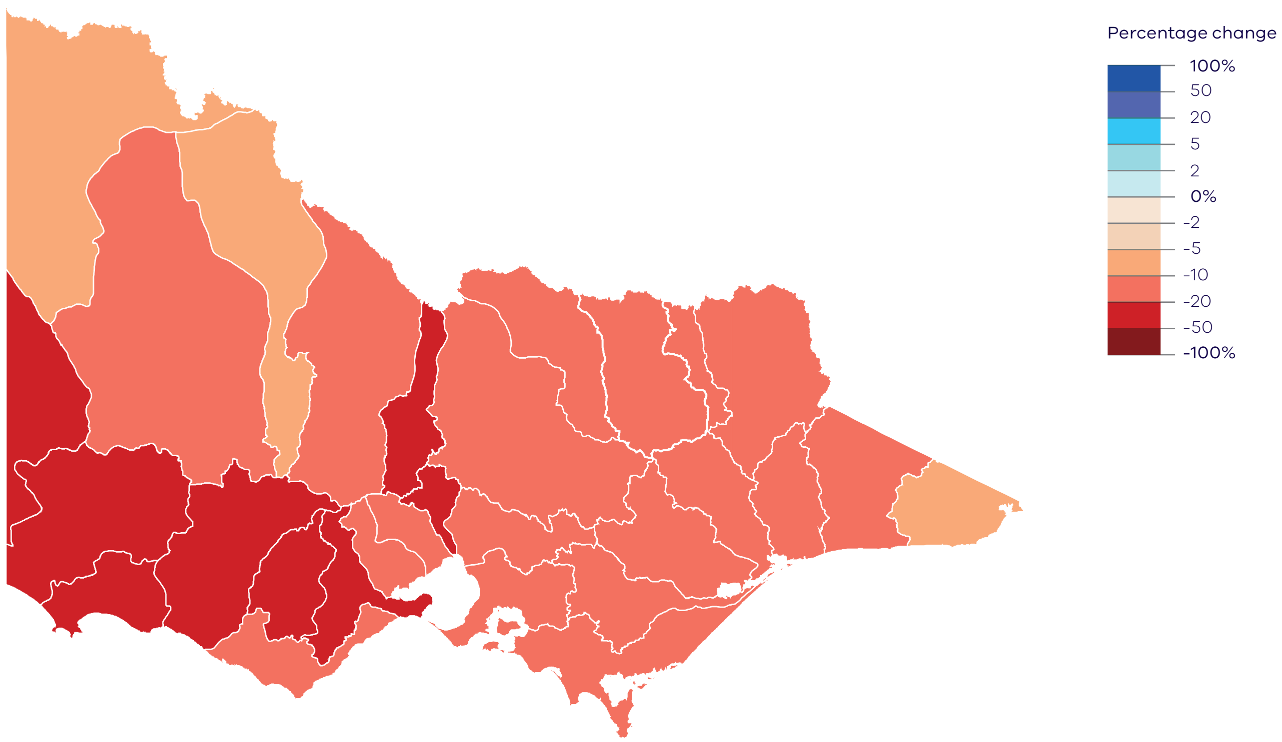
Optimising environmental outcomes of operational water

The VEWH is working closely with storage managers and river operators to identify how operational water can be delivered in ways that meet customer needs and contribute to environmental outcomes. This also helps river operators meet their environmental obligations.

Planning for a range of climatic scenarios each year

Watering requirements can vary considerably between wet and dry years. In drought and dry conditions, the focus is on preventing catastrophic losses and maintaining critical refuge habitats to prevent significant declines of native populations. In wet conditions, the aim shifts to boosting ecological productivity and environmental condition and to increasing populations of native plants and animals. Climatic conditions can change quickly within a year, and the VEWH and its program partners need to be able to respond accordingly. The seasonal watering plan identifies potential watering actions that may be delivered to each system under different climatic scenarios: this is explained in more detail in subsection 1.3.4.

Figure 1.1.3 Projected changes in run-off for 2065 under medium climate change



Source: Water for Victoria, 2016

1.1.7 How do we know the environmental watering program is successful?

Effective monitoring is essential for the continued improvement of the environmental watering program. It provides information that can be shared with all stakeholders to demonstrate the outcomes of watering actions, and it identifies what is needed to improve the effectiveness of future watering actions.

The effect of water for the environment in Victoria is directly assessed through large-scale monitoring programs, which measure multiple indicators at multiple sites over multiple years. There are also discrete investigations that examine responses at a single wetland or river reach.

DELWP funds two programs that monitor environmental watering outcomes at a statewide scale. The Victorian Environmental Flows Monitoring Assessment Program (VEFMAP) investigates the effect that environmental flows in Victorian rivers have on native fish and on aquatic and riparian vegetation. The Wetland Monitoring Assessment Program (WetMAP) examines the effect that water for the environment has on native vegetation, waterbirds, fish and frogs in wetlands.

Selected Victorian waterways are monitored as part of three Murray-Darling Basin environmental water monitoring programs. The MDBA funds environmental condition and intervention monitoring activities at Barmah Forest, Gunbower Forest, Hattah Lakes and the Lindsay, Mulcra and Wallpolla islands as part of the Living Murray program. Annual condition report cards that are produced for each site demonstrate the effect of more than a decade of environmental watering at these important icon sites. The Commonwealth Environmental Water Holder (CEWH) funds fish, vegetation, stream metabolism and bank erosion monitoring in the lower Goulburn River as part of its basin-wide Long-term Intervention Monitoring program. The Australian Government along with key research organisations and jurisdictional agencies funds the Environmental Water Knowledge and Research program, which investigates four themes — vegetation, fish, waterbirds and foodwebs — to improve the science that supports the management of water for the environment in the Murray-Darling Basin.

The VEWH funds waterway managers to conduct discrete, short-term investigations at individual river reaches or wetlands. These investigations have a primary focus on learning and adaptive management.

A secondary focus of the VEWH's monitoring investment is communications, engagement and reporting to the community. To achieve this, the VEWH helps community groups, citizen scientists and Traditional Owners to observe and report the outcomes of the environmental watering program.

The VEWH and its program partners regularly liaise with the scientists who are monitoring responses on-the-ground and with the organisations responsible for overseeing the larger-scale monitoring programs to ensure that the most up-to-date information is used to inform environmental watering decisions. The VEWH also reports some of the available monitoring results in its annual Reflections report, to increase awareness about environmental watering outcomes among all stakeholders and the community.

1.1.8 Where can I find more information about the Victorian environmental watering program?

There is more information about the program on the VEWH website at vewh.vic.gov.au or from the VEWH on (03) 9637 8951 or by email to general.enquiries@vewh.vic.gov.au.

You can get more detailed information about water for the environment in your region by contacting your local waterway manager using the contact details in section 6.3.

Water for the environment fact sheets

The VEWH's fact sheets answer questions about water for the environment. They are:

- What is environmental water?
- Why is environmental watering important?
- What does environmental watering aim to achieve?
- What does environmental watering involve?
- How do we know if environmental watering is successful?
- What is environmental water trading?

The fact sheets are on the VEWH website, or you can get hard copies by emailing general.enquiries@vewh.vic.gov.au.

1.2 The seasonal watering plan

The seasonal watering plan is a statewide plan that guides environmental watering decisions in Victoria. It provides program partners, stakeholders and communities with a sense of what to expect during the water year.

In this section ...

- **What does 'seasonal' mean?**
- **How does the seasonal watering plan fit into the environmental flows planning process?**
- **Who contributes to the seasonal watering plan?**
- **Can the seasonal watering plan be changed?**
- **When isn't a formal variation required to the seasonal watering plan?**

The plan previews all the potential watering actions that could be implemented using water available under all environmental water entitlements held in Victoria. This includes water available under the VEWH's environmental water entitlements and water held by other environmental water holders for use in Victoria (see subsection 1.4.1).

The plan for the upcoming water year is released by 30 June each year. The 2019–20 plan and any variations are valid for this water year (1 July 2019 to 30 June 2020) or until the subsequent seasonal watering plan is released.

1.2.1 What does 'seasonal' mean?

'Seasonal' refers to the variability of climatic conditions in a given year. It includes normal differences between summer, autumn, winter and spring as well as an assessment of whether a year is drier or wetter than average. Environmental watering objectives and water availability may differ depending on seasonal conditions, so it is important that planning for water for the environment considers the range of potential seasonal conditions or water availability scenarios that may unfold, ranging from drought to very wet. This scenario planning provides a guide for the VEWH and waterway managers throughout the year when it comes to deciding what environmental flows to go ahead with. There is more information about how seasonal conditions influence environmental flows planning in subsection 1.3.4.

For each river and wetland system, the potential environmental flows under each seasonal condition or water availability scenario is explained under 'Scenario planning' in the relevant section.

1.2.2 How does the seasonal watering plan fit into the environmental flows planning process?

Each year, waterway managers scope the potential environmental watering actions for their regions for the coming year in seasonal watering proposals. The proposals draw on environmental flow studies and on longer-term plans (such as environmental water management plans, regional waterway strategies and regional catchment strategies). Environmental flow studies and environmental water management plans for Victorian waterways are available on the VEWH's website at vewh.vic.gov.au. Waterway strategies and regional catchment strategies are published on the relevant waterway manager websites. The seasonal watering proposals incorporate information and advice from local communities including Traditional Owners.

The VEWH reviews the proposed watering actions in each seasonal watering proposal and works with waterway managers to identify the potential watering actions for each region and across the state. This seasonal watering plan is a collated summary of the agreed actions from all the seasonal watering proposals.

The different stages of environmental flows planning – including the different strategies and plans, are shown in Figure 1.2.1. There is more information about each of these strategies and plans at vewh.vic.gov.au.

Figure 1.2.1 Victorian environmental watering program planning framework

Key - who is responsible for what

- Waterway managers
- VEWH
- Scientific experts

Regional waterway strategy

- Identifies priority river reaches/wetlands and values in each region
- Developed every eight years
- Previously known as regional river health strategy

Guides priorities for

Environmental water management plan

- Outlines long-term environmental objectives, desired flow regimes and management arrangements
- Will be developed progressively for each system/site identified as a long-term priority for environmental watering
- Updated as required with new information
- Assumes current water recovery commitments/targets

Informs (from Environmental flow study)

Environmental flow study

- Scientific analysis of flow components required to support key environmental values and objectives
- Updated as required with new information

Forms basis of

Seasonal watering proposal

- Describes regional priorities for environmental water use in the coming year under a range of planning scenarios
- Developed annually

Informs (Seasonal watering plan)

Seasonal watering plan

- Describes statewide potential environmental watering in the coming year under a range of planning scenarios
- Developed annually
- Consolidates the seasonal watering proposals accepted by the VEWH
- Can be varied at any time (with same consultative requirements as initial development)

Decisions communicated through

Seasonal watering statement

- Communicates decisions on watering activities to be undertaken as water becomes available during the season
- Authorises waterway managers to undertake watering
- Can be released at any time during the season
- May be one or multiple statements for a system

Water for the environment is delivered

1.2.3 Who contributes to the seasonal watering plan?

Stakeholder engagement on potential environmental watering actions occurs during the development of seasonal watering proposals. The level and method of engagement varies across the state, reflecting the differing systems, watering actions and stakeholders. In some regions, formal environmental watering advisory groups provide the opportunity for waterway managers and interested community members to discuss potential environmental flows in their system or locality for the coming year. In other systems, engagement occurs one-on-one between waterway managers and interested stakeholders. The most interested stakeholders tend to be Traditional Owners, irrigators, farmers, members of the community living close to or with an interest in a specific waterway, members of recreational groups and members of local environmental groups.

Land managers and storage managers also consider and endorse, or provide their written support for the seasonal watering proposals – ensuring planned watering aligns with land and storage management objectives, can feasibly be delivered through planned system operations, and risks can be adequately managed.

For each region, there is a summary of the engagement activities waterway managers undertook when developing seasonal watering proposals (see regional overviews in sections 2 to 5).

1.2.4 Can the seasonal watering plan be changed?

Under the Victorian *Water Act 1989*, the VEWH can only authorise use of water for the environment where it is consistent with a seasonal watering plan. This is to ensure transparency about what environmental flows are planned and how they are managed.

To ensure flexibility to adapt to changing conditions, the Act allows the VEWH to vary any section of a seasonal watering plan. Variations may be needed to incorporate new knowledge or to address circumstances that were not identified before the start of the water year.

The VEWH makes all variations publicly available at vewh.vic.gov.au as separate attachments to the original seasonal watering plan. You can email general.enquiries@vewh.vic.gov.au for a hard copy.

1.2.5 When isn't a formal variation required to the seasonal watering plan?

In some instances, there may be unforeseen circumstances that will call for use of water for the environment that does not require a variation to the seasonal watering plan. These include:

- minor operational adjustments to specific environmental watering actions
- water for the environment being used for environmental emergency management situations
- small volumes of water for the environment being used for technical investigations or infrastructure maintenance
- facilitating the delivery of water for the environment held by other water holders for downstream non-Victorian objectives.

As the VEWH cannot anticipate the specifics of these circumstances, it cannot include further details about them in this plan. Waterway managers are required to consult the VEWH in all instances where releases of water for the environment do not align with the seasonal watering plan.

Minor operational adjustments

Minor operational adjustments to environmental watering actions may occur from time to time. For example, the targeted river reaches, flow rates, timing, magnitude and durations detailed in sections 2 to 5 may need to be adjusted slightly due to changes in predicted rainfall or other water orders, delivery infrastructure constraints, emerging ecological knowledge or the timing of specific ecological triggers (such as a bird-breeding event). In all cases, environmental watering actions will still aim to optimise the environmental outcomes achieved, in line with the objectives set out in the seasonal watering plan.

Environmental emergency management situations

Water for the environment may be needed for an environmental emergency management situation. This may include reducing the impact of natural blackwater or bushfire events, preventing fish deaths or mitigating the effects of blue-green algae blooms. It could also include smoothing the transition to or from a high-natural-flow event (for example, supplementing natural flows with water for the environment to provide a more gradual rise and fall, to minimise the threat of riverbanks slumping).

Small technical investigations and maintenance

There may be instances where a small volume of water for the environment may be used for research and development purposes, or for small-scale infrastructure testing or maintenance. Such instances are considered on a case-by-case basis and must aim to enhance knowledge and improve the management of water for the environment. They must not compromise the potential to achieve the environmental objectives in the seasonal watering plan.

Facilitating the delivery of water held by other water holders for downstream objectives

Some water held by other water holders is stored in Victorian storages and is sometimes called on to meet downstream demands beyond the scope of this plan (such as for the Coorong, Lower Lakes and Murray Mouth area in SA). Delivery of this water is sometimes needed at a time and flow rate that was not scoped in the seasonal watering plan. The VEWH facilitates and authorises such deliveries, provided the risk of adverse impacts on Victoria's rivers, wetlands and floodplains and other risks are appropriately managed.

1.3 Implementing the seasonal watering plan

The seasonal watering plan scopes potential environmental watering for the coming year, but many factors influence decisions about what water for the environment is committed and delivered.

In this section ...

- **How are watering decisions made throughout the year?**
- **When does the Victorian Environmental Water Holder commit and authorise use of water for the environment?**
- **How does the Victorian Environmental Water Holder prioritise different watering actions when there is not enough water for the environment available?**
- **Do seasonal conditions affect how water for the environment is used?**
- **How are shared cultural, economic, recreational, social and Traditional Owner benefits considered in environmental watering decisions?**
- **How are risks managed?**

Some factors that influence decisions about committing and delivering water for the environment are:

- seasonal conditions, weather forecasts and catchment conditions
- river and system operations (such as unregulated flows, catchment inflows, storage levels, other water users' needs and potential delivery constraints)
- ecological or biological factors and triggers (such as plant and animal responses to natural flows or temperature)
- water availability
- risks associated with an environmental watering action
- the opportunity to deliver shared benefits.

It is important there is flexibility to respond to these different factors, as they can significantly influence the environmental outcomes and shared benefits that can be achieved.

1.3.1 How are watering decisions made throughout the year?

As the season unfolds, many of the uncertainties associated with seasonal conditions, water availability and operational context become clearer and this clarity informs decisions about what environmental flows should proceed. Many on-ground factors do not become clear until very close to the anticipated time of delivering the water.

To guide environmental watering decisions, a flexible and adaptive approach is adopted that involves relevant stakeholders. This process of review and adjustment ensures that water for the environment is used in an efficient and seasonally appropriate manner to optimise ecological outcomes across the state.

Waterway managers, storage managers and land managers provide advice about which watering actions are needed and can be delivered in each region during the year. Environmental water holders use that information to decide which watering actions to authorise. All program partners have a role in identifying potential watering actions and enabling the delivery of water for the environment (as explained in subsection 1.3.3).

If planned watering actions need to be significantly changed during the season to respond to unforeseen circumstances, further scientific or community input may be sought to inform decision-makers.

The VEWH regularly publishes updated information about current and anticipated environmental watering actions on its website at vewh.vic.gov.au.

1.3.2 When does the Victorian Environmental Water Holder commit and authorise use of water for the environment?

The VEWH aims to commit as much water as is sensibly possible, as early as possible, to provide waterway managers with certainty to proceed with the planned environmental watering actions.

The VEWH (like other environmental water holders) can commit its water at any point before or during the water year. The VEWH commits water via seasonal watering statements, which authorise waterway managers to use water for the environment. The VEWH publishes seasonal watering statements on its website at vewh.vic.gov.au.

The VEWH can make a seasonal watering statement at any time of the year. Depending on the nature of the system and the entitlement being used, it may make one or multiple statements for a system during the water year. Before issuing a seasonal watering statement, the VEWH must be sure the required delivery arrangements (including any risk management measures) are in place and any costs it must meet are acceptable.

Where many environmental watering actions across different systems require access to the same environmental or bulk entitlement, decisions to commit water may require more thorough consideration. This may require prioritisation of one river or wetland over another, or prioritisation of one flow component over another. Subsection 1.3.3 has further information about how these decisions are made.

In some instances, the VEWH may commit water very close to the anticipated delivery time. This may be necessary because the water demand arises at short notice due to environmental, operational or weather conditions. For example, a colonial waterbird nesting event in Barmah Forest may trigger a need for water for the environment to maintain shallow flooding long enough for the birds to fledge.

There may also be instances where planned environmental flows are not delivered to a site. For example, an ecological trigger or seasonal conditions could nullify the potential benefit of the planned delivery, or a lack of catchment inflows may mean there is not enough water for the planned watering action.

The CEWH and the Southern Connected Basin Environmental Watering Committee (for the Living Murray program) commit water for use in Victoria with similar logic to that outlined above. The VEWH then formally authorises the use of that water through seasonal watering statements.

Can environmental water holders and waterway managers change their minds after a seasonal watering statement has been issued?

The VEWH may withdraw a seasonal watering statement at any point during the year, in consultation with the waterway manager and storage manager for that river or wetland system. It might do so, for example, to address emerging risks or changes in operating conditions or water availability.

Similarly, a waterway manager or storage manager may decide, in consultation with the VEWH, not to proceed with an environmental watering action after a seasonal watering statement has been issued. This could be due to environmental triggers indicating the water was no longer required, resourcing constraints or new information that the potential environmental or public risk of watering is too high.

1.3.3 How does the Victorian Environmental Water Holder prioritise different watering actions when there is not enough water for the environment available?

The VEWH works with its program partners to make decisions about where its available water and funds for the environment are used, carried over or traded to get maximum benefit for the state's waterways — our rivers, wetlands, estuaries and floodplains — and the wildlife that depend on them.

In implementing this program, it is important to recognise the dynamic nature of the environmental watering program. Seasonal conditions can vary considerably between years, which affects both the requirements of particular sites for water for the environment (the demand) and the availability of water for the environment (the supply).

A shortfall in supply might arise because of:

- significant, high-value demands for water for the environment
- drought or low water availability.

To meet a shortfall, the VEWH may look to use tools such as carryover and trade (as explained in subsection 1.4.2). If there is still a shortfall of water, the VEWH, in collaboration with waterway managers and other water holders if relevant, must prioritise between environmental watering actions.

Many factors influence prioritisation decisions (such as the likely environmental outcomes, the previous watering history in that river or wetland, environmental or public risk considerations and seasonal conditions in the region). Trade-offs may need to be made about watering actions undertaken in one year or at one site, and water may need to be provided at the expense of watering actions in the next year or at another site. Trade-offs may also need to be made about foregoing watering actions to sell water allocation and use the resulting revenue for complementary works and measures; it may also be used to improve knowledge and capability to deliver better environmental outcomes in the short or longer term.

In deciding to prioritise one environmental watering action or site over another, the VEWH always seeks to optimise environmental outcomes across the state.

What criteria are used to guide prioritisation decisions?

Figure 1.3.1 shows the criteria considered when making the trade-off decisions and prioritising specific watering actions. Waterway managers provide information about how different watering actions meet these criteria, and about opportunities for shared benefits, in their seasonal watering proposals.

In deciding how to use the available Water Holdings in any given year, the VEWH also considers additional factors, such as:

- decisions by other water holders about the use of their water for the environment
- State and Commonwealth government decisions about water resource policy
- the resources, knowledge and capability of the VEWH and its program partners
- storage managers meeting their obligations to the environment associated with the right to harvest and distribute water sustainably
- complementary works and measures being undertaken
- the availability of funds
- the merit of selling available water allocation to fund works or technical investigations to enhance environmental outcomes
- services associated with the management of the Water Holdings and the delivery of water for the environment.

Prioritisation has historically occurred on a site-by-site basis, but many of the ecological processes that underpin waterway health operate at a landscape scale. The prioritisation process is currently evolving to consider the combination of watering actions that are needed across multiple waterways in a region to achieve the best environmental outcomes. The prioritisation criteria shown in Figure 1.3.1 can be equally applied at individual sites or at the broader landscape scale.

Figure 1.3.1 Criteria for prioritising environmental watering actions

Prioritisation criteria	Types of factors considered
Extent and significance of environmental benefit	▶ Size of the area being watered ▶ Expected ecological outcomes ▶ Expected scale of response ▶ Conservation status of the species or community that will benefit ▶ Expected contribution to regional environmental objectives
Likelihood of success	▶ Evidence that the desired outcomes are likely to be achieved ▶ External threats that may affect getting the desired results
Longer-term benefits	▶ Value added to previous watering undertaken at the site ▶ Longer-term environmental benefits expected ▶ Ability to sustain these values into the future
Urgency of watering needs	▶ History of watering at the site ▶ Potential for irreversible damage if the watering does not occur ▶ Risks associated with not delivering the water
Feasibility of the action	▶ Capacity of infrastructure to meet the delivery requirements ▶ System or operational constraints ▶ Flexibility in the timing of delivery ▶ Likelihood that planned management actions will mitigate external threats
Environmental or third party risks	▶ Adverse environmental outcomes that may arise ▶ Third-party risks associated with the event ▶ Effectiveness of mitigation to manage third-party and environmental risks
Cost effectiveness of the watering action	▶ Likely environmental benefit compared against: • costs to deliver and manage water • costs of interventions to manage external threats and risks
Efficiency of water use	▶ Volume of water needed to achieve the desired outcomes ▶ Volume and timing of return flows that may be used at downstream sites (see section 1.4.2) ▶ Alternative supply options such as use of consumptive water en route or augmenting natural flows ▶ Risks of spills from storages in the upcoming water year and any carryover water (see section 1.4.2) that may be available
After consideration of above criteria	
Cultural, economic, social and Traditional Owner benefits	▶ Traditional Owner values and aspirations ▶ Recreation, community events and activities ▶ Economic benefits

Who is involved in the prioritisation process?

Waterway managers, environmental water holders, storage managers and communities (including recreational user groups, environmental groups, Traditional Owners and farming groups) all have a role in the process of prioritising environmental watering actions, depending on the nature and scale of the decision being made. There is a list of partners and stakeholders engaged in developing the seasonal watering proposal for each system in this plan.

Waterway managers are best placed to advise about the extent and significance of an environmental watering action and about the highest priorities in their region.

The VEWH and other environmental water holders determine the highest watering priorities across regions. The VEWH's decisions are intended to provide the best possible environmental outcomes for the state. The VEWH makes these decisions in consultation with waterway managers and other program partners as relevant.

Advice from storage managers is generally the key to understanding the feasibility of delivering a watering action, including the flexibility of delivery timing and operational constraints.

Land managers provide consent to deliver environmental flows on their land and will advise on the feasibility of delivery after considering land management activities, public access and the risks and benefits of the environmental watering action.

The annual prioritisation process is informed by longer-term site prioritisation by waterway managers in consultation with their communities. This prioritisation is detailed in plans such as regional catchment strategies, regional waterway strategies and environmental water management plans. These plans draw on community and scientific knowledge and prioritise sites for water for the environment (and other river health activities) that have high cultural, economic, environmental, social and Traditional Owner values.

Additional input from the community about prioritising water for the environment is provided annually where needed.

1.3.4 Do seasonal conditions affect how water for the environment is used?

In the same way that rainfall patterns influence how people water their gardens or paddocks, different climatic conditions influence how water for the environment is managed.

Seasonal conditions drive what water will be available during the water year and the environmental watering objectives to be pursued (as explained in subsection 1.2.1). Waterway managers take seasonal conditions into account when prioritising the water for the environment needed at each site. Seasonal planning scenarios describe the range of watering actions that may occur under drought to very wet climatic conditions.

Waterway managers work with the program partners to decide how to optimise the ecological outcomes they can achieve using water for the environment by considering factors including:

- the environmental objectives under each climatic scenario including consideration of any essential water for the environment needs
- how rainfall, natural flooding or the delivery of water for operational and/or consumptive use may contribute to the achievement of the environmental objectives
- how water for the environment may be used to build on natural flows or irrigation deliveries to meet the environment's needs
- natural climatic cues that might increase the likelihood of achieving an ecological outcome.

Planning scenarios are presented in the seasonal watering plan and provide the basis for the adaptive management of water for the environment as the season unfolds. They also provide an early indication of the amount of water that may be used at different sites and whether the VEWH may need to trade water during the season to meet identified environmental needs (as explained in section 1.4).

Figure 1.3.2 provides an example of how different planning scenarios may influence decisions about how water for the environment is managed in a year.

Figure 1.3.2 Example planning scenarios for a river system under a range of climatic conditions

Planning scenario	Drought	Dry	Average	Wet to very wet
Expected Conditions	No or negligible contributions from unregulated flows. Waterways may stop flowing at times, more likely during summer/ autumn	Minor contributions from unregulated reaches and tributaries, more likely in winter/ spring	Unregulated flows provide extended low flows and multiple freshes, more likely in winter/ spring. Minor storage spills may occur	Extended unregulated high flows, multiple large storage spills and overbank flooding, more likely in winter/spring but possible any time of year
Management Objectives	Protect	Maintain	Recover	Enhance
	• Avoid critical loss • Maintain refuges • Avoid catastrophic events	• Maintain river functioning with reduced reproductive capacity • Maintain key functions of high-priority wetlands • Manage within dry-spell tolerances	• Improve ecological health and resilience • Improve recruitment opportunities for key plant and animal species	• Restore key floodplain wetland linkages • Maximise recruitment opportunities for key animal and plant species
Example watering actions to support management objectives	Provide low flows and trigger-based freshes to maintain water quality in deep refuge pools	Provide summer/ autumn low flows to manage water quality and maintain connectivity	Provide year-round low flows to maintain habitat connectivity to support fish movement	Maintain year-round low flows and seasonal freshes to improve the quality of in-stream and bank vegetation and trigger the spawning and movement of native fish
		Extend the duration of flow peaks to freshen water quality in deep pools	Extend the duration and/or magnitude of peaks to provide spawning cues for fish	Maintain connectivity and the exchange of nutrients between the river and floodplain
			Provide seasonal freshes to support the establishment and maintenance of bank vegetation	Slow the recession of natural peaks to avoid bank slumping and erosion
				Top up natural flows if needed, to meet targets for winter low flows and spring peaks

1.3.5 How are shared cultural, economic, recreational, social and Traditional Owner benefits considered in environmental watering decisions?

Environmental flows are essential for maintaining and improving the health of rivers, wetlands and floodplains. By improving the health of rivers, wetlands and floodplains, environmental flows also provide benefits to communities. Community benefits may be direct (for example, water for the environment can increase populations of popular angling fish species, sustain healthy Country and totem species for Aboriginal communities and improve water quality to the benefit of irrigators) or opportunistic (for example, timing the delivery of an environmental flow to increase opportunities for kayakers and telling the public about the flow so they can take advantage of it).

In planning for environmental flows, the primary purpose is to optimise environmental benefits. Year by year and case by case, the VEWH and its partners consider opportunities raised by communities to use water for the environment to provide additional cultural, economic, recreational, social and Traditional Owner benefits. Where possible, these opportunities are incorporated into watering decisions, if they do not compromise environmental outcomes.

Shared community benefits of water for the environment can sometimes be actively optimised by making decisions around the storage, delivery and use of water for the environment to support community events (such as local fishing, waterskiing or rowing competitions).

When planning for and delivering environmental flows, the VEWH and its program partners look for opportunities to achieve shared community benefits in both the short and longer term, where environmental outcomes are not compromised. Longer-term community benefits may sometimes require short-term community inconvenience. For example, floodplain watering in Hattah Lakes may limit access and therefore inconvenience campers for a short period, but the environmental benefits of the watering will likely improve tourism and recreational opportunities in the forest over the longer term. In such cases, waterway managers work closely with land managers to limit disruption to park users as much as possible.

Waterway managers work with communities to identify the cultural, economic, recreational, social, and Traditional Owner values of waterways through regional catchment strategies, regional waterway strategies, environmental water management plans and seasonal watering proposals. Some of the upcoming opportunities for each region are summarised in sections 2 to 5. Program partners will continue to work with stakeholders to look for opportunities to achieve shared community benefits from water for the environment throughout the year.

1.3.6 How are risks managed?

Risk management is an integral part of managing water for the environment. Program partners consider risks continually during long-term and annual planning, implementation and review.

The VEWH, in collaboration with its program partners, has developed a risk management framework that addresses interagency risk, respects the risk management practices of each partner, and documents roles and responsibilities in operating arrangements. The key elements of the framework are described in Table 1.3.1.

The seasonal watering proposals on which this seasonal watering plan is based identify potential risks associated with the specific watering actions proposed for the coming water year. A collaborative approach is the best way to manage the shared environmental watering risks; so, as part of developing the proposals, partners jointly assess risks and identify and commit to mitigation actions.

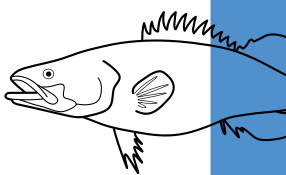
Table 1.3.1 shows the main shared risks of environmental watering. Program partners consider and reassess these and other potential risks as the season unfolds and planned watering actions are due to commence.

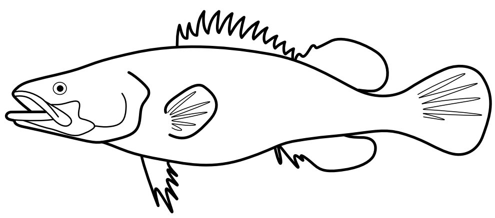
Some risks may only eventuate at the time of delivery. For example, forecast heavy rain that coincides with a planned environmental flow could increase the risk of nuisance flooding. Program partners review risks immediately before a planned environmental flow and implement measures or actions required to mitigate the risks as agreed with all relevant program partners. Watering actions will not be implemented if unacceptable risks to the public or the environment cannot be mitigated.

Even with best-practice risk management controls, there may be unintended impacts from environmental flows or situations where environmental flows cannot be delivered as planned. In those situations, program partners work together to respond to incidents and then learn and adapt their management of risks. The VEWH has developed an agreed approach to incident management to help program partners report, investigate and respond to risks.

Table 1.3.1 Main shared risks of environmental watering

Type of risk	Example mitigating actions
Environmental watering contributes to third-party impacts	• Identify and understand water system capacities and monitor water levels at key locations to inform daily water release decisions and ensure impacts do not eventuate. • Consider potential catchment run-off from forecast rainfall before deciding on the timing of releases of water for the environment. • Implement a communication strategy which may include media releases, public notices and signage before environmental flows, to ensure people are informed of significant deliveries of water for the environment and can adjust their behaviour accordingly. This includes early liaison with potentially affected stakeholders. • Restrict access by closing gates and tracks.
Inability to achieve or demonstrate ecological outcomes from environmental watering	• Undertake intervention monitoring within available resources to identify the ecological response. • Conduct research to better understand responses to water for the environment. • Communicate the outcomes of monitoring and incorporate learnings into future environmental watering. • Consider the need for complementary works to help achieve environmental watering outcomes as part of integrated catchment management, and the likely timeframe for ecological responses to all management actions.
Environmental watering has negative effects on the environment (for example blackwater, bank erosion and the spread of weeds)	• Plan the timing, frequency, duration and variability of environmental flows to limit negative effects. • Monitor environmental watering outcomes and adapt future deliveries and/or scientific recommendations if necessary.





1.4 Managing available water for the environment

Environmental entitlements are held in 15 water supply systems across Victoria. Sections 2 to 5 detail where water made available under these entitlements may be delivered in 2019–20.

In this section ...

- **How much water is available to use as part of the Victorian environmental watering program?**
- **What options are available to effectively and efficiently manage water for the environment?**

To the extent possible, the VEWH and other environmental water holders try to avoid water supply shortfalls by efficiently using water for the environment and by using tools such as carryover and trade. If there is still a shortfall of water, the VEWH in collaboration with waterway managers (and other water holders if relevant) will prioritise environmental watering actions.

1.4.1 How much water is available to use as part of the Victorian environmental watering program?

VEWH environmental entitlements

Water for the environment is made available under the environmental entitlements held by the VEWH.

Table 1.4.1 shows the entitlements held by the VEWH as at 31 May 2019, including those held in trust for the Living Murray program. The VEWH's environmental entitlements can be viewed at waterregister.vic.gov.au/water-entitlements/bulk-entitlements.

Figure 1.4.1 Proportion of water entitlements in Victoria held by private users (e.g. farmers, industry), water corporations or environmental water holders at 30 June 2018.

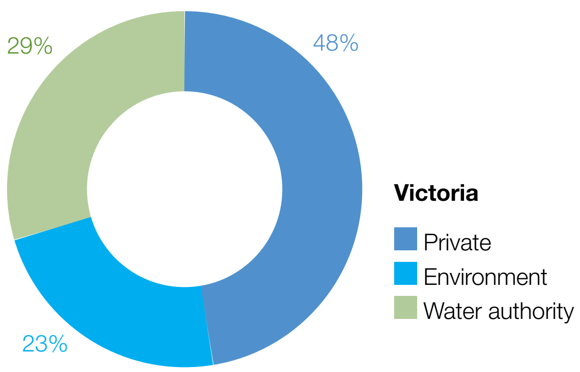


Figure 1.4.1 shows the proportion of water entitlements held in Victoria by private users (e.g. irrigators, industry), water corporations (e.g. for household supply) and environmental water holders (VEWH, Commonwealth Environmental Water Holder).

It is based on the total volume of surface water entitlements recorded in the Victorian Water Register at 30 June 2018. VEWH has incorporated its storage share volumes for some entitlements (e.g. Barwon, Latrobe systems) that are not represented volumetrically in the Water Register. The data does not include water entitlements that are not accounted for in the Water Register, such as minimum or unregulated flows and other rules-based environmental water like the Barmah-Millewa Environmental Water Account or River Murray Increased Flows.

Where possible, the proportion of water entitlements held by each user group is shown in each system section. For some systems, the way water entitlements have been accounted for in the Victorian Water Register or the connected nature of some water supply systems across multiple river basins, means that it is not possible to represent water entitlements proportionally for individual basins.

The water available to use under these entitlements varies from year to year depending on entitlement rules, seasonal conditions (including rainfall and run-off in the catchments) and the water already available in storages.

Table 1.4.1 Environmental entitlements held by the VEWH (as at 31 May 2019)[1]

System	Entitlement	Volume (ML)	Class of entitlement
Central region			
Barwon	Barwon River Environmental Entitlement 2011	N/A[2]	Unregulated
	Upper Barwon River Environmental Entitlement 2018	2,000[3]	Share of inflow
Moorabool	Moorabool River Environmental Entitlement 2010[4]	7,086[3]	Share of inflow
Tarago	Tarago and Bunyip Rivers Environmental Entitlement 2009	3,000[3]	Share of inflow
Werribee	Werribee River Environmental Entitlement 2011	N/A[3]	Share of inflow
Yarra	Yarra Environmental Entitlement 2006[4]	17,000 55	High Unregulated
Gippsland region			
Latrobe	Lower Latrobe Wetlands Environmental Entitlement 2010	N/A[2]	Unregulated
	Blue Rock Environmental Entitlement 2013	18,737[3]	Share of inflow
Macalister	Macalister River Environmental Entitlement 2010	12,461 6,230	High Low
Thomson	Bulk Entitlement (Thomson River – Environment) Order 2005[4]	10,000 8,000[3]	High Share of inflow
Northern region			
Campaspe	Environmental Entitlement (Campaspe River – Living Murray Initiative) 2007	126 5,048	High Low
	Campaspe River Environmental Entitlement 2013	20,652 2,966	High Low
Goulburn	Goulburn River Environmental Entitlement 2010	8,851 3,140	High Low
	Environmental Entitlement (Goulburn System – Living Murray) 2007	39,625 156,980	High Low
	Environmental Entitlement (Goulburn System – NVIRP Stage 1) 2012	36,624[6]	High
	Bulk Entitlement (Goulburn System – Snowy Environmental Reserve) Order 2004	30,252 8,156	High Low
	Water Shares – Snowy River Environmental Reserve	8,321 17,852	High Low
	Water Shares – Living Murray program	5,559	High
	Silver and Wallaby Creeks Environmental Entitlement 2006[4]	N/A	Passing flow only
Loddon	Bulk Entitlement (Loddon River – Environmental Reserve) Order 2005[4]	10,970 2,024	High Low
	Environmental Entitlement (Birch Creek – Bullarook System) 2009[4]	100	N/A[7]
	Water Shares – Snowy River Environmental Reserve	470	High

Table 1.4.1 Environmental entitlements held by the VEWH (as at 31 May 2019)[1] *continued...*

System	Entitlement	Volume (ML)	Class of entitlement
Murray	Bulk Entitlement (River Murray – Flora and Fauna) Conversion Order 1999	29,782 3,894 40,000	High Low Unregulated
	Bulk Entitlement (River Murray – Flora and Fauna) Conversion Order 1999 – Barmah–Millewa Forest Environmental Water Allocation	50,000 25,000	High Low
	Bulk Entitlement (River Murray – Flora and Fauna) Conversion Order 1999 – Living Murray	9,589 101,850 34,300	High Low Unregulated
	Environmental Entitlement (River Murray – NVIRP Stage 1) 2012	27,031[6]	High
	Bulk Entitlement (River Murray – Snowy Environmental Reserve) Conversion Order 2004	29,794	High
	Water shares – Snowy Environmental Reserve	14,671 6,423	High Low
	Water Shares – Living Murray program	12,267	High
Western region			
Wimmera and Glenelg	Wimmera and Glenelg Rivers Environmental Entitlement 2010[4,5]	40,560 1,000	Pipeline product Wetland product

1 *While the VEWH does not hold any entitlements in the Maribyrnong system, water allocation was purchased in this system together with Melbourne Water in all years between 2013–14 and 2018–19 inclusive.*

2 *Use of these entitlements depends on suitable river heights, as specified in both the Latrobe and Barwon environmental entitlements (rather than a permitted volume).*

3 *Water is accumulated continuously according to a share of inflows (Blue Rock Reservoir 9.5 percent, Tarago Reservoir 10.3 percent, Werribee system 10.0 percent, Moorabool system 11.9 percent, Thomson Reservoir 3.9 percent, West Barwon Reservoir 3.8 percent). The actual volume available in any year varies according to inflows. Entitlement volumes presented in this table indicate the entitlement share of storage.*

4 *In addition to volumetric entitlement, the entitlement also includes passing flows.*

5 *In addition to volumetric entitlement, the entitlement also includes unregulated water.*

6 *This entitlement volume is equal to one-third of the total water savings from the Goulburn-Murray Water Connections Project Stage 1, as verified in the latest audit (including mitigation water).*

7 *Allocation against this entitlement is made subject to specific triggers, as specified in the entitlement.*

Water donations

The VEWH may receive water donations from individuals, community groups and other organisations. This water could be used for environmental watering in the water year it was donated (including for actions identified in the seasonal watering plan), or it could be carried over for use in the future (see subsection 1.4.2 for more information about carryover). Some donors may identify a specific use for the water they donate (such as environmental watering in a specific wetland or to protect a certain tree species). In these instances, the VEWH would consider the costs and benefits of each donor proposal before agreeing to accepting a donation.

Water available from other environmental water holders

In northern and western Victoria, the VEWH coordinates with other environmental water holders to deliver environmental outcomes at the broader Murray-Darling Basin scale. One of the VEWH's important roles is to coordinate with Murray-Darling Basin environmental water holders (the CEWH and program partners in New South Wales and South Australia) to optimise the benefits of all water for the environment in Victorian waterways. The seasonal watering plan considers the use of all water for the environment held in Victorian river systems.

Usually, when Commonwealth water is to be delivered in Victoria, the CEWH transfers the agreed amount of water to the VEWH. That amount then becomes part of the Victorian environmental Water Holdings until used or transferred back.

Table 1.4.2 shows the environmental water entitlements held by the CEWH in Victoria. The CEWH also holds water in New South Wales and South Australia, and both New South Wales and South Australia also hold water, which could potentially be made available for environmental watering in Victoria.

Table 1.4.2 Environmental water entitlement held in Victoria by the Commonwealth Environmental Water Holder (as at 31 May 2019)

System	Volume (ML)	Class of entitlement
Broken	534	High-reliability water share
	4	Low-reliability water share
Campaspe	6,624	High-reliability water share
	395	Low-reliability water share
Goulburn	285,205	High-reliability water share
	42,467	Low-reliability water share
Loddon	3,356	High-reliability water share
	527	Low-reliability water share
Murray	362,307	High-reliability water share
	35,413	Low-reliability water share
Ovens	123	High-reliability water share
Wimmera-Mallee	28,000	Low-reliability product

Water for the environment and non-government agencies

In 2007, the Murray–Darling Wetlands Working Group (MDWWG) and the Nature Conservancy (both non-government organisations) partnered to own and manage the Environmental Water Trust. To date, the MDWWG has been very active in wetland protection and management in New South Wales through partnerships with state and federal governments. In 2017–18 and 2018–19, the MDWWG partnered with Goulburn Broken CMA to deliver water for the environment to wetlands in Victoria for the first time. The MDWWG is currently focusing its efforts on wetlands that are on private land, and given the deliveries are outside the Victorian Water Holdings, they are not covered by this seasonal watering plan.

For more information about the MDWWG and the Environmental Water Trust, see murraydarlingwetlands.com.au and environmentalwatertrust.org.au.

1.4.2 What options are available to effectively and efficiently manage water for the environment?

Other water sources

Water for the environment is not the only type of water that can support river, wetland and floodplain health. Waterway managers and environmental water holders in consultation with storage managers consider the potential for environmental watering objectives to be met by other sources of water. The timing of environmental releases can be coordinated with other sources of water to achieve greater benefits than an environmental release alone could produce. Other sources of water can include:

- **system operating water** (including passing flows), which maintains a minimum flow for operational and/or environmental purposes in many rivers, to which water for the environment can be added
- **heavy rainfall** (resulting in unregulated flows), which can naturally meet an environmental objective, so water available under environmental water entitlements is not needed or could be added to extend a natural flow
- **alterations to the timing and route for delivery of consumptive water**, which can achieve environmental objectives without detriment to consumptive water users: water for the environment is sometimes used to cover any additional losses associated with the altered delivery of consumptive water.

These types of water are considered in the development and implementation of the seasonal watering plan to ensure effective system operations and efficient use of water for the environment, and to achieve the greatest benefit to the environment.

Return flows

In some systems, water for the environment delivered through upstream sites can be used again downstream. This helps to ensure water for the environment is used efficiently and effectively to achieve the greatest environmental benefits.

This reuse policy, known as return flows, is available in many systems across northern Victoria. It makes use of water for the environment more efficient, and it helps reduce the volume of water that needs to be recovered for the environment from consumptive water users.

The VEWH's access to return flows is enabled through rules in its environmental water entitlements. Reuse of return flows is also available to the CEWH and the Living Murray when the VEWH delivers water on their behalf.

Where possible, return flows are reused to provide benefits at Victorian environmental sites. If not needed in Victoria, the VEWH, Living Murray and CEWH return flows will continue to flow across the border to SA where they will be used to provide environmental benefits at sites such as the Coorong, Lower Lakes and Murray Mouth area.

Carryover

Some entitlements allow the VEWH to carry over unused water to the following water year. This means that water allocated in one year can be kept in storages for use in the following year, subject to certain conditions.

Carryover provides flexibility and enables water for the environment to be delivered when it is of the greatest value to the environment. For example, carryover can help ensure environmental water holders can meet high winter and spring demands when there is a risk there will be little water available under entitlements at the beginning of the water year.

Carryover can also be used to set water aside to maintain key refuge areas and avoid catastrophic events in drought periods.

Water trading

Water trading allows the VEWH to smooth out some of the variability in water availability across systems and across years. Under certain circumstances, it can enable the VEWH to move water to the systems where it is most needed. The VEWH can trade water allocated to its entitlements by:

- administrative water transfers between the VEWH's entitlements
- administrative water transfers with other water holders
- purchasing water allocation
- selling water allocation.

Administrative water transfers are the most common trades the VEWH undertakes. These occur between the VEWH's entitlements (or accounts) to move water to where it is most needed. Other environmental water holders also transfer their water to the VEWH for delivery in Victoria. These types of water trades are often referred to as administrative water transfers as there is no financial consideration associated with the trade.

The VEWH can also buy or sell water allocation where it is in line with its statutory objectives: essentially, if it optimises environmental outcomes in Victorian waterways.

The VEWH has bought or sold a small amount of water allocation each year since it was established in 2011. Water has been purchased to enhance environmental outcomes in systems where insufficient water for the environment was available. Water has also been sold to raise revenue for investment in projects which optimise environmental watering outcomes.

The VEWH can sell water to invest in complementary works, measures, technical studies or other priorities, where these projects optimise environmental watering outcomes for enduring benefit. The VEWH consults with DELWP where these projects have government policy or program implications.

The VEWH can use revenue raised from the sale of a water allocation to:

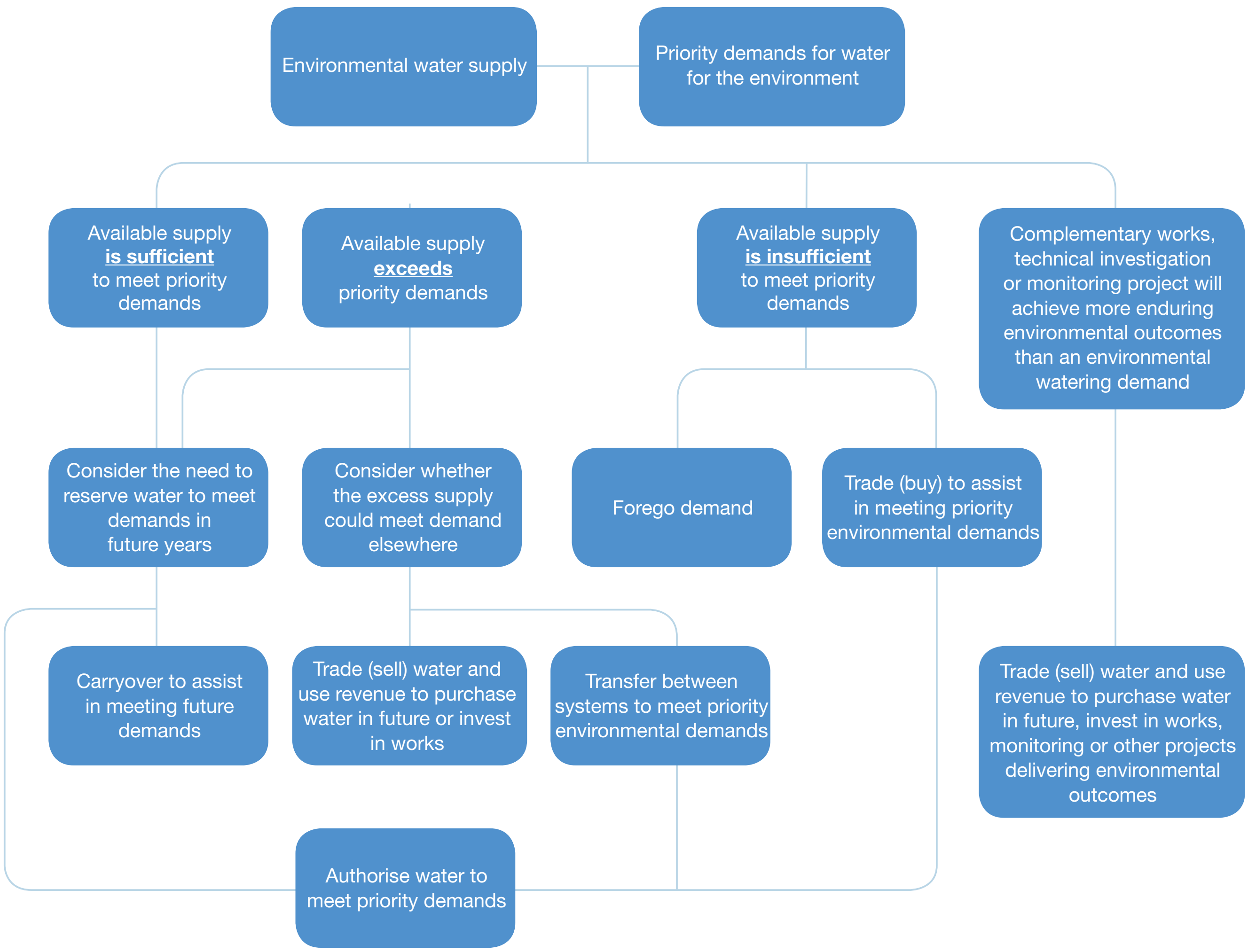
- purchase water to meet shortfalls in any Victorian system
- invest in monitoring or technical studies that will improve future management of water for the environment
- invest in structural works and other on-ground activities that will improve the performance of Victoria's environmental watering program.

Subject to the approval of the Minister for Water, the VEWH can also trade its water entitlements (referred to as a permanent trade). However, the VEWH has not undertaken permanent trades to date.

Figure 1.4.2 shows the key considerations that guide the VEWH's use, carryover and trade decisions.

There is more information about the VEWH's trading activity including its annual trading strategy, on its website at vewh.vic.gov.au.

Figure 1.4.2 Key considerations guiding use, carryover and trade decisions



1.5 How to read the seasonal watering plan

Under the Victorian *Water Act 1989*, the VEWH can only authorise use of water for the environment where it is consistent with a seasonal watering plan. This is to ensure transparency about what environmental flows are planned and how they are managed.

The plan must ensure that the scope, objectives and potential watering activities for each waterway are clear and enable decisions about possible water use to be made effectively and transparently.

Sections 2 to 5 of the seasonal watering plan represent four broad geographic regions of Victoria: the Gippsland, central, western and northern regions. Each regional overview includes:

- a description of the region
- acknowledgement of the role of Traditional Owners in the area
- a description of how communities and program partners are engaged
- examples of community benefits of environmental watering
- examples of integrated catchment management in the region
- a description of how risks are managed.

Each region is divided further into system sections for waterways and wetlands that are supplied with water for the environment from an environmental entitlement. The environmental values, recent conditions, environmental watering objectives and planned actions for the year are presented in each system.

Each system section includes:

- **a system introduction page**, which includes:
  - information about the waterway manager, storage manager and environmental water holders relevant to the system
  - images of the system and some of its important environmental values
  - an interesting fact about the system or an Aboriginal name or definition for the system
  - a pie chart showing the proportion of water entitlements in the system for environmental, urban, industry and irrigation uses
- **a system overview**, which describes the location of the system, its waterways and major features
- **environmental values**, which outlines the primary water-dependent species, communities, ecological processes and habitats that rely on healthy waterways and form the basis for environmental objectives
- **recent conditions**, which describes the factors that will be considered when planning environmental flows in the coming year (such as the past watering regime, climate and rainfall, water availability, system operations, monitoring results and environmental observations)
- **environmental objectives**, which summarises the measurable outcomes that are sought for each environmental value in the system. Each objective will likely rely on ongoing implementation of one or more watering actions as well as complementary actions (such as control of invasive species or installation of fishways). Target outcomes may take years or several decades to achieve.

Figure 1.5.1 Example environmental objectives table

Environmental objectives in the Macalister system

(fish icon)	Restore populations of native fish, specifically Australian grayling Maintain/enhance the structure of native fish communities
(plant icon)	Increase the recruitment and growth of native riparian vegetation

In this example environmental flows that provide optimal spawning opportunities for Australian grayling will contribute to achieving this objective, as will complementary works such as the construction of fishways to increase the habitat range for native fish.

Scope of environmental watering

This information describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Figure 1.5.2. Example potential environmental watering actions and objectives tables

Potential environmental watering actions describe the timing, magnitude, duration and frequency of environmental flows to rivers or the timing of releases to wetlands. Subsection 1.3.3 explains how watering actions are prioritised. The seasonal watering statements issued by the VEWH authorise waterway managers to undertake environmental watering actions described in this table. Subsection 1.2.2 explains how seasonal watering statements fit into the environmental watering planning framework.

Environmental objectives are those listed in the environmental objectives table for each system (as the Figure 1.5.1 example above shows). Each environmental objective will be supported by one or more watering actions and functional watering objectives.

Potential environmental watering action	Functional watering objectives	Environmental objectives
Macalister River reaches 1 and 2		
Winter to summer low flow (up to 90 ML/day in June to December)	• Provide hydraulic habitat for fish by increasing water depth in pools • Provide fish passage for local movement through minimum depth over riffles • Provide permanent wetted habitat for water bugs through minimum water depth in pools • Provide connectivity throughout the river for local movement of platypus and water rats, as well as protection from predation, access to food sources and maintain refuge habitats • Provide flows with low water velocity and appropriate depth and to improve water clarity and enable establishment of in-stream vegetation • Provide sustained wetting of low-level benches (increasing water depth) to limit terrestrial vegetation encroachment	
Summer-autumn low flow (35-90 ML/day in January-May)	• Maintain water depth in pools and hydraulic habitat for native fish. • Maintain permanent wetted habitat in pools and riffles for waterbugs • Maintain shallow, slow-flowing habitat to enable establishment of in-stream vegetation • Maintain a minimum depth in pools to allow for turnover of water and slow water quality degradation • Expose and dry lower channel features for re-oxygenation	

A **functional watering objective** is the physical or biological effect that a potential watering action aims to achieve. Each potential watering action will have one or more functional watering objectives.

Scenario planning

This information indicates the range and priority of potential environmental watering actions that might be delivered in the coming year under different climate and water availability scenarios. For example, it may show which environmental flows may be most important if there is less water for the environment available in a dry year, compared to an average year where there is more water available. The climate scenarios considered are drought, dry, average and wet. Section 1.3.4 explains how seasonal conditions are considered in planning. Potential environmental watering actions are listed in order of priority.

Figure 1.5.3. Example scenario planning table

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No unregulated flows • Passing flows at reduced	• Possible spills from in spring, minor flood levels may occur • Passing flows at may be reduced	• Regular spills from in spring, minor to moderate flood levels may occur	• Large and frequent spills from moderate to major flood levels may occur
Expected availability of water for the environment	• 11,600 ML	• 14,900 ML	• 16,900 ML	• 21,400 ML
Potential environmental watering – tier 1a (high priorities)	• Autumn/winter low flow (reach 1 & 2) • Spring low flow (reach 1 & 2) • 1 spring fresh (reach 2)	• Autumn/winter low flow (reach 1 & 2) • Spring low flow (reach 1 & 2)	• Autumn/winter low flow (reach 1 & 2) • Spring low flow (reach 1 & 2) • 1 spring fresh (reach 2)	• Autumn/winter low flow (reach 1 & 2) • Spring low flow (reach 1 & 2) • 1 spring fresh (reach 2)
Potential environmental watering – tier 1b (high priorities)	• Autumn/winter low flow (reach 1 & 2) • Spring low flow (reach 1 & 2)	• Autumn/winter low flow (reach 1 & 2) • Spring low flow (reach 1 & 2)	• Autumn/winter low flow (reach 1 & 2) • Spring low flow (reach 1 & 2)	• Autumn/winter low flow (reach 1 & 2) • Spring low flow (reach 1 & 2)
Potential environmental watering – tier 2 (additional priorities)	• 1 winter fresh	• 1 winter fresh	• Increase duration of spring fresh	• 1 winter fresh
Possible volume of water for the environment required to meet objectives	• 10,700 ML (tier 1) • 4,000 ML (tier 2)	• 13,400 ML (tier 1) • 4,000 ML (tier 2)	• 15,600 ML (tier 1) • 1,200 ML (tier 2)	• 19,000 ML (tier 1) • 4,000 ML (tier 2)
Priority carryover requirements	• 900 to 1,800 ML			

Assumed volume of water for the environment that will be available over the entire year: the assumed supply.

Tier 1a denotes the high-priority potential environmental watering actions that could be achieved with the assumed supply.

Tier 1b denotes high-priority potential environmental watering actions that are unlikely to be achieved with the assumed supply. These actions may be achieved with natural or unregulated flows, or additional water may need to be transferred or traded into the system to meet demand for these watering actions. If tier 1b actions are not delivered, there may be a decline in environmental condition and the ability to meet environmental objectives in the medium and long terms may be compromised. Section 1.4.2 explains the VEWH's options for efficiently managing water for the environment.

Tier 2 potential environmental watering actions have been identified as being necessary to support overall environmental objectives, but they are not essential to deliver this year. Delivering tier 2 watering actions in the coming year will likely provide an environmental benefit, but not delivering them will not result in a significant decline.

The volume that is planned to be kept in storage to achieve high-priority watering actions the following year. For the seasonal watering plan, predictions of volumes of water available and carryover are made before the beginning of a water year and are based on the best-available information. They are estimates only, and the VEWH and its program partners revise these estimates continually throughout the water year.

Thomson River, by West Gippsland CMA

SECTION 2

Gippsland region

Snowy system
Thomson, Macalister & Latrobe systems

2.1 Gippsland region overview

The systems in the Gippsland region that can receive water from the VEWH's environmental entitlements are the Latrobe River and wetlands, and the Thomson and Macalister rivers. The Snowy River also receives water for the environment, but this is managed by the New South Wales Department of Planning, Industry and Environment.

Environmental values, recent conditions, environmental watering objectives and planned actions for each system in the Gippsland region are presented in the system sections that follow.

Traditional Owners in the Gippsland region

Traditional Owners and their Nations in the Gippsland region continue to have a deep connection to the region's rivers, wetlands and floodplains.

The Registered Aboriginal Parties in this region are the Gunaikurnai Land and Waters Aboriginal Corporation (GLaWAC), Bunurong Land Council Aboriginal Corporation (BLCAC) and Wurundjeri Woi Wurrung Cultural Heritage Aboriginal Corporation. On 22 October 2010, the Federal Court recognised that the Gunaikurnai people hold native title over much of Gippsland. On the same day, Victoria entered into an agreement with the Gunaikurnai people under the *Traditional Owner Settlement Act 2010*. Under the agreement, the Gunaikurnai Traditional Owner Land Management Board was established, to jointly manage parks and reserves between Warragul and Orbost.

Through memorandums of understanding between West Gippsland CMA and GLaWAC, and West Gippsland CMA and BLCAC, they work together to ensure that Traditional Owners have the opportunity to be involved in every CMA project, from the inception stage. An example of this is the involvement of GLaWAC on the project advisory group for the Latrobe Environmental Water Requirements Investigation in 2018–19.

The New South Wales Department of Planning, Industry and Environment has historically worked with Aboriginal communities that have a strong connection to waterways in the Snowy Mountains. These include the Maneroo-Ngarigo, Bidwell Maap, Southern Monero (Monero-Ngarigo / Yuin / Bolga), Wongalu and Wiradjuri people.

In recognition of the cultural importance of water for Aboriginal people and their traditional ecological knowledge, waterway managers are working with Traditional Owners to involve them in management of environmental flows. In 2019–20, this will include continuing to develop an effective working relationship between the West Gippsland CMA Water Team and the newly formed GLaWAC Aboriginal Water Team. The teams share the CMA's Traralgon office. This close proximity increases opportunities for the GLaWAC team to share traditional knowledge of local species and ecosystems with West Gippsland CMA staff. It also presents opportunities for West Gippsland CMA staff to help the GLaWAC Aboriginal Water Team increase their knowledge of and capacity for contemporary water management.

Engagement

Seasonal watering proposals are informed by longer-term regional catchment strategies, regional waterway strategies, relevant technical studies (such as environmental flow studies and environmental water management plans), as well as by input from program partners and stakeholders. The strategies and technical reports collectively describe a range of cultural, economic, environmental, social, and Traditional Owner perspectives and longer-term integrated catchment and waterway management objectives that influence environmental watering actions and priorities. Program partners and other stakeholders help to identify environmental watering priorities and opportunities for the coming year.

The International Association for Public Participation's Public Participation Spectrum (IAP2 Spectrum) has been used to categorise the levels of participation of stakeholders involved in the environmental watering planning process. Table 2.1.1 shows the IAP2 Spectrum categories and participation goals.

Table 2.1.1 International Association for Public Participation's Public Participation Spectrum categories and participation goals[1]

Engagement category	Engagement goal
Inform	Provide balanced and objective information to assist understanding, alternatives, opportunities and/or solutions
Consult	Obtain feedback on analysis, alternatives and/or decisions
Involve	Work directly throughout a process to ensure that concerns and aspirations are consistently understood and considered
Collaborate	Partner in each aspect of the decision including the development of alternatives and the identification of the preferred solution
Empower	Place final decision making in the hands of the stakeholder

1 *The VEWH has the permission of the International Association for Public Participation to reproduce the IAP2 Spectrum.*

Table 2.1.2 shows the partners, stakeholder organisations and individuals with which West Gippsland CMA engaged when preparing the Latrobe, Thomson and Macalister systems seasonal watering proposals. This includes engagement conducted as part of developing the seasonal watering proposals as well as engagement during the preparation of key foundational documents that directly informed the proposals.

The table also shows the level of engagement between West Gippsland CMA and stakeholders of the environmental watering program in the Gippsland region based on the CMA's interpretation of the IAP2 Spectrum.

The level of engagement differs between organisations and between systems, due to the complexity of management arrangements and individual organisation's responsibilities for each system. For example, Parks Victoria review and endorse all seasonal watering proposals that affect the public land they manage. However, their level of engagement can vary from system to system. In the Gippsland region, Parks Victoria is more involved in planning and management of water for the environment for the lower Latrobe wetlands than for the Latrobe River, because it is the land manager for Dowd Morass and Sale Common and it operates the regulators used to release water to these sites. Therefore, Parks Victoria collaborates with other program partners to implement the environmental watering program at the lower Latrobe wetlands. Parks Victoria is not involved in releases of environmental flows to the Latrobe River but it was consulted on environmental flows planning through membership on the project advisory group for the Latrobe Environmental Water Requirements Investigation in 2018–19.

As another example, in the Macalister system VRFish is represented on the Macalister Environmental Water Advisory Group and has a higher level of engagement (that is, it is directly *involved* in environmental watering decisions for the system) than other recreational users that are *informed* about proposed environmental flows in the system.

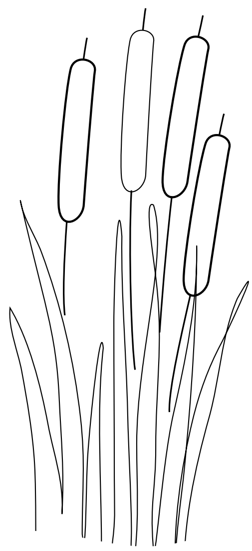


Table 2.1.2 Partners and stakeholders engaged by West Gippsland CMA in developing seasonal watering proposals for the Latrobe, Thomson and Macalister systems and other key foundation documents that have directly informed the proposals

	Latrobe River	Lower Latrobe wetlands	Thomson system	Macalister system
Community groups and environment groups	• Greening Australia • Latrobe Valley Field Naturalists • Native Fish Australia	• Greening Australia • Latrobe Valley Field Naturalists • Native Fish Australia	• Heyfield Wetlands Committee • BirdLife Australia • Landcare groups • Waterwatch volunteers and co-ordinators	• Environment Victoria • Maffra and District Landcare Network • Native Fish Australia
Government agencies	• Gippsland Water • East Gippsland Catchment Management Authority • Parks Victoria	• Gippsland Water • East Gippsland Catchment Management Authority	• Arthur Rylah Institute	• Arthur Rylah Institute • Gippsland Water
Landholders/ farmers	• Individual landholders	• Individual landholders	• Individual landholders	• Macalister Irrigation District irrigators/ diverters
Local businesses	• Port of Sale Heritage River Cruises	• Port of Sale Heritage River Cruises		
Local government	• Baw Baw Shire Council • Latrobe City Council • Wellington Shire Council	• Baw Baw Shire Council • Latrobe City Council • Wellington Shire Council	• Baw Baw Shire Council • Wellington Shire Council	• Wellington Shire Council
Program partners	• Southern Rural Water • Victorian Environmental Water Holder • Department of Environment, Land, Water and Planning	• Field and Game Australia • Parks Victoria • Victorian Environmental Water Holder • Department of Environment, Land, Water and Planning	• Melbourne Water • Southern Rural Water • Victorian Environmental Water Holder	• Southern Rural Water • Victorian Environmental Water Holder
Recreational users	• Field and Game Australia • VRFish	• VRFish	• Kayakers • Canoe clubs • VRFish • Angling clubs • Local birdwatchers • Tourism information centres • Regional tourism associations	• VRFish • Local birdwatchers • Kayakers and canoers
Traditional Owners	• Gunaikurnai Land and Waters Aboriginal Corporation	• Gunaikurnai Land and Waters Aboriginal Corporation	• Gunaikurnai Land and Waters Aboriginal Corporation	• Gunaikurnai Land and Waters Aboriginal Corporation

Key: Inform Consult Involve Collaborate Empower

In the Snowy system, the New South Wales Government is responsible for planning environmental flows in the Snowy River, in consultation with the Victorian Government. The Snowy Advisory Committee (SAC) was formed in 2018 and provides community and expert advice about the pattern of environmental flows to the Snowy River. The committee's participants represent Aboriginal, local community and environmental interests, alongside New South Wales and Victorian government agencies. East Gippsland CMA is a member of the SAC, and the VEWH is an observer.

Community benefits from environmental watering

As subsection 1.1.1 explains, by improving the health of rivers, wetlands and floodplains, environmental flows also provide benefits to communities. Healthy rivers and wetlands support vibrant and healthy communities.

Environmental outcomes provide direct flow-on cultural, economic, recreational, social, and Traditional Owner benefits for communities. In 2019–20, examples in the Gippsland region include:

- supporting populations of native fish that are valued by recreational fishers (for example, Australian bass in the Macalister and Thomson rivers and black bream and estuary perch in the Latrobe system)
- delivering water for the environment to the Heyfield wetlands in the Thomson system, which will complement community efforts to rehabilitate the wetland ecosystem and support educational programs at the site
- supporting waterbirds in the lower Latrobe wetlands, which are valued by bird watchers and duck hunters
- watering vegetation on the banks of the Latrobe, Thomson and Macalister rivers that prevents bank erosion and potential land loss for farmers
- increasing opportunities for canoeing and kayaking on the Snowy River.

Additional opportunities to enhance community benefits can also sometimes be provided by modifying environmental flows, provided environmental outcomes are not compromised. For example:

- environmental flows planned for the Thomson River in spring 2019 — that aim to cue juvenile Australian grayling to migrate into the river from the sea — and in autumn 2020 — that aim to trigger Australian grayling to move downstream for spawning — may be scheduled over a weekend within the appropriate ecological window to provide whitewater rafting opportunities for kayakers and canoeists, without affecting the flow objectives for fish
- West Gippsland CMA will consult with stakeholders about the timing of water deliveries to the lower Latrobe wetlands, to take account of duck-hunting seasons declared and regulated by the Victorian Game Management Authority.[2]

The ability of the VEWH and its partners to deliver these benefits will depend on the weather, climate considerations, the available water and the way the system is being operated to deliver water for other purposes.

Integrated catchment management

Altered water regimes are one of many threats to the health of Victoria's waterways. To be effective, environmental flows need to be part of an integrated approach to catchment management. Many of the environmental objectives from water for the environment in the Gippsland region will not be fully met without simultaneously addressing issues such as barriers to fish movement, high nutrient loads, saltwater intrusion to the Latrobe wetlands, loss of stream bank vegetation and invasive species, to name just some issues.

Victorian and Australian government agencies, community groups and private landowners collectively implement a wide range of programs that aim to protect and improve the environmental condition and function of land, soils and waterways throughout Victoria's catchments.

Examples of complementary programs that are likely to support environmental watering outcomes in the Gippsland region include:

- works by West Gippsland CMA to protect and enhance stream banks along priority reaches of rivers and their tributaries including fencing to exclude stock, revegetation of riverbanks, willow removal and erosion control
- West Gippsland CMA's work with farmers along the Thomson and Macalister rivers on grazing and soil management, and on nutrient and water-use-efficiency projects that help improve water quality and river health
- construction of a fishway on the Thomson River by West Gippsland CMA to improve fish passage near the heritage-listed Horseshoe Bend Tunnel, completed in June 2019. The fishway will allow Australian grayling, which are specifically targeted with releases of water for the environment, and other migratory fish to access 85 km of high-quality river habitat in the upper reaches of the Thomson catchment
- a weed and willow control program by East Gippsland CMA in remote parts of the Snowy River catchment, which led to 200 km of the river now being willow-free: native vegetation is flourishing in areas where willows have been removed, and it provides a valuable source of food and habitat for animals.

For more information about integrated catchment management programs in the Gippsland region refer to the West Gippsland and East Gippsland regional catchment strategies and regional waterway strategies.

[2] *Rules in the Lower Latrobe Wetlands Environmental Entitlement 2011 only allow diversions to the wetlands when water levels in the Latrobe River are more than -0.7m AHD at the Swing Bridge Gauging Station, which may prevent timing of inflows to assist duck season.*

Seasonal outlook 2019–20

Water for the environment for the Latrobe, Thomson and Macalister systems is held in Blue Rock Reservoir, Thomson Reservoir and Lake Glenmaggie respectively.

Environmental entitlements in these systems have unique characteristics that influence planning for environmental flows. The Thomson system receives a share of the daily inflows to the Thomson Reservoir and a secure annual allocation which is available on 1 July each year. In the Latrobe and Macalister systems, the availability of water for the environment depends on system inflows to Lake Glenmaggie and Blue Rock Reservoir. Winter and spring are the peak inflow periods for all systems, so annual allocations are usually well-known before the start of summer.

In dry years, waterway managers rely on carryover and early-season allocations to deliver the highest-priority environmental watering demands. In 2018–19, the Gippsland region experienced one of the driest and hottest periods on record. Environmental flows in 2018–19 were carefully managed to ensure a critical supply of water could be carried over for 2019–20.

The Gippsland system catchments will need significant rain in winter and spring 2019 to saturate the ground and generate substantial streamflow. Forecasts are for lower-than-average rainfall across the region in winter 2019, and waterway managers are therefore preparing to enact environmental watering plans for dry to drought scenarios in 2019–20.

The volume of water needed to meet environmental demands in the Latrobe, Thomson and Macalister systems in winter/spring 2019–20 is similar to the volume required to meet demands for summer/autumn. As supply is mostly determined by winter/spring inflows, waterway managers will be able to confidently plan the supply of watering demands for the whole year by mid to late spring 2019.

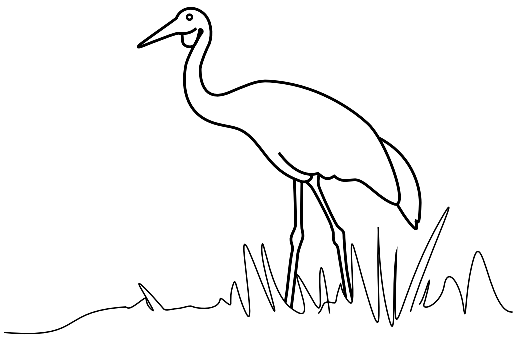
Drought conditions could significantly limit allocations of water for the environment during 2019–20. Most tier 1 environmental watering priorities for the Thomson and Macalister rivers in 2019–20 can be achieved with the volume of water that is likely to be available in those systems, but supply is not assured for several high-priority (that is, tier 1b) environmental watering actions in the Latrobe system. If conditions remain dry, water for the environment will need to be carefully managed throughout the year to ensure there is enough carryover to meet critical demands in 2020–21. Where critical demands cannot be met by existing allocations, the VEWH and its program partners may investigate alternative supply options (such as transfers or trades). The VEWH also works with storage managers to identify opportunities to adjust the pattern of consumptive water deliveries to support environmental watering outcomes while still meeting the needs of consumptive water users.

The New South Wales Department of Planning, Industry and Environment plans and manages environmental flows in the Snowy system in consultation with Victorian and Australian governments and relevant stakeholder groups. The water year for the Snowy system starts in May and finishes in April the following year, which differs from how water is managed in the other Gippsland systems. The total volume for release and daily release targets for the Snowy River from May 2019 to April 2020 are set in place, and daily releases will not vary unless flows increase the risk of flooding downstream or operational constraints prevent delivery.

Risk management

During the development of the seasonal watering proposals for the Latrobe, Thomson and Macalister systems, environmental watering program partners held a workshop to assess risks associated with potential environmental watering actions for 2019–20 and to identify appropriate mitigating strategies. Risks and mitigating actions are continually assessed by program partners throughout the year (see subsection 1.3.6).

In the Snowy system, when weather conditions increase the risk of flooding, the New South Wales Department of Planning, Industry and Environment works with the New South Wales State Emergency Service, the Bureau of Meteorology, East Gippsland CMA and the VEWH to inform the community about the management of planned releases. Releases may be cancelled or rescheduled to limit flood impacts on private land.



2.2 Latrobe system

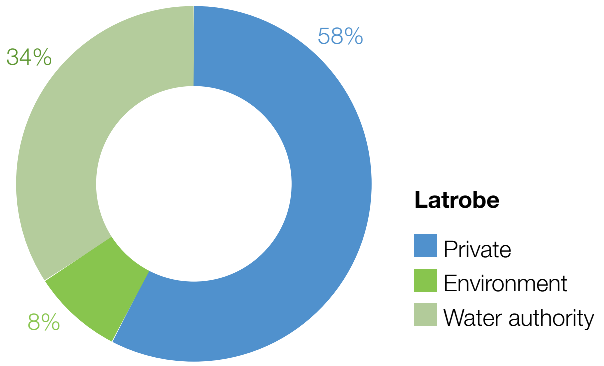
Waterway manager – West Gippsland Catchment Management Authority

Storage manager – Southern Rural Water

Environmental water holder – Victorian Environmental Water Holder

Did you know ...?

Carp are known as the 'rabbits of the river' due to their prolific breeding and the damage they do to native aquatic habitats. In 2018, Parks Victoria worked with local professional fishermen to catch and remove a whopping 25 tonnes of carp from the Sale Common! This helped increase the benefits from an environmental flow delivery which could be provided later, once the wetland was mostly carp-free.



Proportion of water entitlements in the Latrobe basin held by private users, water corporations or environmental water holders at 30 June 2018.

Top: Latrobe River, by West Gippsland CMA
Centre: Rakali, by North Central CMA
Above: Growling grass frog, by East Gippsland CMA

The Latrobe system includes the Latrobe River and lower Latrobe wetlands: Sale Common, Dowd Morass and Heart Morass.

2.2.1 Latrobe River

System overview

The Latrobe River originates on the Baw Baw Plateau and passes through relatively flat to undulating plains cleared for agriculture, before flowing into Lake Wellington (the westernmost point of the Gippsland Lakes). Notable tributaries include the Tanjil River, Narracan Creek, Morwell River, Tyers River, Traralgon Creek and the Thomson River.

Water for the environment is supplied to the Latrobe River from Blue Rock Reservoir on the Tanjil River. Blue Rock Reservoir also supplies water for electricity generators in the Latrobe Valley and town water.

The Latrobe River from Rosedale to the Thomson River confluence (reach 5) is the priority reach for water for the environment because it contains endangered plant communities that have good potential for rehabilitation.

Environmental values

The upper Latrobe River flows through state forest and is relatively intact and ecologically healthy. It contains continuous stands of river red gums and intact riparian vegetation, and it supports native animals including barred galaxias, river blackfish, Gippsland spiny crayfish and nankeen night herons.

The Latrobe River is regulated downstream of Lake Narracan and is highly degraded due to historic river management practices. Most large woody habitat has been removed from the river and many sections have been artificially straightened. These practices have caused significant erosion and widened the channel, which has in turn reduced the quality and quantity of habitat for aquatic plants and animals.

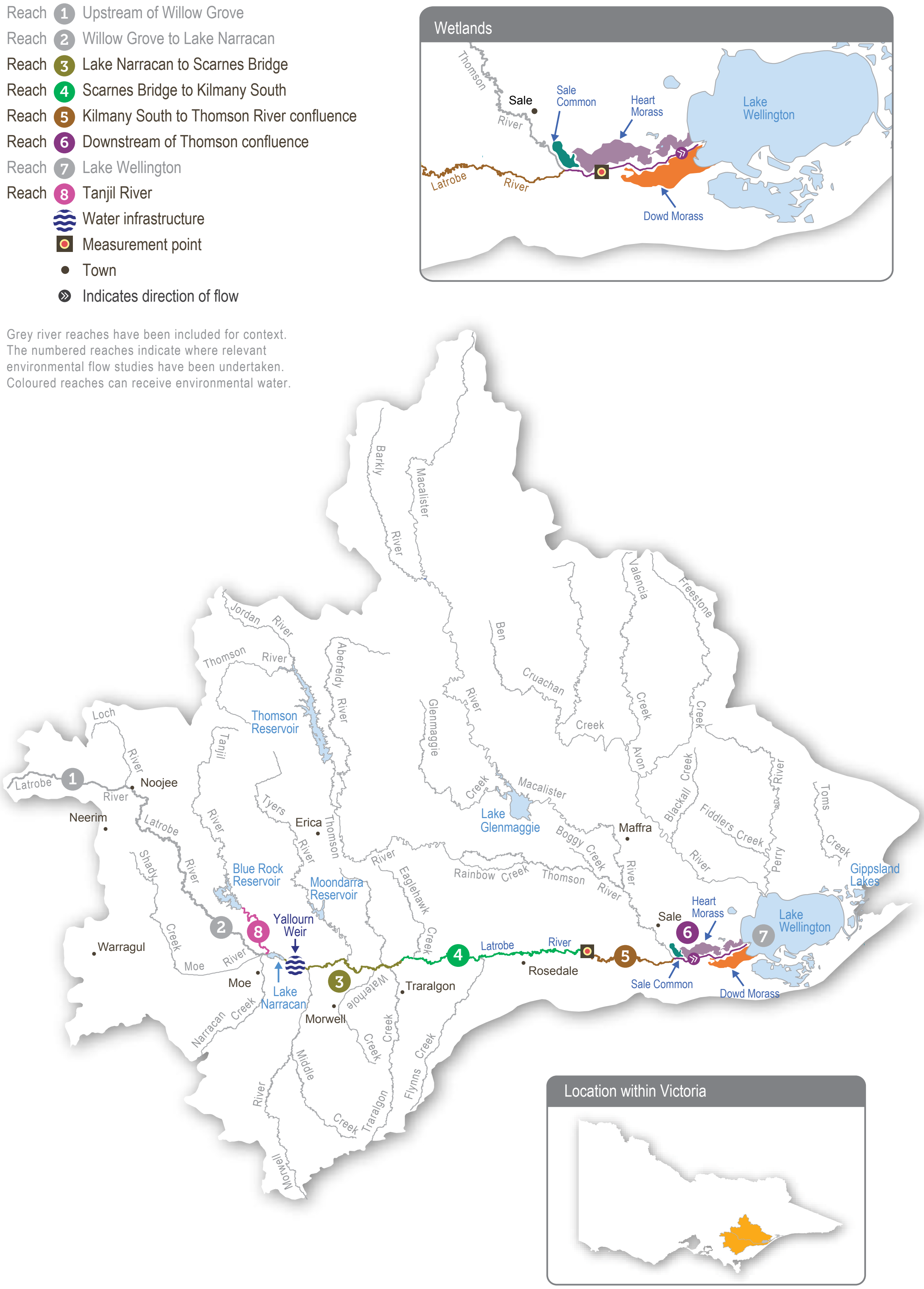
Endangered and vulnerable vegetation are found in all but the most modified sections of the Latrobe River. The banks along the lower reaches support stands of swamp scrub, characterised by swamp paperbark and tea tree. Mature river red gums grow adjacent to the lower Latrobe wetlands and provide nesting habitat for sea eagles and other birds of prey that hunt in the wetlands. The Latrobe River supports several native estuarine and freshwater fish including black bream, Australian bass, Australian grayling and short- and long-finned eel.

The Latrobe River and its tributaries provide an essential source of freshwater to the Gippsland Lakes system, of which the lower Latrobe wetlands are an important component.

Environmental objectives in the Latrobe River

Maintain or increase native fish (migratory, resident and estuary) populations including eels
Increase frog populations and their range Maintain refuge habitats
Maintain or increase in-stream geomorphic diversity
Maintain or increase the abundance and increase the range of existing platypus and rakali (water rat) populations
Maintain the abundance of freshwater turtle populations
Improve the condition and increase extent and diversity of submerged, emergent and riparian vegetation
Increase the abundance of all macro- and micro-invertebrates
Avoid adverse water-quality conditions (such as high salinity) in the lower Latrobe River and estuary

Figure 2.2.1 The Latrobe system



Grey river reaches have been included for context. The numbered reaches indicate where relevant environmental flow studies have been undertaken. Coloured reaches can receive environmental water.

Recent conditions

Climatic conditions in West Gippsland were warmer and drier than average during the 2018–19 water year. Sporadic heavy rainfall in late spring and early summer provided three freshes. An environmental flow was planned for the Latrobe River in November, to coincide with simultaneous environmental flows in the Thomson and Macalister systems. The coordinated releases aimed to deliver a large pulse through the system to support native fish migration and to water the lower Latrobe wetlands. While the environmental flows proceeded in the other systems, the water order was cancelled in the Latrobe system due to the sudden rainfall, meaning that the fresh was supplied mostly by natural flows from the upper Latrobe River and tributaries.

Summer and autumn rainfall was well below average. Low flows were provided in autumn, but a planned autumn fresh did not proceed due to minimal streamflows in the catchments. It was decided that conserving water for use in winter and spring 2019–20 would be more beneficial to the system.

Low flow recommendations were partially achieved from passing flows and unregulated flows during July to November 2018. Water for the environment was used to supply low flows in autumn for a short period, to allow in-stream bars to form and fish to move between habitats.

The environmental flow recommendations for the Latrobe River, Latrobe River estuary and lower Latrobe wetlands were updated in 2018–19. The updated recommendations take a more integrated approach to managing all the major waterways in the Latrobe system, and they have informed planning for 2019–20.

Scope of environmental watering

Table 2.2.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Estuary flows and freshes described in Table 2.2.1 usually depend on contributions in the Thomson system. They aim to meet functional outcomes in the lower Latrobe River estuary as well as provide water to the lower Latrobe wetlands.

Table 2.2.1 Potential environmental watering actions and objectives for the Latrobe River

Potential environmental watering action	Functional watering objective	Environmental objective
Summer/autumn freshes (four to six freshes of 920–1,300 ML/day for four to 15 days during December to May)[1,2]	**Latrobe River objectives** • Wet benches to maintain habitat and support the growth of emergent macrophyte vegetation • Support waterbug and zooplankton communities and maintain breeding substrate for blackfish • Flush sediment (sands and silts) from pools and mix water in pools, helping to provide habitat for frogs and spawning conditions for Australian grayling and blackfish • Provide longitudinal connectivity for platypus, rakali (water rats) and fish **Latrobe River estuary objectives** (at upper magnitude; requires at least 930 ML/day in the Thomson River at Bundalaguah) • Upper estuary: fully flush with freshwater to support submerged vegetation, provide suitable conditions including dissolved oxygen levels for aquatic animals, transport silt, wet benches and deliver freshwater to connected wetlands • Mid-estuary: partially/fully flush the upper layer of the water column to improve water quality, support emergent macrophytes, provide freshwater habitat and associated food sources for freshwater fish and provide breeding opportunities for estuary fish • Lower estuary (at higher magnitude): partially flush the upper layer of the water column; a flow of this magnitude will also provide opportunities to fill to the lower Latrobe wetlands	

Table 2.2.1 Potential environmental watering actions and objectives for the Latrobe River *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Summer/autumn low flows of up to 250–760 ML/day during December to May)[1]	**Latrobe River objectives** • Maintain an adequate depth in pool habitat to support aquatic animals and submerged vegetation • Limit encroachment by terrestrial vegetation and support the growth of emergent macrophyte vegetation • Maintain dissolved oxygen levels in pools • Flush sediments to maintain pool depths **Latrobe River estuary objectives** (at upper magnitude; requires at least 340 ML/day in the Thomson River at Bundalaguah) • Upper estuary: fully flush with freshwater to support submerged vegetation and maintain dissolved oxygen levels for aquatic animals • Mid-estuary: partially flush the upper layers of the water column to provide suitable conditions for freshwater fish and reduce salinity to support emergent macrophytes • Lower estuary: not flushed but provides sufficient velocities to ensure fine sediment remains suspended and transported out of the estuary; a flow of this magnitude will also provide opportunities to fill to the lower Latrobe wetlands	
Winter/spring freshes (four to seven freshes of 2,200–2,710 ML/day for three to 20 days during June to November)[1,2]	**Latrobe River objectives** • Wet banks to improve the condition of riparian vegetation • Provide a variety of wetted areas for emergent macrophytes • Wet the higher benches, to improve habitat and support the growth of riparian vegetation • Maintain channel capacity and bench habitat • Provide sufficient water depth over in-stream benches to support the growth and reproduction of waterbug communities, providing food for turtles **Latrobe River estuary objectives** (at upper magnitude; requires at least 930 ML/day in the Thomson River at Bundalaguah) • Upper estuary: fully flush • Mid-estuary: partially/fully flush the upper layer of the water column to improve water quality, provide a variety of wetted areas for emergent and riparian vegetation and provide freshwater to support migration, habitat and associated food sources of freshwater fish and breeding opportunities for estuary fish • Lower estuary: partially flush the upper portion of the water column and create sufficient velocity to flush suspended silt	

Table 2.2.1 Potential environmental watering actions and objectives for the Latrobe River *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Winter/spring low flows of 610–760 ML/day during June to November[1]	**Latrobe River objectives** • Wet benches to maintain habitat and support the growth of emergent macrophyte vegetation • Support waterbug and zooplankton communities and maintain breeding substrate for blackfish • Flush sediment (sands and silts) from pools and mix the water column in pools, helping to provide habitat for frogs and spawning conditions for blackfish • Longitudinal connectivity for platypus, rakali (water rats) and fish **Latrobe River estuary objectives** (at upper magnitude; requires at least 490 ML/day in the Thomson River at Bundalaguah) • Upper estuary: fully flush with freshwater to provide suitable conditions for waterbugs, to transport silt, to wet the benches and to deliver freshwater to connected wetlands • Mid-estuary: fully flush the upper layer of the water column to improve water quality and provide freshwater for migration, habitat and associated food sources for freshwater fish and breeding opportunities for estuary fish • Lower estuary: partially flush the upper layer of the water column; a flow of this magnitude will also provide opportunities to fill to the lower Latrobe wetlands	

1 *Lower magnitude supports flow objectives in the Latrobe River. Upper magnitude supports flow objectives in both the Latrobe River and estuary, however it is dependent on sufficient inflows from the Thomson River.*

2 *This fresh may involve inundating private land and will be subject to obtaining appropriate landholder agreements.*

Scenario planning

Protecting key ecological functions and high-priority refuges is the priority for environmental flows management in the Latrobe River. Flows are also aimed at preventing a catastrophic reduction in water quality, resulting in fish death events and algal blooms.

To achieve these goals, summer/autumn freshes and low flows in the river and into the Latrobe estuary (subject to water availability) are prioritised under all scenarios. These flows will support vegetation growth, provide connectivity for aquatic animal habitat, supply fresh water to improve water quality and provide water for the lower Latrobe wetlands. As there will be few natural freshes in the regulated parts of the system under drought and dry scenarios, using water for the environment is necessary to achieve these flows. Under all scenarios, only a subset of the required summer/autumn freshes and reduced durations of low flows will be possible with the available supply. Providing additional flows would help manage water quality, particularly salinity in the upper and mid-estuary, to maintain freshwater conditions for aquatic mammals, fish and vegetation.

In average and wet scenarios, winter/spring low flows and freshes are likely to be met naturally by spills from the Blue Rock Reservoir. If this occurs, water for the environment may not be used until summer/autumn.

Under the Blue Rock environmental entitlement, the VEWH accrues a share of inflows daily. It is important to consider rainfall, climate, river conditions and entitlement inflows between July and November when prioritising use of water for the environment. Environmental Water Holdings at the beginning of 2019–20 are likely to be lower than has been the case in previous years, due to ongoing dry conditions. Water Holdings are expected to increase with inflows under all climate scenarios, but under drought and dry scenarios the ability to deliver high-priority flows in full may be constrained by the water available and by competition for outlet capacity, with high demands from other users (particularly for low flows).

Table 2.2.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Table 2.2.2 Potential environmental watering for the Latrobe River under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Small contributions from unregulated reaches and tributaries of the Latrobe River with little opportunity for freshes to occur naturally • Consumptive demand from Blue Rock Reservoir will be very high and regular releases to the Tanjil River will contribute substantially to low flows	• There will be some unregulated flows that contribute to low flows and freshes • Consumptive demand from Blue Rock Reservoir will be high and contribute to low flows	• Unregulated flows will provide low flows throughout the year, and multiple freshes (most likely in winter and spring) • Some spills are likely and there will be releases for consumptive users which will partly contribute to low flows	• Unregulated flows provide strong low flows throughout the year • Multiple spills from Blue Rock Reservoir will provide extended durations of freshes, high flows and overbank flows • No significant releases from consumptive entitlements in Blue Rock Reservoir are likely
Expected availability of environmental water	• Up to 12,000 ML	• Up to 14,000 ML	• Up to 19,000 ML	• Up to 27,000 ML
Potential environmental watering – tier 1a (high priorities)	• Two summer/autumn freshes • Summer/autumn low flows	• Two summer/autumn freshes • Summer/autumn low flows[1]	• Three summer/autumn freshes • Summer/autumn low flows[1]	• Five summer/autumn freshes • Summer/autumn low flows[1]
Potential environmental watering – tier 1b (high priorities with shortfall)	• Two additional summer/autumn freshes • Extended duration of summer/autumn baseflows where possible	• Four additional summer/autumn freshes • Extended duration of summer/autumn baseflows where possible	• Three additional summer/autumn freshes • Extended duration of summer/autumn baseflows where possible	• One additional summer/autumn fresh • Extended duration of summer/autumn baseflows
Potential environmental watering – tier 2 (additional priorities)	• Three to five winter/spring estuary freshes • Winter/spring low flows where possible	• Five to six winter/spring estuary freshes • Winter/spring low flows where possible	• Six winter/spring estuary freshes • Winter/spring low flows where possible	• Six winter/spring estuary freshes • Winter/spring low flows[2]
Possible volume of water for the environment required to achieve objectives[3]	• 10,200 ML (tier 1a) • 7,200 ML for freshes only (tier 1b) • 5,300 ML per river fresh (tier 2)	• 13,800 ML (tier 1a) • 14,400 ML for freshes only (tier 1b) • 10,300 ML per river fresh (tier 2)	• 16,800 ML (tier 1a) • 8,100 ML for freshes only (tier 1b) • 15,000 ML per river fresh (tier 2)	• 24,700 ML (tier 1a) • 3,200 ML for freshes only (tier 1b) • 13,300 ML per river fresh (tier 2)
Priority carryover requirements	N/A – there are no carryover provisions in the Blue Rock environmental entitlement.			

[1] *Lower ranges of summer/autumn low flows are expected to be met by natural flows under dry to wet scenarios, and have not been accounted for in volume estimates.*

[2] *Expected to be met by natural flows under a wet scenario and has not been accounted for in volume estimates.*

[3] *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

Some demands are expected to be met by natural flows. Water for the environment requirements for tier 2 actions are additional to tier 1 requirements. Volume demands from Latrobe storages decrease as inflows from the Thomson River increase.

2.2.2 Lower Latrobe wetlands

System overview

The lower Latrobe wetlands (Dowd Morass, Heart Morass and Sale Common) are an important component of the internationally recognised Gippsland Lakes Ramsar site and provide habitat for a variety of waterbirds of state, national and international conservation significance. The wetlands are located on the floodplain of the Latrobe River between its confluence with the Thomson River, and they form part of the Gippsland Lakes system.

River regulation and water extraction from the Latrobe, Thomson and Macalister rivers has reduced the frequency of small and medium-sized floods that naturally wet the lower Latrobe wetlands. Construction of levees and drains and filling of natural depressions have also altered water movement into and through the wetlands. The drainage and flooding regime in all three wetlands is now managed to some extent with regulators connected to the Latrobe River.

Environmental values

Sale Common is one of only two remaining freshwater wetlands in the Gippsland Lakes system, and it provides sheltered feeding, breeding and resting habitat for a large range of waterbirds.

Dowd Morass is a large, brackish wetland that regularly supports rookeries of colonial nesting waterbirds including Australian white ibis, straw-necked ibis, little black and little pied cormorants, royal spoonbills and great egrets.

Heart Morass is also a large brackish wetland, with open expanses providing shallow feeding habitat for waterbirds including black swans, Eurasian coots and a variety of ducks.

Together, the lower Latrobe wetlands function as a diverse and complementary ecological system. Colonial waterbirds breed among swamp paperbark trees at Dowd Morass in spring. Migratory shorebirds feed on the mudflats that are exposed as the wetlands draw down and dry over summer. Waterfowl and fish-eating birds use open-water habitat at the wetlands year-round. The wetlands also support threatened vegetation communities including swamp scrub, brackish herbland and aquatic herbland.

Environmental objectives in the lower Latrobe wetlands

Maintain the abundance of frog populations
Maintain the abundance of freshwater turtle populations
Maintain or restore a self-sustaining variety of submerged and emergent aquatic vegetation types Maintain or restore the diversity, condition and/or extent of native riparian vegetation fringing wetlands Discourage the introduction and spread, or reduce the extent and density, of undesirable/invasive plants (Sale Common)
Maintain or enhance waterbird breeding, recruitment, foraging and sheltering opportunities
Provide suitable physio-chemical conditions to support aquatic life

Recent conditions

Climatic conditions in West Gippsland were warmer and drier than average during the 2018–19 water year. Several storms in November 2018 had high rainfall, but none of these delivered significant inflows to the wetlands. Managed water delivery through regulators provided the only inflows to the wetlands in 2018–19.

The regulator to Dowd Morass was opened from August to October 2018, briefly in December 2018 and again in April 2019. The regulator was opened when the Latrobe River was high, to dilute saline water in Dowd Morass.

Heart Morass was partially filled between August and October 2018, and further top-ups were provided in December 2018 and March 2019 to manage acid sulphate soils. The managed inflows reduced salinity in the wetland and inundated the semi-aquatic grasses, which provided food for waterbirds.

Water was allowed to draw down naturally in Heart Morass and Dowd Morass from the middle of summer.

Sale Common received water for the environment throughout winter and spring and was one-third full in October 2018. Large stands of semi-aquatic wetland vegetation (such as knotweed and club-rush) dominated the wetland over summer. By autumn, the semi-aquatic vegetation began to dry out and was replaced by terrestrial grasses and sedges.

The environmental flow recommendations for the Latrobe River, Latrobe River estuary and lower Latrobe wetlands were reviewed and updated in early 2019. The updated recommendations take a more integrated approach to managing all the major waterways in the Latrobe system, and they have informed planning for 2019–20.

Scope of environmental watering

Environmental watering in the lower Latrobe wetlands aims to maintain and improve existing values and manage threats. Specific threats to the wetlands include saltwater intrusion and invasive plants and animals such as carp, giant rush and Brazilian milfoil.

Saltwater intrusion from the Gippsland Lakes is a constant threat to Dowd Morass and Heart Morass. Rising sea levels due to climate change and reduced flows from the Latrobe River increase the threat, and studies indicate that intrusions may occur at any time. Vegetation in Heart Morass has been degraded by many years of intensive cattle grazing and saltwater inundation from Lake Wellington, but much of the wetland is now recovering with the aid of restoration programs including grazing exclusion, revegetation and weed control.

Table 2.2.3 describes the potential environmental watering actions in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 2.2.3 Potential environmental watering actions and objectives for the lower Latrobe wetlands

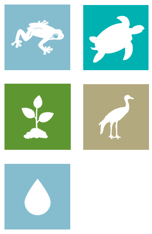
Potential environmental watering action	Functional watering objective	Environmental objective
Sale Common		
Partial fill (during July to December)	• Provide seasonal variation in water depth to support the growth and flowering of semi-aquatic plants • Provide appropriate wetland fringing habitat • Provide conditions that support waterbug communities and food resources for waterbirds • Stimulate bird breeding by providing nesting habitat via wetting reed beds and deep water next to reedbeds	
Fill (during August to November)	• Wet the outer boundaries of the wetland to support the growth and flowering of riparian and fringing wetland plants • Provide connectivity between the river and wetlands	
Fill (any time)	• Prolong wetted habitat to discourage invasive plants, particularly the excessive spread of giant rush: this is most likely to occur in December and January, but it can happen any time	
Partial or near-complete drawdown (during December to April)	• Oxygenate the soil for the germination and recruitment of aquatic vegetation • Fluctuate water levels to provide conditions for the reproduction and expansion of swamp scrub and tall marsh • Allow the die-off of aquatic vegetation and the breakdown of organic matter, to support nutrient recycling • Discourage invasive aquatic plants • Expose the mudflats and wetland fringe, to increase food sources and foraging opportunities for waterbirds	

Table 2.2.3 Potential environmental watering actions and objectives for the lower Latrobe wetlands *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Fill or partial fill (any time)[1]	• Manage unexpected or out-of-season events, which may lead to catastrophic conditions. Such examples are to: - Manage any sudden decline in dissolved oxygen - Provide habitat for waterbirds after breeding events • Maintain ecosystem resilience	
Dowd Morass		
Fill or partial fill (any time)	• Minimise the risk of salt water inundation • Manage unexpected or out-of-season events which may lead to catastrophic conditions. Such examples are to: - Respond to suddenly increasing salinity following intrusions/high water levels from Lake Wellington - Manage any sudden decline in dissolved oxygen and pH - Provide habitat for waterbirds after breeding events • Maintain ecosystem resilience	
Partial fill (during March to December)	• Maintain or improve water quality by reducing salinity • Provide seasonal variation in water depth, to support the growth and flowering of semi-aquatic plants • Provide appropriate wetland fringing habitat and allow the growth and reproduction of waterbug communities • Flood the banks and riparian zone, to create conditions to support bird-nesting • Provide connectivity between the river and wetlands and between wetlands • Provide conditions that support waterbug communities and food resources for waterbirds • Stimulate bird breeding by providing nesting habitat via inundating reed beds and deep water next to reedbeds	
Fill (during August to November)	• Wet vegetation that provides habitat for waterbirds (e.g. floodplain riparian woodland) • Provide conditions that support waterbug communities and food resources for waterbirds • Stimulate bird breeding by providing nesting habitat via inundating reed beds and deep water next to reedbeds • Flood the banks and riparian zone to create conditions for waterbird nesting • Provide connectivity between the river and wetlands and between wetlands	

Table 2.2.3 Potential environmental watering actions and objectives for the lower Latrobe wetlands *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Partial or near-complete drawdown (during January to March)	• Oxygenate the soil for the germination and recruitment of aquatic vegetation • Fluctuate water levels to provide conditions for the reproduction and expansion of swamp scrub and tall marsh • Allow the die-off of aquatic vegetation and the breakdown of organic matter, to encourage nutrient recycling • Expose the mudflats and wetland fringe to increase food sources and foraging opportunities for waterbirds	
Heart Morass		
Fill or partial fill (any time)	• Keep soils wet to minimise the risk of acid sulfate soils • Manage unexpected or out-of-season events, which may lead to catastrophic conditions. Such examples are to: - Respond to decreasing pH from the rewetting of exposed acid sulfate soils (most likely during high-wind events) - Respond to suddenly increasing salinity following intrusions/high water levels from Lake Wellington - Provide habitat for waterbirds following bird-breeding events • Maintain ecosystem resilience	
Partial fill (during August to December)	• Provide seasonal variation in water depth to support the growth and flowering of semi-aquatic plants • Provide appropriate wetland fringing habitat • Provide conditions that support waterbug communities and food resources for waterbirds • Stimulate bird breeding by providing nesting habitat via inundating reed beds and deep water next to reedbeds	
Flushing flow (during June to November)	• Reduce salinity levels by exporting salts and sulfates from the wetland, helping to maintain vegetation diversity • Disperse seeds and propagules	
Drawdown (during December to February)	• Increase soil oxygenation for the germination and recruitment of aquatic vegetation • Fluctuate water levels to provide conditions for the reproduction and expansion of swamp scrub and tall marsh • Allow the die-off of aquatic vegetation and the breakdown of organic matter, encouraging nutrient recycling • Expose the mudflats and wetland fringe, to increase food sources and foraging opportunities for waterbirds	

[1] *Fill or partial fill (any time) will only occur if triggered by a sudden change in wetland conditions. The Lower Latrobe Wetlands Environmental Entitlement 2011 is a non-volumetric entitlement, and wetland watering is permitted any time when flows in the Latrobe River are greater than -0.7m AHD (as recorded at the Swing Bridge (Sale) Gauging Station).*

Scenario planning

Table 2.2.4 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Unregulated flows, climatic conditions and site observations are important considerations for managing the lower Latrobe wetlands. The planned approach in 2019–20 is to permit water levels to fluctuate in accordance with natural seasonality and mimic natural events with small-scale inflows, when conditions and environmental objectives allow.

Under drought and dry conditions, small-scale inflows may be provided to the wetlands at any time, to provide temporary open-water habitat and to mitigate the risks of increasing salinity and acid sulphate soils in Heart Morass and Dowd Morass. As filling of the lower Latrobe wetlands depends on river heights in the lower Latrobe River, flows in the river would likely be insufficient to meet some watering actions such as complete fills and only partial fills may be possible to manage water quality. Under these scenarios, longer drawdowns are expected, and the wetlands will likely draw down to very low levels by the end of summer or during autumn.

Under average conditions, the wetlands are likely to receive moderate, unregulated flows in winter and spring and partially draw down in summer/autumn. The rate and extent of a drawdown is likely to be moderated by small-scale natural or managed environmental flows through regulators. Under wet conditions, unregulated flows are likely to cause greater wetland filling; and widespread drying is unlikely.

Table 2.2.4 Potential environmental watering for the lower Latrobe wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No natural inflows from the Latrobe River, and wetlands are likely to dry completely	• Minor natural inflows from the Latrobe River in winter/spring; expect moderate-to-substantial drawdown in summer	• Moderate winter and spring flows in the Latrobe River likely to fill or partially fill the wetlands; expect minor drawdown in summer	• Major flows in the Latrobe River in winter/spring and possibly autumn/winter likely to fill all wetlands with very little drawdown in summer
Sale Common				
Potential environmental watering – tier 1a (high priorities)	• Partial fill (during July to December) • Fill (during August to November) • Fill (any time) • Partial or near-complete drawdown (during December to April) • Fill or partial fill (any time)			
Potential environmental watering – tier 2 (additional priorities)	• N/A			
Dowd Morass				
Potential environmental watering – tier 1a (high priorities)	• Fill or partial fill (any time) • Partial fill (during March to December) • Fill (during August to November) • Partial or near-complete drawdown (during January to March)			
Potential environmental watering – tier 2 (additional priorities)	• N/A			
Heart Morass				
Potential environmental watering – tier 1a (high priorities)	• Fill or partial fill (any time) • Partial fill (during August to December) • Drawdown (during December to February)			
Potential environmental watering – tier 2 (additional priorities)	• N/A	• Flushing flow (during July to November)		• N/A

2.3 Thomson system

Waterway manager – West Gippsland Catchment Management Authority

Storage managers – Melbourne Water (Thomson Reservoir), Southern Rural Water (Cowwarr Weir)

Environmental water holder – Victorian Environmental Water Holder

Did you know ...?

The Thomson system is home to six species of migratory fish that need to move between saltwater and freshwater. Environmental flows throughout the year help send the right signals to these fish to move between the estuaries and the rivers and spawn.

Top: Thomson River, by West Gippsland CMA
Centre: Stonefly, by Parks Victoria
Above: Australian grayling being released, by David Dawson

System overview

The Thomson River flows from the slopes of the Baw Baw Plateau to join the Latrobe River south of Sale. The major tributaries of the Thomson River are the Aberfeldy and Jordan rivers in the upper reaches and the Macalister River in the lowest reach. Most unregulated flows originate from the Aberfeldy River. Two major structures regulate flow on the Thomson River: Thomson Reservoir — the largest water supply storage for metropolitan Melbourne — and Cowwarr Weir — a regulating structure which supplies irrigation water to parts of the Macalister Irrigation District.

Thomson Reservoir harvests most of the flow from the Thomson River upper catchment and has a significant effect on flow in all downstream reaches. Unregulated flows from the Aberfeldy River, which meets the Thomson River downstream of Thomson Reservoir, are essential for providing natural freshes and high flows in the Thomson River.

Water for the environment is held in the Thomson Reservoir and released into the river as required. Reach 3 of the Thomson River (from the Aberfeldy River confluence to Cowwarr Weir) is the highest priority for environmental watering due to its heritage river status, high-value native riparian vegetation, high-quality in-stream habitat and low abundance of exotic fish species.

At Cowwarr Weir, the Thomson River splits into the old Thomson River course (reach 4a) and Rainbow Creek (reach 4b) (see Figure 2.3.1). Passing flows throughout the year are split two-thirds down reach 4a and one-third down 4b to avoid impacts to irrigators located on Rainbow Creek. Water for the environment is primarily delivered to the old Thomson River course (reach 4a) to support fish migration, because Cowwarr Weir impedes fish movement through Rainbow Creek.

Environmental values

The Thomson River supports six native species of migratory fish that need to move between the sea and freshwater environments to complete their life cycles. A focus for environmental flows management is the Australian grayling, which is listed as a threatened species in Victoria. Australian grayling spawn in response to autumn high flows, and the larvae and juveniles spend time at sea before returning to the freshwater sections of coastal rivers.

The composition and condition of riparian vegetation varies throughout the Thomson River catchment. The vegetation is intact and near-natural condition above Thomson Reservoir in the Baw Baw National Park. Riparian vegetation between Thomson Reservoir and Cowwarr Weir is mostly in good condition but is affected by exotic weeds including blackberry and gorse. Downstream of the Cowwarr Weir, the vegetation is degraded due to stock access and widespread weed invasion.

Environmental objectives in the Thomson system

Restore populations of native fish, specifically Australian grayling

Maintain/enhance the structure of native fish communities

Reduce competition from exotic fish

Maintain channel form diversity including pools, to provide a variety of habitats for aquatic animals

Maintain and restore the structural diversity and zonation of riparian vegetation

Increase the recruitment and growth of native riparian vegetation

Restore and maintain the natural invertebrate community

Heyfield wetlands objectives

Maintain the existing frog populations and provide suitable habitat

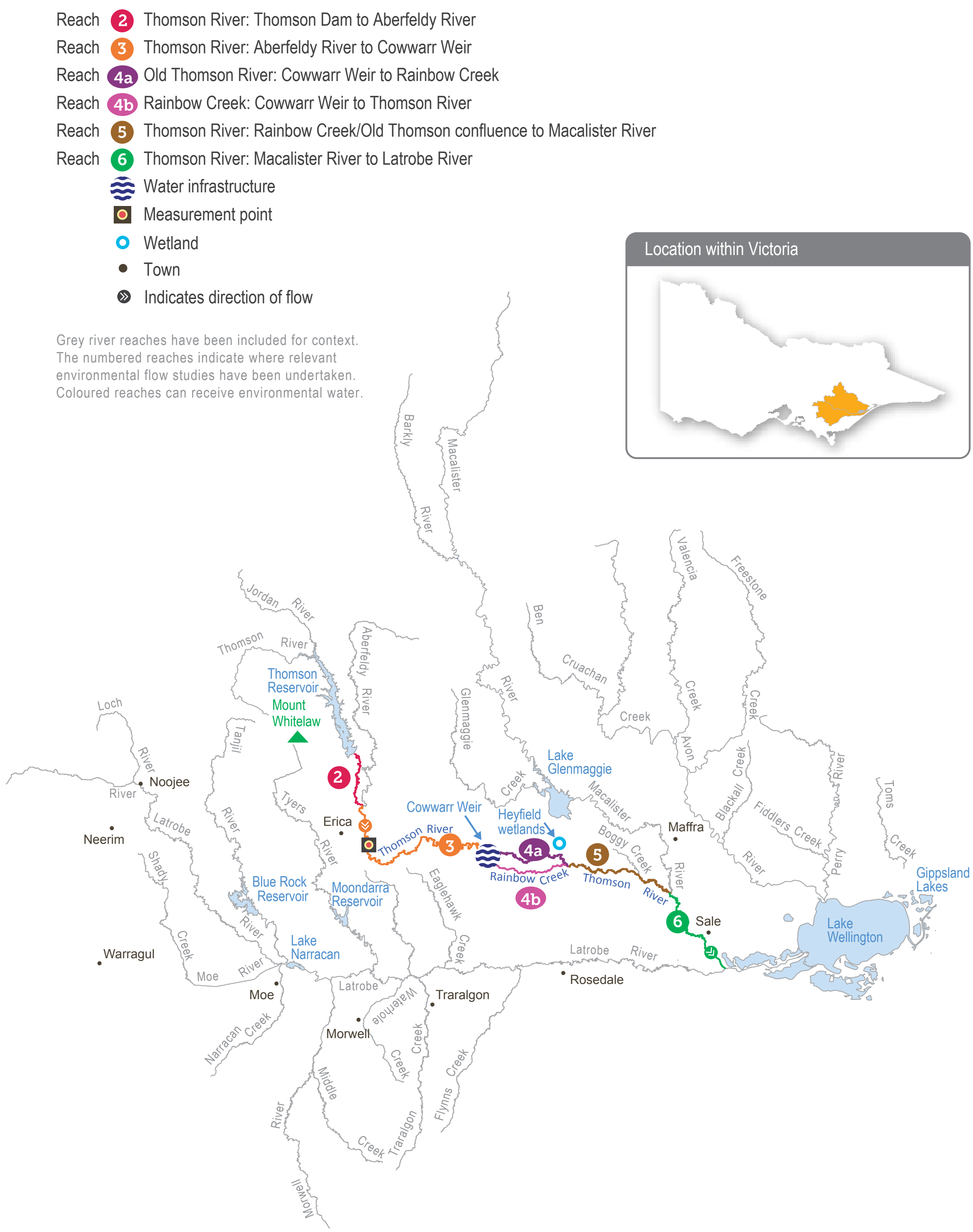
Maintain the existing vegetation, promote the growth and establishment of semi-aquatic species

Enhance the resilience of semi-aquatic and riparian woodland species

Provide freshwater refuge habitat for migratory and non-migratory wetland birds within the Gippsland Plains landscape

Continue to support observed terrestrial woodland and grassland birds by maintaining their riparian woodland habitat

Figure 2.3.1 The Thomson system



Recent conditions

In recent years, water for the environment has primarily been used to deliver autumn and spring freshes to create spawning and recruitment opportunities for native fish including Australian grayling, Australian bass and tupong. Low flows have also been provided to enable fish to move between habitats along the river.

The Thomson system has experienced mostly dry conditions over the past two years. 2018–19 saw below-average rainfall through winter and spring and some of the highest ever recorded temperatures were observed in summer.

Passing flows in the Thomson River were modified during July 2018 to allow some water for the environment to be saved for use later in the year. The modification was agreed by the VEWH, West Gippsland CMA, Southern Rural Water and Melbourne Water, and it saved 1,270 ML of water for the environment. Those savings enabled a winter fresh to be delivered in early August 2018. This and a second partial fresh that was delivered late in August were timed to assist the migration and spawning of Australian bass.

In November 2018, a spring fresh was delivered to trigger the upstream movement of juvenile native fish from the sea and estuary. This fresh was timed to coincide with environmental and unregulated flows from the Macalister and Latrobe Rivers, to optimise outcomes in the lower Latrobe system.

In response to low rainfall throughout summer, consumptive water demands were high. Releases to meet these consumptive orders, combined with limited unregulated flows, met the targets for summer freshes from December 2018 to February 2019.

Construction works for the Thomson River fishway at Horseshoe Bend prevented the delivery of an autumn fresh in 2019. Autumn freshes are needed to trigger migration and spawning of native fish and are generally provided at least two out of every three years. Once completed, the fishway is expected to enhance the response to environmental flows, as it allows fish to move upstream of the Horseshoe Bend Tunnel (a known barrier to fish movement) to access about 85 km of high-quality habitat in the upper Thomson and Aberfeldy rivers.

A combination of water for the environment and consumptive water were used to maintain low flows in the Thomson River over autumn.

Scope of environmental watering

Table 2.3.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 2.3.1 Potential environmental watering actions and objectives for the Thomson system

Potential environmental watering action	Functional watering objective	Environmental objective
Thomson River		
Autumn fresh (one to two freshes of 800 ML/day for four days each during April to May)	• Trigger the downstream migration (and spawning) of Australian grayling • Carry plant seeds from the upper catchment for deposition downstream • Deposit sediments on benches, to provide substrate for vegetation • Wet the bank/bench to deliver dissolved and/or fine particulate organic matter • Scour substrates to remove accumulated fine sediment	
Autumn/winter low flows (up to 230 ML/day during April to June)[1]	• Increase the available habitat for waterbugs • Wet large woody debris to provide food and shelter for waterbugs and fish • Increase water depth to provide habitat for fish and provide opportunities for localised fish movement between habitats	
Spring low flows (230 ML/day in November)	• Provide connectivity along the river to enable fish passage between habitats and supporting juvenile recruitment of native species • Increase available habitat for waterbugs • Wet large woody debris to provide food and shelter for waterbugs and fish	

Table 2.3.1 Potential environmental watering actions and objectives for the Thomson system *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Spring freshes (one to two freshes of 800 ML/day for four days each during October to November)	• Trigger upstream fish migration from marine/estuarine habitats, encouraging tupong spawning and the recruitment of juvenile native species including Australian grayling and Australian bass • Improve and maintain riparian vegetation by inundating the benches and providing variable water levels for plant zonation • Carry plant seeds from the upper catchment for deposition downstream • Deposit dissolved and/or fine particulate sediments on the benches • Scour substrates to remove accumulated fine sediment	
Winter fresh (one to two freshes of 800 ML/day for four days each during June to August)	• Trigger native fish (such as tupong and Australian bass) to migrate towards estuary for spawning (Australian bass) or breeding (tupong) • Carry plant seeds from the upper catchment for deposition downstream • Deposit dissolved and/or fine particulate sediments on the benches, to help regenerate semi-aquatic vegetation communities • Scour substrates to remove accumulated fine sediment	
Summer freshes (up to seven freshes[2] of 230 ML/day for four days each during December to April)	• Increase the water depth to provide habitat for native fish • Wet aquatic and fringing vegetation to maintain its condition and support its growth • Scour sediment to expose fresh habitat area	
Heyfield wetlands		
Fill (August)	• Wet ponds to capacity, to stabilise the banks and support the spring growth of semi-aquatic vegetation • Provide freshwater refuge habitat for waterbirds and frogs (such as growling grass frogs and golden bell frogs)	
Partial fill (during October to November)	• Top up ponds to maintain the existing vegetation and enhance its recruitment by triggering seed dispersal • Provide freshwater refuge habitat for waterbirds and frogs (such as growling grass frogs and golden bell frogs)	
Partial drawdown (during December to February)	• Oxygenate surface soils, break down accumulated organic matter and cycle nutrients • Enhance waterbird food availability by exposing the mudflats and provide access to burrowing invertebrates	

[1] *Passing flows may be flexibly managed at rates less than 230 ML per day in July.*

[2] *Some summer freshes are likely to be met with consumptive water releases.*

Scenario planning

Table 2.3.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The highest-priority watering actions in the Thomson River under all climate scenarios in 2019–20 will be low flows throughout autumn, winter and spring, and freshes in all seasons. The number or magnitude of these flow events will generally be smaller under drought and dry conditions, compared to average and wet conditions.

The recommended low flows for autumn, winter and spring are needed to maintain habitat for fish, waterbugs and aquatic and riparian vegetation, as well as to allow fish to move throughout the system.

Autumn freshes are needed in at least two out of three years, to cue Australian grayling to migrate downstream and spawn. No autumn freshes were delivered in the Thomson River in 2018–19 due to construction work on the Horseshoe Bend fishway, and therefore it is critical to deliver these flows in 2019–20. Summer freshes are needed to maintain habitat and food resources for waterbugs and fish and to maintain fringing riparian vegetation.

Winter freshes provide a cue for native fish including tupong and Australian bass to migrate downstream towards the estuary – where they breed or spawn, while spring freshes encourage juvenile migratory fish to move upstream from the sea or estuary. Spring and winter freshes require significant volumes of water, and it may be difficult to deliver both with the available supply under dry and drought conditions in 2019–20. Under a drought scenario, only a spring fresh is likely to be delivered with the available water. In a dry scenario, the winter fresh will be prioritised, as natural flows in spring are more likely to achieve a partial spring fresh. Fish surveys in 2017–18 indicated low numbers of Australian bass and tupong, and therefore if any additional water for the environment becomes available, it would likely be used to provide both winter and spring freshes in 2019–20 to help grow these populations in the Thomson system.

New flow recommendations for the Latrobe River estuary and lower Latrobe wetlands (see subsections 2.2.1 and 2.2.2) are highly dependent on flow contributions from the Thomson–Macalister system. Consequently, timing of the Thomson spring fresh will be influenced by conditions in these systems. Where possible, spring freshes in both the Thomson and Macalister systems will be timed to coincide with releases in the Latrobe system, to optimise outcomes in the Latrobe estuary and lower Latrobe wetlands.

Under all scenarios, 4,300 ML of water for the environment is expected to be carried over at the end of 2019–20 to meet critical minimum demands (winter, spring and autumn low flows and freshes) for environmental flows in 2020–21, under a drought scenario.

A trial watering is proposed at the Heyfield wetlands in 2019–20. The Heyfield wetlands consist of a cluster of several shallow pools and one deep freshwater pool located on a single 26 ha site adjacent to the township of Heyfield. The wetlands are isolated from Thomson River flows due to levees and changed flow regimes, and environmental watering intends to provide a more-natural filling regime to support existing the vegetation and to provide refuge habitat for waterbirds. A winter fill, then a partial fill in spring to top up the ponds before summer, followed by natural drying over the summer months, is proposed under all climatic scenarios.

Table 2.3.2 Potential environmental watering for the Thomson system under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No unregulated flows • Large volume of consumptive water released from storage	• Unregulated flows from Aberfeldy River and other tributaries contribute to baseflows and freshes • Moderate volume of consumptive water released from storage	• Unregulated flows from Aberfeldy River and other tributaries contribute to baseflows, freshes and high flows • Small volume of consumptive water released from storage	• Unregulated flows from Aberfeldy River and other tributaries contribute to baseflows, freshes and sustained high flows • Minimal volume of consumptive water released from storage
Expected availability of environmental water	• 16,400–25,700 ML	• 19,400–28,700 ML	• 22,400–31,700 ML	• 25,400–34,700 ML
Potential environmental watering – tier 1a (high priorities)	• One autumn fresh • Autumn/winter low flow • Spring low flows • One spring fresh • Up to seven summer freshes	• One autumn fresh • Autumn/winter low flow • Spring low flows • Up to seven summer freshes • One winter fresh	• One autumn fresh • Autumn/winter low flow • Spring low flows • One spring fresh • Up to seven summer freshes • One winter fresh	• One autumn fresh • Autumn/winter low flow • Spring low flows • One spring fresh • Up to seven summer freshes • One to two winter freshes
Potential environmental watering – tier 1b (high priorities with shortfall)	• One winter fresh	• One spring fresh	• One additional winter fresh	
Potential environmental watering – tier 2 (additional priorities)			• One additional spring fresh	• One additional autumn fresh
Possible volume of water for the environment required to achieve objectives[1]	• 14,300 ML (tier 1a) • 3,200 ML (tier 1b)	• 15,600 ML (tier 1a) • 3,200 ML (tier 1b)	• 19,600 ML (tier 1a) • 3,200 ML (tier 1b) • 3,200 ML (tier 2)	• 23,700 ML (tier 1a) • 3,200 ML (tier 2)
Priority carryover requirements	• 4,300 ML			
Heyfield wetlands				
Potential environmental watering – tier 1a (high priorities)	• Fill (August) • Partial fill (during October to November) • Partial drawdown (during December to February)	• Fill (August) • Partial fill (during October to November) • Partial drawdown (during December to February)	• Fill (August) • Partial fill (during October to November) • Partial drawdown (during December to February)	• Fill (August) • Partial fill (during October to November) • Partial drawdown (during December to February)
Possible volume of water for the environment required to achieve objectives	• 15 ML (tier 1a)	• 15 ML (tier 1a)	• 10 ML (tier 1a)	• 7 ML (tier 1a)

[1] *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

2.4 Macalister system

Waterway manager – West Gippsland Catchment Management Authority

Storage manager – Southern Rural Water

Environmental water holder – Victorian Environmental Water Holder

Did you know …?

The Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP) is monitoring vegetation in the lower Macalister River. Monitoring results will help water managers and the community understand how environmental flows in the Macalister River have contributed to helping the recovery of native vegetation along the river. Arthur Rylah Institute scientists will be looking for diversity in species, successful seed dispersal and germination of seeds.

Top: Upper Macalister River, by West Gippsland CMA
Centre: Platypus, courtesy of Healesville Sanctuary
Above: Long-necked turtle, by Hugh McGregor

System overview

The Macalister River flows from Mt Howitt in the Alpine National Park and joins the Thomson River south of Maffra. The river winds its way in a south-easterly direction through mostly forested, confined valleys and narrow floodplains upstream of Lake Glenmaggie. The downstream reaches flow through wide alluvial floodplains that have been cleared for agriculture. The Wellington River and Glenmaggie Creek are the main tributaries of the Macalister River.

Lake Glenmaggie is the major water-harvesting storage regulating the Macalister River. Maffra Weir is a small diversion weir located further downstream in Maffra.

Before the construction of Lake Glenmaggie, the Macalister River would regularly receive high and medium flows in winter and spring. Although Lake Glenmaggie regularly spills, high flows are less frequent than natural because much of the water is captured by the storage. A notable impact of irrigation and water-harvesting is reversed seasonality of flows between Lake Glenmaggie and Maffra Weir. Summer flows through this reach are much higher than natural due to the delivery of irrigation water. Winter flows in this reach are lower than natural because a high proportion of the inflows are captured and there are no irrigation demands over winter. Downstream of Maffra Weir, most flows are diverted for irrigation in summer/autumn. The changed hydrology restricts fish migration, limits the growth and recruitment of in-stream and riparian plants and reduces the quality of in-stream habitat.

Water for the environment is stored in Lake Glenmaggie and released to the Macalister River. The river is divided into two reaches for the purposes of managing environmental flows: Lake Glenmaggie to Maffra Weir (reach 1) and Maffra Weir to the Thomson River (reach 2).

Maffra Weir is a major barrier to fish movement along the river, so environmental watering for migratory fish objectives mainly focus on reach 2. All other objectives apply to both reaches 1 and 2.

Environmental values

There are seven migratory native fish species that move between the Macalister River, the estuary and the sea to complete their life cycle. These species include the Australian grayling, short-finned eel, long-finned eel, tupong, Australian bass, short-headed lamprey and common galaxias. Yellow-eye mullet, which is an estuarine species, has been recorded in the river. Platypus and rakali (water rats) are widely distributed through the Macalister River and its tributaries.

The riparian vegetation corridor along the regulated reaches of the Macalister River is fragmented. Immediately downstream of Lake Glenmaggie, the vegetation is in good condition and includes remnant river red gums and good-quality stands of shrubs, particularly in areas where revegetation has occurred in combination with stock exclusion. Further downstream, the vegetation is degraded. In recent years, the cover of in-stream vegetation has declined, which may be due to a combination of increased water turbidity, erosion and a lack of an appropriate water regime to encourage plant growth. The cover of non-woody plants (such as reeds, sedges and rushes) along the fringes of the river is patchy.

Environmental objectives in the Macalister River

Increase the distribution, recruitment and abundance of all native fish, and increase opportunities for the spawning and recruitment of native migratory fish (such as the Australian grayling)
Improve and maintain the form of the riverbank and bed to provide physical habitat for aquatic ecology
Increase the abundance of platypus and rakali (water rats)
Improve native emergent (non-woody) and fringing (woody) vegetation in the riparian zone Reinstate or instate submerged aquatic vegetation
Increase the abundance and number of functional groups of waterbugs

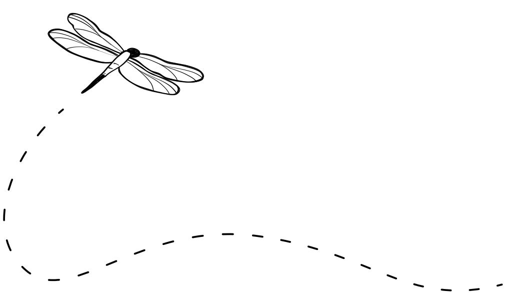
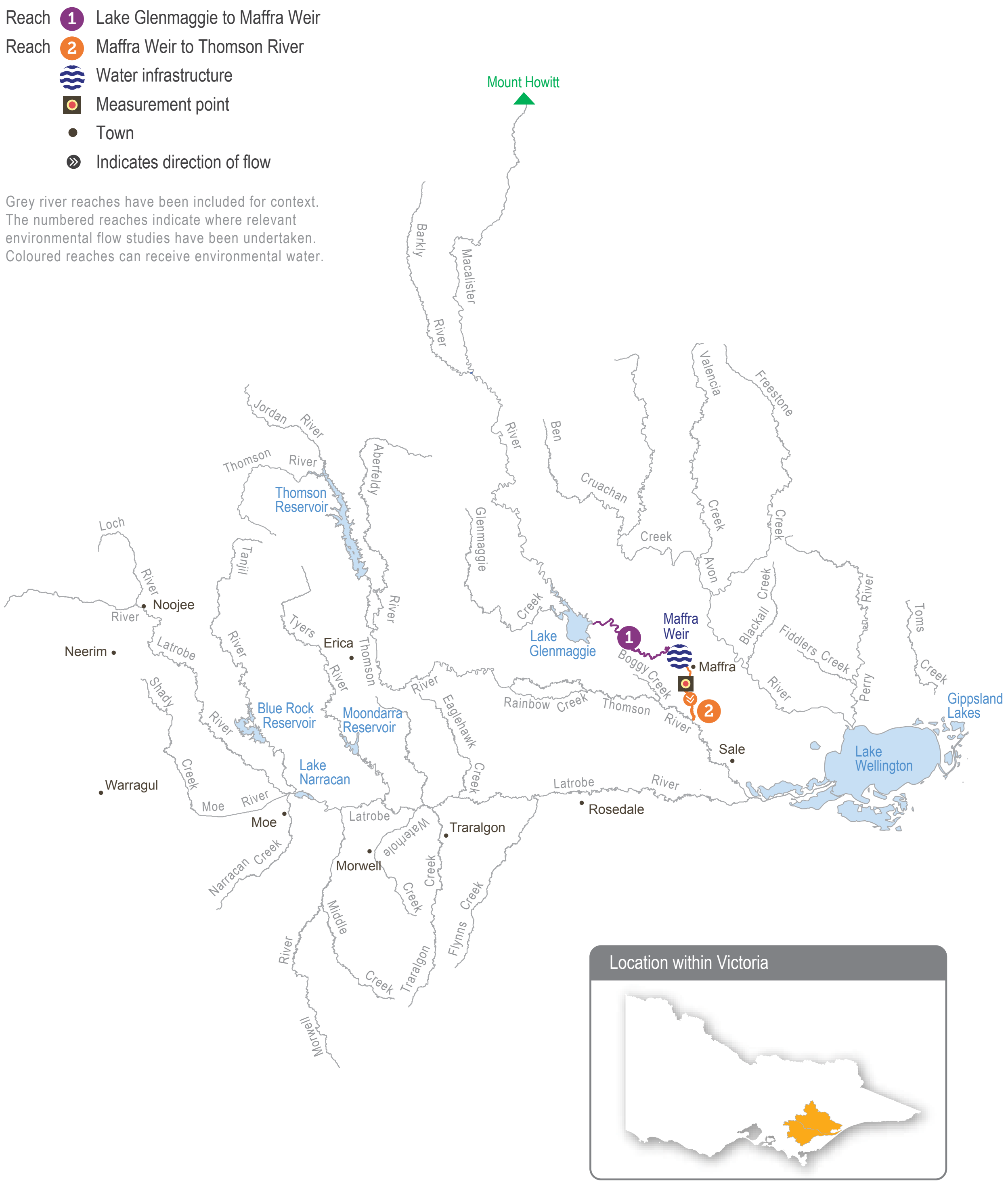


Figure 2.4.1 The Macalister system



Recent conditions

Climatic conditions in the Macalister River catchment have been very dry over the last two years.

The 2017–18 year began with a dry winter/spring. Average rainfall in December 2017 and January 2018 caused Lake Glenmaggie to spill in December 2017, but the rest of summer/autumn 2018 were drier than average.

Dry conditions persisted into 2018–19, with below-average to well-below-average rainfall and above-average temperatures for most of the year. Lake Glenmaggie did not spill in 2018–19, which is rare for this system.

The reach between Lake Glenmaggie and Maffra Weir had consistent flow to meet operational demands throughout the irrigation season. Due to low inflows however, passing flows at Maffra Weir were reduced in March from 60 ML per day to 30 ML per day or less, in accordance with system rules.

Water for the environment was used to supplement low passing flows in reach 2 from late March to protect water quality, and it was also used to provide freshes at critical times and to supplement low flows when irrigation demand fell.

A winter fresh was delivered in August 2018 to trigger the migration and spawning of tupong and Australian bass. A spring fresh was delivered in early November 2018 to encourage juvenile fish to migrate into the Macalister River from the sea, and to wet bankside vegetation and enable native seed dispersal.

An autumn fresh targeting fish migration was not delivered in April 2019. This fresh is usually timed to coincide with releases in the Thomson and Latrobe rivers to enhance migration cues. Construction of the Thomson River fishway at Horseshoe Bend meant an autumn fresh could not be delivered in the Thomson River. The lack of a complementary flow in the Thomson River reduced the value of the fresh in the Macalister River, and it was decided that the water should be held in storage to meet anticipated environmental demand in 2019–20. Foregoing the autumn fresh for one year is not expected to affect Australian grayling populations, but delivering the event in autumn 2020 will be a priority.

Scope of environmental watering

Table 2.4.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

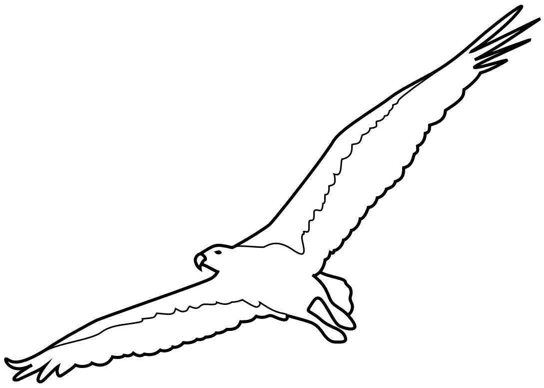
Table 2.4.1 Potential environmental watering actions and objectives for the Macalister River

Potential environmental watering action	Functional watering objective	Environmental objective
Macalister River reaches 1 and 2		
Winter to summer low flow (up to 90 ML/day during June to December)	• Provide hydraulic habitat for fish by increasing the water depth in pools • Provide fish passage for local movement through minimum depth over riffles • Provide permanent wetted habitat for waterbugs through minimum water depth in pools • Provide connectivity throughout the river for the local movement of platypus and rakali (water rats), as well as protection from predation, access to food sources; and to maintain refuge habitats • Provide flows with low water velocity and appropriate depth to improve water clarity and enable establishment of in-stream vegetation • Provide sustained wetting of low-level benches (increasing water depth) to limit terrestrial vegetation encroachment	
Summer/autumn low flow (35–90 ML/day during January to May)	• Maintain the water depth in pools and hydraulic habitat for native fish • Maintain permanent wetted habitat in pools and riffles for waterbugs • Maintain shallow, slow-flowing habitat to enable the establishment of in-stream vegetation • Maintain a minimum depth in pools to allow for turnover of water and to slow degradation of water quality to support aquatic life • Expose and dry lower channel features for re-oxygenation	

Table 2.4.1 Potential environmental watering actions and objectives for the Macalister River *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Spring fresh (up to 1,500 ML/day for three days during September to October)[1]	• Cue the up-stream migration of adult fish (e.g. short-headed lamprey), and the recruitment of juveniles (e.g. Australian grayling, tupong, common galaxias, Australian bass, short and long-finned eels) from marine/estuarine environments • Wet a greater area of the stream channel (increasing water depth) to limit terrestrial vegetation encroachment • Wet mid and higher-level benches to water woody vegetation • Flush pools to improve the water quality and increase wetted habitat for waterbugs • Provide flows with sufficient shear stress to flush fine sediment from small gaps to improve geomorphic habitat	
Macalister River reach 2		
Autumn fresh (up to 350 ML/day for four to five days during April to May)	• Cue downstream migration for Australian grayling towards the estuary for spawning	
Spring/summer fresh (700 ML/day for up to five days during September to December)	• Cue upstream migration of adult fish (e.g. short-headed lamprey), and recruitment of juveniles (e.g. Australian grayling, tupong, common galaxias, Australian bass, short and long-finned eels) from marine/estuarine environments • Wet a greater area of the stream channel (increasing water depth) to limit terrestrial vegetation encroachment • Wet low and mid-level benches to facilitate the dispersal of emergent and fringing vegetation throughout the reach	
Summer/autumn fresh (one to three freshes of 140 ML/day for three days during December to May)	• Increase the depth to allow fish to move throughout the reach • Flush pools to maintain water quality • Flush substrates and improve the quality of existing waterbug habitat and food supply • Wet low benches to facilitate the longitudinal dispersal of emergent vegetation • Provide flows with sufficient shear stress to flush fine sediment from small gaps to improve geomorphic habitat	
Winter fresh (one to two freshes of 700 ML/day for four to five days during June to August)	• Cue the downstream migration of tupong and Australian bass towards the estuary for spawning (Australian bass) and breeding (tupong)	

[1] *This fresh will only be delivered following a spill in Lake Glenmaggie (if the magnitude is lower than minor flood level), to extend or slow the rate of ramp down. If a spill occurs, delivering this fresh will meet the functional flow objectives of the lower magnitude spring/summer fresh.*



Scenario planning

Table 2.4.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Providing year-round low flows and freshes in winter, spring and autumn are the highest priorities for 2019–20 under all climate scenarios, to provide connectivity through the river system so fish and other animals can move. Under drought and dry scenarios, water for the environment may be used to supplement reduced passing flows to maintain connectivity between habitats and water quality downstream of Maffra Weir.

Spring freshes are needed to trigger upstream migration of native migratory fish including tupong, lampreys and eels and to encourage juveniles to move into the Macalister River from the Latrobe River estuary. In most years, spring freshes are delivered by spills from Lake Glenmaggie, however Lake Glenmaggie did not spill in 2018–19 and early forecasts suggest Lake Glenmaggie may not spill again in spring 2019 and therefore a managed spring/summer fresh has been prioritised under all scenarios. In a drought scenario, a summer fresh may also be required to improve water quality and to prevent low levels of dissolved oxygen affecting aquatic life.

Autumn freshes are needed in the Macalister River to cue Australian grayling to breed. Australian grayling only live for up to three years, so autumn freshes are a priority in most years and under most climate scenarios, to ensure regular recruitment and the ongoing sustainability of the population. This watering action is a high priority in 2019–20 as the fresh was not delivered in 2018–19.

If additional water for the environment is available in average or wet conditions, winter freshes may be provided to trigger tupong and Australian bass to migrate downstream to the sea. A target carryover volume has been determined and is a high priority under all scenarios, to ensure there is sufficient water to deliver winter low flows in July 2019.

Table 2.4.2 Potential environmental watering for the Macalister River under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No unregulated flows • Passing flows at Maffra Weir reduced	• Possible spills from Lake Glenmaggie in spring, minor flood levels may occur • Passing flows at Maffra Weir may be reduced	• Regular spills from Lake Glenmaggie in spring, minor to moderate flood levels may occur	• Large and frequent spills from Lake Glenmaggie, moderate to major flood levels may occur
Expected availability of environmental water	• 12,500 ML	• 15,800 ML	• 17,800 ML	• 22,300 ML
Potential environmental watering – tier 1a (high priorities)	• Winter to summer low flow (reach 1 and 2) • Summer/autumn low flow • One to three summer/autumn freshes (reach 2) • One autumn fresh (reach 2) • One winter fresh (reach 2)	• Winter to summer low flow (reach 1 and 2) • Summer/autumn low flow • One to three summer/autumn freshes (reach 2) • One spring/ summer fresh (reach 2) or spring fresh (reach 1 and 2) following spill • One autumn fresh (reach 2) • One winter fresh (reach 2)	• Winter to summer low flow (reach 1 and 2) • One spring/ summer fresh (reach 2) or spring fresh (reach 1 and 2) following spill • One autumn fresh (reach 2) • One winter fresh (reach 2)	• Winter to summer low flow (reach 1 and 2) • One spring fresh (reach 1 and 2) following spill • One autumn fresh (reach 2) • Two winter freshes (reach 2)
Potential environmental watering – tier 1b (high priorities with shortfall)	• One spring/ summer fresh (reach 2)	• Extend baseflow duration through winter and spring months if Lake Glenmaggie spills	• Extend baseflow duration through winter and spring months following Lake Glenmaggie spill	• Extend baseflow duration through winter and spring months following Lake Glenmaggie spill
Potential environmental watering – tier 2 (additional priorities)	• Extend baseflows through winter and spring months	• One additional winter fresh (reach 2)	• One additional winter fresh (reach 2)	• One additional spring/summer fresh (reach 2)
Possible volume of water for the environment required to achieve objectives[1]	• 10,400 ML (tier 1a) • 3,500 ML (tier 1b) • 1,100 ML (tier 2)	• 13,800 ML (tier 1a) • 1,100 ML (tier 1b) • 2,800 ML (tier 2)	• 16,600 ML (tier 1a) • 1,100 ML (tier 1b) • 2,800 ML (tier 2)	• 19,000 ML (tier 1a) • 900 ML (tier 1b) • 3,500 ML (tier 2)
Priority carryover requirements	• 1,500–1,900 ML			

1 *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

2.5 Snowy system

Waterway managers – East Gippsland Catchment Management Authority and New South Wales Department of Planning, Industry and Environment

Storage manager – Snowy Hydro Limited

Environmental water holders – Victorian Environmental Water Holder, New South Wales Department of Planning, Industry and Environment

Did you know ...?

A new Snowy Advisory Committee was formed in 2018. The committee will guide decision-making around environmental flows for the iconic Snowy River. Membership includes local community members, Aboriginal representation, environmental experts and NSW Government and Victorian Government delegates.

Top: Snowy River, by East Gippsland CMA
Centre: Eastern curlew, by East Gippsland CMA
Above: Snowy River mouth, used by fish including flathead, mulloway and black bream, by Mark Toomey, VEWH

System overview

The Snowy River originates on the slopes of Mount Kosciuszko. It drains the eastern slopes of the Snowy Mountains in New South Wales before flowing through the Snowy River National Park in Victoria and into Bass Strait.

There are four major dams and multiple diversion weirs in the upper Snowy River catchment that divert water to the Murrumbidgee and River Murray valleys. The hydrological effects of the Snowy Mountains Scheme are substantial, but they are partly alleviated by the contribution of flows from tributaries (such as the Delegate River in New South Wales and the Buchan and Brodribb rivers in Victoria).

Construction and operation of the Snowy Mountains Hydro-electric Scheme previously diverted 99 percent of the Snowy River's mean annual natural flow at Jindabyne. The loss of flow changed the structure and function of the river, reduced the opening of the Snowy River entrance to Bass Strait and resulted in a decline in environmental values.

The Victorian, New South Wales and Commonwealth governments have recovered water to help restore damage done by decades of limited flow. Victorian water for the environment available for use in the Snowy system is held in the Murray, Goulburn and Loddon systems. This water is made available for environmental flows in the Snowy River via a substitution method, whereby Victorian water for the environment replaces water that was earmarked for transfer from the Snowy to Victoria to support irrigation demands.

Environmental values

The remaining environmental values in the upper reaches and tributaries of the Snowy River include freshwater fish (such as river blackfish and Australian grayling). The lower reaches support estuary perch and Australian bass that move between saltwater and freshwater systems. The estuary contains estuarine and saltwater species such as flathead, mulloway and black bream. The floodplain wetlands of the Snowy River near Marlo provide feeding and breeding areas for wetland and migratory birds.

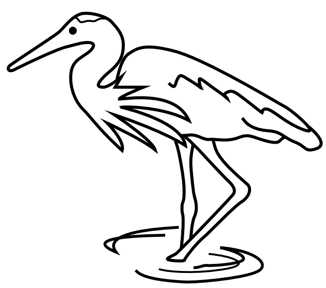
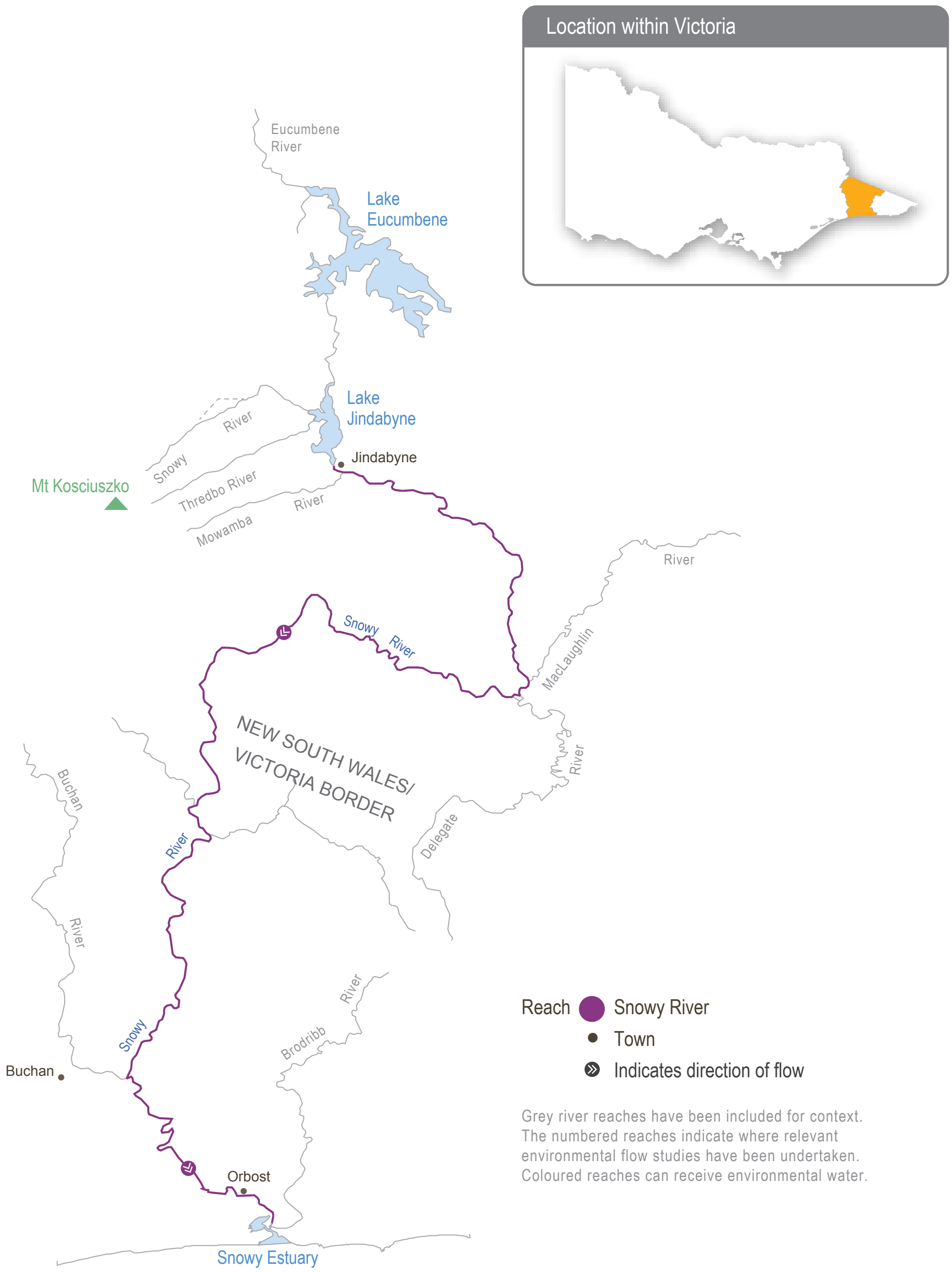


Figure 2.5.1 The Snowy system



Recent conditions

The water year in the Snowy system runs from May to April. In 2018–19, about 137,087 ML[3] of water for the environment was used to deliver five winter/spring high-flow events in the Snowy River. A major flushing flow was planned for October 2018, but prolonged, dry conditions and low inflows into Jindabyne Dam resulted in the flow rate being reduced, from 8,620 ML per day to 5,000 ML per day.

Scope of environmental watering

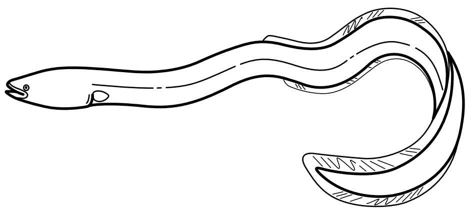
The New South Wales Department of Planning, Industry and Environment plans environmental flow releases in the Snowy River, in consultation with the Victorian Government.

Environmental watering from May 2019 to April 2020 will aim to mimic the typical flow pattern of a mixed snowmelt/rainfall river system characteristic of the Snowy Mountains. The releases will aim to support ecological processes in the Snowy River below Jindabyne Dam and maintain a healthy river that is much smaller than the natural channel that existed before the river was regulated.

East Gippsland CMA has monitored the lower reaches and estuary over the past seven years. The results show that the managed environmental flows help improve physical and ecological processes, increase ecosystem productivity and improve aquatic habitat.

Five high-flow releases are scheduled between June and November 2019. A large, flushing flow is scheduled for late October 2019 and includes an eight-hour peak at a rate equivalent to 5,000 ML per day. Other peak flows will mimic winter rainfall events. These peak flows aim to improve the physical attributes of the river by scouring and depositing sediment and increasing available aquatic habitat. High flows will be sustained from July to December, to help mix water in the estuary to benefit plants and fish (such as Australian bass). Low flows will then be released until the end of the water year in April 2020.

The total volume planned for release in 2019–20 (including contributions from water savings in Victoria and New South Wales) is 118,671 ML.



3 Preliminary figure of total releases in 2018–19. This volume may alter slightly due to accounting adjustments. Volume will be verified in Snowy Hydro Limited's annual water operating plan.

Werribee River, by Melbourne Water

SECTION 3

Central region

Werribee system
Maribyrnong system
Moorabool system
Yarra system
Barwon system
Tarago system

3.1 Central region overview

There are six systems in the central region that can receive managed environmental flows: the Yarra and Tarago in the east and the Werribee, Maribyrnong, Moorabool and Barwon (upper Barwon River and lower Barwon wetlands) in the west. It is possible to move water between these systems through trade, but most water for the environment in these systems is prioritised to provide benefits for the river where it is stored.

Traditional Owners in the central region

Traditional Owners and their Nations in the central region continue to have a deep connection to the region's rivers, wetlands and floodplains.

Traditional Owner Groups in the central region include the Bunurong Land Council Aboriginal Corporation, Eastern Maar Aboriginal Corporation, Gunaikurnai Land and Waters Aboriginal Corporation, Wathaurung Aboriginal Corporation and Wurundjeri Woi Wurrung Cultural Heritage Aboriginal Corporation.

In recognition of the cultural importance of water for Aboriginal people and their traditional ecological knowledge, Corangamite CMA and Melbourne Water are working with Traditional Owners to involve them in management of environmental flows. In 2019–20 this will include the following initiatives:

- continuing the partnership between Melbourne Water, the VEWH and the Wurundjeri Woi Wurrung Cultural Heritage Aboriginal Corporation, which uses Yarra River billabongs as a case study of how to include Wurundjeri as active participants in the planning, delivery, and monitoring of environmental flows. In 2019–20, the partners will focus on developing innovative ways of incorporating Wurundjeri knowledge of Country and cultural values into decisions about where, when and how to deliver water on the lower Yarra floodplain
- involving the Wurundjeri Narrap (ranger) team in environmental water management, as they document the outcomes of environmental flows by monitoring water quality and frogs at billabongs that have received water for the environment.

Engagement

Seasonal watering proposals are informed by longer-term regional catchment strategies, regional waterway strategies, relevant technical studies (such as environmental flow studies and environmental water management plans), as well as by input from program partners and affected stakeholders. The strategies and technical reports collectively describe a range of cultural, economic, environmental, social, and Traditional Owner perspectives and longer-term integrated catchment and waterway management objectives that influence environmental watering actions and priorities. Program partners and other stakeholders help to identify environmental watering priorities and opportunities for the coming year.

The International Association for Public Participation's Public Participation Spectrum (IAP2 Spectrum) has been used to categorise the levels of participation of stakeholders involved in the environmental watering planning process. Table 3.1.1 shows the IAP2 Spectrum categories and participation goals.

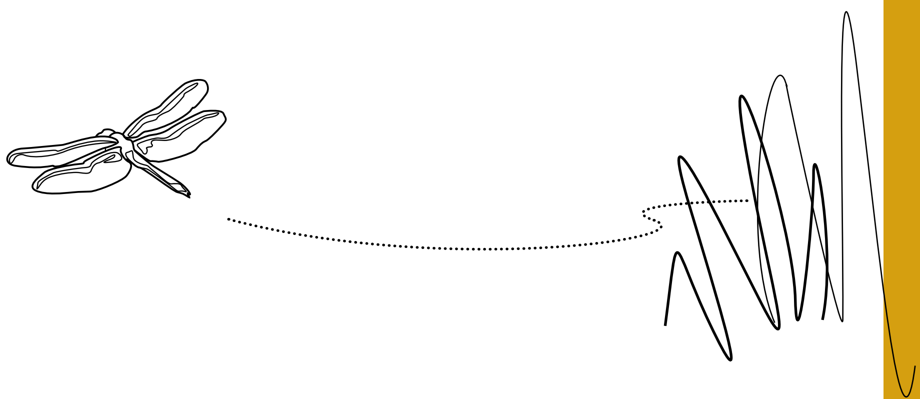


Table 3.1.1 International Association for Public Participation's Public Participation Spectrum categories and participation goals[1]

Engagement category	Engagement goal
Inform	Provide balanced and objective information to assist understanding, alternatives, opportunities and/or solutions
Consult	Obtain feedback on analysis, alternatives and/or decisions
Involve	Work directly throughout a process to ensure that concerns and aspirations are consistently understood and considered
Collaborate	Partner in each aspect of the decision including the development of alternatives and the identification of the preferred solution
Empower	Place final decision making in the hands of the stakeholder

1 *The VEWH has the permission of the International Association for Public Participation to reproduce the IAP2 Spectrum.*

Tables 3.1.2 and 3.1.3 show the partners, stakeholder organisations and individuals engaged with the environmental watering program in the central region. This includes engagement conducted as part of developing the seasonal watering proposals as well as engagement during the preparation of key foundational documents that directly informed the proposals. The tables also show the level of engagement, based on Melbourne Water and Corangamite CMA's interpretation of the IAP2 Spectrum.

The level of engagement differs between organisations and between systems, due to the complexity of management arrangements and individual organisation's responsibilities for each system. For example, in most systems storage managers are engaged as key program partners, but in the Yarra and Tarago systems Melbourne Water acts as both waterway manager and storage manager, and engages internally with its diversions and operations divisions to coordinate the use of water from headworks storages.

Table 3.1.2 Partners and stakeholders engaged by Melbourne Water in developing seasonal water proposals for the Yarra, Tarago, Maribyrnong and Werribee systems and other key foundation documents that have directly informed the proposals

	Yarra system	Tarago system	Maribyrnong system	Werribee system
Community groups and environment groups	• Environment Victoria • Yarra River Keeper	• Friends of Robin Hood Reserve • Waterwatch co-ordinators	• Friends of the Maribyrnong Valley • Jacksons Creek Econetwork • Landcare groups	• Werribee Riverkeeper
Government agencies	• Arthur Rylah Institute • Environment Protection Authority • Port Phillip and Westernport CMA • Yarra Valley Water	• Environment Protection Authority • Parks Victoria • Port Phillip and Westernport CMA		• Parks Victoria • Port Phillip and Westernport CMA
Landholders/ farmers	• Individual landholders		• Licenced diverters from the Maribyrnong River at Keilor	• Zoos Victoria
Local government	• Banyule City Council • Boroondara City Council • Manningham City Council • Nillumbik City Council • Yarra Ranges Shire Council	• Baw Baw Shire Council • Cardinia Shire Council		• Melton Shire Council • Wyndham City Council
Program partners	• Parks Victoria • Melbourne Water Service Delivery • Victorian Environmental Water Holder • Department of Environment, Land, Water and Planning	• Melbourne Water Service Delivery • Parks Victoria • Victorian Environmental Water Holder	• Department of Environment, Land, Water and Planning • Western Water • Southern Rural Water • Victorian Environmental Water Holder	• Southern Rural Water • Victorian Environmental Water Holder • Department of Environment, Land, Water and Planning
Recreational users	• Paddle Victoria • Native Fish Australia • Warburton Holiday Park • Whitehorse Canoe Club • VRFish	• Glen Cromie Caravan Park • Local Anglers • VRFish		• Werribee Anglers Club
Traditional Owners	• Wurundjeri Woi Wurrung Cultural Heritage Aboriginal Corporation	• Boon Wurrung Foundation • Bunurong Land Council Aboriginal Corporation	• Wurundjeri Woi Wurrung Cultural Heritage Aboriginal Corporation	
Universities	• Melbourne University – research collaborators • Monash University			

Key: Inform Consult Involve Collaborate Empower

Table 3.1.3 Partners and stakeholders engaged by Corangamite CMA in developing seasonal watering proposals for the Moorabool and Barwon systems and other key foundation documents that have directly informed the proposals

	Moorabool system	Upper Barwon River	Lower Barwon wetlands
Community groups and environment groups	• Australian Platypus Conservancy • Geelong Landcare Network • Local community groups • Moorabool Stakeholder Advisory Committee • People for a Living Moorabool	• Land and Water Resources - Otway Catchment • Upper Barwon Surface Water Advisory Group	• Environment Victoria • Geelong Environment Council • Geelong Field Naturalists Club • Lower Barwon Community Advisory Committee
Government agencies			• Victorian Fisheries Authority
Landholders/ farmers	• Individual landholders who are on the Moorabool Stakeholder Advisory Committee	• Individual landholders who are on the Upper Barwon Surface Water Advisory Group	• Individual landholders
Local businesses			• Commercial eel fishers
Local government		• Colac Otway Shire Council	• City of Greater Geelong
Program partners	• Barwon Water • Central Highlands Water • Department of Environment, Land, Water and Planning • Parks Victoria • Southern Rural Water • Victorian Environmental Water Holder	• Barwon Water • Department of Environment, Land, Water and Planning • Southern Rural Water • Victorian Environmental Water Holder	• Barwon Water • Department of Environment, Land, Water and Planning • Parks Victoria • Southern Rural Water • Victorian Environmental Water Holder
Recreational users	• Individual recreational users who are on the Moorabool Stakeholder Advisory Committee	• Individual recreational users who are on the Upper Barwon Surface Water Advisory Group	• Field and Game Australia • Geelong Gun and Rod Association • VRFish
Traditional Owners	• Wathaurung Aboriginal Corporation	• Eastern Maar Aboriginal Corporation • Wathaurung Aboriginal Corporation	• Wathaurung Aboriginal Corporation
Universities			• Federation University • RMIT University

Key: Inform Consult Involve Collaborate Empower

Community benefits from environmental watering

As subsection 1.1.1 explains, by improving the health of rivers, wetlands and floodplains, environmental flows also provide benefits to communities. Healthy rivers and wetlands support vibrant and healthy communities.

Environmental outcomes provide direct flow-on cultural, economic, social, recreational and Traditional Owner benefits for communities. In 2019–20, examples in the central region included:

- supporting the health and migration of native fish species which are prized by recreational fishers (such as Macquarie perch and estuary perch in the Yarra River and eels in the Moorabool and Barwon rivers)
- providing habitat for waterbirds in the lower Barwon wetlands, which are valued by bird watchers and duck hunters
- improving the amenity of parks, picnic sites and other recreational attractions, making visiting these sites more enjoyable.

Additional opportunities to enhance community benefits can also sometimes be provided by modifying environmental flows, provided environmental outcomes are not compromised. For example:

- Corangamite CMA will consult with stakeholders about the timing of water deliveries to the lower Barwon wetlands to take account of duck hunting seasons declared and regulated by the Victorian Game Management Authority[4]
- Melbourne Water may time a summer fresh in the Tarago River to occur on the Australia Day long weekend in January 2020 so residents of the Glen Crombie Caravan Park alongside the river can enjoy the Australia Day weekend with additional flows in the river.

The ability of the VEWH and its partners to deliver these benefits will depend on the weather, climate considerations, the available water and the way the system is being operated to deliver water for other purposes.

Integrated catchment management

Altered water regimes are one of many threats to the health of Victoria's waterways. To be effective, planning and releases of water for the environment need to be part of an integrated approach to catchment management. Many of the environmental objectives in this seasonal watering plan will not be fully met without also addressing issues such as excessive catchment erosion, barriers to fish movement, high nutrient loads, loss of stream bank vegetation and invasive species, to name just some issues.

Victorian and Australian government agencies, community groups and private landowners collectively implement programs and activities to protect and improve the environmental condition and function of land, soils and waterways throughout Victoria's catchments. *Water for Victoria* identifies 36 priority waterways across Victoria. In the central region, the Moorabool River is an initial priority for investment in works to complement outcomes achievable with environmental flows in the river.

Some examples of complementary programs that are likely to support environmental watering outcomes in the central region are:

- Corangamite CMA's ongoing investigations into the surface water and groundwater interactions in the Moorabool River and their continued partnership with the Batesford Quarry operators to allow water from the quarry to be discharged to the river: this water is an important contribution to flow
- projects by Corangamite CMA to upgrade the lower Barwon River barrage and modernise the outlet structures at Hospital Swamps and Reedy Lake
- Melbourne Water's performance review and rectification works for the Dights Falls fishway on the Yarra River, which will increase the range of flows that allow fish to move upstream
- Melbourne Water's Rural Land Program, which offers assistance and funding to landholders to undertake works that limit soil and nutrient run-off from agricultural land
- continued works by Corangamite CMA and Melbourne Water to protect and enhance stream banks along priority reaches in the catchments including willow removal, revegetation and fencing to exclude stock.

For more information about integrated catchment management programs in the central region refer to Melbourne Water's *Healthy Waterways Strategy* and to the Port Phillip and Westernport CMA and Corangamite CMAs' regional catchment strategies and waterway strategies.

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4 *Rules in the Barwon River Environmental Entitlement 2011 only allow diversions to Reedy Lake and Hospital Swamps when water levels in the Barwon River are more than 0.7m AHD at the Lower Barwon Gauging Station, which may prevent timing of inflows to assist duck season.*

Seasonal outlook 2019–20

Catchments to the west of Melbourne generally experience drier climatic conditions than those to the east, and water for the environment allocations can vary between systems. The Yarra River environmental entitlement has a guaranteed allocation of 17 GL every year, unless a formal qualification of rights has been declared. Annual allocations to environmental water entitlements in the Werribee, Tarago and Moorabool systems are linked to catchment inflows, so dry conditions will result in less water being available. Carryover of unused allocations from wet years helps meet environmental demands in these systems in dry years. The Maribyrnong system does not have an environmental entitlement, and the VEWH may purchase allocations from willing sellers in that system to meet environmental demands. Water can also be traded in other systems, and water purchased in Lal Lal Reservoir in 2018–19 will help to meet environmental objectives in the Moorabool River throughout 2019–20.

Water delivery infrastructure limits the volume of water for the environment that can be delivered to priority waterways throughout the central region, and therefore releases are usually planned to supplement unregulated flows and to make up shortfalls associated with low flows and small-to-medium-sized freshes. Catchment conditions and seasonal hydrological patterns, rather than water availability, influence which flow components are prioritised in most years.

Winter and spring are usually the wettest seasons in the central region and contribute most of the annual inflow to system storages. All catchments throughout the central region had below-average rainfall in 2018–19, and the Bureau of Meteorology predicts that winter 2019 will see average or below-average rainfall and higher-than-average temperatures. These predictions mean that catchment inflows and streamflow downstream of catchment storages will likely remain low during 2019–20.

If 2019–20 is very dry, deliveries of water for the environment throughout the region will aim to maintain critical refuges for water-dependent plants and animals. If conditions are closer to average or wet, environmental releases will aim to improve the health of the environment by increasing the quality and quantity of aquatic habitat for animals and trigger native fish to migrate and possibly spawn.

Risk management

During the development of the seasonal watering proposals for the Yarra, Tarago, Maribyrnong, Werribee, Moorabool and Barwon systems, environmental watering program partners held a workshop to assess risks associated with potential environmental watering actions for 2019–20 and to identify appropriate mitigating strategies. Risks and mitigating actions are continually assessed by program partners throughout the year (see subsection 1.3.6).

3.2 Yarra system

Waterway manager – Melbourne Water

Storage manager – Melbourne Water

Environmental water holder – Victorian Environmental Water Holder

Did you know ...?

In an Australian first, the *Yarra River Protection (Willip-gin Birrarung Murron) Act 2017* enables the identification of the Yarra River and the many hundreds of parcels of public land it flows through as one living, integrated natural entity for protection and improvement.

The Act is the first in Victoria to use the language of Traditional Owners in its title, and one of the first in Australia to include Traditional Owner language in the Act's body. Woi-wurrung language is used in recognition of Traditional Owners' custodianship of the river and connection to the lands through which the river flows.

Top: Yarra River, by Cheryl Edwards, Melbourne Water
Centre: Kookaburra by the Yarra, by Melbourne Water
Above: Yarra wetland vegetation, by Melbourne Water

System overview

The Yarra River flows west from the Yarra Ranges upstream of Warburton, through the Yarra Valley and then opens out into a wider plain as it meanders through the suburbs and city of Melbourne before entering Port Phillip Bay. Over time, the lower Yarra River (downstream of Yering Gorge) has been straightened, widened and cleared of natural debris as Melbourne has developed. The earliest recorded alterations to its course date back to 1879.

Up to 400,000 ML per year (long-term average diversion limit) can be harvested from the Yarra River system for consumptive use in Melbourne and surrounding areas. The Upper Yarra, O'Shannassy and Maroondah reservoirs harvest water from headwater tributaries, and a pump station at Yering is used to divert water from the Yarra River to Sugarloaf Reservoir.

Flow in the upper reaches of the Yarra River is influenced by tributaries (such as Armstrong Creek, MacMahons Creek, Starvation Creek, Woori Yallock Creek, Watts River and Little Yarra River). Urbanised tributaries (such as Olinda Creek, Mullum Mullum Creek, Diamond Creek, Plenty River and Merri Creek) provide additional water to the middle and lower reaches of the Yarra River.

Environmental flows can be released from the Upper Yarra, Maroondah and O'Shannassy reservoirs to support ecological processes and environmental outcomes in downstream river reaches and wetlands. The priority environmental flow reaches in the Yarra River are reaches 2 and 5, shown in Figure 3.2.1. Water for the environment that is delivered to reaches 2 and 5 will help meet flow targets in downstream reaches.

Environmental values

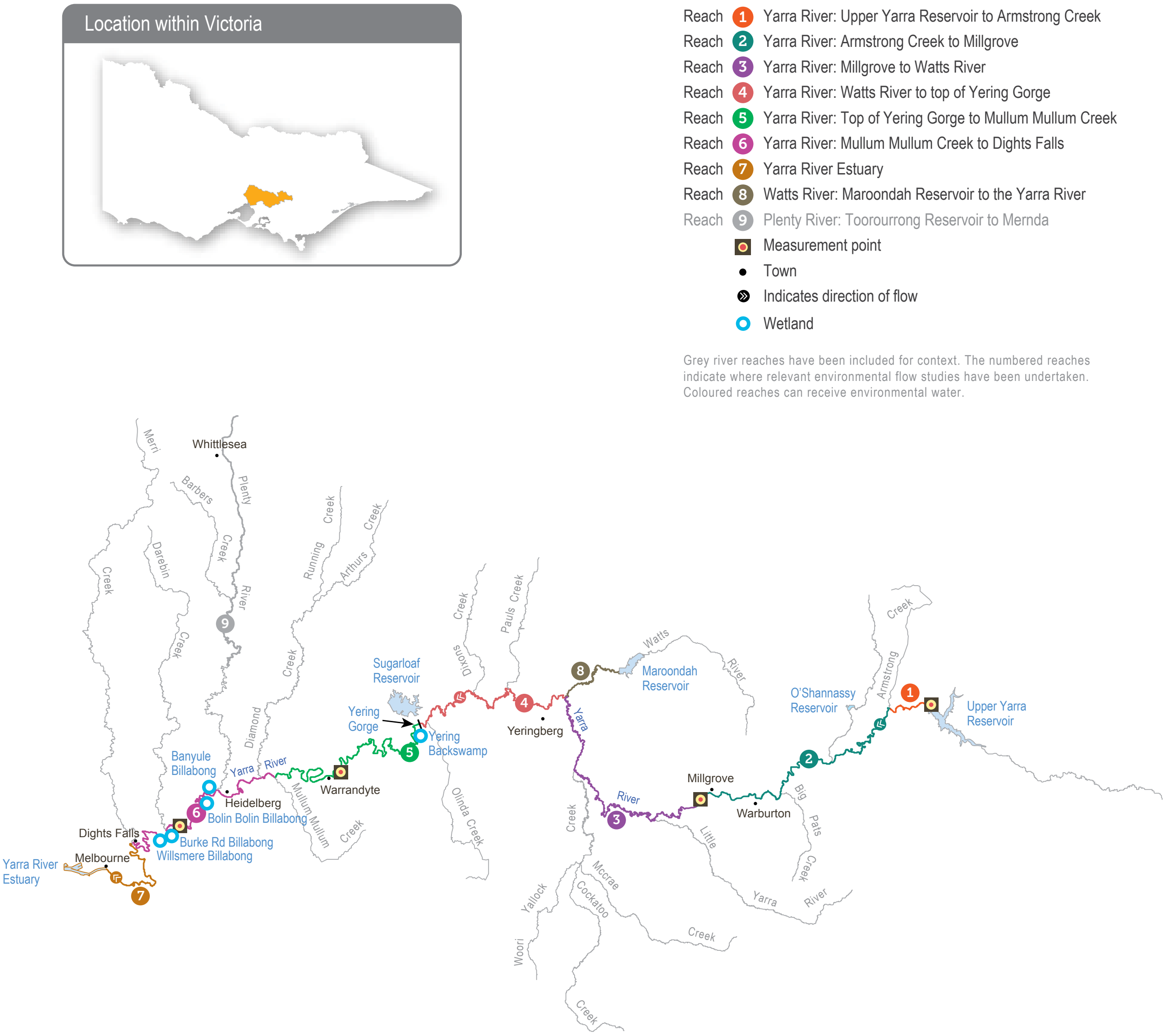
The upper Yarra River (reaches 1–3) provides habitat for a range of native fish species including river blackfish, mountain galaxias and common galaxias, and has good-quality riparian and aquatic vegetation. The middle and lower Yarra River (reaches 4–6) flows through forested gorges, cleared floodplains and some highly-urbanised areas, and supports several populations of native fish including Australian grayling, river blackfish, Macquarie perch and tupong. Macquarie perch was introduced to the Yarra River last century, and the population is now considered one of the largest and most important in Victoria.

Billabongs are an important feature of the Yarra River floodplain between Millgrove and Yering Gorge and in the lower reaches around Banyule Flats near Heidelberg. The billabongs support distinct vegetation communities and provide foraging and breeding habitat for waterbirds and frogs. Except in very high flows, most billabongs are disconnected from the Yarra River.

Environmental objectives in the Yarra System

Protect and increase populations of native fish including threatened species (such as the Australian grayling, Macquarie perch and river blackfish)
Maintain the form of the river channel Scour silt build-up in riffles and clean cobbles
Maintain the population of resident platypus
Increase, strengthen and maintain native riparian and aquatic vegetation on the riverbank and in the channel, as well as on the upper Yarra floodplain and in the billabongs along the river
Protect and increase communities of waterbugs, which break down dead organic matter and support the river's food chain
Improve water quality in river pools, ensuring adequate dissolved oxygen concentration in the water to support fish, crustaceans and waterbugs
Aboriginal environmental outcomes
Traditional Owners have specifically identified Aboriginal environmental outcomes associated with these watering actions

Figure 3.2.1 The Yarra system



Recent conditions

Inflows to the main Yarra River storages were slightly below average in winter 2018 and representative of a dry year from spring 2018 through to autumn 2019.

Environmental flows were used to achieve two winter/spring freshes, with the aim of scouring sediments to improve riffle habitat within the river to create opportunities for fish to lay eggs. The freshes also favour flood-tolerant native vegetation on the banks of the river.

Two summer freshes were also delivered, to maintain habitat and enable localised fish movements, as well as to improve water quality in deep pools.

A planned autumn high flow was not delivered, as recent modelling indicated that the Dights Falls fishway was less effective when flow exceeded 1,000 ML per day. Water for the environment was instead used to deliver the second winter/spring fresh (at flows which facilitate movement through the fishway) and to target vegetation objectives. Works will be undertaken in 2019–20 to improve the function of the Dights Falls fishway.

Water for the environment was used to fill Yering Backswamp and the Willsmere and Burke Road billabongs in spring, to maintain water-dependent vegetation and aquatic animals. This is the first time Willsmere and Burke Road billabongs have received water for the environment. Monitoring of water levels, water quality and frogs by the Wurundjeri Land and Compensation Cultural Heritage Council will inform future management of these billabongs.

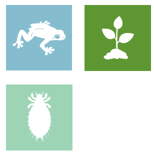
Scope of environmental watering

Table 3.2.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 3.2.1 Potential environmental watering actions and objectives for the Yarra system

Potential environmental watering action	Functional watering objective	Environmental objective
Summer/autumn low flows (varying rates from 80 – >350 ML/day during December to May)	• Minimise the risk of stratification and low dissolved oxygen in pools through mixing • Maintain habitat for fish, macroinvertebrates and platypus	
Winter/spring low flows (varying rates from 200 – >350 ML/day during June to November)	• Minimise the risk of stratification and low dissolved oxygen in pools through mixing • Maintain access to habitats for fish, macroinvertebrates and platypus • Wet bank vegetation to promote growth	
Summer/autumn fresh (up to three freshes of 80–750 ML/day for two to four days during December to May)	• Flush pools in the low flow season to prevent a decline in water quality • Scour sediment and biofilm from gravel in riffles and pools to maintain habitat quality for fish and macroinvertebrates • Provide opportunities for localised movement of fish, macroinvertebrates and platypus • Wet the banks of the river to maintain flood-tolerant vegetation on the banks	
Autumn high flow (one fresh of 560–1,300 ML/day for seven to 14 days during April to May)	• Cue the migration of Australian grayling • Scour sediment and biofilm from gravel in riffles and pools to maintain habitat quality for fish and macroinvertebrates	
Winter/spring freshes (two freshes of 700–2,500 ML/day for three to seven days during June to September)	• Scour sediment and biofilm from gravel in riffles to improve spawning opportunities for Macquarie perch • Inundate native riparian vegetation on the banks of the river to promote growth	

Table 3.2.1 Potential environmental watering actions and objectives for the Yarra system *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Winter/spring high flow (one high flow of 700–2,500 ML/day for 14 days during June to November)	• Scour sediment and biofilm from gravel in riffles • Provide prolonged inundation to favour flood-tolerant native vegetation in the riparian zone • Provide cues for upstream migration of juvenile migratory fish (e.g. Australian grayling and tupong) • Promote spawning of Macquarie perch	
Bankfull (flows in 2,700–5,000 ML/day for two days any time)	• Mobilise sediment to minimise the development of bars and islands in the river channel • Prevent the encroachment of terrestrial vegetation into the channel • Engage floodplain billabongs • Entrain organic material into the waterway	
Billabong watering		
Yering Backswamp (partial or complete fill in autumn and winter/spring)	• Water to support the growth of threatened wetland plant species and encourage the regeneration of spreading aquatic herbs • Provide habitat for frogs and macroinvertebrates	
Banyule Billabong (partial or complete fill in winter/spring)	• Water to support the growth of threatened wetland plant species to rehabilitate shallow marsh, deep marsh and freshwater meadows • Provide habitat for frogs, macroinvertebrates and eels	

Scenario planning

Table 3.2.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Environmental flow planning in the Yarra River primarily focuses on providing sufficient low flow throughout the year to maintain habitat for aquatic life and on providing high flows at critical times to support the migration and breeding requirements of native fish. The extent to which the required flows are met by natural tributary inflows varies between dry, average and wet climate scenarios. Water for the environment is used to fill the main shortfalls under each climate scenario, where possible.

The highest priorities for watering are summer/autumn low flows and freshes, an autumn high flow, filling Yering Backswamp and Banyule Billabong, and winter/spring low flows where they are not likely to be met naturally. The summer/autumn low flows and freshes help to maintain water quality and improve aquatic habitats, while winter/spring low flows are important to maintain habitat and longitudinal connectivity for fish and platypus. The autumn high flow aims to cue the migration and spawning of Australian grayling. It is a high priority under all climate scenarios, because this event was not delivered in 2017–18 or 2018–19. Australian grayling only survive for about three years and individuals need conditions for successful breeding in at least two out of every three years to maintain the population.

The environmental entitlement for the Yarra system is highly secure and it is expected that the volume of water available for use in 2019–20 will be sufficient to deliver all of the high-priority watering actions under average and wet climate scenarios. But, under a dry climate scenario with lower contributions from tributary systems, a larger proportion of the available environmental allocation will be used to deliver summer/autumn low flows. There may not be sufficient water to deliver the recommended winter/spring low flows. If these flows are not delivered, the risk of poor water quality increases, and habitats for fish, macroinvertebrates and platypus may be temporarily disconnected.

Watering at Yering Backswamp and Banyule Billabong is considered a high priority under all climate scenarios in 2019–20. There are numerous billabongs throughout the Yarra catchment which no longer fill naturally with the same frequency, due to changes in the catchment. Having at least two billabongs inundated across the landscape provides refuge habitat for rare and threatened species.

Watering actions in 2020–21 are likely to be similar to those recommended for 2019–20. The total demand for high-priority watering actions under average climate conditions in 2020–21 is estimated to be about 18,000 ML. A carryover volume of 12,000 ML has been identified to ensure there is sufficient water to deliver the required autumn fresh in another two to three years, as required.

Table 3.2.2 Potential environmental watering for the Yarra system under a range of planning scenarios

Planning scenario	Dry	Average	Wet
Expected river conditions	• Low streamflows year-round • Lack of unregulated freshes and high flows • Passing flows are not likely to meet the minimum environmental flow recommendations • Potential poor water quality, particularly in summer • Pools may stratify	• Minimum passing-flow recommendations are likely to be met • Unregulated flows may provide some freshes, but their duration and/or magnitude will likely be less than recommended environmental flows • Potential poor water quality, particularly in summer • Pools may stratify • Small reservoirs may spill • Overbank flows are not likely	• Passing flow recommendations are likely to be met • High, unregulated flows will occur, most likely in winter and spring • Major spills from reservoirs may occur • Some natural inundation of billabongs may occur
Expected availability of environmental water	• 29,000 ML total		
Potential environmental watering – tier 1a (high priorities)	• Summer/autumn low flows • Summer/autumn freshes • Autumn high flow • Fill Yering Backswamp and Banyule Billabong	• Summer/autumn low flows • Summer/autumn freshes • Autumn high flow • Fill Yering Backswamp and Banyule Billabong • Winter/spring low flows	• Summer/autumn freshes • Autumn high flow • Fill Yering Backswamp and Banyule Billabong
Potential environmental watering – tier 1b (high priorities with shortfall)	• Winter/spring low flows	• N/A	• N/A
Potential environmental watering – tier 2 (additional priorities)	• Winter/spring freshes • Winter/spring high flows • Bankfull	• Winter/spring freshes • Winter/spring high flows • Bankfull	• Winter/spring freshes • Winter/spring high flows • Bankfull
Possible volume of water for the environment required to achieve objectives[1]	• 17,000 ML (tier 1a) • 3,000 ML (tier 1b) • 20,000 ML (tier 2)	• 18,000 ML (tier 1a) • 20,000 ML (tier 2)	• 13,000 ML (tier 1a) • 10,000 ML (tier 2)
Priority carryover requirements	• Minimum of 1,000 ML		

[1] *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

3.3 Tarago system

Waterway manager – Melbourne Water

Storage manager – Melbourne Water

Environmental water holder – Victorian Environmental Water Holder

Did you know ...?

Monitoring in the Tarago system has shown good adult and juvenile populations of one of Australia's most iconic mammals – the platypus. Environmental flows can help provide the habitat and food platypus need at different stages of their breeding cycles.

Top: Tarago flow gauging station, by Melbourne Water
Centre: Australian grayling, Bunyip River, by Tarmo Raadik, ARI
Above: Mayfly emerging, by Priya Crawford-Wilson, Melbourne Water

System overview

The Tarago River rises in the Tarago State Forest and flows into the Tarago Reservoir at Neerim. The reservoir harvests inflows from all upstream tributaries to supply towns on the Mornington Peninsula and Westernport region and is used to manage flows for downstream irrigators. Downstream of the reservoir, the river flows close to the town of Rokeby before meeting the Bunyip River at Longwarry North. From there, the Bunyip River flows through a modified, straightened channel — Bunyip Main Drain — that discharges into Westernport Bay. The Bunyip Main Drain supplies many irrigators in the catchment.

Water available under the Tarago environmental entitlement is stored in and released from Tarago Reservoir. This water is primarily used to meet environmental objectives in reach 2, which is between the reservoir and the confluence of the Tarago and Bunyip rivers, as Figure 3.3.1 shows. Water for the environment that is delivered to reach 2 also supports environmental flow recommendations in reach 6 (Bunyip Main Drain).

Year-round passing flows in the Bunyip and Tarago rivers are stipulated under both the environmental entitlement and Melbourne Water's bulk entitlement. Downstream of Tarago Reservoir at Drouin West, this equates to the lesser of 12 ML per day or natural flows. The magnitude of these passing flows is generally sufficient to meet the minimum low-flow requirements in summer/autumn, but it is much less than the recommended minimum flows in winter/spring; and it does not provide any of the freshes or higher flows that are needed throughout the year to support environmental outcomes.

Water releases to meet irrigation demands create variable flow patterns in the Tarago and Bunyip rivers throughout the year. The magnitude and timing of these releases can influence environmental outcomes, and Melbourne Water continues to work with Southern Rural Water to optimise the shared value derived from irrigation releases.

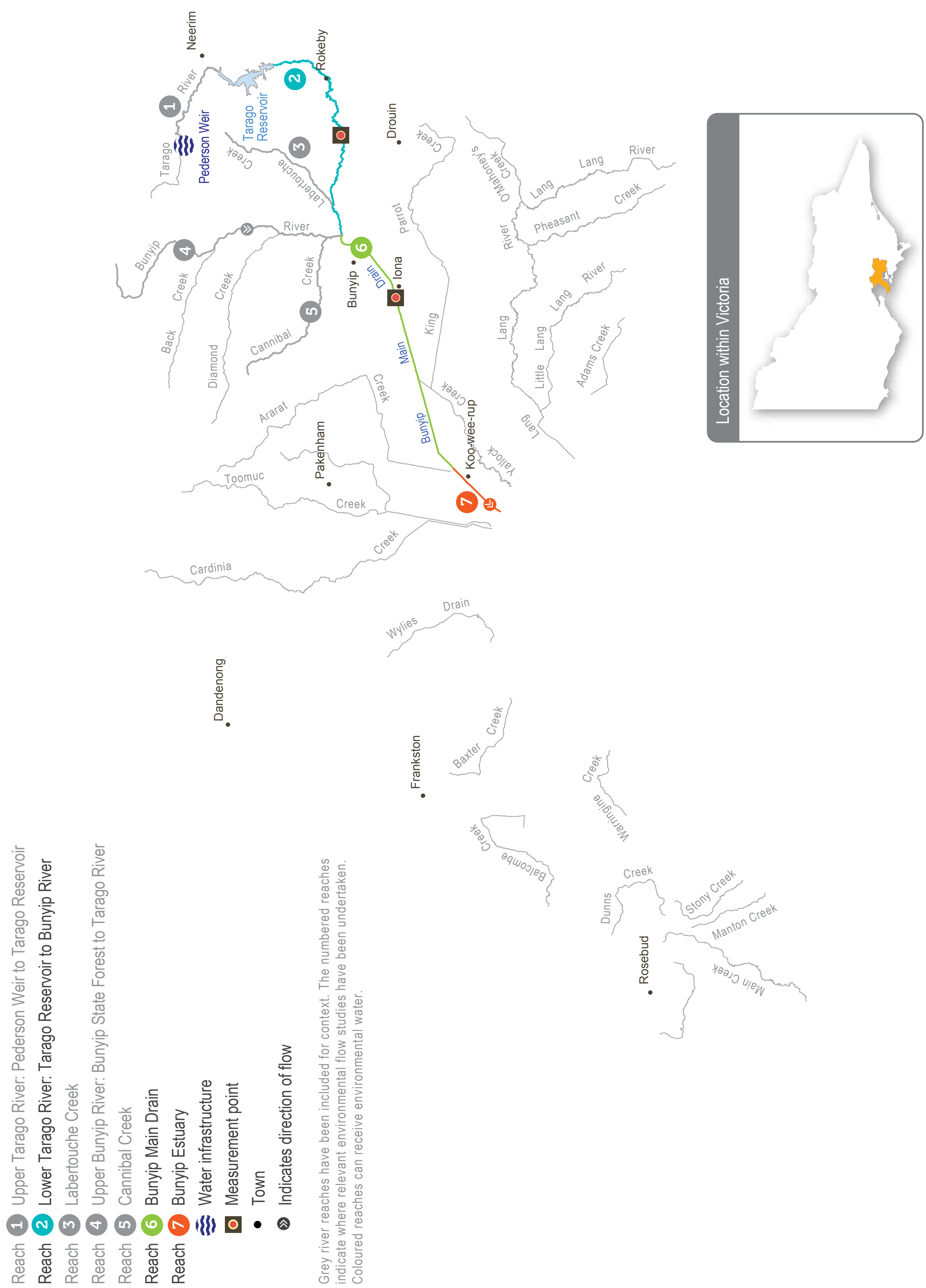
Environmental values

The Tarago system contains several significant and threatened native plant and animal species including the Australian grayling, long pink-bells, tree geebung and swamp bush-pea. The upper catchment (reach 2) has healthy riparian vegetation and diverse in-stream habitat that support platypus and native fish including river blackfish and mountain galaxias. The lower catchment (reach 6) has been highly modified, but it still contains patches of remnant vegetation and healthy populations of Australian grayling and platypus.

Environmental objectives in the Tarago system

Increase populations of native fish including threatened species (such as the Australian grayling)
Maintain channel form and structure
Increase platypus populations
Increase and maintain native riparian and aquatic plant communities on the riverbank and in the channel
Increase the diversity and biomass of waterbugs, to support aquatic foodwebs

Figure 3.3.1 The Tarago system



Recent conditions

The Tarago catchment experienced below-average rainfall in 2018–19, resulting in low inflows to the Tarago Reservoir. Despite the dry conditions, local rainfall delivered three winter/spring freshes at the start of the water year. Water for the environment was used to deliver an autumn fresh and an autumn high flow, to trigger Australian grayling spawning.

Melbourne Water has funded the Arthur Rylah Institute to investigate Australian grayling flow requirements in the Bunyip-Tarago system since 2008. That work has clearly demonstrated that Australian grayling migrate and spawn in response to environmental flows that are delivered at specific times of the year. The research program is progressing to a long-term tagging study from 2019.

Scope of environmental watering

Table 3.3.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 3.3.1 Potential watering actions and objectives for the Tarago system

Potential environmental watering action	Functional watering objective	Environmental objective
Summer/autumn freshes (up to five freshes of 75 ML/day for two days each during December to May)	• Scour sediment from holes and around large woody debris to maintain habitat for native fish in low-flow periods • Allow the localised movement of resident fish • Prevent terrestrial vegetation growth on sandbars • Maintain water quality by aeration through times of low flow	
Autumn high flow (one fresh with a peak of 100 ML/day maintained for two days in a minimum seven-day fresh duration during April to May)	• Cue spawning for diadromous fish (such as Australian grayling) • Allow the downstream movement of Australian grayling • Assist the dispersal of juvenile platypus	
Spring high flow (one to two freshes during September to October with two to three days in a minimum seven-to-10 day fresh at a peak of 200–300 ML/day)	• Form and maintain scour holes around large wood • Prevent the encroachment of terrestrial vegetation into the channel • Cue the upstream migration of juvenile diadromous fish (such as Australian grayling) from the sea or estuary into the river • Wet higher benches to maintain the fringing aquatic vegetation and ensure vertical zonation of the fringing vegetation • Provide a cue for platypus to select nesting burrows above high water level	
Winter/spring freshes (two freshes of 100–200 ML/day at peak for one to two days during June to September)	• Prevent sediment build-up and remove biofilm from large woody debris to maintain habitat for macroinvertebrates and fish including river blackfish • Maintain access to habitats by ensuring sufficient depth through riffles to allow fish movement between pools and reaches • Cue the downstream migration of species such as eel and tupong • Inundate the banks, wetting the lower benches to maintain the fringing aquatic vegetation	
Winter/spring low flows (75 ML/day [or natural] during June to November)	• Prevent the encroachment of terrestrial vegetation in the channel • Wet the banks to promote riparian vegetation growth • Maintain an adequate depth through riffles to allow access to habitats for fish and platypus • Maintain water quality through increased low flows to flush the system and inundate additional habitat for fish and macroinvertebrates • Maintain foraging habitat for platypus	

Scenario planning

Table 3.3.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The Bureau of Meteorology forecasts issued in autumn 2019 predict that the Tarago system will have below-average rainfall and above-average temperatures in 2019–20. If these forecasts eventuate, then available environmental Water Holdings will be managed under a dry scenario, with summer/autumn freshes, an autumn high flow, spring high flow and a winter/spring fresh being the highest-priority watering actions. In this case, water availability would likely only be sufficient to meet the summer/autumn freshes and a partial autumn high flow.

Summer/autumn freshes are critical in dry years as they top up pool habitats and improve water quality, which helps to maintain the quality and quantity of available habitat for fish, macroinvertebrates and platypus. Freshes temporarily increase river depth in riffles and run habitats between pools, which allows native fish to move within and between reaches. Freshes also inundate sand bars and lower sections of the riverbank, which helps to prevent the colonisation and growth of unwanted terrestrial species.

Autumn high flows are needed to cue Australian grayling to spawn. Under a dry scenario, the autumn high flow should be delivered in two out of three years; in wetter periods, it should be delivered annually. Australian grayling have a short lifespan, so continued spawning is important to maintain and enhance population numbers. The autumn high flow was fully achieved in 2017–18 and partially achieved in 2018–19. Hence, full delivery of an autumn high flow is a secondary priority for 2019–20, although a partial autumn high flow using a lesser volume of water may be delivered under dry and average conditions.

Without additional water secured, under a dry climate scenario the high-priority (tier 1b) spring high flow and winter/spring fresh will not be delivered. The recommended spring high flow, which aims to encourage juvenile fish to migrate upstream from the estuary, has not been fully achieved since 2012–13. It is however a lower priority than the tier 1a flow components, because recent monitoring has shown that the Australian grayling and other diadromous fish may migrate on lower flows.

The winter/spring freshes cue downstream migration of species such as eel and tupong. Unless these flow components are achieved naturally, the appropriate triggers for these fish to migrate will not occur.

Under wetter conditions, it is expected that water for the environment may be used to increase the magnitude or extend the duration of some unregulated events throughout winter and spring to improve habitat for waterbugs and allow fish movement along the river.

Table 3.3.2 Potential environmental watering for the Tarago system under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Very low streamflow • Very low inflows • Reduced passing flows • Irrigation releases likely	• Low streamflow • Some reduction to passing flows • Irrigation releases likely	• Average streamflows • Partial freshes naturally provided	• Above-average streamflows • Partial or full freshes naturally provided • Irrigation releases unlikely
Expected availability of environmental water	• 1,700 ML	• 2,000–2,500 ML	• 2,500–3,500 ML	• 3,800–5,000 ML
Potential environmental watering – tier 1a (high priorities)	• Summer/autumn freshes	• Summer/autumn freshes • Autumn high flow (partial event)	• Summer/autumn freshes • Autumn high flow (partial event) • Winter/spring high flow (partial event)	• Summer/autumn freshes • Autumn high flow • Spring high flow • Winter/spring freshes
Potential environmental watering – tier 1b (high priorities with shortfall)	• Winter/spring high flow (partial event) • Autumn high flow (partial event)	• Winter/spring high flow (partial event) • Winter/spring fresh	• Spring high flow • Winter/spring freshes	• N/A
Potential environmental watering – tier 2 (additional priorities)	• Winter/spring freshes • Autumn high flows • Spring high flows	• Autumn high flows • Spring high flows	• Autumn high flows	• N/A
Possible volume of water for the environment required to achieve objectives[1]	• 1,000 ML (tier 1a) • 1,000 ML (tier 1b) • 800 ML (tier 2)	• 1,000–1,500 ML (tier 1a) • 1,000 ML (tier 1b) • 400 ML (tier 2)	• 1,500–2,700 ML (tier 1a) • 1,500 ML (tier 1b) • 3,000 ML (tier 2)	• 3,500 ML (tier 1a) • 2,700 ML (tier 2)
Priority carryover requirements	• Up to 1,000 ML			

[1] *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

3.4 Maribyrnong system

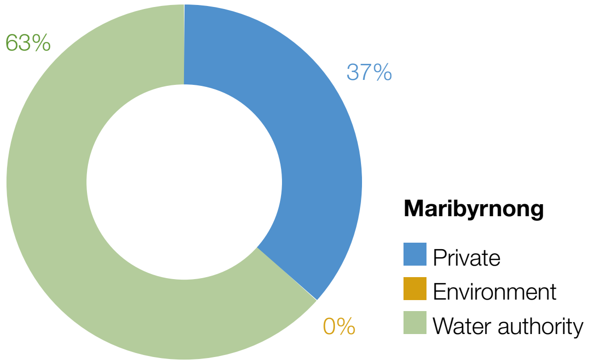
Waterway manager – Melbourne Water

Storage manager – Southern Rural Water

Environmental water holder – N/A

Did you know ...?

The VEWH does not hold an entitlement to water for the environment in the Maribyrnong system. Environmental flows since 2014 have been enabled through opportunistic purchases of unused water held under diversion licences used for farming. The arrangement is negotiated each year with interested parties.



Proportion of water entitlements in the Maribyrnong basin held by private users, water corporations or environmental water holders at 30 June 2018.

Top: View from Maribyrnong River to Melbourne, by Melbourne Water
Centre: Maribyrnong vegetation, by Melbourne Water
Above: Boating on the Maribyrnong River, by Melbourne Water

System overview

The Maribyrnong catchment is located to the north-west of Melbourne. The main waterways in the catchment are Jacksons Creek, which flows south-east from Mount Macedon, and Deep Creek, which flows south from Lancefield. These two tributaries join at Keilor North to form the Maribyrnong River, which flows south to join the Yarra River at Yarraville, before flowing into Port Phillip Bay.

Rosslynne Reservoir is the only major storage in the Maribyrnong catchment, and it is located in the upper reaches of Jacksons Creek near Gisborne. The release capacity of 20 ML per day from the reservoir is a significant constraint on the outcomes that can be achieved by environmental flow deliveries in the Maribyrnong system. Water for the environment is primarily used to support outcomes in Jacksons Creek between Rosslynne Reservoir and the confluence with Deep Creek (that is, environmental flow reaches 6 and 7 shown in Figure 3.4.1). These two reaches are described as upper and lower Jacksons Creek respectively.

The VEWH does not hold an environmental entitlement in the Maribyrnong system, and it relies on opportunistic, temporary trade to meet demands. Each year for the last six years, Melbourne Water and the VEWH have worked with local diversion licence holders to purchase unused water that can be delivered to support environmental outcomes. This arrangement is negotiated each year and will only occur with the agreement of all parties involved.

Environmental values

The upper Maribyrnong catchment contains areas of intact streamside vegetation, which provide important habitat for native fish including migratory short-finned eels, common and ornate galaxias, flathead gudgeon, tupong and Australian smelt. A large population of waterbugs provides abundant food for a significant platypus population in several reaches in the Maribyrnong system.

Environmental objectives in the Maribyrnong system

Protect and increase populations of native small-bodied fish
Maintain channel morphology
Maintain the platypus population
Maintain and improve the condition, abundance, diversity and structure of in-stream and riparian vegetation Prevent terrestrial vegetation encroachment into the channel
Support a wide range and high biomass of waterbugs, to break down dead organic matter and support the river's food chain
Maintain water quality, particularly dissolved oxygen concentrations

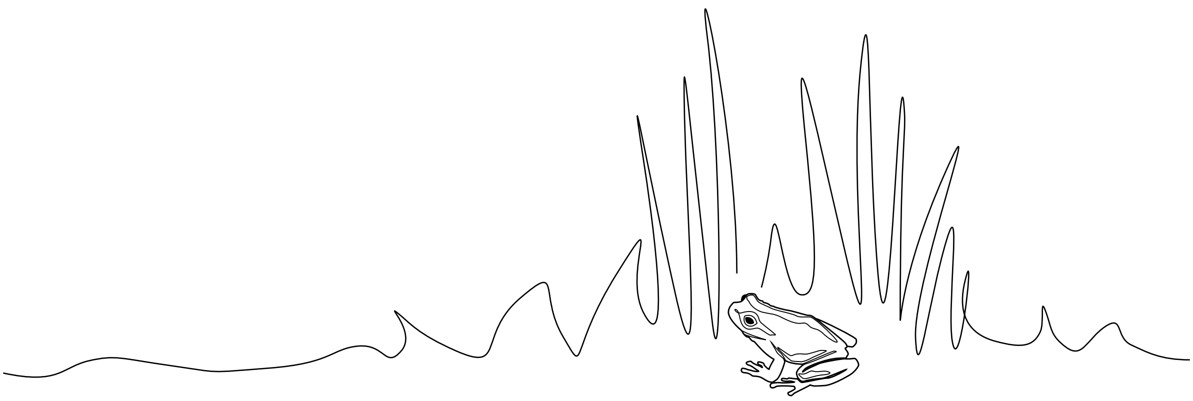
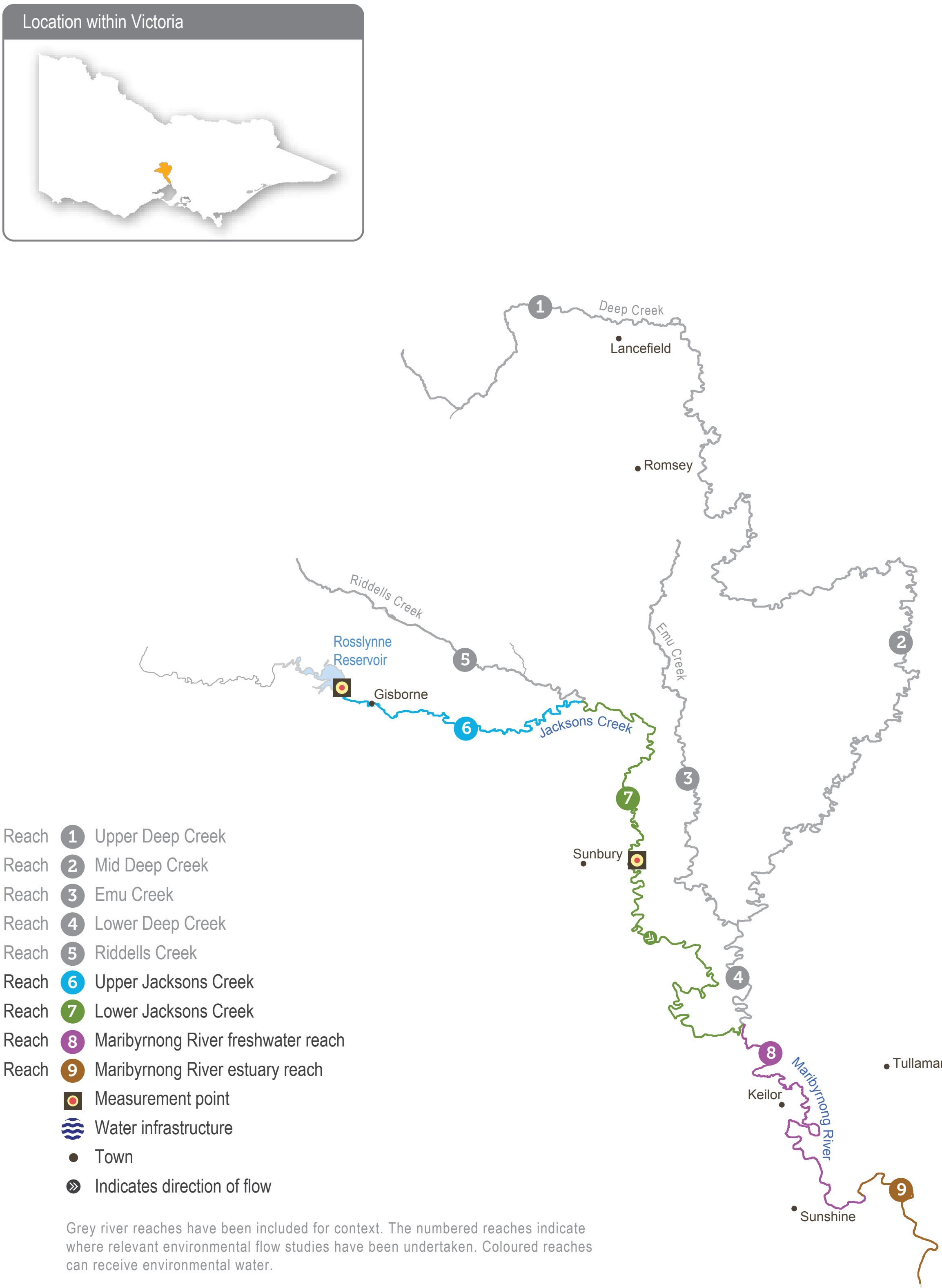


Figure 3.4.1 The Maribyrnong system



Grey river reaches have been included for context. The numbered reaches indicate where relevant environmental flow studies have been undertaken. Coloured reaches can receive environmental water.

Recent conditions

The Maribyrnong catchment experienced lower-than-average rainfall between summer 2016–17 and summer 2018–19, and inflows to Rosslynne Reservoir during that period were well-below average. The storage level in April 2019 was 17 percent (4,400 ML), which is the lowest volume since mid-2016. The dry conditions meant that winter/spring low-flow requirements in reaches 6 and 7 were either not met or only partially met by natural catchment run-off over the last two years.

In 2018–19, water for the environment was used to deliver autumn freshes to reaches 6 and 7, to prevent adverse water quality conditions and to flush fine sediments from hard surfaces. These functions are critical during very low flow periods to maintain suitable habitat and food resources for small-bodied native fish, waterbugs and platypus. The autumn freshes also provided opportunities for fish to disperse throughout each reach and helped support in-stream and riparian vegetation.

Scope of environmental watering

Table 3.4.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 3.4.1 Potential environmental watering actions and objectives for the Maribyrnong system

Potential environmental watering action	Functional watering objective	Environmental objective
Summer/autumn freshes (up to five freshes of 20–40 ML/day for up to seven days) during December to May	• Flush pools to maintain water quality • Scour substrates to remove fine sediment • Inundate the in-stream vegetation and riparian benches to support the growth of native riparian plants and to limit encroachment by terrestrial plant species • Provide passage for small-bodied native fish and platypus between habitats	
Winter/spring high flows (20–40 ML/day) during June to November	• Inundate the in-stream vegetation and riparian benches to support the growth of native riparian plants and to limit encroachment by terrestrial plant species • Scour substrates to remove fine sediment • Provide passage for small-bodied native fish and platypus between habitats	
Summer/autumn low flows (4–6 ML/day) during December to May	• Maintain waterbug habitat by providing suitable depth over riffles, maintaining pools and inundating large woody debris • Inundate the in-stream vegetation • Provide passage for small-bodied native fish and platypus between habitats	

Scenario planning

Table 3.4.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Under drought or dry conditions, any available water for the environment would be used to maintain suitable habitat for plants and animals in Jacksons Creek (reaches 6 and 7). Summer/autumn low flows and freshes aim to maintain the health of native fish, waterbugs and platypus populations, by providing access to food and habitat resources in drier conditions.

Under average and wet conditions, unregulated flows are expected to meet some of the environmental flow objectives. Water for the environment may be used to improve and enhance environmental outcomes for aquatic plants and animals, by filling gaps not met by unregulated flows (for example, by providing additional freshes) or by extending the duration of unregulated events.

Table 3.4.2 Potential environmental watering for the Maribyrnong system under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Unregulated flows unlikely • Passing flows ceased • Some baseflow from groundwater contributions in lower Jacksons Creek	• Low volumes of unregulated flows • Passing flows may meet some low-flow objectives • Some baseflow from groundwater contributions in lower Jacksons Creek	• Unregulated flows meet some objectives • Passing flows may meet several low-flow objectives	• Unregulated flows meet most objectives • Passing flows may meet most low-flow objectives
Potential environmental watering – tier 1a	• Due to a lack of formal environmental entitlement, the Maribyrnong system will not receive an environmental allocation in 2019–20 and therefore no tier 1a watering actions have been identified. Water will need to be purchased from willing sellers to support tier 1b or tier 2 watering actions			
Potential environmental watering – tier 1b	• Summer/autumn low flows • Two summer/ autumn freshes	• Three summer/ autumn freshes	• Three summer/ autumn freshes • Winter/spring low flows (up to 14 days)	• Two summer/ autumn freshes • Winter/spring low flows (up to 21 days)
Potential environmental watering – tier 2	• Two summer/ autumn freshes	• Two summer/ autumn freshes	• Two summer/ autumn freshes • Increased duration winter/spring low flows	• Two summer/ autumn freshes • Increased duration winter/spring low flows
Possible volume of water for the environment required to achieve objectives[1]	• 300 ML (tier 1b) • 200 ML (tier 2)	• 300 ML (tier 1b) • 200 ML (tier 2)	• 600 ML (tier 1b) • 200 ML (tier 2)	• 600 ML (tier 1b) • 200 ML (tier 2)

[1] *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

3.5 Werribee system

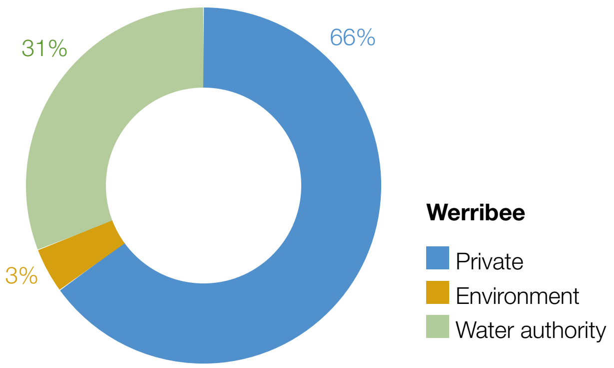
Waterway manager – Melbourne Water

Storage manager – Southern Rural Water

Environmental water holder – Victorian Environmental Water Holder

Did you know ...?

The Werribee River is known to Wadawurrung people as *Wirribi yulluk*, which means ‘wide river with big red gums’.



Proportion of water entitlements in the Werribee basin held by private users, water corporations or environmental water holders at 30 June 2018.

Top: Werribee fishway, by Melbourne Water
Centre: Werribee gorge, by Melbourne Water
Above: Werribee riverbank vegetation, by Melbourne Water

System overview

The Werribee River flows south-east from the Wombat State Forest near Ballan, through the Werribee Gorge to Bacchus Marsh and then into Port Phillip Bay at Werribee. The Lerderderg River is a major tributary that joins the river at Bacchus Marsh. The main storages in the Werribee system are Pykes Creek Reservoir, Melton Reservoir and Merrimu Reservoir.

The four reaches in the Werribee system that can receive water for the environment are Pyrites Creek between Lake Merrimu and Melton Reservoir (reach 6), the Werribee River between Melton Reservoir and the Werribee Diversion Weir (reach 8), the Werribee River between the Werribee Diversion Weir and Werribee Park Tourism Precinct (reach 9) and the Werribee estuary downstream of the Werribee Park Tourism Precinct (the estuary).

Environmental watering that targets environmental objectives in reach 9 and the estuary is delivered from Melton Reservoir and therefore also benefits reach 8. Water for the environment released from Lake Merrimu is re-harvested in Melton Reservoir, where it can be held and released at an appropriate time to achieve environmental objectives in the lower Werribee River.

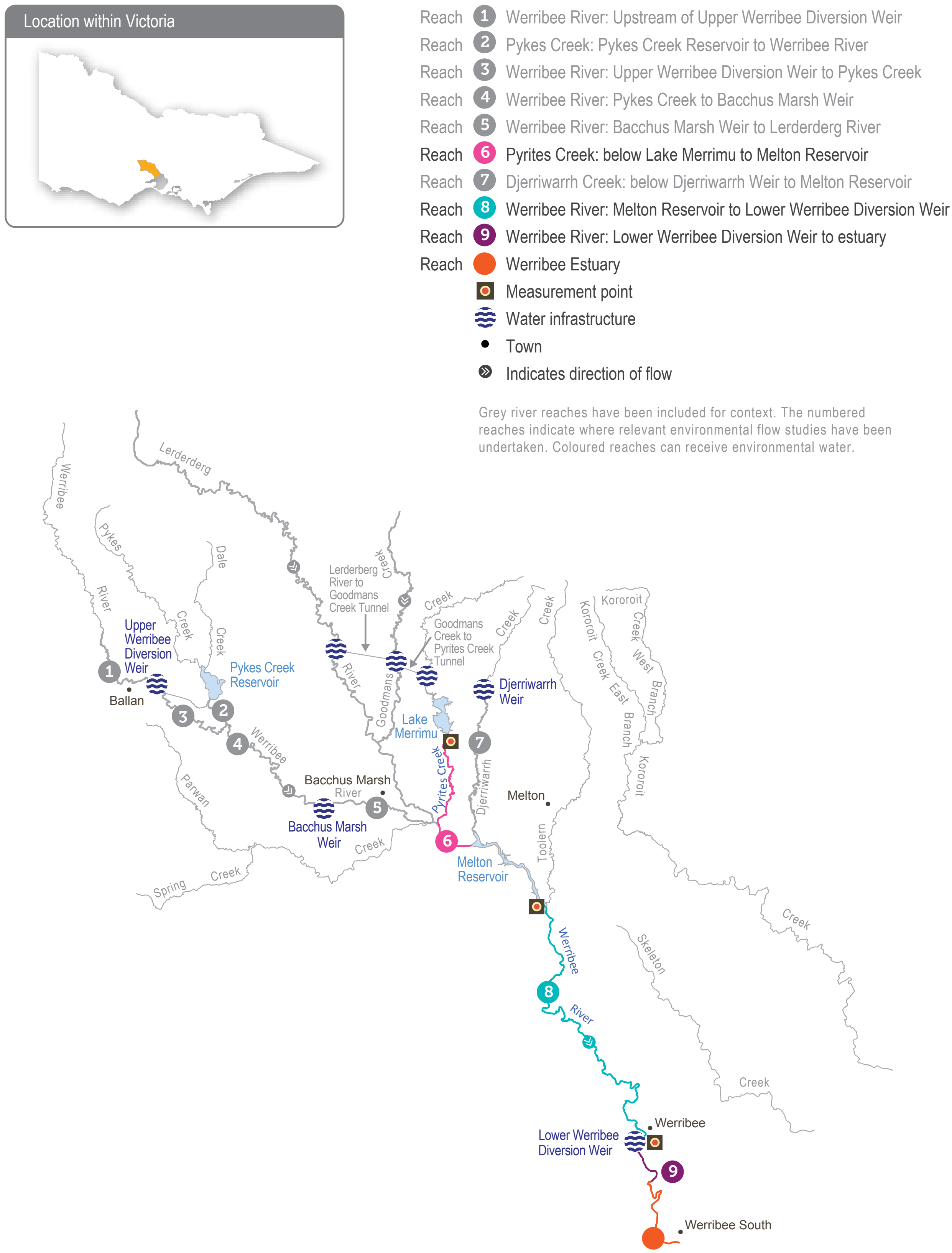
Environmental values

The Werribee system supports a range of native fish including river blackfish, flathead gudgeon, short-finned eel, tupong, Australian smelt, several species of galaxiids, and a large population of black bream in the estuary. Several species of frogs and diverse macroinvertebrate communities inhabit the upper reaches and platypus are present in the lower reaches. The freshwater-saltwater interface of the Werribee River estuary is a regionally significant ecosystem due to the many aquatic plants and animals it supports, providing nursery habitat for juvenile freshwater fish species and estuarine species such as black bream.

Environmental objectives in the Werribee system

Fish	Protect and increase populations of native fish including black bream and galaxiids
Frogs	Maintain the population of frogs
Geomorphology	Maintain channel beds and pool habitats Maintain clean substrate surfaces to support biological processes
Platypus	Maintain the platypus population
Vegetation	Maintain the health and increase the cover of in-stream, riparian and estuary plants Limit the spread of terrestrial plants and promote the recruitment of native water-dependent plant species on the banks and benches of waterways
Waterbugs	Maintain the population of waterbugs, to break down dead organic matter and support the river's food chain
Water quality	Maintain dissolved oxygen and salinity levels in pools

Figure 3.5.1 The Werribee system



Recent conditions

The Werribee system experienced below-average rainfall for most of 2017–18 and 2018–19. Storms in November and December 2018 and January 2019 provided some natural events after a very dry winter/spring period.

Pyrites Creek (reach 6) is an ephemeral system that naturally flows from winter until early summer (depending on local inflows) and then dries out over summer/autumn. Water for the environment is delivered to reinstate parts of this natural flow regime. In 2018–19, water for the environment was used to deliver low flows and two freshes (in October and December 2018) to Pyrites Creek (reach 6) from late spring 2018 until early summer. These flows flushed organic matter from benches and supported the recruitment and growth of native vegetation in the stream and along the margins of the banks. A significant proportion of flow in Pyrites Creek seeps into groundwater reserves or evaporates, but all flow that reached Melton Reservoir was re-harvested for later use.

The lower Werribee River had lower-than-average flows for much of 2018–19. The only notable natural event was an unseasonal storm in January 2019 that delivered a large fresh. Water for the environment was released from Melton Reservoir to deliver three freshes and a low flow to the lower Werribee River in autumn 2019. These flows helped to maintain water quality and allowed native fish, platypus and waterbugs to access feeding and breeding habitat.

Low water availability and dry climate conditions meant that the recommended spring freshes were not achieved in the lower Werribee in 2017–18 or 2018–19. Spring freshes help support the migration of native fish between the marine and estuary environments into freshwater reaches of the Werribee River, and the lack of these flows helps to explain why fewer migratory fish have been detected in routine fish surveys in the lower Werribee River over the last two years.

Scope of environmental watering

Table 3.5.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 3.5.1 Potential environmental watering actions and objectives for the Werribee River

Potential environmental watering action	Functional watering objective	Environmental objective
Pyrites Creek (reach 6)		
Spring freshes (up to three freshes of 30 ML/day for two days during September to October)	• Drown terrestrial plant species that cannot tolerate being inundated • Increase the growth and recruitment of riparian and in-stream vegetation • Scour silt, biofilms and algae from substrates to maintain the quality and quantity of food and habitat for waterbugs • Inundate depressions adjacent to the stream that frogs can use for breeding	
Spring/summer high flows (up to three high flows of 130 ML/day for two days during September to December)	• Drown terrestrial plant species that cannot tolerate being inundated • Increase the growth and recruitment of riparian and in-stream vegetation • Transport carbon to drive aquatic food webs • Scour silt, biofilms and algae from substrates to maintain the quality and quantity of food and habitat for waterbugs • Inundate depressions adjacent to the stream that frogs can use for breeding	
Winter/spring/summer low flows (2 ML/day [or natural] during June to December)	• Maintain access to food and habitat for waterbugs, native fish and frogs • Increase the growth and recruitment of in-stream vegetation	

Table 3.5.1 Potential environmental watering actions and objectives for the Werribee River *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Lower Werribee River (reaches 8, 9 and estuary)		
Spring/summer freshes (up to two freshes of 50–80 ML/day for two days during November to December)	• Drown terrestrial species and support the growth and recruitment of water-dependent riparian vegetation • Flush silt and scour biofilms and algae from substrates on the stream bed and maintain pools and channel dimensions • Provide movement cues and enough flows for fish to move upstream past natural and artificial barriers to support native fish recruitment in the estuary • Maintain the quality and quantity of food and habitat for waterbugs • Inundate depressions adjacent to stream that frogs can use for breeding	
Year-round low flows (10 ML/day)[1]	• Maintain the growth and recruitment of in-stream vegetation • Support the growth and recruitment of water-dependent riparian vegetation • Maintain water quality and food in pool habitats for native fish • Maintain access to habitat for native fish, frogs, platypus and waterbugs • Maintain flow through pool habitats to allow mixing or suppression/ dilution of saline groundwater intrusion	
Summer/autumn freshes (up to five freshes of 80 ML/day[2] for two days during November to April)	• Drown terrestrial species and support the growth and recruitment of water-dependent riparian vegetation • Flush silt and scour biofilms and algae from substrates on the stream bed and maintain pools and channel dimensions • Maintain access to habitat and improve water quality for native fish, frogs and platypus • Provide enough flow for native fish to move downstream past natural or artificial barriers • Maintain the quality and quantity of food and habitat for waterbugs	
Winter/spring/summer freshes (up to four freshes of 350 ML/day for three days during June to December)	• Drown terrestrial species and support the growth and recruitment of water-dependent riparian vegetation • Flush silt and scour biofilms and algae from substrates on the stream bed and maintain pools and channel dimensions • Provide movement cues and enough flows for fish to move upstream past natural and artificial barriers • Maintain water quality and quantity of food and habitat for waterbugs • Inundate depressions adjacent to stream that frogs can use for breeding	
Increased winter/spring low flows (up to 80 ML/day or natural during June to November)	• Provide flows to allow fish to move upstream past natural and artificial barriers • Support the growth and recruitment of water-dependent riparian vegetation • Maintain permanent pools and increase the extent of habitat for waterbugs, platypus and frogs • Maintain flow through pool habitats to allow mixing or suppression/ dilution of saline groundwater	

1 *The original recommendation from the flow study (Ecological Associates 2005, Jacobs 2014) is for 89 ML per day for four days throughout autumn. Construction of a fishway has reduced the required flow rate, and less flow is required to enable fish movement.*

2 *The original recommendation from the flow study (Ecological Associates 2005, Jacobs 2014) is for 137 ML delivered in one day. The recommendation has been revised due to operational constraints to be 160 ML delivered over two days. Monitoring has shown that this achieves the hydraulic and water quality objective.*

Scenario planning

Table 3.5.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

In 2019–20, there are similar watering actions planned under each climate scenario, but sometimes the frequency, magnitude and target river reach of a specific watering action may differ within and between each climate scenario. For example, what may be a low-priority action in a dry climate scenario may become a high priority in an average to wet scenario, when there is more water available in the system and storages — through unregulated flows and/or allocation to the entitlement — to support the delivery of larger flow objectives.

Under drought conditions, the expected volume of supply should be sufficient to enable the delivery of the highest-priority tier 1a flows in both Pyrites Creek (reach 6) and the lower reaches of the Werribee River. Water for the environment will be used to deliver low flows and some freshes during winter, spring and summer in Pyrites Creek (reach 6). Low flows will maintain habitat for frogs, waterbugs and native fish, and they will support aquatic plant species. Freshes delivered will improve habitat for aquatic species by flushing fine sediment from pools and preventing the encroachment of terrestrial plant species into the river channel. In the lower reaches (reaches 8 9 and the estuary) of the Werribee River, freshes and low flows will be delivered to improve water quality during spring, summer and autumn to mitigate the risks of fish kills, high salinity and blue-green algae and provide enough flows to allow native fish, platypus and other aquatic species to move through the system.

Watering priorities under dry to wet conditions are similar to those under drought conditions, with the addition of freshes targeting the estuary during spring/summer to support the upstream movement of diadromous fish species into the Werribee system and with additional periods of low flows in the lower reaches of the Werribee River to expand habitat availability for aquatic plants and animals.

Securing supply to deliver a fresh in the lower reaches during winter/spring/early summer under all climate scenarios is a high priority as it provides movement cues for native fish, including black bream and common galaxias, that require higher flows to migrate. Providing a fresh will also flush sediment from pool habitats, inundate habitat for frog species along the river and improve water quality. Under drought and dry climate conditions, this flow will likely be the only cue for native fish to move and access breeding habitats, due to little or no flows reaching reach 9 and the estuary due to river regulation. Under wetter conditions, it is expected that spills from Melton Reservoir and catchment inflows may naturally achieve one fresh, and the additional fresh will provide a second opportunity for aquatic species to move, breed and access additional habitat resources.

Under average or wet conditions, it is likely that some low flows in Pyrites Creek (reach 6) will be met naturally, and spills from Melton Reservoir will provide some unregulated flow to the lower Werribee River. Under wetter conditions, water for the environment will be used to deliver spring/summer/autumn freshes throughout the system to improve water quality, provide movement cues for native fish and increase feeding and breeding habitat for other aquatic species (such as platypus, frogs and waterbugs). Under average and wet conditions, additional water for the environment is needed compared to drought and dry conditions, as there is little ability to re-harvest releases from Merrimu Reservoir and store water in Melton Reservoir when it is full. When flows cannot be re-harvested, flows must be completely met from water allocation held in Melton Reservoir to deliver watering actions in the lower Werribee River.

A minimum volume of 200 ML in Lake Merrimu, to help protect the health of Pyrites Creek (reach 6), and 350 ML in Melton Reservoir, for the lower Werribee River, is planned to be carried over into 2020–21. This will provide some supply certainty, to mitigate water quality and blue-green algae risks in Pyrites Creek (reach 6) and the Werribee River, due to inflow variability and low allocation availability in the Werribee system in dry conditions.

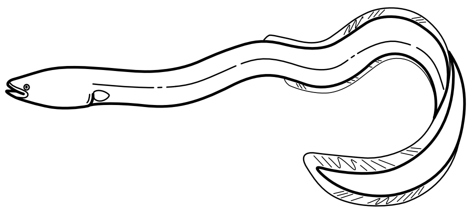


Table 3.5.2 Potential environmental watering for the Werribee system under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No unregulated flows • Minimal consumptive releases out of storage into reach 8 in summer/autumn	• No unregulated flows below Melton Reservoir, minimal passing flows to reach 6 • Consumptive releases out of storage into reach 8 in summer/autumn	• Unregulated spills in winter/spring from Melton into reaches 8 and 9 and the estuary; most reach 6 low flows met by passing flows • Consumptive releases out of storage into reach 8 in summer/autumn	• Unregulated spills in winter/spring from Melton into reaches 8 and 9 and the estuary; all reach 6 low flows provided • Consumptive releases out of storage into reach 8 in summer/autumn
Expected availability of environmental water[1]	• 800 ML	• 1,400 ML	• 1,800 ML	• 2,400 ML
Potential environmental watering (tier 1a)	• Winter/spring/summer low flows reach 6 • Two spring freshes reach 6 • Two summer/autumn freshes reaches 8 & 9 • Autumn low flows estuary	• Winter/spring/summer low flows reach 6 • Three spring freshes reach 6 • Two summer/autumn freshes reaches 8 & 9 • Autumn low flows estuary • One spring/summer fresh estuary	• Three spring freshes reach 6 • Two summer/autumn freshes reaches 8 & 9 • Autumn low flows estuary • Two spring/summer freshes estuary • Winter/spring/summer low flows reaches 8 & 9 • Winter/spring/summer low flows reach 6	• Three spring freshes reach 6 • Three spring/summer high flows reach 6 • Two summer/autumn freshes reaches 8 & 9 • Autumn low flows estuary • Two spring/summer freshes estuary • Winter/spring/summer low flows reaches 8 & 9
Potential environmental watering (tier 1b)	• One winter/spring/summer fresh reaches 8 & 9	• One winter/spring/summer fresh reaches 8 & 9	• One winter/spring/summer fresh reaches 8 & 9	• One winter/spring/summer fresh reaches 8 & 9
Potential environmental watering (tier 2)	• Increased winter/spring low flows reaches 8 & 9	• Increased winter/spring low flows reaches 8 & 9	• Increased winter/spring low flows reaches 8 & 9	• Increased winter/spring low flows reaches 8 & 9
Possible volume of water for the environment required to achieve objectives[2]	• 350 ML (tier 1a) • 1,300 ML (tier 1b) • 10,000 ML (tier 2)	• 700 ML (tier 1a) • 1,300 ML (tier 1b) • 10,000 ML (tier 2)	• 900 ML (tier 1a) • 1,300 ML (tier 1b) • 10,000 ML (tier 2)	• 1,200 ML (tier 1a) • 1,300 ML (tier 1b) • 10,000 ML (tier 2)
Priority carryover requirements	• 200 ML – 550 ML[3]			

1 Melbourne Water holds water shares in the Werribee Headworks system that form part of the Southern Rural Water Bulk Entitlement. In its role as waterway manager, Melbourne Water uses these shares to achieve targets in the Healthy Waterways Strategy. The likely available allocation against these water shares is detailed for each planning scenario.

2 Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.

3 Inflows into Lake Merrimu are highly irregular, and the decision to carry over more water in each water storage considers seasonal outlooks, inflows to storages and catchment conditions during the water year. A conservative water use strategy is favoured in the Werribee system, and the volume carried over is often more than the critical 200 ML requirement in Lake Merrimu.

3.6 Moorabool system

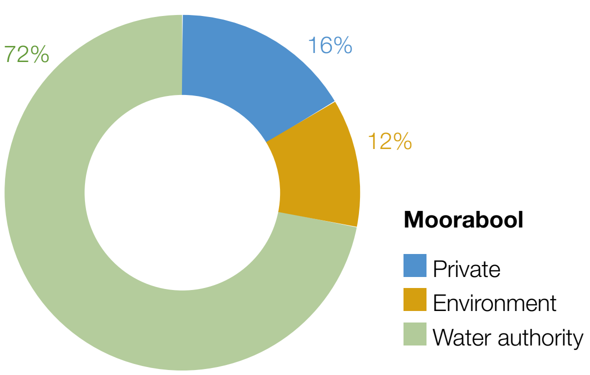
Waterway manager – Corangamite Catchment Management Authority

Storage manager – Central Highlands Water

Environmental water holder – Victorian Environmental Water Holder

Did you know ...?

The Moorabool River is known to Wadawurrung people as *Mooroobull yulluk*. ‘Mooroobull’ is the name of the stone curlew’s call, and ‘yulluk’ means ‘running waters’.



Proportion of water entitlements in the Moorabool basin held by private users, water corporations or environmental water holders at 30 June 2018.

Top: Moorabool River at Dog Rocks, by Andrew Sharpe, VEWH
Centre: Short-finned eel, by Trevor Pescott
Above: Moorabool River in-stream vegetation, by Danielle Berkelmans

System overview

The Moorabool River is a tributary of the Barwon River. It flows south from the Central Highlands between Ballarat and Ballan to join the Barwon River at Fyansford just north of Geelong. The Moorabool River is a highly regulated catchment with major storages that include Lal Lal, Moorabool and Bostock reservoirs.

The lower section of the Moorabool River between She Oaks and Batesford has nine private diversion weirs that are significant barriers to fish. These barriers have increased the extent of slow-flowing habitat and reduced habitat diversity.

The Moorabool is a water supply catchment for Barwon Water and Central Highlands Water. Releases from Lal Lal Reservoir for urban water supply contribute to environmental outcomes in reach 3a and 3b (upstream of Barwon Water's diversion point at She Oaks) and allow more-efficient delivery of water for the environment to reach 4. Barwon Water and Corangamite CMA coordinate to make releases in tandem, where possible, to maximise these benefits.

Water allocated to the Moorabool River environmental entitlement is stored in Lal Lal Reservoir. The entitlement includes passing flows that are a significant component of annual streamflows and help maintain low flows through winter. The priority reaches for deliveries of water for the environment are between Lal Lal Reservoir and She Oaks Weir (reaches 3a and 3b, as shown in Figure 3.6.1), as that is where the small amount of available water can have the most benefit: water use is limited by both inflow to the reservoir and by a use cap specified in the entitlement. Environmental flows may also provide some benefits to flow-dependent values in the reach between She Oaks Weir and the confluence with the Barwon River.

Environmental values

Despite substantial extraction and many years of drought, the Moorabool River retains significant environmental values. The river is home to native fish species including the Australian grayling, river blackfish, Australian smelt, flat-headed gudgeon, southern pygmy perch, short-finned eel, spotted galaxias, and tupong. The system contains extensive areas of endangered remnant vegetation including stream bank shrubland and riparian woodland ecological vegetation communities. Platypus, rakali (water rats) and a range of waterbugs are also present. The Moorabool River flows into the Barwon River, connecting it to the Ramsar-listed lower Barwon wetlands.

Environmental objectives in the Moorabool River

Maintain self-sustaining populations of native fish (in particular short-finned eel, Australian grayling, spotted galaxias and tupong)
Maintain physical habitat diversity
Restore self-sustaining breeding populations of platypus and support the dispersal of juveniles
Maintain riparian vegetation communities Maintain in-stream macrophyte communities
Maintain diverse waterbug communities
Improve water quality

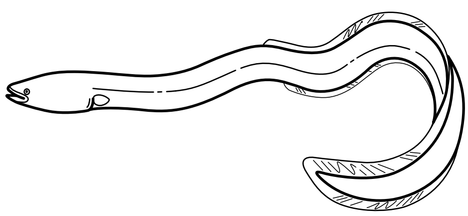
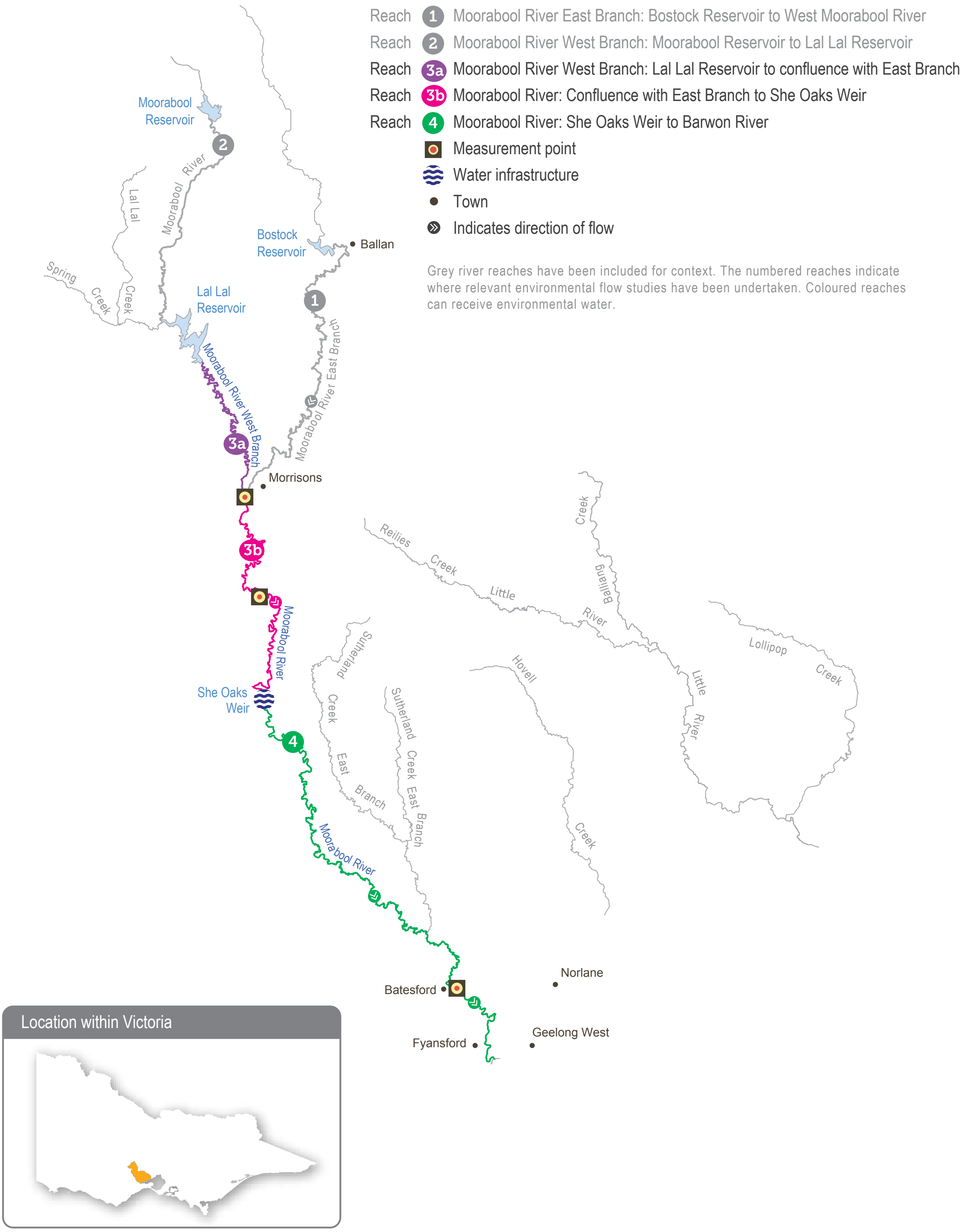


Figure 3.6.1 The Moorabool system



Recent conditions

The Moorabool system typically behaves as a boom-or-bust system and is very dependent on seasonal rainfall. The catchment has experienced dry conditions over the past two years, and the environment's share of inflows has been low. High importance was therefore placed on maintaining low flows during summer near Batesford, where, without environmental flows, the river can stop flowing.

In 2019, the VEWH in partnership with Central Highlands Water, Barwon Water and the Corangamite CMA, secured additional water to use in the Moorabool River to mitigate the effects of drought. The additional water was from one-off transactions that allowed the delivery of priority watering actions including an autumn fresh, which connected habitats along the river and improved water quality. As in previous years, the coordination of environmental flows with releases of water for operational or consumptive purposes greatly increased the efficiency of environmental watering. The ability to piggyback on operational releases means that less allocation of water for the environment is needed to meet target flows.

Scope of environmental watering

Table 3.6.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 3.6.1 Potential environmental watering actions and objectives for the Moorabool River

Potential environmental watering action[1]	Functional watering objective	Environmental objective
Summer low flows (> 5 ML/day during December to May)	• Maintain pool and riffle habitats for fish, macroinvertebrates, platypus and submerged aquatic vegetation • Improve water quality in refuge pools	
Winter low flows (> 5 ML/day during June to November)	• Maintain a clear flow path and allow fish movement throughout the reach • Control intrusions by terrestrial vegetation into the stream bed	
Spring fresh (one to two freshes of 80 ML/day for five days during September to November)	• Trigger upstream migration of juvenile galaxias, tupong, short-finned eel and grayling • Provide connectivity between channels and pools to support fish movement • Scour biofilms and algae from stream bed and transport organic matter	
Winter fresh (80 ML/day for five days during May to August)	• Allow fish and platypus to move through the reach and maintain access to habitat • Trigger downstream spawning migration of adult tupong • Scour biofilms and algae from the stream bed and transport organic matter • Promote the growth and recruitment of native riparian vegetation including woody shrubs, and promote strong vegetation zonation on the banks	
Autumn fresh (60 ML/day for five days during April to May)	• Encourage downstream spawning migration of Australian grayling and short-finned eel • Allow fish and platypus movement through the reach and maintain access to habitat • Flush silt and scour biofilms and algae from the stream bed • Water the fringing vegetation	
Summer fresh (one to two freshes of 30–60 ML/day for three to five days during January to March)	• Flush silt and scour biofilms and algae from the stream bed • Water the fringing vegetation	

[1] The target reaches for environmental watering are reaches 3a, 3b and 4 of the Moorabool system unless otherwise stated.

Scenario planning

Table 3.6.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The main environmental flow priorities under all climate scenarios in the Moorabool River in 2019–20 will be to provide recommended low flows all year and trigger-based freshes. Water quality is monitored throughout summer to identify when freshes need to be released, to avoid dangerously low levels of dissolved oxygen or dangerously high levels of salinity.

In scenarios where more water is naturally available and the risk of poor water quality lessens (transitioning from dry to average or wet), priorities shift to delivering freshes for key fish migration cues, and connectivity for plants and animals to disperse.

Although environmental watering in the Moorabool River primarily targets outcomes in reaches 3a and 3b, deliveries will be planned where possible to also provide benefits in reach 4. The Corangamite CMA and the VEWH prioritise carryover of 1,000 ML each year (if possible) to allow delivery of trigger-based freshes in the following year, if there is low allocation.

Table 3.6.2 Potential environmental watering for the Moorabool River under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Disconnected pools in some parts during July to December	• Cease-to-flow events	• Continuous flow throughout winter • Low flow over summer • High peaks in winter months	• Continuous flow year-round • Bankfull flows persist throughout winter • Overbank conditions in some parts in spring/ autumn
Expected availability of environmental water	• 1,200 ML	• 2,000 ML	• 3,000 ML	• 5,000 ML
Potential environmental watering – tier 1a (high priorities)	• Summer/autumn freshes (trigger-based[1]) • Summer low flows	• Summer/autumn freshes (trigger based[1]) • Summer low flows • Winter low flows • Spring fresh	• Summer low flows • Winter low flows • Spring fresh • Winter fresh	• Summer low flows • Winter low flows • Spring fresh • Winter fresh • Autumn fresh
Potential environmental watering – tier 1b (high priorities with shortfall)	• Winter low flows • Spring freshes • Winter fresh • Autumn fresh • Summer freshes	• Winter fresh • Autumn fresh • Summer freshes • Additional spring freshes	• Autumn fresh • Summer freshes • Additional spring freshes	• Summer freshes • Additional spring freshes
Potential environmental watering – tier 2 (additional priorities)	• As per tier 1, but at higher peak flows and longer durations	• As per tier 1, but at higher peak flows and longer durations	• As per tier 1, but at higher peak flows and longer durations	• As per tier 1, but at higher peak flows and longer durations
Possible volume of water for the environment required to achieve objectives[2]	• 1,160 ML (tier 1a) • 2,240 ML (tier 1b) • 6,600 ML (tier 2)	• 1,900 ML (tier 1a) • 1,500 ML (tier 1b) • 6,600 ML (tier 2)	• 2,330 ML (tier 1a) • 1,070 ML (tier 1b) • 6,600 ML (tier 2)	• 2,330 ML (tier 1a) • 1,070 ML (tier 1b) • 6,600 ML (tier 2)
Priority carryover requirements	• up to 1,000 ML			

1 Dissolved oxygen levels below 5 mg/L is the trigger to deliver summer/autumn freshes in drought and dry climate scenarios.

2 Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.

3.7 Barwon system

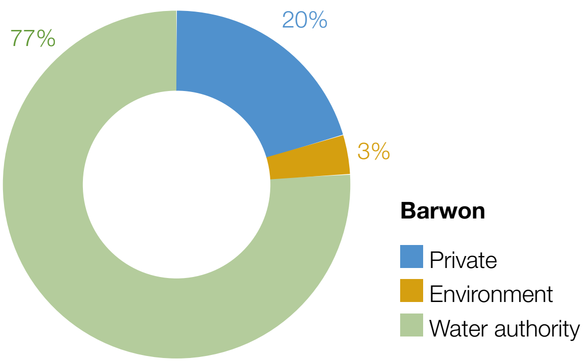
Waterway manager – Corangamite Catchment Management Authority

Storage manager – Barwon Water

Environmental water holder – Victorian Environmental Water Holder

Did you know ...?

The Barwon River is known to the Wadawurrung people as *Barra Warre yulluk* which means 'from the mountains to the sea'.



Proportion of water entitlements in the Barwon basin held by private users, water corporations or environmental water holders at 30 June 2018.

Top: Buckleys Falls, Barwon River, by Corangamite CMA
Centre: Vegetation on the Barwon River, by Chloe Wiesenfeld
Above: Coastal saltmarsh at Hospital Swamps, by Saul Vermeeren

The Barwon River flows east from the Otway Ranges passing the towns of Forrest, Birregurra, Winchelsea and Inverleigh and the City of Geelong before discharging into Bass Strait at Barwon Heads. The Leigh and Moorabool rivers are major tributaries, joining the Barwon River at Inverleigh and Fyansford respectively. Other tributaries including Birregurra, Boundary, Callahan, Dewing, Matthews, Pennyroyal, Deans Marsh and Gosling creeks flow into the Barwon River upstream of Winchelsea. The main storages in the Barwon River catchments are the West Barwon and Wurdee Boluc reservoirs.

The Barwon estuary contains a Ramsar-listed system of wetlands and lakes collectively called the lower Barwon wetlands. Water for the environment can be used to manage water levels in Reedy Lake and Hospital Swamps, which connect to the Barwon River.

3.7.1 Upper Barwon River

System overview

Flows in the upper Barwon River are regulated by the operation of the West Barwon Reservoir upstream of Forrest. Releases can be either directly from the reservoir down the west branch, or down the east branch via a diversion channel. The junction of the two branches is near Boundary Creek. Upstream of Birregurra, water can also be diverted into the Wurdee Boluc inlet channel, a 57-km, concrete-lined channel that transfers water to Wurdee Boluc Reservoir.

Barwon Water releases passing flows in the order of 1–5 ML per day (and up to 15 ML per day in September during a wet year) from the West Barwon Reservoir into the West Barwon River. Flood spills from the reservoir and natural inflows from unregulated and partly regulated tributaries add to the passing flows.

A new entitlement was established in April 2018, enabling water for the environment to be used in the upper Barwon River for the first time in 2018–19. The entitlement provides 1,000 ML per year on average from the West Barwon Reservoir.

In light of this new entitlement, the Corangamite CMA updated the Upper Barwon, Yarowee and Leigh rivers environmental flows study in 2018–19, to ensure management decisions are underpinned by the best-available science and information. The Environmental Flows Technical Panel included a representative of the Wadawurrung Traditional Owner group, to specifically consider the Aboriginal values of the waterways in their region.

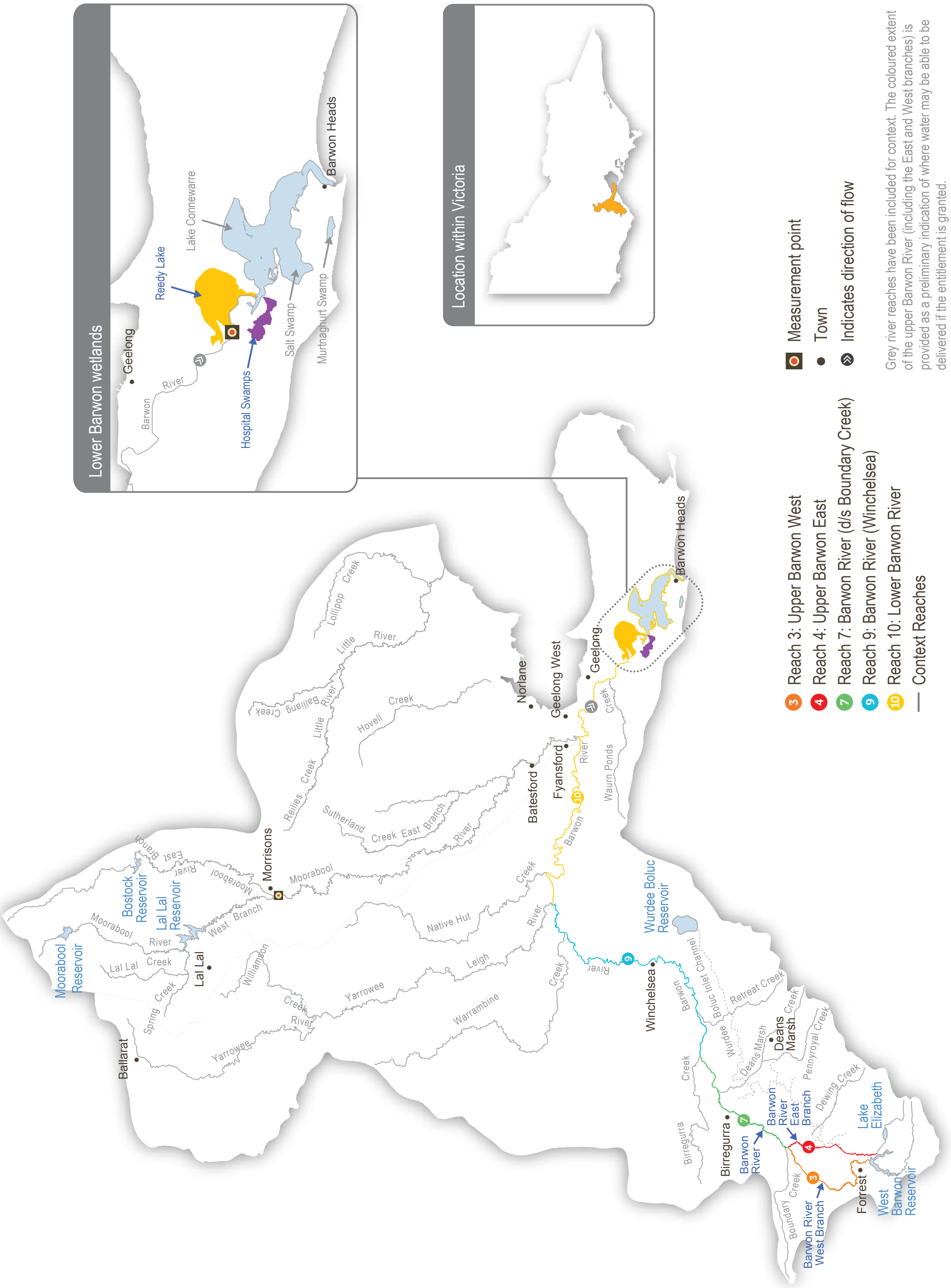
Environmental values

The upper Barwon River is home to native fish species including the Australian grayling, river blackfish, short-finned eel, southern pygmy perch, Australian smelt and various galaxias. The system retains some submerged aquatic vegetation, undercut banks, overhanging vegetation and riffle-pool sequences: these provide important habitat for fish and other aquatic animals.

Environmental objectives in the upper Barwon River

Maintain the abundance, and improve the breeding and recruitment of migratory fish species including short-finned eels, Australian grayling and tupong, broad-finned galaxias and common jollytail Maintain the abundance, and improve the breeding and recruitment of resident freshwater fish including several species of galaxias, Australian smelt, big-headed gudgeon, Yarra pygmy perch and river blackfish
Maintain the abundance, improve the condition and extend the distribution of platypus populations
Improve the condition and extent of native in-stream vegetation, to provide structural habitat for macroinvertebrates and various fish species Increase the extent and diversity of emergent macrophyte vegetation, to provide structural habitat and stabilise banks Increase the extent and diversity of native riparian vegetation Improve the condition and extent of native floodplain vegetation
Increase the abundance of waterbugs as a food source for fish, frog and platypus populations
Maintain water quality for native fish, waterbugs, aquatic vegetation and other water-dependent animals

Figure 3.7.1 The Barwon system



Recent conditions

The Barwon River catchment was drier and warmer than average in 2018–19. The very first release of water for the environment started in January 2019, with a summer fresh delivered down the west branch of the Barwon River to mitigate observed cease-to-flow conditions at Ricketts Marsh.

Despite adopting a conservative flow rate for this first release, some flow spilt out of the channel at constriction points created by historic infrastructure and exotic vegetation. These constrictions will need to be managed in future, to realise the full benefit of the environmental watering program.

The release shed light on the capacity of water for the environment to affect downstream reaches. It took two weeks for the released water to travel from West Barwon Reservoir to Winchelsea. The peak flow at Winchelsea was only 20 percent of the maximum flow release at the reservoir outlet. These statistics highlight the importance of wetting-up a river to reduce losses, and they confirm that the influence of water for the environment is limited to the upper reaches under the current system operations.

Scope of environmental watering

Table 3.7.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

The 2019–20 watering year will be the second year that water for the environment is delivered to the upper Barwon system, so all planned deliveries will be monitored and where necessary adjusted to better meet their functional objectives and minimise potential adverse outcomes. Rates of rise may be more gradual and peak-flow rates and volumes limited while a better understanding of the system is gained.

Table 3.7.1 Potential environmental watering actions and objectives for the upper Barwon River

Potential environmental watering action[1]	Functional watering objective	Environmental objective
Summer/autumn low flows (0.5–30 ML/day during December to May)	• Provide water in pools for habitat and food sources • Maintain an adequate depth of permanent water in the channel to support resident fish, platypus and macroinvertebrates, promote recruitment of native aquatic vegetation and limit encroachment by terrestrial plants • Provide minimum velocity to maintain mixing in pools	
Summer/autumn fresh (15–50 ML/day for two days during December to May)	• Provide water over riffles to allow fish to move between pools to breed, feed and find new habitats • Submerge woody debris and clean hard surfaces to provide breeding substrate • Sustain macroinvertebrate communities in the dry period by inundating benches • Provide longitudinal connectivity between reaches • Provide a mosaic of habitats within the stream channel, on benches and on lower banks that have different inundation patterns • Support plant growth on terraces, the channel edge and lower bank • Provide minimum velocity to mix and flush pools	
Winter/spring low flow (10–50 ML/day during April to November)	• Provide water in pools for habitat and food sources • Maintain an adequate depth of permanent water in the channel to promote the recruitment of aquatic and riparian plants and to limit the encroachment of terrestrial species • Provide minimum velocity, to mix pools • Mobilise sediment from the base of pools for a sustained duration	

1 Potential watering actions apply to both the east and west branch of the upper Barwon River.

Scenario planning

Table 3.7.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

It is acknowledged that the current environmental entitlement can only support a limited number of the flow components (that is, tier 1a) recommended for the upper Barwon River. Low flows and freshes are the highest priority under all climate scenarios. The flow rate and volume of these flow events may be modified (that is, reduced) at times, due to system constraints and expected water availability.

Watering actions in the east branch of the Barwon River will be prioritised where possible (subject to resolving deliverability issues identified in 2018–19) because it has higher environmental values than the first reach of the west branch and because relatively small flows in the east branch have the potential to deliver significant environmental outcomes. Some flows may need to be delivered down the west branch, to achieve target flow objectives further downstream.

An additional 18,000 ML of water for the environment is required to achieve the remaining priority watering actions (tier 1b) in the upper Barwon River. The volumes associated with these flow components have also been modified, to be safely delivered within the current system operations.

The tier 1a watering actions described here should help to maintain current environmental values and conditions in the upper Barwon River, but larger environmental entitlements and complementary works that address non-flow-related impacts in the catchment will be needed, to significantly improve environmental conditions.

It is intended to carry over up to 500 ML for the following year, to ensure the highest-priority flow components under a drought scenario can be achieved.

Table 3.7.2 Potential environmental watering for the upper Barwon River under a range of planning scenarios[1]

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No flow at Ricketts Marsh for six months • Disconnected pools	• No flow at Ricketts Marsh for four months • Cease-to-flow events	• Low summer flows, high peaks in winter	• High flows throughout winter with very high peaks; consistent, steady summer flows
Expected availability of environmental water	• 500 ML	• 800 ML	• 1,000 ML	• 2,000 ML
Potential environmental watering – tier 1a (high priorities)	• Summer/autumn low flow (east branch) • Summer/autumn freshes (east branch, reduced volumes)	• Summer/autumn low flow (east branch) • Summer/autumn freshes (east branch, reduced volumes) • Summer/autumn low flow (west branch, reduced volume)	• Summer/autumn low flow (east branch) • Summer/autumn freshes (east branch, reduced volumes) • Summer/autumn low flow (west branch, reduced volume)	• Summer/autumn low flow (east branch) • Summer/autumn freshes (east branch, reduced volumes) • Summer/autumn low flow (west branch, reduced volume)
Potential environmental watering – tier 1b (high priorities with shortfall)	• Summer/autumn low flow (west branch) • Winter/spring low flow (east branch) • Summer/autumn fresh (west branch, reduced volume) • Winter/spring low flow (west branch	• Summer/autumn low flow (west branch) • Winter/spring low flow (east branch) • Summer/autumn fresh (west branch, reduced volume) • Winter/spring low flow (west branch, reduced volume	• Summer/autumn low flow (west branch) • Winter/spring low flow (east branch) • Summer/autumn fresh (west branch, reduced volume) • Winter/spring low flow (west branch, reduced volume	• Summer/autumn low flow (west branch) • Winter/spring low flow (east branch) • Summer/autumn fresh (west branch, reduced volume) • Winter/spring low flow (west branc
Potential environmental watering – tier 2 (additional priorities)	• There are no tier 2 watering demands because additional watering actions cannot be delivered within the existing infrastructure and flow constrictions.			
Possible volume of water for the environment required to achieve objectives	• 500 ML (tier 1a) • 18,200 ML (tier 1b	• 800 ML (tier 1a) • 17,900 ML (tier 1b)	• 1,000 ML (tier 1a) • 17,700 ML (tier 1b)	• 2,000 ML (tier 1a) • 16,700 ML (tier 1b)
Priority carryover requirements	• Up to 500 ML			

[1] *Potential watering actions apply to both the east and west branch of the upper Barwon River.*

3.7.2 Lower Barwon wetlands

System overview

The estuarine reach of the Barwon River contains a system of wetlands and lakes including Lake Connewarre, Reedy Lake, Hospital Swamps, Salt Swamp and Murtnaghurt Lagoon. Water for the environment can be used to manage water levels in Reedy Lake and Hospital Swamps, which connect to the Barwon River.

The environmental entitlement for the lower Barwon wetlands does not provide access to water held in storage. Instead, it allows water to be diverted from the Barwon River into Reedy Lake and Hospital Swamps when river levels are above 0.7 m AHD. High water levels in the Barwon River can also result in natural inundation of the wetlands.

Environmental values

Reedy Lake and Hospital Swamps form part of the internationally recognised Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site, which is used by many thousands of migratory birds from around the world. The wetlands support about 47 threatened plant and animal species and communities. These include some of Victoria's rarest species (such as the brolga, orange-bellied parrot, Australasian bittern, growling grass frog, Australian grayling and dwarf galaxias) and subtropical and temperate coastal saltmarsh communities.

Reedy Lake supports a range of vegetation communities including coastal saltmarsh, herbfields and reed beds. Reedy Lake was a partly-ephemeral system, but river regulation meant the lake was permanently inundated from the 1970s until 2016. Permanent inundation favoured the reed bed community in the lake and over time it has increased its extent and replaced much of the coastal saltmarsh and herbfield communities and open-water habitat. While reed beds form an important part of the lake's ecosystem, their continued expansion has reduced habitat diversity and the number and diversity of internationally-important migratory waterbirds that are able to use the wetland.

The Corangamite CMA and the VEWH have implemented the first three years of a four-year watering regime at Reedy Lake which includes three years of partial summer/autumn drying and one year of full summer inundation.

The new water regime has already helped to control carp numbers and improve conditions for communities of coastal saltmarsh and herbfields. Achieving a more natural wetting and drying regime will continue to improve the ecology of the lower Barwon wetlands.

Hospital Swamps is made up of five unique wetland basins that support important ecological processes and significant ecological values including large areas of threatened coastal saltmarsh and diverse waterbird populations. Vegetation communities in Hospital Swamps have remained largely unchanged over time due to the maintenance of natural wetting and drying cycles.

Environmental objectives in the lower Barwon wetlands

	Provide habitat for fish breeding and growth and improved conditions for migration and dispersal, when wetlands are connected to the Barwon River
	Provide varying water levels and conditions to promote soil salinisation, to support the persistence and growth of threatened salt-dependent ecological vegetation communities
	Maintain the high diversity of ecological vegetation communities in the wetlands Increase the growth and extent of coastal saltmarsh, herbfields and lignum shrubland ecological vegetation communities
	Provide suitable foraging habitat including mud flats and shallow water for wading birds, and refuge for waterbirds and shorebirds

Recent conditions

Hospital Swamps and Reedy Lake underwent a wetting and drying regime in 2018–19. Water levels in the wetlands peaked in July 2018 in response to localised rainfall. High water levels in winter promoted major fish breeding and recruitment opportunities and supported the growth of vegetation, which provides summer feeding habitat for waterbirds.

Structures that control inflow from Barwon River to the wetlands were closed in November 2018 to allow water levels to draw down slowly over summer. The outlet structure at Reedy Lake was opened shortly after, to allow water levels to fluctuate with tidal influences.

The inlet structures remained closed for longer than normal, because at the end of the planned wetland drying cycle water levels in the Barwon River were below the permissible level of diversion (0.7 m AHD) at the lower barrage gauging station. The inlet structures were opened in late March 2019 and temporarily closed in April 2019, again due to low river levels.

Scope of environmental watering

Table 3.7.3 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

The main objective for environmental watering in the lower Barwon wetlands is to implement natural wetting and drying cycles. Hospital Swamps has had an appropriate wetting and drying regime for many years and there is no plan to change its management in 2019–20. It will be filled in winter and spring when water levels in the Barwon River are high, and allowed to draw down over summer.

The plan for Reedy Lake will be to implement the fourth year of its wetting and drying regime. For the past three years, the wetland has been allowed to draw down over summer (from winter/spring filling), to reduce the extent of reed beds and allow other vegetation communities to recolonise. In 2019–20, water levels in the lake will be maintained over summer, to support the breeding and recruitment of fish and the breeding and feeding of waterbirds.

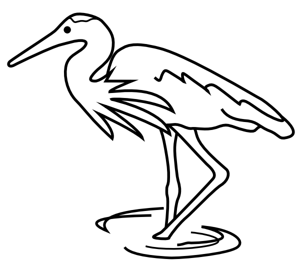


Table 3.7.3 Potential environmental watering actions and objectives for the lower Barwon wetlands

Potential environmental watering action	Functional watering objective	Environmental objective
Reedy Lake		
Autumn/winter/spring fill and top-ups (all year)[1] The inlet to Reedy Lake will be opened in autumn in response to a sustained increase in flows in the Barwon River	• Maintain the water level at or above 0.8 m AHD (allowing for natural fluctuations) • Maintain connectivity with the Barwon River • Inundate the vegetation at the wetland margins to provide feeding habitat for waterbirds • Provide rising water levels to promote waterbird breeding • Promote major fish breeding and recruitment opportunities • Allow fish to move between the river, lake and estuary	
Hospital Swamps		
Autumn/winter/spring fill and top-ups (during March and April to December)[1] Hospital Swamps will be connected to the Barwon River for at least six weeks by keeping the inlet and outlet open	• Create habitat to support waterbug and fish populations • Stimulate fish and waterbird breeding • Allow fish to access the wetland from the river • Dilute salt in the soil and surface water over winter • Promote and sustain the growth of important wetland vegetation communities	
Summer/autumn drawdown (during December to March and April) The inlet to Hospital Swamps will be closed to allow water levels to drop through evaporation; during this period, the outlet will be opened for short periods of time if a summer storm increases water levels above 0.85 m AHD to reduce levels.	• Reduce the threat of carp and associated impacts on native plants and animals • Prevent the expansion of tall reeds by increasing the salt content of the water and soil • Increase habitat diversity (including in salt pans, mudflats and shallow water) • Provide wading bird habitat in early summer • Provide refuge and foraging habitat for waterbirds in early summer • Increase lake shore salinity and increase soil salinisation • Initiate the decomposition of organic matter on the wetland bed, to increase lake productivity when it is refilled • Improve soil health and allow weathering of heavy metals in lake fringe soils • Provide suitable conditions for threatened vegetation communities (such as coastal saltmarsh, herbfields and lignum shrubland) • Allow seasonal recruitment of aquatic macrophytes at the wetland fringes	

[1] *Water can only be diverted into the lower Barwon wetlands when water levels in the Barwon River are above 0.7 m AHD at the Lower barrage gauging station, in line with provisions for accessing water conditions of the environmental entitlement.*

Scenario planning

Table 3.7.4 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Reedy Lake has experienced a drying phase in each of the last three years, and the environmental values in the lake will benefit from a wetter regime in 2019–20, if possible. Maintaining water levels at or above 0.8 m AHD in Reedy Lake is therefore a priority action under all scenarios. High water levels throughout summer are expected to promote major fish and bird breeding and recruitment. Under all climate scenarios, Hospital Swamps will be allowed to draw down over summer.

The extent of wetting for both Reedy Lake and Hospital Swamps will vary in response to natural conditions. Under a wet scenario, the Barwon River is likely to experience more sustained high flows, and therefore the extent of inundation may be higher and the amount of drawdown of Hospital Swamps lower than under a dry scenario.

Corangamite CMA will monitor water levels, water quality and environmental condition at Hospital Swamps throughout the drawdown period and adjust the water levels as needed.

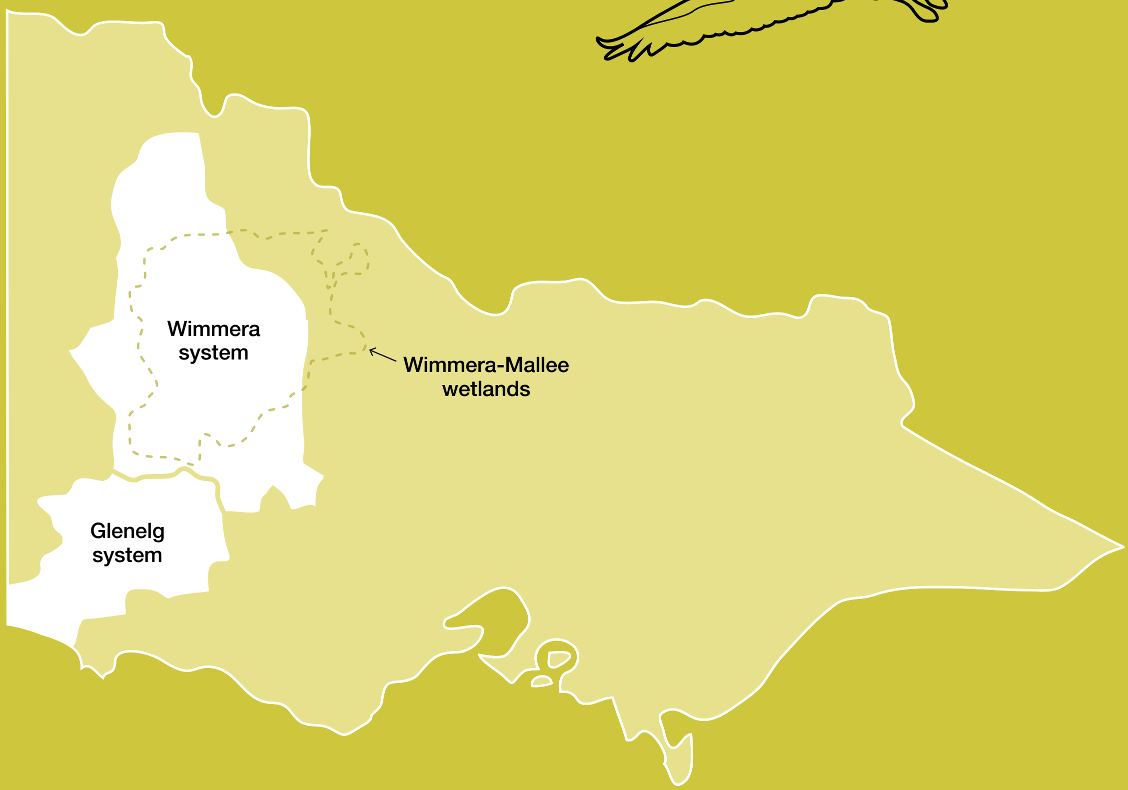
Table 3.7.4 Potential environmental watering for the lower Barwon wetlands under a range of planning scenarios

Planning scenario	Dry	Average	Wet
Expected river conditions	• Some natural inflows from the Barwon River in winter/spring • Dry conditions over summer will assist in the drawdown of the wetlands	• Some natural inflows from the Barwon River in winter/spring • Conditions over summer may assist drawdown of the wetland water levels	• Overbank flows likely to inundate the wetlands as a result of higher river flows, stormwater inflows and local rain/run-off • Extensive drawdown of wetlands is unlikely
Reedy Lake			
Potential environmental watering	• Autumn/winter/spring fill and top-ups (all year)		
Hospital Swamps			
Potential environmental watering	• Autumn/winter/spring filling flows (during March and April to December) • Summer/autumn drawdown (during December to March and April)		

Wimmera River, by John Tiddy

SECTION 4

Western region


Wimmera system
Wimmera-Mallee wetlands
Glenelg system

4.1 Western region overview

In the western region, regulated environmental flows can be delivered to the Wimmera River system, the Glenelg River and the Wimmera-Mallee wetlands. The Wimmera River system and Wimmera-Mallee wetlands are part of the Murray-Darling Basin.

Water for the environment in the western region is supplied from the Wimmera-Mallee headworks system. The Wimmera and Glenelg systems share water available under the environmental entitlement and the VEWH works with the Wimmera and Glenelg Hopkins CMAs to determine how the available allocation will be used in each river in a given year. There is an additional volume of water available to the Glenelg River, as a compensation flow account. The Commonwealth Environmental Water Holder (CEWH) also holds entitlement in the Wimmera system that can be used to supply the Wimmera River and lower Mount William Creek systems. Water for the environment available to the Wimmera-Mallee wetlands is provided under the same entitlement but not shared with the Glenelg system. Instead, the water is available for use in small wetlands supplied by the Wimmera-Mallee pipeline across the Wimmera, Mallee and North Central CMA regions.

Cultural, economic, environmental, recreational, social and Traditional Owner values, recent conditions, environmental watering objectives and planned actions for each system in the western region are presented in the system sections that follow.

Traditional Owners in the western region

Traditional Owners and their Nations in the western region continue to have a deep connection to the region's rivers, wetlands and floodplains.

The Registered Aboriginal Parties in the region are the Barengi Gadjin Land Council Aboriginal Corporation (BGLC), Eastern Maar Aboriginal Corporation, Gunditj Mirring Traditional Owners Aboriginal Corporation and Martang Pty Ltd.

In 2005, the Wotjobaluk, Jaadwa, Jadawadjali, Wergaia and Jupagalk peoples, who are often referred to collectively as the Wotjobaluk Peoples and who are represented by BGLC, were recognised in a Native Title Consent Determination. BGLC also entered into an Indigenous Land Use Agreement with the Victorian and Australian governments in 2005.

In 2007 the Gunditjmara people were granted non-exclusive native title rights and interests over almost 140,000 ha of vacant Crown land, national parks, reserves, rivers, creeks and sea in Victoria's western district, and the State of Victoria reached an Indigenous Land Use Agreement with the Gunditjmara People that establishes how they will exercise their rights and interests in the determination area.

In recognition of the cultural importance of water for Aboriginal people and their traditional ecological knowledge, waterway managers are working with Traditional Owners to involve them in management of environmental flows. In 2019–20, this will include the following initiatives:

- Work will continue on the Towards Cultural Flows project, a partnership between Glenelg Hopkins CMA, Gunditj Mirring Traditional Owners Aboriginal Corporation, BGLC and Burrandies Aboriginal Corporation (in South Australia), which aims to understand and support Traditional Owners' interests, aspirations, challenges and opportunities for water management on the Glenelg River. In 2019–20, they will continue to provide opportunities for Traditional Owners to spend time on Country, to increase their knowledge and expertise in water management while educating the CMA about cultural values that can guide future environmental planning.
- The highly successful watering of Ranch Billabong at Dimboola by Wimmera CMA will be repeated. The Ranch Billabong contains important environmental values, and during an Aboriginal Waterways Assessment in 2017 it was highlighted as a culturally significant site by the local Aboriginal community. Wimmera CMA worked in partnership with BGLC to arrange environmental flows and a community event in December 2018, with a follow-up watering in March 2019. The Ranch Billabong watering sparked activity from native wildlife and halved salinity levels, which improved growth of aquatic plants. Wimmera CMA and BGLC are planning to build on these outcomes by delivering additional water in 2019. The watering will also improve the site's amenity and suitability for gatherings and events (such as earth oven and bark canoe re-creations).

Engagement

Seasonal watering proposals are informed by longer-term regional catchment strategies, regional waterway strategies, relevant technical studies (such as environmental flow studies and environmental water management plans), as well as by input from program partners and affected stakeholders. The strategies and technical reports collectively describe a range of cultural, economic, environmental, recreational, social and Traditional Owner perspectives and longer-term integrated catchment and waterway management objectives that influence environmental watering actions and priorities. Program partners and other stakeholders help to identify environmental watering priorities and opportunities for the coming year.

The International Association for Public Participation's Public Participation Spectrum (IAP2 Spectrum) has been used to categorise the levels of participation of stakeholders involved in the environmental watering planning process. Table 4.1.1 shows the IAP2 Spectrum categories and participation goals.

Table 4.1.1 IAP2 Spectrum categories and participation goals[1]

Engagement category	Engagement goal
Inform	Provide balanced and objective information to assist understanding, alternatives, opportunities and/or solutions
Consult	Obtain feedback on analysis, alternatives and/or decisions
Involve	Work directly throughout a process to ensure that concerns and aspirations are consistently understood and considered
Collaborate	Partner in each aspect of the decision including the development of alternatives and the identification of the preferred solution
Empower	Place final decision making in the hands of the stakeholder

1 *The VEWH has the permission of the International Association for Public Participation to reproduce the IAP2 Spectrum.*

Tables 4.1.2 to 4.1.4 show the partners, stakeholder organisations and individuals with which the Wimmera, Glenelg Hopkins, Mallee and North Central CMAs engaged when preparing seasonal watering proposals. This includes engagement conducted as part of developing seasonal watering proposals as well as engagement during the preparation of key foundation documents that directly informed the proposals. The tables also show the level of engagement, based on the Wimmera, Glenelg Hopkins, North Central and Mallee CMAs' interpretation of the IAP2 Spectrum. The level of engagement differs between organisations and between systems, due to the complexity of management arrangements and individual organisation's responsibilities for each system. For example, in the Wimmera region councils have strong involvement in environmental flows planning and delivery, because they manage town weir pools in Horsham, Dimboola and Jeparit through which environmental flows must pass. Councils in the Wimmera region have also expressed a strong interest in water for the environment, because of the benefits watering provides the region's economy, tourism and environment. For these reasons, Wimmera CMA works with the councils in the planning process and during the year to ensure their concerns and aspirations are understood and considered. In other parts of the western region, where local governments are less involved in management, they may be informed of the seasonal watering proposals and invited to comments.

Table 4.1.2 Partners and stakeholders engaged by Glenelg Hopkins CMA in developing the seasonal watering proposal for the Glenelg system and other key foundation documents that have directly informed the proposal

Glenelg system	
Community groups and environment groups	• Friends of the Glenelg River • Glenelg River User Group
Government agencies	• Parks Victoria • Victorian Fisheries Authority
Landholders	• Individual landholders
Local businesses	• Balmoral Bush Nursing Centre • Balmoral Post Office • Glenelg River Boat Cruises • Grampians Resort • Paestan Canoe Hire • Nelson Boat and Canoe Hire • Vickery Brothers (sand extraction)
Program partners	• Department of Environment, Land, Water and Planning • GWMWater • Victorian Environmental Water Holder • Wimmera Catchment Management Authority
Recreational users	• Balmoral Angling Club • Casterton Angling Society • Dartmoor Angling Club • Individual anglers • South-west Fishing Reports • VRFish
Traditional Owners	• Barengi Gadjin Land Council Aboriginal Corporation • Gunditj Mirring Traditional Owners Aboriginal Corporation

Key: Inform Consult Involve Collaborate Empower

Table 4.1.3 Partners and stakeholders engaged by Wimmera CMA in developing the seasonal watering proposal for the Wimmera system and other key foundation documents that have directly informed the proposal

Wimmera system	
Community groups and environment groups	• Friends of Bungalally and Burnt Creek Group • Yarriambiack Creek Advisory Committee
Government agencies	• Parks Victoria • Victorian Fisheries Authority
Landholders/farmers	• Individual landholders
Local government	• Hindmarsh Shire Council • Horsham Rural City Council • Northern Grampians Shire Council • Yarriambiack Shire Council
Program partners	• Commonwealth Environmental Water Office • Department of Environment, Land, Water and Planning • Glenelg Hopkins Catchment Management Authority • GWMWater • Victorian Environmental Water Holder
Recreational users	• Canoeing Victoria • Dimboola Fishing Classic • Dimboola Rowing Club • Dimboola Water Ski Club • Hindmarsh Ski Club • Horsham Fishing Competition Committee • Horsham Triathlon Committee • Jeparit Anglers' Club • Lake Lonsdale Action Group • Natimuk Field and Game Club • Natimuk Lake Water Ski Club • VRFish • Wimmera Anglers' Association
Traditional Owners	• Barengi Gadjin Land Council Aboriginal Corporation

Key: Inform Consult Involve Collaborate Empower

Table 4.1.4 Partners and stakeholders engaged by Mallee, North Central and Wimmera catchment management authorities in developing seasonal watering proposals for the Wimmera-Mallee wetlands system and other key foundation documents that have directly informed the proposals

Wimmera-Mallee wetlands system	
Community groups and environment groups	• Berriwillock, Birchip, Culgoa, Hopetoun, Lalbert, Nullawil, Millewa-Carwarp, Sea Lake, Ultima, Waitche and Woomelang-Lascelles Landcare groups • Mid-Murray Field Naturalists Incorporated Association
	• Donald and District and Birchip Landcare groups
Landholders/ farmers	• Individual landholders
	• Birchip Cropping Group
Program partners	• GWMWater • Parks Victoria • Victorian Environmental Water Holder
	• Arthur Rylah Institute • Department of Environment, Land, Water and Planning
Recreational users	• Green Lake Regional Park • Lake Tchum Committee • Natimuk and District Field and Game • Ouyen Lake Project
	• Wimmera Bushwalking Club
Traditional Owners	• Barenji Gadjin Land Council Aboriginal Corporation • Dja Dja Wurrung Clans Aboriginal Corporation

Key: Inform Consult Involve Collaborate Empower

Community benefits from environmental watering

As described in subsection 1.1.1, by improving the health of rivers, wetlands and floodplains, environmental flows also provide benefits to communities. Healthy rivers and wetlands support vibrant and healthy communities.

Environmental outcomes provide direct flow-on cultural, economic, recreational, social and Traditional Owner benefits for communities. In 2019–20, examples in the western region included:

- supporting native fish species which are prized by recreational fishers (such as estuary perch, black bream and tupong in the Glenelg River and freshwater catfish and golden perch in the Wimmera system)
- social and economic benefits for local communities: research in 2017–18 found recreational visitors to the Wimmera River had spent an estimated $1.36 million, and the physical and mental health benefits at sites that received water for the environment totalled almost $8 million across the Wimmera and southern Mallee.

Additional opportunities to enhance community benefits can also sometimes be provided by modifying environmental flows, provided environmental outcomes are not compromised.

The following are two examples:

- Wimmera CMA may actively support community events by consulting with local community groups about the timing of environmental flows to coincide with events such as water skiing during the Kanamaroo Festival in Horsham, the Peter Taylor Barefoot Waterski Memorial Tournament in Dimboola and the Horsham triathlon and fishing competitions in the Wimmera River at Horsham, Dimboola and Jeparit.
- Glenelg Hopkins CMA will consider timing the release of a summer fresh to the Glenelg River to align with the Johnny Mullagh Cup cricket match held in Harrow; the match is played by Aboriginal descendants of the first Australian international team that toured England in 1868.

The ability of the VEWH and its partners to deliver these benefits will depend on the weather, climate considerations, the available water and the way the system is being operated to deliver water for other purposes.

Integrated catchment management

Altered water regimes are one of many threats to the health of Victoria's waterways. To be effective, water for the environment planning and releases of water for the environment need to be part of an integrated approach to catchment management. Many of the environmental objectives outlined in this seasonal watering plan will not be fully met without simultaneously addressing issues such as excessive catchment erosion, barriers to fish movement, high nutrient loads, loss of stream bank vegetation and invasive species, to name just a few issues.

Victorian and Australian government agencies, community groups and private landowners collectively implement a wide range of programs that aim to protect and improve the environmental condition and function of land, soils and waterways throughout Victoria's catchments.

Examples of complementary programs that are likely to support environmental watering outcomes in the western region include:

- major works by Glenelg Hopkins CMA to improve fish passage at Sandford Weir and Dergholm Gauge, in combination with delivery of water for the environment to facilitate the movement of migratory fish from the estuary to the upstream reaches of the Glenelg and Wannon rivers
- erosion control by Wimmera CMA in the upper Wimmera catchment to improve water quality
- stock-exclusion fencing along priority waterways by Wimmera and Glenelg Hopkins CMAs throughout the Wimmera and Glenelg catchments, to support the re-establishment of riparian and in-stream vegetation, with over 600 farming families involved along the Glenelg River alone
- carp management activities in both the Wimmera and Glenelg systems to reduce the number of carp and to build understanding about their behaviour in both rivers to facilitate better environmental watering outcomes
- extensive installation of large woody fish habitat in Glenelg River reach 2 using red gum trunks and root balls to restore complex habitat
- control of invasive species in the Wimmera-Mallee wetlands.

For more information about integrated catchment management programs in the western region refer to the Glenelg Hopkins, Wimmera, North Central and Mallee regional catchment strategies and waterway strategies.

Seasonal outlook 2019–20

The western region experienced near-average rainfall through winter 2018, but because the catchment was still very dry from the previous year the catchment run off was low, and most major storages received very modest inflows. The main gains in winter 2018 were flows into Rocklands Reservoir and through the Glenelg tributaries. From early spring 2018 to the end of autumn 2019, rainfall was below average and temperatures were above-average, resulting in system inflows for the entire 2018–19 year that were just 20 percent of the historic average of inflows. For the first time on record, there was no measurable flow in the upper Wimmera River at Huddlestons Weir for the entire year.

Dry and hot conditions over the two previous years caused storage levels to decline to below 40 percent of total storage capacity in early April 2019, and the allocations to the VEWH's entitlement reached a maximum of 55 percent in April 2019. The CEWH did not receive any allocation in 2018–19, but it retained some carryover from previous years which was used.

Waterway managers and the VEWH were cautious with the use of water for the environment in 2018–19, to assure supply for the upcoming 2019–20 year. Some good natural flow in the Glenelg catchment reduced the need for supply of the Glenelg River in winter and spring. In both the Wimmera and Glenelg systems, passing flows were reduced at times and accrued for use late in the year.

Below-average rainfall and above-average temperatures are predicted to continue for the western region through winter 2019. If dry conditions persist, the highest priority for the use of water for the environment will be to protect water quality, maintain connectivity between deep pool habitats and continue to improve the resilience of in-stream native plants and animals. Carryover available going into 2019–20 will be particularly important going into all climatic scenarios this year, as allocation to the environmental entitlements in the western region are not expected to be made in July 2019. It is also unlikely that under drier climatic conditions, without significant inflows to storages during winter and spring, both the wetland entitlement and CEWH's entitlement are expected to receive no allocations in 2019–20.

If conditions become wetter and environmental allocations increase, priority will be given to reserving water for use in 2020–21 and delivering some larger flows to maintain or improve conditions in the waterways and wetlands. The continuing focus of environmental watering in the Wimmera-Mallee wetlands will be to provide refuge and maintain habitat in the dry landscape, to support local plants and animals.

Risk management

During the development of the seasonal watering proposals for the Glenelg and Wimmera systems, environmental watering program partners held a workshop to assess risks associated with potential environmental watering actions for 2019–20 and identify appropriate mitigating strategies. Risks and mitigating actions are continually assessed by program partners throughout the year (see subsection 1.3.6).

4.2 Glenelg system

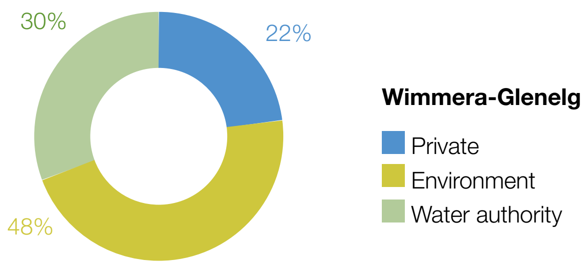
Waterway manager – Glenelg Hopkins Catchment Management Authority

Storage manager – GWMWater

Environmental water holder – Victorian Environmental Water Holder

Did you know ...?

The Glenelg River, known as *Bochara* in the Dhawurd Wurrung language, features in creation stories from the south-west Victoria region and is a traditional boundary between the Gunditjmara, Boandik and Jadawadjali people.



Proportion of water entitlements held across the Wimmera and Glenelg basins held by private users, water corporations or environmental water holders at 30 June 2018.

The Wimmera-Glenelg headworks system captures run-off from both the Wimmera and Glenelg catchments. Entitlements to water held in this system cannot be accounted for separately in the two river basins, therefore this figure shows the proportion of entitlements across both systems.

Top: Glenelg River, by Glenelg Hopkins CMA
Centre: Glenelg spiny freshwater crayfish, by Glenelg Hopkins CMA
Above: Glenelg riverbank in flower, by Glenelg Hopkins CMA

System overview

The Glenelg River rises in the Grampians and flows west through Harrow and then south to Casterton and Dartmoor. The Glenelg River estuary flows west from Dartmoor and passes through South Australia for a short distance before returning to Victoria and flowing into the sea at Nelson. At over 500 km, the Glenelg River is one of the longest rivers in Victoria.

The Glenelg River is an integral part of the Wimmera-Mallee headworks system, which supplies towns and properties across the western region. Moora Moora Reservoir and Rocklands Reservoir, in the upper Glenelg catchment and three weirs on the upper Wannon River, are all used to divert water from the Glenelg system to the Wimmera catchment. Water for the environment is actively managed in the main stem of the Glenelg River between Moora Moora Reservoir and Rocklands Reservoir and below Rocklands Reservoir. Passing-flow rules are in place for the Glenelg River and upper Wannon River.

The priority reaches of the Glenelg River that can be targeted by environmental flow releases are Moora Moora Reservoir to Rocklands Reservoir (reach 0), Rocklands Reservoir to 5-Mile Outlet (reach 1a), 5-Mile Outlet to the confluence with the Chetwynd River (reach 1b), Chetwynd River to the Wannon River (reach 2) and Wannon River to the tidal extent just below the confluence with Crawford River (reach 3). Water for the environment in the Glenelg system is released from Rocklands Reservoir for reach 1a via the reservoir wall outlet and for reach 1b via the 5-Mile and 12-Mile outlets. Releases are made at these points to meet objectives in these reaches as well as reaches 2 and 3. The Glenelg River estuary benefits from releases of water for the environment to upstream reaches, but releases do not currently target the estuary.

The Glenelg River upstream of Rocklands Reservoir (reach 0) runs mostly through the Grampians National Park and retains significant environmental values. Flows through this reach are affected by the operation of Moora Moora Reservoir and work is continuing in 2019–20 to confirm its flow requirements. Work is also continuing to better understand how environmental releases from Rocklands Reservoir can influence the health of the Glenelg River estuary, which is listed as a heritage river reach and a site of international significance under the Ramsar Convention.

Environmental values

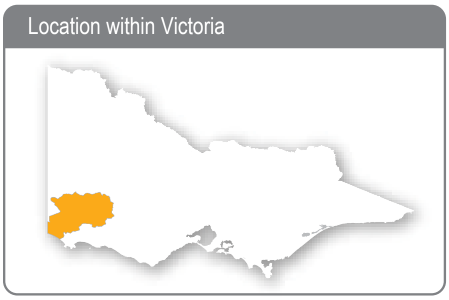
The lower reaches of the Glenelg River are part of a landscape recognised as one of Australia's 15 national biodiversity hotspots. Its listing is due in part to the aquatic life it supports including the endangered Glenelg freshwater mussel and Glenelg spiny crayfish. It is also home to platypus and populations of native fish including river blackfish, estuary perch, tupong and several species of pygmy perch. Some of these fish species migrate long distances upstream from the Glenelg River estuary to complete their life cycles. Frasers Swamp is another important feature of the upper Glenelg system, and is home to a healthy growling grass frog population.

The Glenelg River supports a variety of riparian vegetation communities including the endangered Wimmera bottlebrush. Riparian and floodplain vegetation is comprised of river red gum woodlands with paperbark, bottlebrush and tea tree understorey.

Environmental objectives in the Glenelg River

	Protect and increase populations of native fish
	Maintain deep pool habitats and connectivity along the river
	Maintain the platypus population
	Maintain the health and increase the abundance of in-stream and riparian vegetation (such as river red gums and Wimmera River bottlebrush)
	Maintain a wide range and large number of waterbugs to provide energy, break down organic matter and support the river's food chain
	Maintain water quality for native fish, waterbugs, aquatic vegetation and other water-dependent animals

Figure 4.2.1 The Glenelg system



Grey river reaches have been included for context. The numbered reaches indicate where relevant environmental flow studies have been undertaken. Coloured reaches can receive environmental water.

Recent conditions

The regions experienced below-average rainfall for much of 2018–19. Several natural high-flow events in July and August 2018 met many of the environmental flow objectives for those months, but inflows to storages were well-below average between September 2018 and April 2019. The dry conditions meant the VEWH only received a portion of allocation against its Wimmera-Glenelg environmental entitlement. As of March 2019, the VEWH had received 55 percent allocation for the year, but the total volume of available water for the environment was supplemented by system reserves that were carried over from 2017–18. Passing flows were suspended during the high-flow events in July and August, to reduce the flood risk to communities downstream of Rocklands Reservoir, and water accumulated at those times was used to help meet environmental objectives in spring.

A combination of natural inflows and managed environmental flows maintained continuous flow between Rocklands Reservoir and the Glenelg estuary for most of 2018–19. The only disruption to this flow occurred in March 2019, when releases were suspended for two weeks to allow maintenance works on headworks infrastructure, carp screen cleaning and an upgrade of the Sandford fishway.

Water for the environment was used throughout the year to provide opportunities for native fish, platypus and crayfish to disperse between river reaches and to access a variety of habitats throughout the system. Spring flows also watered riparian vegetation including recently recruited seedlings, and helped move nutrients, leaf litter and small branches from the riverbank into the river channel where they can provide food, energy and habitat for aquatic biota. Low flows delivered during 2018–19 maintained the quality and quantity of water in riffles and pools along the river, to provide suitable habitat for waterbugs, native fish and other aquatic species. Occasional freshes reduced salinity and water temperature and increased dissolved oxygen concentrations in deeper pools along the river system.

Hot and dry conditions through summer and autumn increased seepage and evaporation losses, which meant that some target low flows did not achieve intended flow rates in downstream reaches. Fish monitoring conducted as part of the Victorian Environmental Flows Monitoring Assessment Program (VEFMAP) in autumn recorded a nationally threatened Australian grayling in the Glenelg River below Casterton (reach 3) for the first time in 122 years. The presence of Australian grayling and other fish species that rely on specific flows in freshwater reaches and the estuary indicates that managed environmental flows in the Glenelg River are helping to meet the requirements of native fish.

In late November 2018, water for the environment was delivered over 12 days to reach 0 from Moora Moora Reservoir. This is the second time water for the environment has been released from Moora Moora Reservoir, and the event was monitored to understand how water can be delivered from the reservoir to maintain and improve remnant plant and animal populations. Temporary gauges installed in reach 0 showed that the released water spread along several natural flow paths and did not contribute any detectable flow at the end of the reach.

Scope of environmental watering

Table 4.2.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

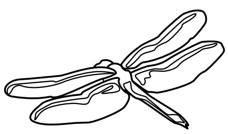


Table 4.2.1 Potential environmental watering actions and objectives for the Glenelg system

Potential environmental watering action	Functional watering objective	Environmental objective
Summer/autumn freshes targeting reach 1a (two freshes of 60 ML/day for two to three days each during December to May)	• Scour sand from pools to increase the quality and quantity of fish and waterbug habitat • Inundate emergent vegetation on the lower banks • Flush pools to improve water quality and lower temperatures • Provide sufficient flow to allow platypus to access habitat	
Summer/autumn freshes targeting reaches 1b (two freshes of 100 ML/day for two to three days each during December to May)		
Summer/autumn freshes targeting reach 2 (two freshes of 150 ML/day for two to three days each during December to May)		
Summer/autumn freshes targeting reach 3 (two freshes of 150 ML/day for three days each or natural during January to April)		
Summer/autumn low flows targeting reach 1a (10 ML/day or natural during December to May)[1]	• Protect against rapid water quality decline over the low-flow period • Maintain edge habitats, pools and shallow-water habitat for fish, waterbugs and platypus • Maintain a near-permanent inundated stream channel to promote the growth of in-stream vegetation and prevent encroachment by terrestrial plants	
Summer/autumn low flows targeting reach 1b (15 ML/day or natural during December to May)[1]		
Summer/autumn low flows targeting reach 2 (25 ML/day or natural during December to May)[1]		
Summer/autumn low flows targeting reach 3 (80 ML/day or natural during January to April)		
Autumn/winter low flows targeting reach 3 (260 ML/day or natural during May to June)	• Trigger fish movement and possibly assist seagrass germination in the estuarine reach downstream of reach 3, as based on estuary salinity profiles	
Winter/spring freshes targeting reach 1b (one to five freshes of 250 ML/day for one to five days during June to November)[2]	• Wet benches to improve the condition of emergent vegetation and maintain habitat diversity • Provide adequate depth for fish passage and cue fish movement • Provide triggers for platypus burrow selection • Scour sand from pools to improve the quality of fish habitat • Inundate vegetation in the river channel and on the channel benches to support recruitment and growth	
Winter/spring freshes targeting reach 2 (one to five freshes of 300 ML/day for one to five days during June to November)		
Winter/spring low flows targeting reach 1a (60 ML/day or natural during June to November)[1,3]	• Maintain water quality for fish and waterbugs • Inundate aquatic vegetation to maintain its condition and prevent encroachment by terrestrial species • Maintain shallow-water habitat for fish, waterbugs and platypus	
Winter/spring low flows targeting reach 1b (100 ML or natural per day during June to November)[1,3]		
Winter/spring low flows targeting reach 2 (160 ML/day or natural during June to November)[1,3]		
Winter/spring low flows targeting reach 3 (400 ML/day or natural during July to December)	• Inundate benches to increase habitat and allow widespread fish passage and keep the estuary mouth open (based on estuary mouth flows)	

Table 4.2.1 Potential environmental watering actions and objectives for the Glenelg system *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Winter/spring trial release to reach 0 (up to 50 ML/day during July to November)	• Develop an operational understanding of our ability to deliver environmental flows to support plant, waterbug and animal populations in this reach including the capacity of infrastructure, metering and safety considerations	

[1] *Cease-to-flow events occur naturally in the Glenelg system and may be actively managed with deliveries of water for the environment to reduce stress on environmental values. In the most-recent flows study, the recommendation is that cease-to-flow events should occur as infrequently as possible and not exceed the duration of events that might have occurred naturally. Cease-to-flow events ideally should be followed with a fresh.*

[2] *Winter/spring freshes in reach 1a are important to the health of the Glenelg River but due to operational constraints and potential flooding risks they can only be achieved through natural events.*

[3] *Passing flows provided under the environmental entitlement generally provide winter/spring low flows. However, if passing flows are reduced, managed releases of water for the environment may be required to supplement them.*

Scenario planning

Table 4.2.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

While proposed watering actions are similar in each climatic scenario, the magnitude, duration and/or frequency differ between scenarios. Moreover, the proportion of each action that is likely to be delivered by natural inflows will also vary between scenarios. For these reasons, the volume of water for the environmental required under each scenario also differs.

The highest priorities (tier 1a) under drought conditions are to deliver summer/autumn low flows in reaches 1a, 1b and 2. These flows will be used to maintain connectivity and water quality between pool habitats upstream of Casterton, in reach 2. Additional priority actions under dry, average and wet climate scenarios include summer/autumn freshes in all reaches and winter/spring low flows in reach 1a. The only exception to this are the summer/autumn freshes in reach 3 under average conditions, that are likely to benefit from freshes delivered in reach 2 as well as tributary inflows under wetter conditions.

The flows described above are unlikely to meet all environmental objectives however, as under a drought scenario flows of shorter duration are expected throughout the Glenelg River and a lower number of freshes than recommended is likely. Extended periods of cease-to-flow are likely to occur below Casterton, especially during drought and dry conditions, which increases the risks of fish kills, high salinity and blue-green algae blooms in the lower reaches of the Glenelg River. To mitigate the risks, it will be important to secure supply to deliver summer/autumn freshes in all reaches, as well as summer/autumn lows flows, to extend flows to Dartmoor in reach 3 under drought conditions. Extending summer/autumn low flows to reach 3, delivering winter/spring freshes in reach 1b and reach 2 and winter/spring low flows in reach 1a and reach 1b are a high priority under dry conditions, with summer/autumn freshes in reach 3 under average conditions. Under wet conditions, delivering winter/spring freshes in reach 1b and reach 2 are a high priority.

Additional priorities (tier 2) under dry to wet conditions are delivering the full watering regimes during the water year in the Glenelg River including winter/spring freshes to reach 2 in drought conditions and extending winter/spring low flows through to reach 3 in dry to wet conditions.

A third trial release to reach 0 from Moora Moora Reservoir is planned subject to climatic conditions and water availability. Releases aim to improve the understanding of how water for the environment can be delivered from Moora Moora Reservoir to support important plant and animal populations in reach 0. Water monitoring associated with the planned release will be used to refine the preliminary environmental flow recommendations that were developed in 2013. Delivering a trial flow in reach 0 is a high priority under dry, average and wet climatic conditions, although natural inflows under average and wet scenarios may make it difficult to distinguish the effect of managed releases. The trial flow is therefore identified as a tier 1a watering action under dry conditions and a tier 1b watering action under average and wet conditions. The trial delivery to reach 0 is a lower priority in drought conditions because any available water for the environment will be used to maintain critical habitat for aquatic life.

Reserving water for carryover into the 2020–21 water year will be a priority under all scenarios to ensure sufficient water is available to deliver the highest-priority flows during summer and autumn 2021. The volume carried over against the Wimmera-Glenelg environmental entitlement will be decided through consultation with both Wimmera and Glenelg Hopkins CMAs during the year and will be based on use during 2019–20, seasonal conditions and seasonal outlooks for 2020–21.

Table 4.2.2 Potential environmental watering for the Glenelg system under a range of planning scenarios

Planning scenario[1]	Drought	Dry	Average	Wet
Expected availability of water for the environment[2, 3]	• 35,600 ML	• 49,400 ML	• 63,600 ML	• 73,800 ML
Expected river conditions	• Some passing, compensation and low unregulated flows, particularly in winter/spring	• Some passing, compensation and low unregulated flows, particularly in winter/spring	• Some passing, compensation and unregulated flows, particularly in winter/spring	• Passing flows and unregulated flows meet some watering requirements in winter/spring
Potential environmental watering – tier 1a (high priorities)	• Summer/autumn low flows reach 1b • Summer/autumn low flows reach 2 • Summer/autumn low flows reach 1a	• Summer/autumn low flows reach 1b • Summer/autumn low flows reach 2 • Two summer/ autumn freshes reach 3 • Two summer/ autumn freshes reach 1b • Two summer/ autumn freshes reach 2 • Winter/spring trial release reach 0 • Summer/autumn low flows reach 1a • Two summer/ autumn freshes reach 1a	• Summer/autumn low flows reach 1a • Summer/autumn low flows reach 1b • Summer/autumn low flows reach 2 • Two summer/ autumn freshes reach 1b • Two summer/ autumn freshes reach 2 • Winter/spring low flows reach 1a • Two summer/ autumn freshes reach 1a	• Summer/autumn low flows reach 1a • Summer/autumn low flows reach 1b • Summer/autumn low flows reach 2 • Summer/autumn low flows reach 3 • Two summer/ autumn freshes reach 1b • Two summer/ autumn freshes reach 2 • Two summer/ autumn freshes reach 3 • Two summer/ autumn freshes reach 1a • Winter/spring low flows reach 1a
Potential environmental watering – tier 1b (high priorities with shortfall)	• Two summer/ autumn freshes reach 1b • Two summer/ autumn freshes reach 2 • Two summer/ autumn freshes reach 3 • Summer/autumn low flows reach 3 • Two summer/ autumn freshes reach 1a	• Summer/autumn low flows reach 3 • Two winter/spring freshes reach 1b • Two winter/spring freshes reach 2 • Winter/spring low flows reach 1a • Winter/spring low flows reach 1b	• Summer/autumn low flows reach 3 • Two summer/ autumn freshes reach 3 • Three winter/spring freshes reach 1b • Three winter/spring freshes reach 2 • Winter/spring trial release reach 0 • Winter/spring low flows reach 1b	• Five winter/spring freshes 1b • Winter/spring trial release reach 0 • Five winter/spring freshes reach 2

Table 4.2.2 Potential environmental watering for the Glenelg system under a range of planning scenarios *continued...*

Planning scenario[1]	Drought	Dry	Average	Wet
Potential environmental watering – tier 2 (additional priorities)	• Winter/spring low flows reaches 1a • Winter/spring low flows reaches 1b • Two winter/spring freshes reach 1b • Two winter/spring freshes reach 2 • Winter/spring trial release reach 0 • Winter/spring low flows reach 2	• Winter/spring low flows reach 2 • Winter/spring low flows reach 3	• Winter/spring low flows reach 2 • Winter/spring low flows reach 3	• Winter/spring low flows reach 2 • Winter/spring low flows reach 3
Possible volume of water for the environment required to achieve objective[4]	• 10,115 ML (tier 1a) • 8,760 ML (tier 1b) • 35,063 ML (tier 2)	• 14,779 ML (tier 1a) • 26,313 ML (tier 1b) • 12,190 ML (tier 2)	• 19,293 ML (tier 1a) • 19,002 ML (tier 1b) • 19,813 ML (tier 2)	• 23,927 ML (tier 1a) • 13,579 ML (tier 1b) • 12,349 ML (tier 2)

1 *Potential watering actions are listed in priority order for each planning scenario.*

2 *Water for the environment in the Wimmera-Glenelg system held by the VEWH is shared between the Glenelg and Wimmera systems. The VEWH volumes specified show the likely availability of the VEWH's environmental entitlement for both systems.*

3 *The VEWH volumes specified include volumes carried over from 2018–19 and expected allocations to be made to the Glenelg River Compensation Flows account in 2019–20. The Compensation Flows allocation can only be used in the Glenelg River.*

4 *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

4.3 Wimmera system

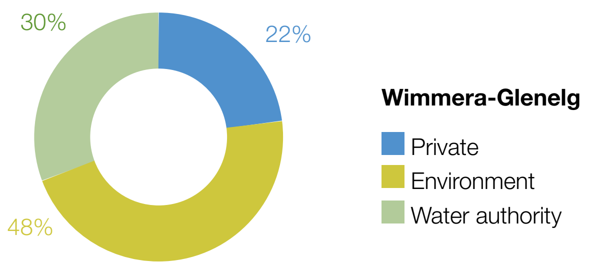
Waterway manager – Wimmera Catchment Management Authority

Storage manager – GWMWater

Environmental water holders – Victorian Environmental Water Holder, Commonwealth Environmental Water Holder

Did you know ...?

The Wimmera River is known as *Barringgi Gadyin* to the Wotjobaluk Traditional Owners and is a key feature of the local creation story. In 2018–19 water for the environment was delivered to Ranch Billabong for the first time in partnership with the Barengi Gadjin Land Council Aboriginal Corporation, to help restore native plant and animal habitats on their Country.



Proportion of water entitlements held across the Wimmera and Glenelg basins held by private users, water corporations or environmental water holders at 30 June 2018.

The Wimmera-Glenelg headworks system captures run-off from both the Wimmera and Glenelg catchments. Entitlements to water held in this system cannot be accounted for separately in the two river basins, therefore this figure shows the proportion of entitlements across both systems.

Top: Wimmera River at Ellis' Crossing, by Greg Fletcher, Wimmera CMA
Centre: Great cormorant at Mt William Creek, by Greg Fletcher, Wimmera CMA
Above: Watering at Ranch Billabong, a first for culture and environment, by Greg Fletcher, Wimmera CMA

System overview

The Wimmera River rises in the Pyrenees Range near Elmhurst and flows through Horsham, Dimboola and Jeparit before terminating at Lake Hindmarsh, which is Victoria's largest freshwater lake and the first of a series of terminal lakes. The Wimmera River receives flows from several regulated tributaries including the MacKenzie River and the Mount William and Burnt creeks. These tributaries, Bungalally Creek and the Wimmera River downstream of Mount William Creek can receive environmental flows. In exceptionally wet periods, Lake Hindmarsh may overflow into Outlet Creek and on to Lake Albacutya, which is an internationally recognised Ramsar-listed wetland. There are numerous wetlands beyond Lake Albacutya as well, which have not filled with water for decades.

Water in the Wimmera system is stored in three on-stream reservoirs — Lake Wartook on the MacKenzie River, Lake Lonsdale on Mount William Creek and Lake Bellfield on Fyans Creek — and in several off-stream storages — Taylors Lake, Lake Fyans and Toolondo Reservoir. A channel system enables water to be moved between several storages. Water can also be transferred from Rocklands Reservoir in the Glenelg system to the Wimmera system via the Rocklands–Toolondo Channel and from Moora Moora Reservoir via the Moora Channel. The connected storages and channels are collectively called the Wimmera—Mallee System Headworks, and harvested water is used for towns and stock and domestic supply throughout the Wimmera catchment and parts of the Avoca, Hopkins, Loddon, Glenelg and Mallee catchments. Passing flows are provided to the Wimmera River and to lower Mount William and Fyans creeks.

Priority reaches in the Wimmera system that can receive water for the environment are Wimmera River reaches 3 and 4, MacKenzie River reaches 2 and 3, upper and lower Mount William Creek, upper and lower Burnt Creek and Bungalally Creek.

Yarriambiack Creek is a distributary of the upper Wimmera River that would have naturally received some flows during high-flow events. Modifications to the Yarriambiack Creek offtake increase flow rates in Yarriambiack Creek but reduce the transfer of water for the environment to the high-priority reaches of the Wimmera River. During very dry years, flows entering Yarriambiack Creek may be blocked to ensure watering objectives in the Wimmera River are not compromised.

Two wetlands in the Wimmera system have been included in the environmental watering program in recent years.

Dock Lake, one of the Wimmera's large terminal lakes near Horsham, would have naturally filled when the nearby Green Lake filled and overflowed. In the 1930s, Dock Lake was modified to allow it to be used as a water storage for irrigation supply in the Wimmera-Mallee system. Dock Lake was removed from the supply system after the completion of the Wimmera-Mallee pipeline in 2010 and is now an ephemeral system. In late 2016, large-scale flooding in the catchment partially filled Dock Lake when Green Lake filled and overflowed. Managed water deliveries can now only be delivered through a small channel from Green Lake, when there is enough water in Green Lake to gravity-feed Dock Lake.

Ranch Billabong, near Dimboola, is located on land managed by Barengi Gadjin Land Council Aboriginal Corporation (BGLC). The billabong system was disconnected from the Wimmera River by levees. These levees and river regulation in the Wimmera River have significantly altered the natural water regime of Ranch Billabong. Restoring habitat for native animals, fish and plant communities at Ranch Billabong is an important outcome for the environment, Traditional Owners and their Nations.

Environmental values

The Wimmera system is home to many plant and animal species. It supports populations of native fish such as flat-headed gudgeon, obscure galaxias, river blackfish, southern pygmy perch and Australian smelt. Populations of the critically endangered Wimmera bottlebrush also occur along the MacKenzie River other locations near the Grampians.

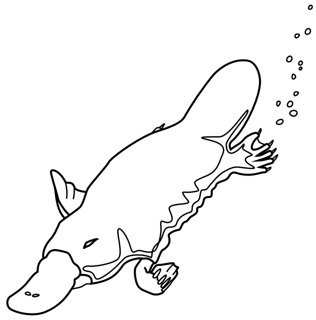
The Wimmera River supports abundant native fish, waterbird, turtle, frog and rakali (water rats) populations and one of Victoria's few self-sustaining populations of freshwater catfish.

The MacKenzie River contains the only self-sustaining population of platypus in the Wimmera system and supports populations of native fish including river blackfish and southern pygmy perch. It also supports threatened Glenelg spiny crayfish and western swamp crayfish and turtles. During dry periods, the middle and upper reaches of the MacKenzie River maintain regular flow (due to managed releases from Lake Wartook for consumptive supplies and environmental watering) and provide refuge for these populations.

Vegetation along Burnt and Bungalally creeks provide habitat corridors for terrestrial and riparian wildlife and upper Burnt Creek contains an important native fish community and a population of threatened western swamp crayfish. Mount William Creek supports regionally important populations of river blackfish and southern pygmy perch.

Dock Lake is a natural wetland that was modified and used as part of the Wimmera-Mallee headworks system until 2010. When it is inundated, Dock Lake supports large populations of feeding and breeding waterbirds. It also supports frogs and small-bodied native fish.

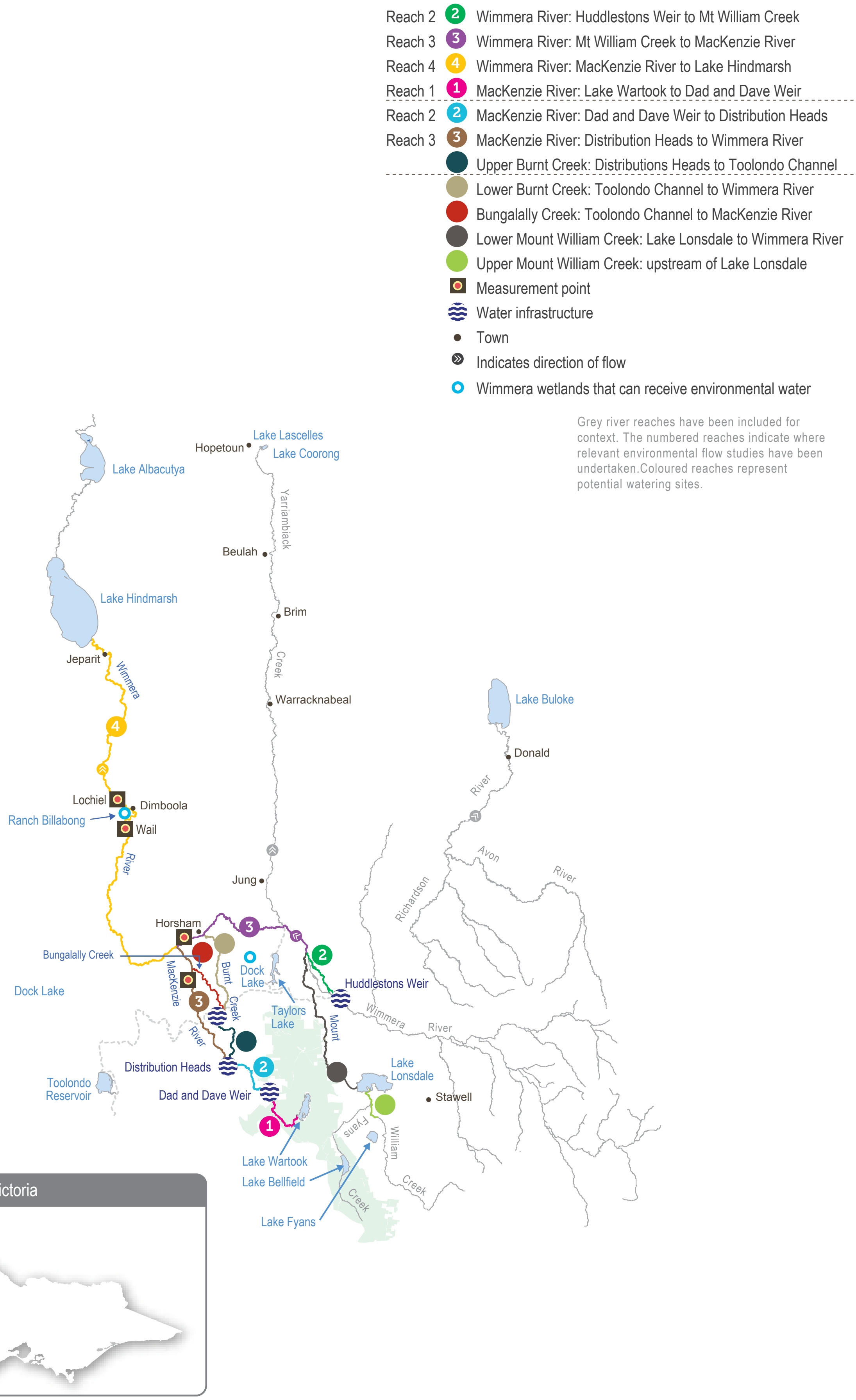
Ranch Billabong is a small wetland near Dimboola that supports river red gum trees, a variety of aquatic and amphibious plant species, ducks and frogs.



Environmental objectives in the Wimmera system

Protect and increase populations of native fish including one of Victoria's few self-sustaining populations of freshwater catfish
Maintain the frog population by providing feeding and breeding habitat
Maintain channel capacity and diversity as well as prevent colonisation of waterways by terrestrial plant species
Maintain and increase the resident platypus population by providing places to breed and feed, as well as opportunities for juveniles to disperse
Maintain the turtle population by providing feeding and breeding habitat
Improve the condition, abundance and diversity of aquatic, emergent and riparian vegetation
Increase the waterbird population by providing roosting, feeding and breeding habitat
Increase the abundance and diversity of waterbugs, which break down dead organic matter and support the waterway's food chain Maintain the crayfish population by providing feeding and breeding habitat
Maintain and improve water quality to provide suitable conditions for waterbugs, native fish and other water-dependent plants and animals
Aboriginal environmental outcomes
Watering is planned to be delivered in partnership with Traditional Owners and achieve Aboriginal environmental outcomes

Figure 4.3.1 The Wimmera system



Recent conditions

The Wimmera region has experienced below-average rainfall for most of the last two years. Local rainfall in late winter 2018 generated modest run off in the eastern parts of the catchment, but western tributaries had very little to no flow throughout 2018–19 and no flow was recorded in the upper Wimmera River (measured at Glenorchy) for the first time since records began in the mid-1960s. Some unregulated flows in the Wimmera River's eastern tributaries provided low flows in the lower Wimmera and MacKenzie river systems. Low volumes of passing flows that were available at Lake Lonsdale were suspended in winter and subsequently released during spring to meet Wimmera River flow objectives.

The dry conditions meant the VEWH only received a portion of allocation against its Wimmera-Glenelg environmental entitlement. As of March 2019, the VEWH had received 55 percent allocation for the year, but the total volume of available water for the environment was supplemented by system reserves that were carried over from 2017–18. The Commonwealth Environmental Water Holder (CEWH) did not receive any allocation in 2017–18 or 2018–19. The water that was allocated to the CEWH in 2016–17 was carried over and used in the Wimmera system during 2018–19 to support environmental outcomes in the Wimmera River and Mount William Creek.

The modest inflows from tributaries during winter and deliveries of water for the environment have maintained and protected the condition of the rivers and creeks, despite the very dry conditions experienced in the Wimmera system during 2018–19.

Fish monitoring conducted as part of the Victorian Environmental Flows Monitoring Assessment Program (VEFMAP) in autumn 2018 showed that populations of golden perch, freshwater catfish and small-bodied native fish have been maintained in all reaches of the Wimmera River that could receive water for the environment. In Mount William Creek, the continued improvement of both fringing and in-stream vegetation is supporting a stable population of small-bodied fish including obscure galaxias and flat-headed gudgeons. Platypus surveys in the MacKenzie River in April 2018 also showed the platypus population has grown and doubled its range within the river since 2016. However, the MacKenzie River platypus population remains small and lacks genetic diversity and potential translocations are being considered to boost its resilience.

Scope of environmental watering

Table 4.3.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 4.3.1 Potential environmental watering actions and objectives for the Wimmera system

Potential environmental watering action	Functional watering objective	Environmental objective
Wimmera River (reach 4)		
Summer/autumn low flows (15–30 ML/day or natural[1] during December to May)	• Maintain in-stream habitat to support native fish populations and waterbugs • Maintain near-permanent inundated stream channel for riparian vegetation and to prevent the growth of terrestrial plants in the stream bed	
Winter/spring low flows (15–30 ML/day during June to November)	• Provide flow variability to maintain access to habitat for native fish, waterbugs and in-stream vegetation	
Summer/autumn freshes (one to three freshes of 70 ML/day for two to seven days during December to May)	• Flush pools to improve water quality and maintain habitat for fish and waterbugs • Provide fish passage to allow fish to move through the reach	
Winter/spring freshes (one to five freshes of 70 ML/day for one to four days during June to November)	• Increase water depth to provide stimulus for fish movement • Provide flow variability to maintain water quality and diversity of fish habitats • Wet lower benches, entraining organic debris and promoting habitat diversity for waterbugs	

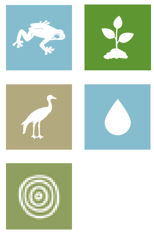
Table 4.3.1 Potential environmental watering actions and objectives for the Wimmera system *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Winter/spring freshes (one to three freshes of 200 ML/day for one to three days during June to November)[2]	• Provide variable flow for native fish movement • Maintain water quality and habitat diversity by flushing surface sediments from hard substrates for macroinvertebrates	
MacKenzie River (reach 2 and 3)		
Year-round low flows (of 2–27 ML/day or natural, year-round)[1]	• Maintain edge habitats and deeper pools and runs for waterbugs • Maintain near-permanent inundated stream channel for riparian vegetation and to prevent the growth of terrestrial plants in the stream bed, and to support the growth of aquatic vegetation for fish habitat • Maintain a sufficient area of pool habitat for native fish and crayfish populations • Facilitate the annual dispersal of juvenile platypus into the Wimmera River	
Summer/autumn freshes (three to four freshes of 5–50 ML/day for two to seven days each during December to May)	• Provide variable flows in the low-flow season for fish movement • Maintain water quality and habitat diversity for waterbugs	
Winter/spring freshes (five freshes of 35–55 ML/day for two to seven days during June to November)	• Stimulate fish movement by increasing flow rates and water depth • Maintain water quality • Increase habitat availability and connectivity for aquatic species including in-stream and riparian vegetation, platypus, native fish and waterbugs	
Winter/spring freshes (one to five freshes of up to 130–190 ML/day for one to four days during June to November)	• Stimulate fish movement and maintain water quality • Flush sediments from hard substrates to support waterbugs • Wet the higher benches to entrain organic debris and promote habitat diversity for aquatic species including in-stream and riparian vegetation, platypus, native fish and waterbugs	
Burnt Creek		
Year-round low flows targeting upper Burnt Creek (1 ML/day or natural, year-round)[1]	• Maintain edge habitats and shallow-water habitat for waterbugs • Maintain the inundated stream channel to protect riparian vegetation and prevent excessive stream bed colonisation by terrestrial vegetation species • Maintain a sufficient area of pool habitat for native fish and crayfish populations	
Summer/autumn freshes targeting upper Burnt Creek (three freshes of 30 ML/day for two to seven days each during December to May)	• Prevent a decline in water quality by flushing pools in the low flow season	

Table 4.3.1 Potential environmental watering actions and objectives for the Wimmera system *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Winter/spring freshes targeting upper Burnt Creek (one to five freshes of 55 ML/ day for three to seven days during June to November)	• Allow fish to move throughout the reach • Flush sediments from hard substrates to increase biofilm production and food for waterbugs	
Winter/spring freshes targeting upper Burnt Creek (one to three freshes of up to 160 ML/ day for one to three days during June to November)	• Disturb biofilms present on rocks or woody debris, to stimulate new growth and provide food for waterbugs	
Year-round fresh targeting lower Burnt Creek (one fresh of 45 ML/day or natural for two days at any time)[3]	• Inundate riparian vegetation to maintain plant condition and facilitate recruitment • Move organic debris in the channel to support waterbugs • Maintain the structural integrity of the channel	
Mount William Creek		
Top-up of upper Mount William Creek pools (winter/spring and summer/autumn)	• Maintain habitat for native fish and waterbugs	
Year-round low flows targeting lower Mount William Creek (5 ML/day or natural, year-round)[1]	• Maintain edge habitats and shallow-water habitat for waterbugs and endemic fish • Maintain near-permanent inundated stream channel for riparian vegetation and to prevent the growth of terrestrial plants in the stream bed	
Summer/autumn freshes targeting lower Mount William Creek (three freshes of 20–30 ML/day for two to seven days during December to May)	• Prevent a decline in water quality by flushing pools during low flows • Provide variable flows and habitat diversity during the low-flow season for waterbugs, for fish movement and to maintain water quality	
Winter/spring freshes targeting lower Mount William Creek (one to five freshes of up to 100 ML/day for one to seven days during June to November)	• Wet benches to entrain organic debris and promote habitat diversity for native fish • Flush surface sediments from hard substrates to support waterbugs	
Bungalally Creek		
Bankfull (one fresh of 60 ML/day for two days at any time)[3]	• Inundate the riparian zone to maintain its condition and facilitate the recruitment of riparian vegetation communities • Maintain the structural integrity of the channel and prevent the loss of channel capacity	
Dock Lake		
Partial fill (winter/spring)	• Maintain and improve the diversity and abundance of wetland vegetation • Support feeding and breeding habitat for waterbirds, frogs, waterbugs and turtles	

Table 4.3.1 Potential environmental watering actions and objectives for the Wimmera system *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Ranch Billabong		
Top-ups (winter/spring and summer/autumn)	• Maintain and improve wetland vegetation diversity and abundance • Improve water quality for frogs and waterbirds	

[1] *Cease-to-flow events occur naturally in the Wimmera system and may be actively managed with deliveries of water for the environment to reduce stress on environmental values. In the most-recent flow study, the recommendation is that cease-to-flow events should occur as infrequently as possible and not exceed the duration of events that might have occurred naturally. Cease-to-flow may be managed to conserve water for the environment allocation, and events ideally should be followed with a fresh.*

[2] *Depending on catchment conditions, the timing of this fresh may vary to optimise environmental outcomes.*

[3] *These actions will only occur if on-ground works have been completed to prevent third-party impacts potentially caused by bankfull events in these creeks.*

Scenario planning

Table 4.3.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Similar watering actions are planned under each climate scenario for 2019–20, but the magnitude, duration and frequency of specific watering actions may vary, depending on likely water availability and the extent to which actions are met by natural events. For example, a low-priority action under a dry climate scenario may become a high-priority action under an average to wet scenario if more water is available. The environmental watering demands presented under each climate scenario reflect the environmental objectives for different climate scenarios.

If current dry conditions continue, it is unlikely that water for the environment will be able to be delivered from Lake Lonsdale. Under these circumstances, Mount William Creek downstream of Lake Lonsdale will receive little to no flow, and most demands for the Wimmera River will need to be met from Taylors Lake.

The highest priorities (tier 1a) under extreme drought conditions are to deliver summer/autumn low flows, summer/autumn freshes, winter/spring freshes and winter/spring low flows in MacKenzie reaches 2 and 3, Wimmera River reach 4, upper Burnt Creek and to provide top-ups to Ranch Billabong and upper Mount William Creek. Additional priority actions under very dry, dry, average and wet climate scenarios include winter/spring freshes in MacKenzie River reach 3 and delivering additional freshes and larger-magnitude low flows in the MacKenzie River, Wimmera River reach 4 and upper Burnt Creek. Delivering flows in lower Mount William Creek in very dry to wet conditions is a priority if Lake Lonsdale gets sufficient inflows and water quality improves. In average and wet conditions, bankfull flows in lower Burnt Creek and Bungalally Creek will be a priority.

The flows described above are unlikely to meet the environmental objectives under all conditions, with significant ecological consequences of shorter-duration and lower-than-recommended freshes occurring through the system's rivers and creeks. Extended periods of cease-to-flow are likely to occur, especially during extreme drought, very dry and dry conditions, which increases the risk of fish deaths, high salinity and blue-green algae blooms in all river and creek systems in the Wimmera. To mitigate the risks, ensuring sufficient supply to provide additional flows (tier 2) such as extra freshes in the Wimmera River reach 4 and MacKenzie River reach 3 and increased duration of winter/spring low flows in MacKenzie River reach 3, Wimmera River reach 4, upper Burnt Creek and lower Mount William Creek are a priority under very dry conditions. Additionally, increasing the duration of low flows and delivering additional freshes during summer/autumn in upper Burnt Creek and lower Mount William Creek, will provide some improvement to water quality during the drier months. In dry to wet conditions, the additional supply of water for the environment is required to increase the duration, magnitude and number of low flows and freshes delivered during the season to improve water quality and increase the habitat available to aquatic plants and animals.

Additional priorities under dry to wet conditions are maximising the duration and magnitude of the flows delivered in summer/autumn and winter/spring to be in line with the recommended watering regimes for the Wimmera River, MacKenzie River, upper Burnt Creek and lower Mount William Creek. These flows provide additional benefits for the native fish, waterbugs, aquatic plants and riparian plants that rely on larger flows under these conditions to improve populations or resilience in future years. Under average and wet conditions, unregulated flows and increased allocations of water for the environment will provide an opportunity for more environmental watering objectives to be met, with some flows being met by natural river flows and passing flows.

A partial fill of Dock Lake is planned in average or wet seasonal conditions. There are substantial delivery obstacles to overcome before environmental watering of Dock Lake can occur, but if possible, it would be the first time the wetland has received water for the environment. Water for the environment delivered to this wetland may trigger another substantial waterbird response, similar to the outcomes from water diverted to Dock Lake by GWMWater during the 2016 floods.

Under all climate scenarios, a small volume of water for the environment may be delivered to top up Ranch Billabong near Dimboola, to support wetland and riparian vegetation. Water delivered will help to restore and build on the environmental outcomes and improve water quality for waterbirds and frogs in the billabong. This wetland cannot receive natural flows from the Wimmera River due to levee banks under regulated conditions, and it requires water to be pumped from the river to the billabong.

Reserving water for carryover into the 2020–21 water year will be a priority under all scenarios, to ensure sufficient water is available to deliver the highest-priority flows during summer and autumn 2021. The volume carried over against the Wimmera-Glenelg environmental entitlement will be decided in consultation with the Wimmera and Glenelg Hopkins CMAs during the year, and it will be based on use during 2019–20, seasonal conditions and seasonal outlooks for 2020–21.

With drier conditions expected in the western region, waterway managers are exploring contingency measures (such as using the Wimmera-Mallee pipeline network) to pipe water for the environment directly into critical refuges sites in some river systems.[6]

6 *A variation to the seasonal watering plan would be required to complete watering actions such as these.*

Table 4.3.2 Potential environmental watering for the Wimmera system under a range of planning scenarios

Planning scenario	Extreme drought	Very dry	Dry	Average	Wet
Expected river conditions	• No passing flows or unregulated flows	• Some passing flows but no unregulated flows	• Some passing but no unregulated flows	• Passing and unregulated flows particularly in winter/spring	• Passing flows and unregulated flows
Expected availability of water for the environment entitlements[1,2]	• 29,900 ML	• 35,500 ML	• 49,300 ML	• 62,700 ML	• 70,400 ML
Potential environmental watering – tier 1a (high priorities)[3]					
MacKenzie River reaches 2 & 3	• Summer/ autumn low flows reach 2 and reach 3[3] • Three summer/ autumn freshes reach 2 • Winter/spring low flows reach 2	• Summer/ autumn low flows reach 2 and reach 3[3] • Three summer/ autumn freshes reach 2 • Winter/spring low flows reach 3 • One winter/ spring freshes reach 3	• Summer/ autumn low flows reach 2 and reach 3[3] • Four summer/ autumn freshes reach 2 • Winter/spring low flows reach 3 • Two winter/ spring freshes reach 3	• Summer/ autumn low flows reach 3 • Four summer/ autumn freshes reach 3 • Winter/spring low flows reach 3 • Five winter/ spring freshes reach 3	• Summer/ autumn low flows reach 3 • Four summer/ autumn freshes reach 3 • Winter/spring low flows reach 3 • Five winter/ spring freshes reach 3
Wimmera River reach 4	• Summer/ autumn low flows • One summer/ autumn freshes • Winter/spring low flows • One winter/ spring freshes	• Summer/ autumn low flows • Two summer/ autumn freshes • Winter/spring low flows • One winter/ spring freshes	• Summer/ autumn low flows • Two summer/ autumn freshes • Winter/spring low flows • Two winter/ spring freshes	• Summer/ autumn low flows • Two summer/ autumn freshes • Winter/spring low flows • Five winter/ spring freshes	• Summer/ autumn low flows • Three summer/ autumn freshes • Winter/spring low flows • Five winter/ spring freshes

Table 4.3.2 Potential environmental watering for the Wimmera system under a range of planning scenarios *continued...*

Planning scenario	Extreme drought	Very dry	Dry	Average	Wet
Upper Burnt Creek	• Summer/ autumn low flows • Three summer/ autumn freshes • Winter/spring low flows	• Summer/ autumn low flows • Three summer/ autumn freshes • Winter/spring low flows	• Summer/ autumn low flows • Three summer/ autumn freshes • Winter/spring low flows	• Summer/ autumn low flows • Three summer/ autumn freshes • Winter/spring low flows	• Summer/ autumn low flows • Three summer/ autumn freshes • Winter/spring low flows
Upper Mount William Creek	• Top-ups	• Top-ups	• Top-ups	• N/A	• N/A
Lower Mount William Creek	• N/A	• N/A	• Summer/ autumn low flows • Three summer/ autumn freshes • Winter/spring low flows • Three winter/ spring freshes	• Summer/ autumn low flows • Three summer/ autumn freshes • Winter/spring low flows • Five winter/ spring freshes	• Summer/ autumn low flows • Three summer/ autumn freshes • Winter/spring low flows • Five winter/ spring freshes
Lower Burnt Creek	• N/A	• N/A	• N/A	• Bankfull	• Bankfull
Bungalally Creek	• N/A	• N/A	• N/A	• Bankfull	• Bankfull
Dock Lake	• N/A	• N/A	• N/A	• Partial fill	• Partial fill
Ranch Billabong	• Top-ups	• Top-ups	• Top-ups	• Top-ups	• Top-ups
Potential environmental watering – tier 1b (high priorities with shortfalls)					
MacKenzie River reaches 2 & 3	• N/A	• Increased duration winter/ spring low flows reach 3 • Two winter/ spring freshes reach 3	• Increased duration summer/ autumn low flows reach 3 • Three summer/ autumn freshes reach 3	• Increased duration summer/ autumn low flows reach 3 • Three summer/ autumn freshes reach 3 • Increased duration winter/ spring low flows reach 3 • Five winter/ spring freshes reach 3	• Increased duration summer/ autumn low flows reach 3 • Three summer/ autumn freshes reach 3 • Increased duration winter/ spring low flows reach 3 • Five winter/ spring freshes reach 3

Table 4.3.2 Potential environmental watering for the Wimmera system under a range of planning scenarios *continued...*

Planning scenario	Extreme drought	Very dry	Dry	Average	Wet
Wimmera River reach 4	• N/A	• Increased duration winter/spring low flows • Two winter/spring freshes	• Increased duration summer/autumn low flows • Two summer/autumn freshes • Increased duration winter/spring low flows • Three winter/spring freshes	• Increased duration summer/autumn low flows • Two summer/autumn freshes • Increased duration winter/spring low flows • Five winter/spring freshes	• Increased duration winter/spring low flows • Five winter/spring freshes
Upper Burnt Creek	• N/A	• Increased duration summer/autumn low flows • Three summer/autumn freshes • Increased duration winter/spring low flows	• Increased duration summer/autumn low flows • Increased duration and magnitude summer/autumn freshes	• Increased duration summer/autumn low flows • Increased duration and magnitude summer/autumn freshes • Increased duration winter/spring low flows • Increased duration and magnitude winter/spring freshes	• Increased duration summer/autumn low flows • Increased duration and magnitude summer/autumn freshes • Increased duration winter/spring low flows • Increased duration and magnitude winter/spring freshes
Upper Mount William Creek	• N/A	• Top-ups	• N/A	• N/A	• N/A
Lower Mount William Creek	• N/A	• Summer/autumn low flows • Three summer/autumn freshes • Winter/spring low flows	• Increased duration summer/autumn low flows • Three summer/autumn freshes • Winter/spring low flows	• Winter/spring low flows • Five winter/spring freshes	• Winter/spring low flows • Five winter/spring freshes

Table 4.3.2 Potential environmental watering for the Wimmera system under a range of planning scenarios *continued...*

Planning scenario	Extreme drought	Very dry	Dry	Average	Wet
Potential environmental watering – tier 2 (additional priorities)[5]					
MacKenzie River reaches 2 & 3	• N/A	• N/A	• Increased duration summer/ autumn low flows reach 3 • Increased duration and magnitude summer/ autumn freshes reach 3	• Increased duration summer/ autumn low flows reach 3 • Increased duration and magnitude summer/ autumn freshes reach 3	• Increased duration and magnitude summer/ autumn freshes reach 3
Wimmera River reach 4	• N/A	• N/A	• Increased duration summer/ autumn low flows • Increased duration and magnitude summer/ autumn freshes	• Increased duration summer/ autumn low flows • Increased duration and magnitude summer/ autumn freshes • Winter/spring low flows (reach 3)	• Increased duration and magnitude summer/ autumn freshes • Winter/spring low flows (reach 3)
Upper Burnt Creek	• N/A	• N/A	• Increased duration summer/ autumn low flows • Increased duration and magnitude summer/ autumn freshes • Increased duration winter/ spring low flows • Increased duration and magnitude winter/spring freshes	• Increased duration summer/ autumn low flows • Increased duration and magnitude summer/ autumn freshes	• Increased duration and magnitude summer/ autumn freshes • Increased duration summer/ autumn low flows

Table 4.3.2 Potential environmental watering for the Wimmera system under a range of planning scenarios *continued...*

Planning scenario	Extreme drought	Very dry	Dry	Average	Wet
Lower Mount William Creek	• N/A	• N/A	• Increased duration summer/ autumn low flows • Increased duration and magnitude summer/ autumn freshes	• Increased duration summer/ autumn low flows • Increased duration and magnitude summer/ autumn freshes	• Increased duration summer/ autumn low flows • Increased duration and magnitude summer/ autumn freshes
Possible volume of water for the environment required to achieve objectives[4,5]	• 9,090 ML (tier 1a)	• 10,115 ML (tier 1a) • 8,105 ML (tier 1b)	• 14,779 ML (tier 1a) • 13,721 ML (tier 1b) • 3,135 ML (tier 2)	• 19,443 ML (tier 1a) • 21,062 ML (tier 1b) • 15,670 ML (tier 2)	• 23,297 ML (tier 1a) • 20,413 ML (tier 1b) • 15,635 ML (tier 2)

1 *Water for the environment in the Wimmera-Glenelg system held by the VEWH is shared between the Glenelg and Wimmera systems. The VEWH volumes specified show the likely availability of the VEWH's environmental entitlement for both systems.*

2 *Water for the environment held by the CEWH is only available for use in the Wimmera system.*

3 *Under extreme drought, very dry and dry scenarios the highest priority is to deliver summer/autumn low flows in reach 2 and to top up refuge pools in reach 3 of the MacKenzie River system.*

4 *A prioritisation process will be undertaken in consultation with the Wimmera and Glenelg Hopkins CMAs to determine the potential watering actions that will be undertaken in each system in the 2019–20 year, taking into consideration both VEWH and CEWH environmental entitlements.*

5 *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

4.4 Wimmera-Mallee wetlands

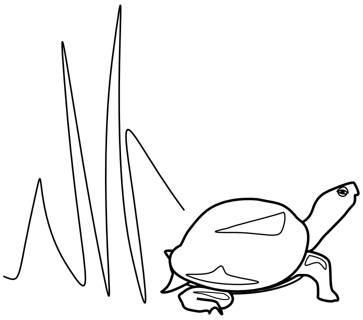
Waterway managers – Mallee, North Central and Wimmera catchment management authorities

Storage manager – GWMWater

Environmental water holder – Victorian Environmental Water Holder

Did you know ...?

The Wimmera-Mallee wetlands provide a critical habitat for native species such as turtles, waterbirds and the vulnerable growling grass frog, who rely on them as drinking holes and refuges in times of drought.



Top: Wetland at Carapugna, Spring 2018, by Wimmera CMA
Centre: Australasian grebe at Crow Swamp, by Jenny Stephens
Above: White plumed honey eaters at Mutton Swamp, by Jenny Stephens

System overview

The Wimmera-Mallee wetlands include 51 wetlands on public and private land spread across north-west Victoria. Historically, these wetlands received water most years from the open channels associated with the Wimmera-Mallee Domestic and Stock Channel System.

The Wimmera-Mallee Pipeline Project (WMPP) replaced stock and domestic supply dams with tanks, and the open-channel distribution system with pipelines, to improve water efficiency. A portion of the water savings from the WMPP was converted to an environmental entitlement to improve the condition of the area's flow-stressed rivers, creeks and wetlands; the rest was used to create regional development opportunities and boost the reliability of supply for other users. The WMPP reduced the amount of open-water habitat in areas that were formerly supplied by the open-channel system, so a separate 1,000 ML environmental entitlement was created to water selected wetlands that were previously supplied through the channel system. In 2011, a project identified priority wetlands that could receive water from the new environmental entitlement, and 51 wetlands have been connected to the Wimmera-Mallee pipeline system to receive that water.

Water for the environment can only be delivered to the wetlands when there is sufficient capacity in the Wimmera-Mallee pipeline system, which can be affected by demand from other pipeline customers. The North Central, Mallee and Wimmera CMAs work closely with GWMWater and land managers (including Parks Victoria, the Department of Environment, Land, Water and Planning and private landowners) to take account of pipeline capacity constraints when managing environmental deliveries to wetlands.

Environmental values

There are a wide range of wetland types in the Wimmera-Mallee wetlands system including freshwater meadows, open freshwater lakes and freshwater marshes. This diversity provides a range of different wetland habitats for plants and animals in the western part of the state. The wetlands also vary in size, consist of many different vegetation communities and are home to native waterbird populations including brolgas, egrets, blue-billed ducks, freckled ducks, Australian painted snipes and glossy ibis. The wetlands are used by the vulnerable growling grass frog, turtles and many other native animals that rely on them as drought refuges and drinking holes. Rare and vulnerable vegetation species (such as spiny lignum, ridged water milfoil, chariot wheel and cane grass) are also present in some wetlands.

Environmental objectives in the Wimmera-Mallee wetlands

Maintain and increase the population of frogs and turtles
Maintain and improve the condition of aquatic and fringing plants including lignum, river red gum and black box communities Improve the diversity of vegetation communities by providing watering regimes to support plant life cycles in and around the wetlands
Maintain and increase populations of waterbirds and other native birds by providing resting, feeding and breeding habitat
Maintain the population of waterbugs
Provide watering holes for native animals and terrestrial birds across the landscape

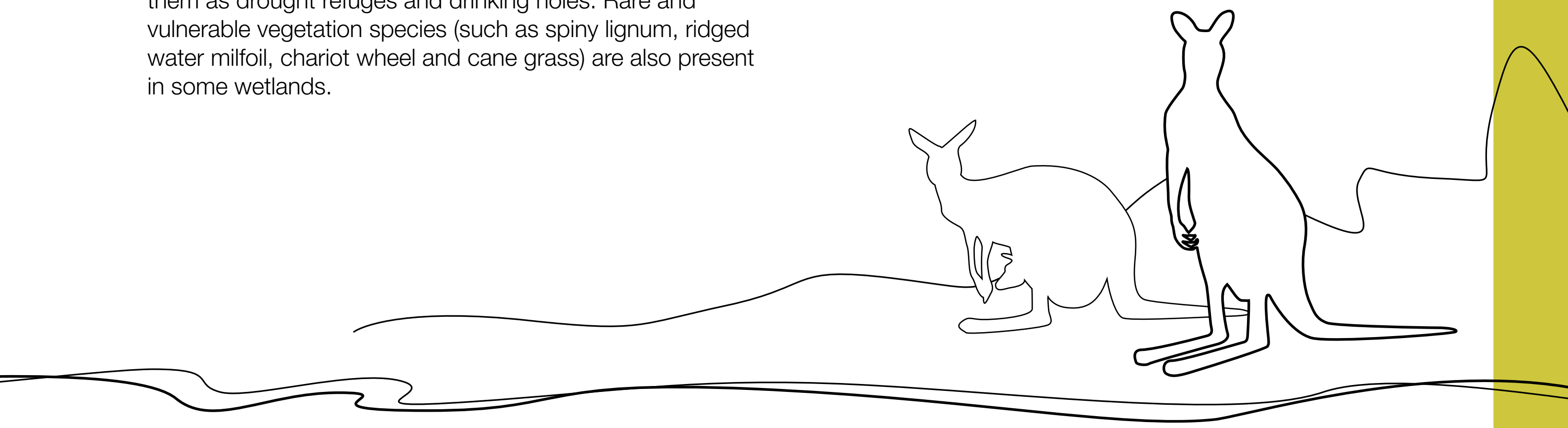
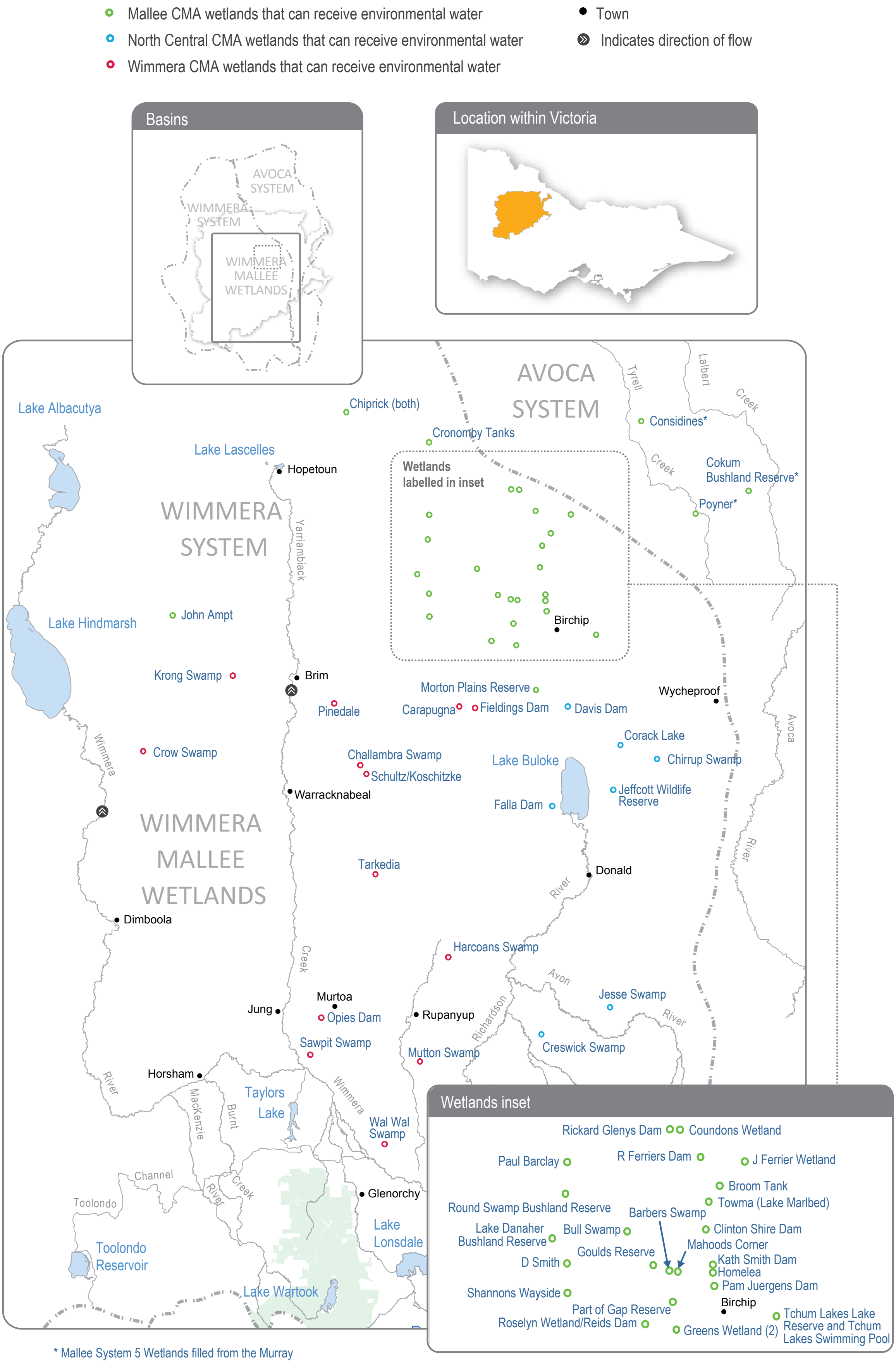


Figure 4.4.1 The Wimmera-Mallee wetlands



* Mallee System 5 Wetlands filled from the Murray

Recent conditions

The Wimmera-Mallee received below-average rainfall and had above-average temperatures throughout 2018–19. A large rainfall event in December 2018 caused floods across some of the region and filled some wetlands. The dry conditions experienced over the last two years have meant that there was little to no inflow into storages in the Wimmera-Mallee headworks system, and no allocation was made to the wetland environmental entitlement in 2018–19. Environmental demand for the Wimmera-Mallee wetlands in 2018–19 was met by water for the environment carried over from previous seasons.

Water for the environment was delivered to 44 Wimmera-Mallee wetlands in 2018–19: 25 wetlands in the Mallee CMA area, 12 in the Wimmera CMA area and seven in the North Central CMA area. Deliveries were made in winter/spring 2018 and autumn/winter 2019 to maintain and improve ecological outcomes from natural or managed flows in previous years. Some wetlands received water once during 2018–19, while others received multiple deliveries to maintain their water-dependent values.

Water for the environment delivered to the Wimmera-Mallee wetlands maintained and improved the health of native plants and provided feeding and breeding habitat for many animals (such as eastern long-necked turtles, frogs, yabbies, egrets, herons, ducks, grebes, swans, stilts and other water and woodland birds). Aquatic and fringing plant communities in wetlands that received water (naturally or through managed deliveries) in 2018–19 have responded well. Black box trees at the edge of some wetlands flowered and set seed, while many wetlands had vigorous growth of aquatic and semi-aquatic plants including nardoo, water milfoil, water ribbons, lignum and cane grass.

Scope of environmental watering

Table 4.4.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Watering actions for the Wimmera-Mallee wetlands will typically be in winter/spring 2019 or autumn/winter 2020, but they may occur at any time of the year depending on environmental need, seasonal conditions and pipeline capacity.

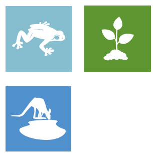
Table 4.4.1 Potential environmental watering actions and objectives for the Wimmera-Mallee wetlands

Potential environmental watering action	Functional watering objective	Environmental objective
North Central wetlands		
Chirrup Swamp	• Provide a permanent water source for refuge and to support feeding and breeding opportunities for frogs, waterbirds and turtles	
Corack Lake	• Provide a permanent water source for refuge and nursery habitat for turtles and frogs • Maintain varying depths of water to support aquatic and fringing plants' life cycles • Maintain varying depths of water to support a variety of feeding habitats for waterbirds	
Creswick Swamp	• Maintain varying depths of water to support the life cycle of aquatic plants including threatened marbled marshwort • Provide a permanent water source for refuge and to support feeding and breeding opportunities for frogs and turtles • Maintain water levels to prolong inundation and ensure successful waterbird breeding events, if they start	
Davis Dam	• Inundate black box and rare cane grass to allow plants to complete their life cycles and to support juvenile plants • Provide a semi-permanent water source to support refuge, feeding and breeding opportunities for frogs • Provide a permanent water source for refuge and to support feeding and breeding opportunities for waterbirds and terrestrial species	

Table 4.4.1 Potential environmental watering actions and objectives for the Wimmera-Mallee wetlands *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Falla Dam	• Provide a permanent water source for refuge and to support feeding and breeding opportunities for frogs, waterbirds and terrestrial species • Stimulate frog and turtle breeding by providing a deep, permanent water source in spring • Stimulate aquatic and fringing vegetation growth in winter/spring	
Jeffcott Wildlife Reserve	• Maintain a minimum depth of water to support the life cycles of aquatic plants • Provide a permanent water source for refuge and to support feeding and breeding opportunities for frogs, waterbugs, waterbirds and turtles	
Jesse Swamp	• Maintain varying depths of water to support aquatic and fringing plant life cycles • Provide a permanent water source for refuge and to support feeding and breeding opportunities for frogs, waterbirds and terrestrial species	
Wimmera wetlands		
Carapugna	• Provide a permanent water source for refuge and to support feeding and breeding opportunities for frogs, waterbirds and terrestrial species • Stimulate aquatic and fringing vegetation growth and allow plants to complete their life cycles including ridged water milfoil, black box and spiny lignum	
Challambra Swamp		
Crow Swamp		
Fieldings Dam		
Harcoans Swamp		
Krong Swamp		
Mutton Swamp		
Opies Dam		
Pinedale		
Sawpit Swamp		
Schultz/Koschitzke		
Tarkedia Dam		
Wal Wal Swamp		
Mallee wetlands		
Barbers Swamp	• Provide a permanent water source for refuge and to support feeding and breeding opportunities for waterbirds and terrestrial species • Stimulate aquatic and fringing vegetation growth and allow the plants to complete their life cycles including ridged water milfoil, black box and spiny lignum • Maintain water levels to prolong inundation and ensure successful waterbird breeding events if they start	
Bull Swamp		
Cokum Bushland Reserve		
Morton Plains Reserve		
Tchum Lakes Lake Reserve (North Lake - wetland)		
Tchum Lakes Swimming Pool (North Lake – dam)		

Table 4.4.1 Potential environmental watering actions and objectives for the Wimmera-Mallee wetlands *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Broom Tank Clinton Shire Dam Considines Greens Wetland Pam Juergens Dam Poyner Roselyn Wetland	• Stimulate aquatic and fringing vegetation growth and allow the plants to complete their life cycles including black box and lignum • Provide a permanent water source for refuge and to support feeding and breeding opportunities for waterbirds and terrestrial species	
Goulds Reserve Newer Swamp Part of Gap Reserve Towma (Lake Marlbed)	• Stimulate aquatic and fringing vegetation growth and allow the plants to complete their life cycles including black box and lignum	
Coundons Wetland J Ferrier Wetland	• Stimulate aquatic and fringing vegetation growth and allow the plants to complete their life cycles including black box and lignum • Provide a permanent water source for refuge and to support feeding and breeding opportunities for waterbirds and terrestrial species • Provide a permanent water source for refuge and to support feeding and breeding opportunities for frogs and turtles	
Mahoods Corner Shannons Wayside	• Provide a permanent water source for refuge and to support feeding and breeding opportunities for waterbirds and terrestrial species	
Chiprick D Smith Wetland Homelea Wetland John Ampt Kath Smith Dam Paul Barclay R Ferriers Dam Rickard Glenys Dam	• Provide a permanent water source for refuge and to support feeding and breeding opportunities for waterbirds and terrestrial species	
Cronomby Tanks Lake Danaher Bushland Reserve	• Stimulate aquatic and fringing vegetation growth and allow the plants to complete their life cycles including black box and lignum • Provide a permanent water source for refuge and to support feeding and breeding opportunities for frogs and turtles	

Scenario planning

Table 4.4.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The potential watering actions in 2019–20 have been determined by considering the environmental values, watering requirements and recent watering histories. Recent and upcoming climatic conditions, water availability and the expected capacity in the Wimmera-Mallee pipeline system also influence the ability to meet watering demands of the wetlands.

Under drought conditions, the highest priority is to provide some permanent water in the deeper sections of the wetlands, to provide drought refuge for wetland plants, waterbirds, frogs, turtles and terrestrial animals across the landscape. Under wetter climate scenarios, allocation to the environmental entitlement may allow more water to be delivered, depending on capacity in the pipeline system.

Large rainfall events and catchment inflows may partially or fully fill some wetlands, and water for the environment may be used to top up, fill or over-top wetlands to improve fringing wetland plant growth and provide additional habitat for waterbirds, frogs and turtles.

Allocations to the environmental entitlement to supply the wetlands in the Wimmera-Mallee wetland system is highly variable, and the ability to carry over unused water from one year to another allows waterway managers and the VEWH to effectively manage the systems in dry periods. The North Central, Mallee and Wimmera CMAs and the VEWH have determined that at least 120–231 ML should be carried over at the end of 2019–20, to support critical environmental demands in 2020–21. This includes providing fills and top-ups to deeper sections of the wetlands, to maintain permanent refuge for water-dependent plants and animals during winter/spring 2020.

Table 4.4.2 Potential environmental watering for the Wimmera-Mallee wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected catchment conditions	• No catchment inflows to the wetlands are expected	• No catchment inflows to the wetlands are expected	• Some localised catchment inflows may increase water levels in some wetlands	• Catchment inflows are likely to increase water levels in most wetlands
Expected availability of water for the environment	• 1,000 ML carryover • 0 ML allocation • 1,000 ML available	• 1,000 ML carryover • 0 ML allocation • 1,000 ML available	• 1,000 ML carryover • 250 ML allocation • 1,250 ML available	• 1,000 ML carryover • 1,000 ML allocation • 2,000 ML available
Potential environmental watering	• Carapugna • Challambra Swamp • Chiprick • Chirrup Swamp • Clinton Shire Dam • Cokum Bushland Reserve[1] • Considines[1] • Corack Lake • Coundons Wetland • Creswick Swamp • Cronomby Tanks • Crow Swamp • D Smith Wetland • Fieldings Dam • Harcoans Swamp • Homelea Wetland • J Ferrier Wetland • Jeffcott Wildlife Reserve • Jesse Swamp • John Ampt	• Carapugna • Challambra Swamp • Chiprick • Chirrup Swamp • Clinton Shire Dam • Cokum Bushland Reserve[1] • Considines[1] • Corack Lake • Coundons Wetland • Creswick Swamp • Cronomby Tanks • Crow Swamp • D Smith Wetland • Davis Dam • Falla Dam • Fieldings Dam • Harcoans Swamp • Homelea Wetland • J Ferrier Wetland • Jeffcott Wildlife Reserve	• Broom Tank • Carapugna • Challambra Swamp • Chiprick • Chirrup Swamp • Clinton Shire Dam • Cokum Bushland Reserve[1] • Considines[1] • Corack Lake • Coundons wetland • Creswick Swamp • Cronomby Tanks • Crow Swamp • D Smith Wetland • Davis Dam • Falla Dam • Fieldings Dam • Goulds Reserve • Harcoans Swamp • Homelea Wetland • J Ferrier Wetland	• Barbers Swamp • Broom Tank • Bull Swamp • Carapugna • Challambra Swamp • Chirrup Swamp • Chiprick • Clinton Shire Dam • Cokum Bushland Reserve[1] • Considines[1] • Corack Lake • Coundons wetland • Creswick Swamp • Cronomby Tanks • Crow Swamp • D Smith Wetland • Davis Dam • Falla Dam • Fieldings Dam • Goulds Reserve • Greens Wetland

Table 4.4.2 Potential environmental watering for the Wimmera-Mallee wetlands under a range of planning scenarios *continued...*

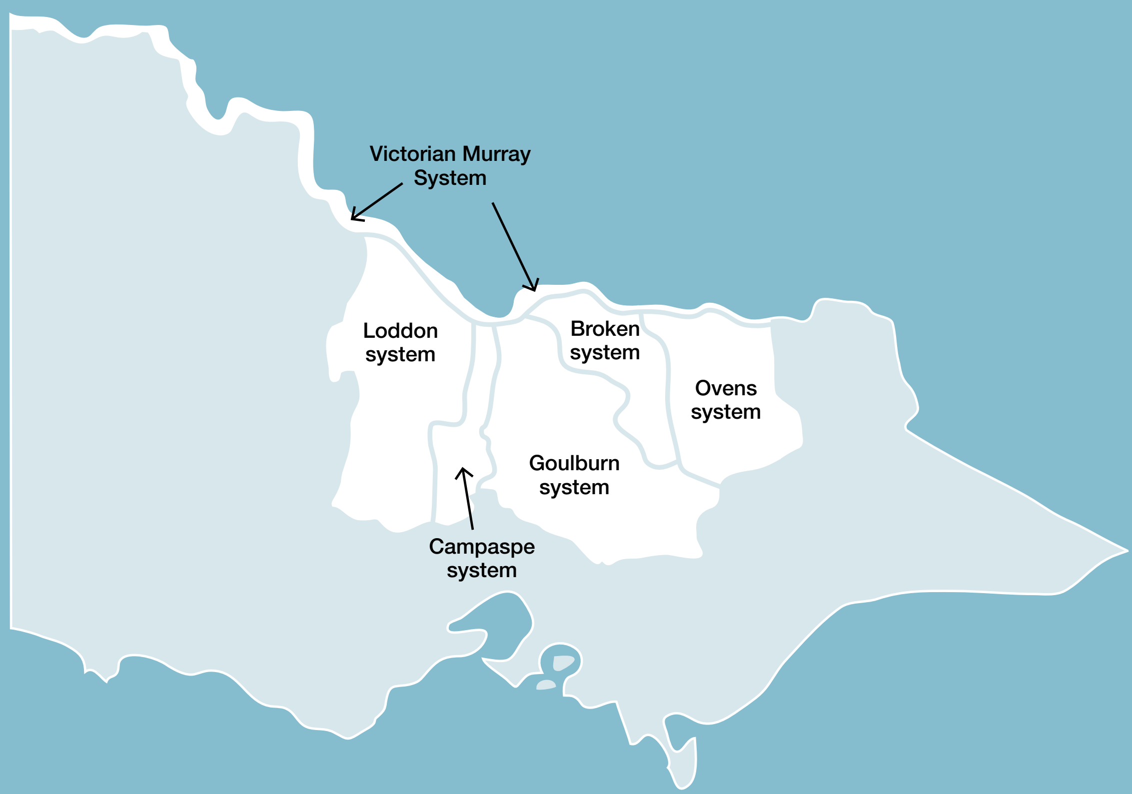
Planning scenario	Drought	Dry	Average	Wet
Potential environmental watering	• Kath Smith Dam • Lake Danaher Bushland Reserve • Mahoods Corner • Morton Plains Reserve • Mutton Swamp • Opies Dam • Pam Juergens Dam • Paul Barclay • Pinedale • R Ferriers Dam • Rickard Glenys Dam • Sawpit Swamp • Schultz/Koschitzke • Tarkedia Dam • Towma (Lake Marlbed) • Wal Wal Swamp	• Jesse Swamp • John Ampt • Kath Smith Dam • Lake Danaher Bushland Reserve • Mahoods Corner • Morton Plains Reserve • Mutton Swamp • Opies Dam • Pam Juergens Dam • Part of Gap Reserve • Paul Barclay • Pinedale • R Ferriers Dam • Rickard Glenys Dam • Sawpit Swamp • Schultz/Koschitzke • Shannons Wayside • Tarkedia Dam • Tchum Lakes Swimming Pool (North Lake - Dam) • Towma (Lake Marlbed) • Wal Wal Swamp	• Jeffcott Wildlife Reserve • Jesse Swamp • John Ampt • Kath Smith Dam • Lake Danaher Bushland Reserve • Mahoods Corner • Morton Plains Reserve • Mutton Swamp • Opies Dam • Pam Juergens Dam • Part of Gap Reserve • Paul Barclay • Pinedale • R Ferriers Dam • Rickard Glenys Dam • Sawpit Swamp • Schultz/Koschitzke • Shannons Wayside • Tarkedia Dam • Tchum Lakes Lake Reserve (North Lake - Wetland) • Tchum Lakes Swimming Pool (North Lake - Dam) • Towma (Lake Marlbed) • Wal Wal Swamp	• Harcoans Swamp • Homelea Wetland • J Ferrier Wetland • Jeffcott Wildlife Reserve • Jesse Swamp • John Ampt • Kath Smith Dam • Lake Danaher Bushland Reserve • Mahoods Corner • Morton Plains Reserve • Mutton Swamp • Newer Swamp • Opies Dam • Pam Juergens Dam • Part of Gap Reserve • Paul Barclay • Pinedale • Poyner[1] • R Ferriers Dam • Rickard Glenys Dam • Roselyn Wetland • Sawpit Swamp • Schultz/Koschitzke • Shannons Wayside • Tarkedia Dam • Tchum Lakes Lake Reserve (North Lake - Wetland) • Tchum Lakes Swimming Pool (North Lake - Dam) • Towma (Lake Marlbed) • Wal Wal Swamp
Possible volume of water for the environment required to achieve objectives	• 268 ML	• 315 ML	• 444 ML	• 620 ML
Priority carryover requirements	• 120 ML	• 231 ML	• 231 ML	• 231 ML

1 *Water supplied to these wetlands in supply system 5 is subject to water availability in the River Murray system*

 Buffalo River, by North East CMA

SECTION 5

Northern region


Victorian Murray System
Loddon system
Broken system
Ovens system
Goulburn system
Campaspe system

5.1 Northern region overview

The northern region has six river systems, four major floodplain sites and many wetlands that can receive water for the environment. The Broken, Campaspe, Goulburn, Loddon and Ovens river systems are tributaries of the River Murray. The four major floodplain sites along the River Murray corridor are Barmah Forest, Gunbower Forest, Hattah Lakes and Lindsay, Mulcra and Wallpolla islands. The other wetlands are distributed across the Broken, Goulburn, Loddon and Murray floodplains. The rivers and wetlands in the northern region are managed by the North East, Goulburn Broken, North Central and Mallee CMAs.

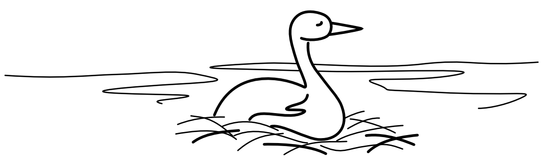
Many of the water systems in the northern region are connected through infrastructure (such as Goulburn Weir and the Waranga Western Channel), which allows water to be physically delivered from the Goulburn River to the Loddon and Campaspe systems. Water trading also enables transfers of allocation between systems. Within the limitations of each mechanism, water for the environment can be moved between systems for delivery to environmental sites across northern Victoria, although most water for the environment is usually used to provide benefits in the systems in which the water is held.

Environmental values, recent conditions, environmental watering objectives and planned actions for each system in the northern region are presented in the system sections that follow.

Traditional Owners in the northern region

Traditional Owners and their Nations in the northern region continue to have a deep connection to the region's rivers, wetlands and floodplains.

The Traditional Owner groups in and around northern Victoria include Barapa Barapa, Dhudhuroa, Latji Latji, Ngintait, Nyeri Nyeri, Taungurung, Tati Tati, Wadi Wadi, Wamba Wemba, Waywurru, Weki Weki, Yorta Yorta and Yaithmathang. The Dja Dja Wurrung Clans Aboriginal Corporation, First People of the Millewa-Mallee Aboriginal Corporation (representing Latji Latji, Nyeri Nyeri, Ngintait), Taungurung Land and Waters Council Aboriginal Corporation and Yorta Yorta Nation Aboriginal Corporation are Registered Aboriginal Parties under the *Aboriginal Heritage Act 2006*.



Three formal agreements with Traditional Owners in the northern region are in place:

- In 2013, the Dja Dja Wurrung entered into a recognition and settlement agreement under the *Traditional Owner Settlement Act 2010* in Victoria. Under the agreement, Dja Dja Wurrung has rights to access and use water for traditional purposes, providing the take of water does not affect other parties.
- In 2004, the Victorian Government entered into a cooperative management agreement with the Yorta Yorta to improve collaboration in the management of their Country including Barmah State Forest and reserves along the Goulburn River.
- In 2018, the Victorian Government, the Taungurung Clans Aboriginal Corporation and the Taungurung Traditional Owner group signed agreements under the *Traditional Owner Settlement Act 2010* and related legislation.

In recognition of the cultural importance of water for Aboriginal people and their traditional ecological knowledge, waterway managers across the northern region are working with Traditional Owners to involve them in management of environmental flows. In 2019–20, this may include the following initiatives:

- The first-ever delivery of water for the environment to Horseshoe Lagoon, Kanyapella Basin and Loch Garry, which are important to Taungurung (Horseshoe Lagoon) and Yorta Yorta (Kanyapella Basin and Loch Garry) people respectively. The Taungurung Land & Water Council and the Yorta Yorta Nation Aboriginal Corporation have been involved in writing the environmental water management plans for the wetlands and setting ecological objectives. Taungurung people may also be involved in delivering water to Horseshoe Lagoon, which is significant as many Taungurung people live and work off-Country.

- A partnership between the Barapa Barapa people, Wamba Wemba people and North Central CMA to involve Traditional Owners in the planning, monitoring and reporting of watering in Guttrum Forest, as part of the ongoing Barapa Barapa Wamba Wemba Water for Country project.
- Collaboration between Goulburn Broken CMA and Yorta Yorta people, to ensure cultural values are considered in watering decisions. This has led to Yorta Yorta people being involved in developing plans and objectives for a number of sites in the Goulburn Broken catchment. Examples include in Barmah Forest, where drought refuges may be watered to protect the broad-shelled turtle, which is an important totem species for Yorta Yorta people; and Loch Gary, where a proposed wetland fill in autumn 2020 would support waterbird habitat, which has been identified as an ecological objective by the Yorta Yorta people.
- Input of Wadi Wadi Traditional Owners into planned watering of wetlands near Robinvale in the Mallee CMA region.

Engagement

Seasonal watering proposals are informed by longer-term regional catchment strategies, regional waterway strategies, relevant technical studies (such as environmental flow studies and environmental water management plans), as well as by input from program partners and stakeholders. The strategies and technical reports collectively describe a range of cultural, economic, environmental, social and Traditional Owner perspectives and longer-term integrated catchment and waterway management objectives that influence environmental watering actions and priorities for the coming year

The International Association for Public Participation's Public Participation Spectrum (IAP2 Spectrum) has been used to categorise the levels of participation of stakeholders involved in the environmental watering planning process. Table 5.1.1 shows the IAP2 Spectrum categories and participation goals.

Table 5.1.1 IAP2 Spectrum categories and participation goals[1]

Engagement category	Engagement goal
Inform	Provide balanced and objective information to assist understanding, alternatives, opportunities and/or solutions
Consult	Obtain feedback on analysis, alternatives and/or decisions
Involve	Work directly throughout a process to ensure that concerns and aspirations are consistently understood and considered
Collaborate	Partner in each aspect of the decision including the development of alternatives and the identification of the preferred solution
Empower	Place final decision making in the hands of the stakeholder

1 *The VEWH has the permission of the International Association for Public Participation to reproduce the IAP2 Spectrum.*

Tables 5.1.2 to 5.1.5 show the partners, stakeholder organisations and individuals with which the Goulburn Broken, North Central, North East and Mallee CMAs engaged when preparing seasonal watering proposals. This includes engagement conducted as part of developing seasonal watering proposals as well as engagement during the preparation of key foundational documents that directly informed the proposals. The tables also show the level of engagement, based on the Goulburn Broken, North Central, North East and Mallee CMAs' interpretation of the IAP2 Spectrum.

The level of engagement differs between organisations and between systems, due to the complexity of management arrangements and individual organisation's responsibilities for each system. For example, under a cooperative management agreement between Yorta Yorta Nation Aboriginal Corporation and the State of Victoria, the Yorta Yorta Traditional Owner Land Management Board is legally required to be involved in decisions about the management of Barmah Forest. Therefore, the Yorta Yorta Traditional Owner Land Management Board is listed as a program partner that collaborates with Goulburn Broken CMA on the planning and delivery of water for the environment releases at Barmah Forest. Elsewhere in the northern region, Traditional Owners are consulted or informed about environmental watering and their recommendations are included in planning. Waterway managers are working with Traditional Owner groups in their regions to strengthen their involvement in water for the environment planning.

Table 5.1.2 Partners and stakeholders engaged by Goulburn Broken CMA in developing seasonal watering proposals for Barmah Forest and the Goulburn and Broken systems and other key foundation documents that have directly informed the proposals

	Barmah Forest	Goulburn River	Goulburn wetlands and Broken wetlands	Broken River and upper Broken Creek	Lower Broken Creek
Community groups and environment groups		• Goulburn Valley Environment Group	• Goulburn Murray Landcare Network • Goulburn Valley Environment Group • Kinnairds Wetland Advisory Committee • Turtles Australia	• Goulburn Valley Environment Group	• Broken Environmental Water Advisory Group
Landholders/ farmers		• Individual landholders who are on the Goulburn Environmental Water Advisory Group	• Individual landholders	• Individual landholders	• Individual landholders who are on the Broken Environmental Water Advisory Group
Program partners	• Commonwealth Environmental Water Office • Department of Environment, Land, Water and Planning • Goulburn-Murray Water • Murray-Darling Basin Authority • New South Wales Office of Environment and Heritage • Parks Victoria • Victorian Environmental Water Holder • Yorta Yorta Traditional Owner Land Management Board	• Commonwealth Environmental Water Office • Goulburn-Murray Water • Murray-Darling Basin Authority • Parks Victoria • Victorian Environmental Water Holder	• Department of Environment, Land Water and Planning • Goulburn-Murray Water • Moira Shire • Parks Victoria	• Commonwealth Environmental Water Office • Goulburn-Murray Water • Parks Victoria • Victorian Environmental Water Holder	• Commonwealth Environmental Water Office • Goulburn-Murray Water • Parks Victoria • Victorian Environmental Water Holder
Recreational users		• A local ecotourism operator • Trellys Fishing and Hunting	• Field and Game Australia • Trellys Fishing and Hunting		• Nathalia Angling Club Numurkah Angling Club
Traditional Owners		• Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation	• Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation	• Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation	• Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation

Key: Inform Consult Involve Collaborate Empower

Table 5.1.3 Partners and stakeholders engaged by North Central CMA in developing seasonal watering proposals for Gunbower Creek and Forest, the central Murray wetlands, the Loddon and Campaspe systems and other key foundation documents that have directly informed the proposals

	Gunbower Creek and Forest	Central Murray wetlands and Boort wetlands	Campaspe River	Coliban River	Loddon River	Birch Creek
Community groups and environment groups	• BirdLife Australia • Gunbower Landcare Group					
Government agencies						• Parks Victoria
Landholders/ farmers	• Individual community members • Individual irrigators	• Individual community members • Individual landholders	• Individual Landholders	• Individual Landholders	• Individual Landholders	• Individual Landholders
Local government	• Campaspe Shire Council • Gannawarra Shire Council					
Local businesses	• Forestry businesses • Apiary licensees	• Forestry businesses • Apiary licensees				
Program partners	• Commonwealth Environmental Water Office • Department of Environment, Land, Water and Planning • Forestry Corporation of New South Wales • Goulburn-Murray Water • Murray-Darling Basin Authority • Parks Victoria • VicForests • Victorian Environmental Water Holder	• Campaspe Shire Council • Commonwealth Environmental Water Office • Department of Environment, Land, Water and Planning • Forestry Corporation of New South Wales • Goulburn-Murray Water • Loddon Shire Council • Murray-Darling Basin Authority • Parks Victoria • Swan Hill Rural City Council • VicForests • Victorian Environmental Water Holder	• Commonwealth Environmental Water Office • Goulburn-Murray Water • Victorian Environmental Water Holder • Department of Environment, Land, Water and Planning	• Coliban Water • Commonwealth Environmental Water Office • Victorian Environmental Water Holder • Department of Environment, Land, Water and Planning	• Commonwealth Environmental Water Office • Goulburn-Murray Water • Victorian Environmental Water Holder • Department of Environment, Land, Water and Planning	• Goulburn-Murray Water • Victorian Environmental Water Holder • Department of Environment, Land, Water and Planning

Table 5.1.3 Partners and stakeholders engaged by North Central CMA in developing seasonal watering proposals for Gunbower Creek and Forest, the central Murray wetlands, the Loddon and Campaspe systems and other key foundation documents that have directly informed the proposals *continued...*

	Gunbower Creek and Forest	Central Murray wetlands and Boort wetlands	Campaspe River	Coliban River	Loddon River	Birch Creek
Recreational users	• Field and Game Australia • Gateway to Gannawarra Visitor Centre	• BirdLife Australia • Field and Game Australia	• Local canoe clubs • Victorian Game Authority	• Local canoe clubs • Victorian Game Authority	• Field and Game Australia • VRFish	
Technical specialists	• Vegetation, fish and bird ecologists on the Gunbower Technical Advisory Group					
Traditional Owners	• Barapa Barapa Traditional Owners • Yorta Yorta Nation Aboriginal Corporation	• Barapa Barapa Traditional Owners • Dja Dja Wurrung Clans Aboriginal Corporation • Wamba Wemba Traditional Owners • Yorta Yorta Nation Aboriginal Corporation	• Dja Dja Wurrung Clans Aboriginal Corporation • Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation	• Dja Dja Wurrung Clans Aboriginal Corporation	• Barapa Barapa Traditional Owners • Dja Dja Wurrung Clans Aboriginal Corporation • Wamba Wemba Traditional Owners	• Dja Dja Wurrung Clans Aboriginal Corporation

Key: Inform Consult Involve Collaborate Empower

Table 5.1.4 Partners and stakeholders engaged by Mallee CMA in developing seasonal watering proposals for Hattah Lakes, the lower Murray wetlands and Lindsay, Mulcra and Wallpolla islands and other key foundation documents that have directly informed the proposals

	Hattah Lakes	Lower Murray wetlands	Lindsay, Mulcra and Wallpolla islands
Community groups and environment groups		• Mid-Murray Field Naturalists Incorporated Association	
Landholders/ farmers	• Individual landholders		
Local businesses	• Individual small business owners	• Mallee Tours • Mildura Information Centre • Murray Offroad Adventures • Sunraysia Apiarist Association • Visit Mildura • Wildside Outdoors	• Mallee Tours • Mildura Information Centre • Murray Offroad Adventures • Sunraysia Apiarist Association • Visit Mildura • Wildside Outdoors
Local government	• Mildura Rural City Council	• Mildura Rural City Council	• Mildura Rural City Council
Program partners	• Commonwealth Environmental Water Office • Murray-Darling Basin Authority • Parks Victoria • Victorian Environmental Water Holder	• Murray-Darling Basin Authority • Parks Victoria • Victorian Environmental Water Holder	• Commonwealth Environmental Water Office • Murray-Darling Basin Authority • Parks Victoria • Victorian Environmental Water Holder
	• Department of Environment, Land, Water and Planning	• Department of Environment, Land, Water and Planning	• Department of Environment, Land, Water and Planning
	• Goulburn-Murray Water	• Goulburn-Murray Water	
Recreational users	• Mildura Birdlife Club • Sunraysia Bushwalkers	• Mildura Birdlife Club • Sunraysia Bushwalkers	• Mildura Birdlife Club • Sunraysia Bushwalkers
Traditional Owners	• Latje Latje Traditional Owners • Munutunga Traditional Owners • Tati Tati Traditional Owners • Wadi Wadi Traditional Owners	• Wadi Wadi Traditional Owners and the broader Aboriginal community	• First People of the Millewa-Mallee Aboriginal Corporation

Key: Inform Consult Involve Collaborate Empower

Table 5.1.5 Partners and stakeholders engaged by North East CMA in developing the seasonal watering proposal for the Ovens system and other key foundation documents that have directly informed the proposal

Ovens system	
Community groups and environment groups	• Wangaratta Sustainability Network
Government agencies	• Arthur Rylah Institute • Victorian Fisheries Authority
Landholders/ farmers	• Catholic Education Department – Sandhurst Diocese
Local government	• Rural City of Wangaratta
Program partners	• Commonwealth Environmental Water Office • Goulburn-Murray Water • Victorian Environmental Water Holder
Traditional Owners	• Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation

Key: Inform Consult Involve Collaborate Empower

Community benefits from environmental watering

As described in subsection 1.1.1, environmental flows that improve the health of rivers, wetlands and floodplains also provide benefits to communities, because healthy rivers and wetlands support vibrant and healthy communities.

Environmental outcomes provide direct flow-on cultural, economic, recreational, social and Traditional Owner benefits for communities. In 2019–20, examples in the northern region include:

- supporting Murray cod, golden perch and other recreational fish species in waterways across the region including the Ovens River, Broken River, Goulburn River, Broken Creek, Campaspe River, Gunbower Creek, Loddon River, Pyramid Creek and the Mullaroo and Lindsay rivers
- providing increased opportunities for birdwatching by providing nesting sites, food and habitat for a wide variety of waterbirds in wetlands across the entire northern region
- recreational users and local businesses taking advantage of high water levels in waterways and wetlands (such as Gunbower Creek and Forest, Barmah Forest, the Campaspe River, Hattah Lakes and the lower Murray wetlands) for activities like fishing, boating and canoeing.

Additional opportunities to enhance community benefits can also sometimes be provided by modifying environmental flows, provided environmental outcomes are not compromised. For example, North Central CMA may time a summer fresh in the Campaspe River to occur on the Australia Day long weekend in January 2020, so people camping and picnicking alongside the river can enjoy the Australia Day weekend with additional flows in the river.

The ability of the VEWH and its partners to deliver these benefits will depend on the weather, climate considerations, the available water and the way the system is being operated to deliver water for other purposes.

Integrated catchment management

Altered water regimes are one of many threats to the health of Victoria's waterways. To be effective, planning and releases of water for the environment need to be part of an integrated approach to catchment management. Many of the environmental objectives for the northern region will not be fully met without simultaneously addressing issues such as excessive catchment erosion, barriers to fish movement, high nutrient loads, loss of stream bank vegetation and invasive species, to name just a few issues.

Victorian and Australian government agencies, community groups and private landowners collectively implement a wide range of programs that aim to protect and improve the environmental condition and function of land, soils and waterways throughout Victoria's catchments.

Examples of complementary programs that are likely to support environmental watering outcomes in the northern region include the following:

- Construction of a fish screen at Cohuna Weir on Gunbower Creek by North Central CMA. The fish screen was completed in July 2018 to prevent native fish and larvae in Gunbower Creek entering the number 2 irrigation channel. The Cohuna Weir fish screen is the first screen on a gravity-fed irrigation channel in Australia.
- Fishways built at the Chute, Box Creek regulator, Kerang Weir and Little Murray River in recent years have improved fish passage and supported fish migration between the Loddon and Murray systems.

- A willow removal program at Birch Creek conducted in 2018 is helping to rehabilitate natural geomorphic processes and improve water quality in the system.
- The Caring for the Campaspe project is a collaboration with landholders that focuses on protecting and enhancing riparian and fringing vegetation along the Campaspe River.
- A proposed strategic action plan for Barmah Forest includes the management of invasive animals (such as feral horses) that do significant damage to native vegetation by overgrazing on the floodplain marshes. If implemented, this plan would complement existing grazing exclosure fencing that protects one of the highest-value floodplain marsh wetlands in the forest, Little Rushy Swamp. Broad management of threats (such as grazing by feral horses) is required to recover the health of the Barmah Forest. Fencing extremely high-value areas is a temporary measure to avoid local extinction of species (such as Moira grass) ahead of improved long-term management actions (such as removing feral horses).

For more information about integrated catchment management programs in the northern region, refer to the North East, Goulburn Broken, North Central and Mallee CMAs' regional catchment strategies and regional waterway strategies.

Seasonal outlook 2019–20

Northern Victoria has experienced mostly below-average rainfall and corresponding low levels of inflows into waterways and storages since the start of 2017. Storage levels and overall water availability continued to decline during 2018–19, and environmental watering was modified where required to help conserve water for 2019–20.

Each year on 15 May, the Northern Victoria Resource Manager (NVRM) releases a water availability outlook for northern Victoria for the coming year. These seasonal outlooks are updated monthly once the season begins, and are available at www.nvrm.net.au.

The 2019–20 outlook at 15 May 2019 indicated that early-season allocations are expected to be low in most systems. The opening high-reliability entitlement allocation is forecast to be one percent or zero in the Murray, Goulburn, Loddon, Broken and Bullarook systems under continuing dry to extremely dry conditions. The opening allocations for high-reliability entitlements in the Campaspe system are forecast to be 17 percent. Under ongoing extreme dry to dry scenarios (that is, if inflows are similar to the lowest one to 10 percent of inflows on record), most systems are not expected to reach 50 percent high-reliability allocation in 2019–20. The NVRM has not provided an outlook for low-reliability entitlements, but for planning purposes the VEWH has assumed no allocation against low-reliability entitlements during 2019–20, unless significant rain provides inflows that are in line with above-average to wet climate scenarios.

Carryover into 2019–20 becomes especially critical to meet early-season demands. The VEWH is planning to carry over moderate volumes of water across the northern Victorian systems to meet early-season demands, and it works with the Commonwealth Environmental Water Holder (CEWH) and the Living Murray program to optimise the use of all water for the environment across northern Victoria.

In 2017–18, a large volume (around 314,000 ML) of River Murray Increased Flows (RMIF) water was released from the Snowy storages because of Snowy Hydro releases for electricity generation. A small portion of this RMIF was used in 2017–18 and a large amount was used in 2018–19 for environmental outcomes in the Murray system. Around one-sixth (50,000 ML) was intentionally set aside to carry over into 2019–20 to meet environmental demands in Victoria, NSW and SA as a reserve to mitigate against ongoing dry conditions. This reserve will be critical to maintaining the health of the River Murray system in 2019–20, especially if winter and spring are dry.

Demands for water for the environment in northern Victoria are usually highest in winter and spring. Most systems in northern Victoria have lower demands under drought to dry scenarios, where the focus is on maintaining condition, and operational water deliveries meet many of the minimum-flow requirements in rivers. Environmental demands generally increase under wetter conditions, because extra water is needed to extend the duration of natural high flows and connect additional floodplain habitats to optimise environmental outcomes during these important productive periods.

If dry conditions continue through winter and spring 2019, water for the environment will be used to provide winter flows in creeks and rivers to maintain habitat, particularly for native fish. Some wetlands are also likely to be watered in winter/spring 2019, to provide some habitat in the landscape for waterbirds and turtles and to ensure the maximum tolerable dry periods for wetland plant communities are not exceeded. Different wetlands are watered each year during prolonged dry periods, to ensure some water is present in the landscape for mobile animals and to prevent critical declines in the condition of vegetation communities at priority wetlands. This approach is important, to protect the outcomes of previous environmental watering actions and to prevent declines that may be difficult to recover in the future.

Even under dry conditions, higher river flows may occur, due to the operational delivery of water. Operational deliveries are water released from upstream to meet a downstream demand. Depending on their magnitude and timing, operational flows in some systems may support environmental outcomes or cause environmental harm. While program partners work closely with river operators to achieve positive environmental outcomes year-round, the nature of downstream demands means this is not always possible.

In 2019–20, high operational flows are expected under some scenarios in the River Murray and the Goulburn River. For example, operational transfers of water from Hume Reservoir to the lower Murray in spring may create an opportunity to piggyback environmental flows above choke capacity through the Barmah–Millewa Forest. This would help achieve environmental outcomes in the forest that would not be achievable with environmental flows alone. In the Goulburn River, the potential for high summer operational flows (inter-valley transfers) increases the need for environmental watering actions in winter and spring that may improve riparian vegetation and bank stability and help protect the river from summer operational flows.

Large rainfall events may result in unregulated flows that meet or exceed many of the flow targets for water for the environment in downstream waterways. Unregulated flows can reduce the amount of water for the environment that needs to be delivered to meet the highest-priority objectives, allowing additional watering actions during the year. However, if spills from storages occur, some or all unused water carried over from 2018–19 may be deducted from water for the environment accounts.

What is the *Basin Plan 2012*?

Northern Victoria is a part of the Murray-Darling Basin and deliveries of water for the environment in the northern region are subject to the requirements of the *Basin Plan 2012*, also known as the Murray-Darling Basin Plan or just the Basin Plan. The Murray-Darling Basin Authority (MDBA) developed the Basin Plan under the *Commonwealth Water Act 2007* and it became law in November 2012. The Basin Plan sets legal limits on the amount of water that can be taken from the Murray-Darling Basin's surface and groundwater resources. Chapter 8 of the Basin Plan also sets out a high-level environmental watering plan, which defines environmental objectives to protect, restore and build the resilience of water-dependent ecosystems and their associated functions. The VEWH's environmental planning and delivery is consistent with the requirements of the Basin Plan. The potential environmental watering outlined in sections 4 and 5 of this seasonal watering plan fulfil Victoria's obligations to identify annual environmental watering priorities for Victoria's water resource areas under section 8.26 of the *Basin Plan 2012*.

What is River Murray Increased Flows (RMIF)?

River Murray Increased Flows (RMIF) is water for the environment that has been recovered as part of the Snowy Water Initiative, established in 2002 to address environmental impacts associated with the operation of the Snowy Mountains Scheme. RMIF is stored in Snowy Hydro Limited's storages and released to maintain and improve environmental values in the River Murray. RMIF becomes available when:

- Snowy Hydro Limited release more than their nominated annual release volume, as part of their power generation operations
- Environmental water managers request additional RMIF be made available when volumes in River Murray storages exceed specified limits.

The call for and use of RMIF is coordinated by the Southern Connected Basin Environmental Watering Committee, and it must be authorised by both the VEWH and NSW Office of Environment and Heritage.

Northern Victoria and the southern Murray-Darling Basin

Rivers, creeks and floodplains in northern Victoria form part of the southern-connected Murray-Darling Basin. Water flows directly from the Victorian rivers and floodplains into the River Murray, which means that environmental flows delivered in northern Victorian systems can achieve ecological objectives at multiple sites throughout the Murray-Darling Basin. For example, water for the environment delivered in the Goulburn River flows into the River Murray and can be shepherded all the way to the Lower Lakes and Coorong in South Australia, providing environmental outcomes at Gunbower Forest, Hattah Lakes, Lindsay Island and the Chowilla floodplain along the way.

The Basin Plan 2012 and the 2014 *Basin-wide environmental watering strategy* guide the long-term planning of water for the environment in the Murray-Darling Basin. Under the Basin Plan, environmental objectives are met by achieving outcomes for connectivity, native vegetation, waterbirds and native fish.

Objectives and outcomes under the Basin Plan reflect local site- and state-based objectives, though site-based objectives are often broader in scope and specifically cover additional values (such as frogs, turtle, waterbugs and physical processes like sediment movement). Watering actions that support Basin Plan outcomes have significant benefits for many other species that rely on the surrounding landscape (such as squirrel gliders living along the lower Campaspe River or flocks of regent parrots moving into the Hattah Lakes floodplain after watering).

The VEWH coordinates its activities with other environmental water holders in northern Victoria, NSW and SA to achieve environmental outcomes at the southern-connected Murray-Darling Basin scale. Collaborative planning focuses on how upstream and downstream objectives align and how the broader operation of the River Murray system can help support environmental outcomes.

Annual planning is documented in basin annual environmental watering priorities (by MDBA under the Basin Plan), in annual portfolio management plans (by the Commonwealth Environmental Water Office, and in the VEWH's annual seasonal watering plan (that is, this document). In Victoria, all water for the environment must be delivered in line with the VEWH's seasonal watering plan, meaning coordination during annual planning is fundamental to successful basin-scale outcomes.

All environmental water holders in the Murray-Darling Basin are placing an increased emphasis on coordinating water deliveries to achieve landscape-scale environmental outcomes. Examples include:

- delivering a winter fresh in the Goulburn River, which subsequently passed through to the Lower Lakes in South Australia and through the barrages to the Coorong to trigger upstream migration of fish (such as lamprey)
- efficient water use meant that 78 percent of the flows delivered to Gunbower Forest in 2018–19 were from return flows that had been delivered upstream in the Campaspe and Goulburn rivers (for environmental purposes) then reused in Gunbower Forest, providing benefits not only to those rivers but also to the forest and River Murray as well.

The VEWH holds Victorian environmental entitlements for water recovered under interstate projects and agreements — Living Murray and RMIF entitlements — and these require coordinated decision-making about where they are used. The primary objective of Living Murray entitlements is to support Murray icon sites, which include the Barmah Forest, Gunbower Forest, Hattah Lakes and the Lindsay–Mulcra–Wallpolla islands in Victoria. RMIF also support environmental objectives along the Murray system in Victoria, NSW and SA. Recommendations for the coordinated use of Living Murray allocation and RMIF are made by the Southern Connected Basin Environmental Watering Committee.

The VEWH partners with the Commonwealth Environmental Water Office to optimise the benefits of water for the environment held by the CEWH and delivered in Victoria. Delivery of the Living Murray's and Commonwealth's environmental Water Holdings, to meet Victorian environmental watering objectives, is included in relevant system sections in the following pages of this document.

Water for the environment delivered through northern Victorian waterways can often be reused to achieve further environmental benefits downstream. If return flows are not reused at Victorian environmental sites, VEWH, Living Murray and CEWH return flows continue to flow across the border to South Australia where they will be used to provide environmental benefits along the River Murray and in the Coorong, Lower Lakes and Murray Mouth area.

The VEWH may also order, or authorise waterway managers to order, Living Murray and Commonwealth water for the environment for environmental outcomes at downstream (non-Victorian) sites. As well, the VEWH may order water for delivery in the Murray system to non-Victorian sites under river operating rules that help improve environmental outcomes while maintaining the reliability of entitlements for all water users. In previous years, this has included deliveries to the Murray from the lower Darling, orders for delivery from Lake Victoria and orders for delivery to the River Murray itself.

Risk management

During the development of the seasonal watering proposals for the northern region systems, environmental watering program partners held workshops to assess risks associated with potential environmental watering actions for 2019–20 and identify appropriate mitigating strategies. Risks and mitigating actions are continually assessed by program partners throughout the year (see subsection 1.3.6).

5.2 Victorian Murray system

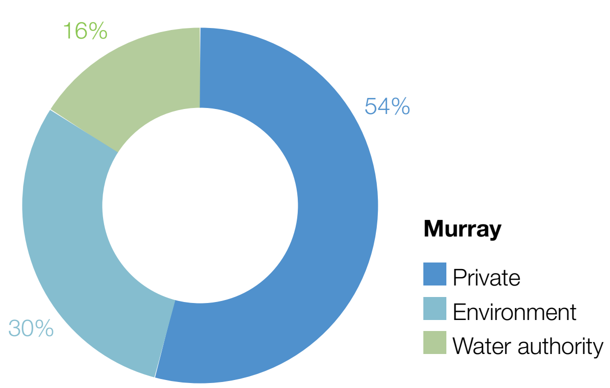
Waterway managers – Goulburn Broken, Mallee and North Central catchment management authorities

Storage managers – Goulburn-Murray Water, Lower Murray Water, Murray-Darling Basin Authority (River Murray Operations), SA Water

Environmental water holders – Victorian Environmental Water Holder (including the Living Murray program), Commonwealth Environmental Water Holder

Did you know ...?

The Murray is Australia's longest and most iconic river and supports freshwater, floodplain, wetland and estuarine environments of national and international significance. This includes Australia's (and the world's!) largest river redgum forest at Barmah, wetlands listed under the Convention on Wetlands of International Importance (the Ramsar Convention), and Australia's largest freshwater fish species, the Murray cod.



Proportion of water entitlements in the Murray basin held by private users, water corporations or environmental water holders at 30 June 2018.

Top: Hattah Lakes, by Mallee CMA
Centre: Brolga courting dance, McDonald Swamp, by North Central CMA
Above: Black winged stints flying over Lake Hawthorn, Mallee CMA

The Victorian Murray system contains many significant floodplains and wetland systems covering the Goulburn Broken, North Central and Mallee CMA areas. The Barmah Forest, Kerang wetlands and Hattah Lakes are internationally significant, Ramsar-listed sites due to the abundance and range of waterbird species that use them. Many other wetlands in the system are either nationally or regionally significant.

Water for the environment can be supplied to the Victorian Murray system from a range of sources. These include entitlements held by the VEWH, which includes those held on behalf of the Living Murray program and River Murray Increased Flows portfolios, and the Commonwealth Environmental Water Holder; reuse of return flows; and in some instances use of operational water en route. The source of the water and the ability to deliver all watering actions will depend on water availability, water commitments by other environmental water holders and operational requirements. As a result, the following Victorian Murray system sections do not specify the expected availability of water for the environment.

5.2.1 Barmah Forest

System overview

The Barmah–Millewa Forest covers 66,000 ha and spans the NSW and Victorian borders between the townships of Tocumwal, Deniliquin and Echuca (Figure 5.2.1). It is an internationally significant, Ramsar-listed wetland due to its outstanding natural values, and it is one of six icon sites for environmental outcomes in the Living Murray initiative. The forest's Victorian component is the Barmah National Park and part of the River Murray Reserve, covering 28,500 ha of forest and wetlands.

Flooding in the Barmah–Millewa Forest depends on flows in the River Murray. A natural narrowing of the river (known as the Barmah choke) restricts flow and results in overbank flooding when flows downstream of Yarrawonga Weir exceed the channel's capacity. This restriction influences both the operation of Yarrawonga Weir and the upper limit of environmental flows that can be delivered to the forests.

The delivery of irrigation water during summer and autumn is managed to minimise unseasonal flooding of the forest. Regulators along the River Murray remain closed during summer and autumn to restrict flow through low-lying flood runners. The delivery of water to Barmah Forest is also limited by an imposed flow constraint downstream of Yarrawonga Weir to prevent flooding of private land. The current constraint limits releases to a maximum of 18,000 ML per day until the end of September (with potentially affected landholder support) and to 15,000 ML per day for the rest of the year. To overcome this constraint, most environmental flows are directed into Barmah and Millewa forests via regulators rather than overbank flows. It is currently not possible to achieve the desired flooding depth and duration for floodplain marsh vegetation in both forests at the same time without natural flooding.

Water management at Barmah–Millewa Forest seeks to build on unregulated flows and the delivery of consumptive and operational water en route to optimise environmental outcomes when possible. As Barmah–Millewa Forest is located towards the upper reaches of the regulated portion of the River Murray, water for the environment delivered to the forest can often be used again at sites further downstream, as part of multi-site watering events.

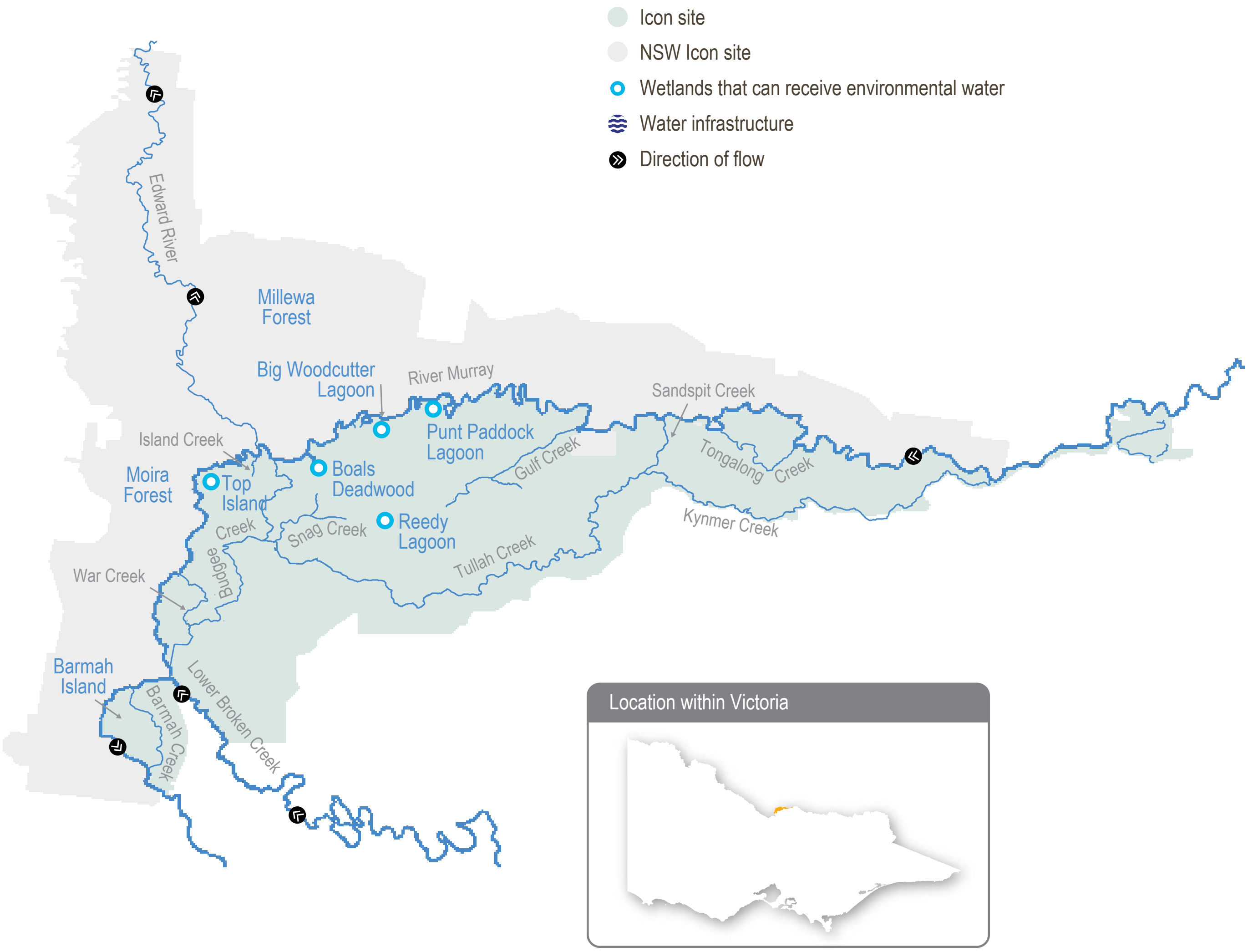
Environmental values

The Barmah–Millewa Forest is the largest river red gum forest in Australia and the most-intact freshwater floodplain system along the River Murray. The forest supports important floodplain vegetation communities including the threatened Moira grass plains and is a significant feeding and breeding site for waterbirds including bitterns, ibis, egrets, spoonbills and night herons. Significant populations of native fish, frogs and turtles also live in the forest's waterways. Barmah Forest is known to support 74 plant and animal species protected under state and national legislation.

Environmental objectives in the Barmah Forest

Fish	Provide habitat for native fish and increase the population
Frogs	Maintain or increase the habitat available for frogs
Nutrient cycling	Enable nutrient cycling (particularly carbon) between the floodplain and river through connectivity
Turtles	Maintain or increase the habitat available for turtles including the broad-shelled turtle
Vegetation	Enhance the health of river red gum communities and aquatic vegetation in the wetlands and watercourses and on the floodplain Promote the growth of floodplain marsh vegetation communities, particularly the extent of Moira grass growing in these areas
Waterbirds	Provide feeding and nesting habitat for the successful recruitment of colonial nesting waterbirds
Water quality	Provide early-season flushing of the lower floodplain to cycle nutrients during cooler conditions and reduce the risk of poor water quality events in summer

Figure 5.2.1 Barmah Forest



Recent conditions

Forest regulators were opened in July 2018 to allow water to pass through Barmah Forest while the flow in the River Murray was below channel capacity. From September 2018, the volume of operational transfers between Hume Reservoir and Lake Victoria increased and exceeded the channel capacity. These operational transfers caused sustained low-level flooding of the Barmah floodplain. Water for the environment was released in November and December 2018 to enhance the low-level flooding and optimise environmental outcomes triggered by the operational transfers. All flows reduced in late December 2018, and the forest dried out over the rest of summer and autumn.

Around 30 percent of the Barmah floodplain was inundated in spring, resulting in an excellent vegetation response for wetland plants in the shallow freshwater marshlands. Exceptional growth and flowering of Moira grass was recorded, and it was observed to grow in parts of its former range where it has not been recorded for many years. This was an important outcome for a species that has suffered a 90 percent decline in extent since 1930.

Waterbirds also responded to the spring/summer flood. Many species were observed breeding or calling throughout the wetlands including Australasian and little bitterns, and relatively small numbers of colonial nesting waterbirds (such as cormorants, ibis and night herons) also bred. In most years, additional environmental flows are provided during summer to help birds complete their breeding, but this was not required in 2018–19 due to the relatively low numbers of colonial waterbird nests.

Most of the operational flows in spring 2018 were directed through Barmah Forest to optimise the transfers to Lake Victoria. As a result, only around five percent of the Millewa Forest floodplain was inundated. Watering low-lying wetlands in Millewa Forest will be the priority objective if overbank environmental flows occur in 2019–20.

Scope of environmental watering

Table 5.2.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

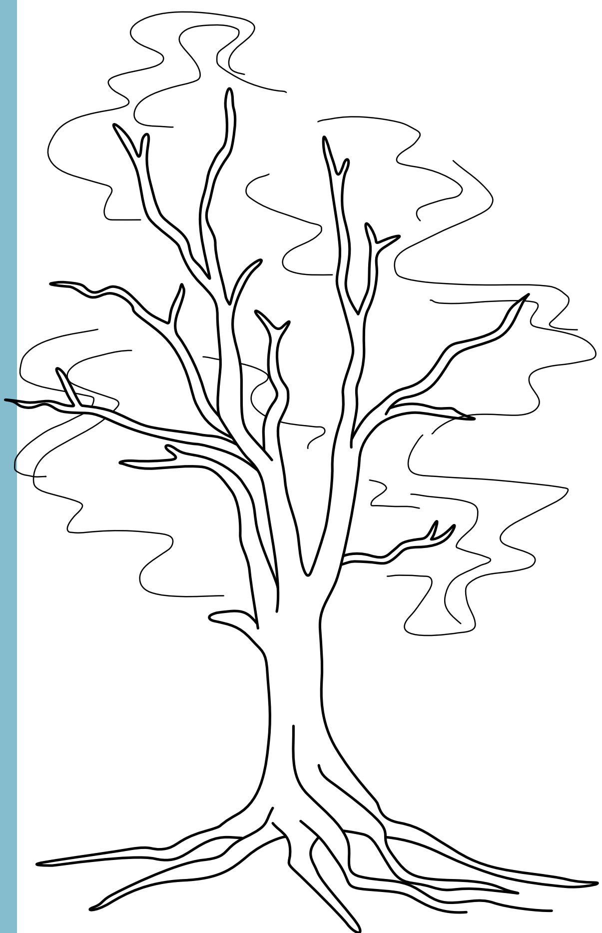


Table 5.2.1 Potential environmental watering actions and objectives for the Barmah Forest

Potential environmental watering action	Functional watering objective	Environmental objective
Winter/spring low flows to various waterways in Barmah Forest (variable flow rates during July to December)	• Provide flow in forest waterways to maintain habitat for native fish and turtles • Facilitate the movement of native fish between floodplain waterways and the river • Remove accumulated organic matter to cycle carbon to the river system and minimise the risk of anoxic blackwater	
Spring/summer freshes (in-channel) in the River Murray channel (up to three events of at least 500 ML/day of variability for eight days during October to December)	• Trigger spawning of native fish species, primarily golden and silver perch	
Spring/summer freshes (drought) to Gulf and Boals creeks (100 ML/day for three to five days as required during November to April)	• Maintain critical drought-refuge areas in Barmah Forest to provide habitat for native fish and turtle populations • Flush drought-refuge pools to maintain water quality	
Spring/summer/autumn low flows to floodplain waterways including Sandspit, Gulf, Big Woodcutter, Boals, Island and Punt Paddock Lagoon (200 ML/day for 30 to 60 days during November to April)[1]	• Provide flows to replenish refuge areas and maintain water quality • Provide flows to replenish permanent waterways, to maintain fish and turtle populations • Maintain connectivity to the river • Remove accumulated organic matter, cycle carbon to the river system and minimise the risk of anoxic blackwater	
Spring inundation of floodplain marshes (variable flow rates up to 18,000 ML/day downstream of Yarrawonga Weir for three months during September to December)[1]	• Provide flooding of sufficient duration to allow the growth of floodplain marsh vegetation in open plains • Provide water to in-forest wetlands and low-lying floodplain areas to create foraging opportunities for birds and increase available habitat for turtles, frogs and small-bodied native fish	
Targeted wetland watering to Boals Deadwood, Reedy Lagoon and Top Island wetlands (200–400 ML/day for four and a half months during September to February)	• Provide a cue to initiate waterbird breeding or maintain a breeding event • Maintain wetland vegetation to provide habitat for colonial nesting and flow-dependent waterbirds	
Autumn/winter low flows in the River Murray (up to 4,000 ML/day downstream of Yarrawonga in May to June)	• Increase water depth in the River Murray channel to provide habitat for large-bodied native fish in the River Murray and unregulated anabranches in Barmah–Millewa Forest	

[1] *Likely to target Millewa Forest in 2019–20, unless the Murray–Darling Basin Authority directs operational transfers via Barmah Forest.*

Scenario planning

Table 5.2.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The ecological objectives at Barmah–Millewa Forest require sustained river flows, peaking with high flows in spring. These are achieved using a suite of small-scale works to improve water management, directing water from the River Murray channel into the forest and then allowing most of it to return to the river for use further downstream. Demands for water for the environment in Barmah Forest vary significantly in response to natural conditions. Under dry conditions, objectives focus on maintaining refuges to sustain fish and turtle populations. Actions to achieve these objectives require relatively small volumes of water to be directed into the forest, and they return relatively small volumes of water back to the river.

Under average or wet conditions, the focus shifts to building resilience in the system by increasing the ecological response to natural flood events. Specific actions may include extending the duration of natural flooding to increase the germination of wetland plants (such as Moira grass) in floodplain marshes or extending watering in river red gum forests to maintain the health of the trees. These actions require large volumes of water to be directed into the forest, with most of it returned to the river.

Water for the environment was delivered in May 2019 and June 2019, to increase native fish habitat in the River Murray channel. Targeted wetland watering may occur under a range of conditions to support the breeding of colonial nesting waterbirds and other flood-dependent birds.

All potential watering actions are tier 1a under each climatic scenario, except for the spring inundation of floodplain marshes under dry and drought conditions (tier 2). While not a required action for Barmah Forest in 2019–20, other water deliveries in the Murray system may allow the action to be delivered. For example, above-channel-capacity operational transfers from Hume Reservoir may occur through Barmah Forest during spring, meaning a relatively small volume of additional environmental flow could be delivered to achieve the floodplain marsh environmental objectives. A multi-site environmental watering objective supporting whole-of-River-Murray and/or downstream environmental objectives during winter and spring may also deliver flows through Barmah Forest, and these could be supplemented to optimise the site-based outcomes at Barmah Forest. The volume of water for the environment required to achieve the floodplain marsh flow objectives under dry or drought conditions depends on demands for the operational or environmental multi-site events, and it is therefore not estimated in Table 5.2.2 below.

Table 5.2.2 Potential environmental watering for the Barmah Forest under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Unregulated flow periods unlikely • Flows in the River Murray will remain within channel all year	• Some small unregulated flows in late winter/spring • Low chance of overbank flows in late winter/spring	• Likely chance of small-to-medium unregulated flows in winter/spring • Likely chance of overbank flows in winter/spring	• High probability of moderate-to-large unregulated flows in winter/spring • Expected large overbank flows
Potential environmental watering (tier 1a)	• Winter/spring low flows • Spring/summer freshes (in-channel) • Spring/summer freshes (drought)	• Winter/spring low flows • Spring/summer freshes (in-channel) • Spring/summer/autumn low flows • Fill Boals Deadwood, Reedy Lagoon and Top Island wetlands	• Winter/spring low flows • Spring/summer freshes (in-channel) • Spring/summer/autumn low flows • Spring inundation of floodplain marshes • Fill Boals Deadwood, Reedy Lagoon and Top Island wetlands • autumn/winter low flows	• Winter/spring low flows • Spring/summer freshes (in-channel) • Spring inundation of floodplain marshes • Fill Boals Deadwood, Reedy Lagoon and Top Island wetlands • autumn/winter low flows
Potential environmental watering (tier 2)	• Spring inundation of floodplain marshes	• Spring inundation of floodplain marshes		
Possible volume of water for the environment required to achieve objectives[1]	• 3,500 ML (no return flows, tier 1a)	• 51,500 ML (with return flows, tier 1a)	• 566,000 ML (with return flows)	• 570,000 ML (with return flows)

[1] *The possible volumes of water for the environment required in Barmah Forest are estimates and highly variable. The actual volume delivered is measured and depends on seasonal conditions. Unregulated and/or operational flows may meet a small to large portion of the demand.*

5.2.2 Gunbower Creek and Forest

System overview

Gunbower Forest is a large, flood-dependent forest situated on the River Murray floodplain in northern Victoria between Torrumbarry and Koondrook (Figure 5.2.2).

Covering 19,450 ha, it is bounded by the River Murray to the north and Gunbower Creek to the south. It is an internationally significant site under the Ramsar Convention and forms part of the Living Murray Gunbower-Koondrook-Perricoota forests icon site. River regulation and water extraction from the River Murray and Gunbower Creek has reduced the frequency, duration and magnitude of flood events in Gunbower Forest. This has affected the extent and condition of floodplain habitats and the health of plant and animal communities (such as river red gum and black box communities, native fish, birds, platypus, frogs and turtles) that depend on those habitats.

Gunbower Creek is managed primarily as an irrigation carrier and supplies the Torrumbarry Irrigation Area from the River Murray. Daily variations in water levels in the creek through spring, summer and autumn are much higher now than under natural conditions, due to changing irrigation demand. Frequent or rapid fluctuations in water levels can greatly affect native fish populations and other ecological processes. Water for the environment is used to reduce water level fluctuations by filling the gaps in flows caused by irrigation demand within the creek. This action supports native fish migration and breeding and promotes other ecological processes while maintaining water delivery for irrigation needs.

The Living Murray structural works program in the middle and lower forest was completed in 2013. The works allow up to 4,500 ha of the wetlands and floodplain to be watered with considerably less water than would be required if the new watering infrastructure was not in place. The works enable efficient watering through Gunbower Creek and the forest to maintain wetland and floodplain condition, and they provide a link between the creek, forest floodplain and the River Murray. Frequent connections between the river and floodplain habitats allow biota to move between habitats, and they also support critical ecosystem functions (such as carbon exchange).

Environmental values

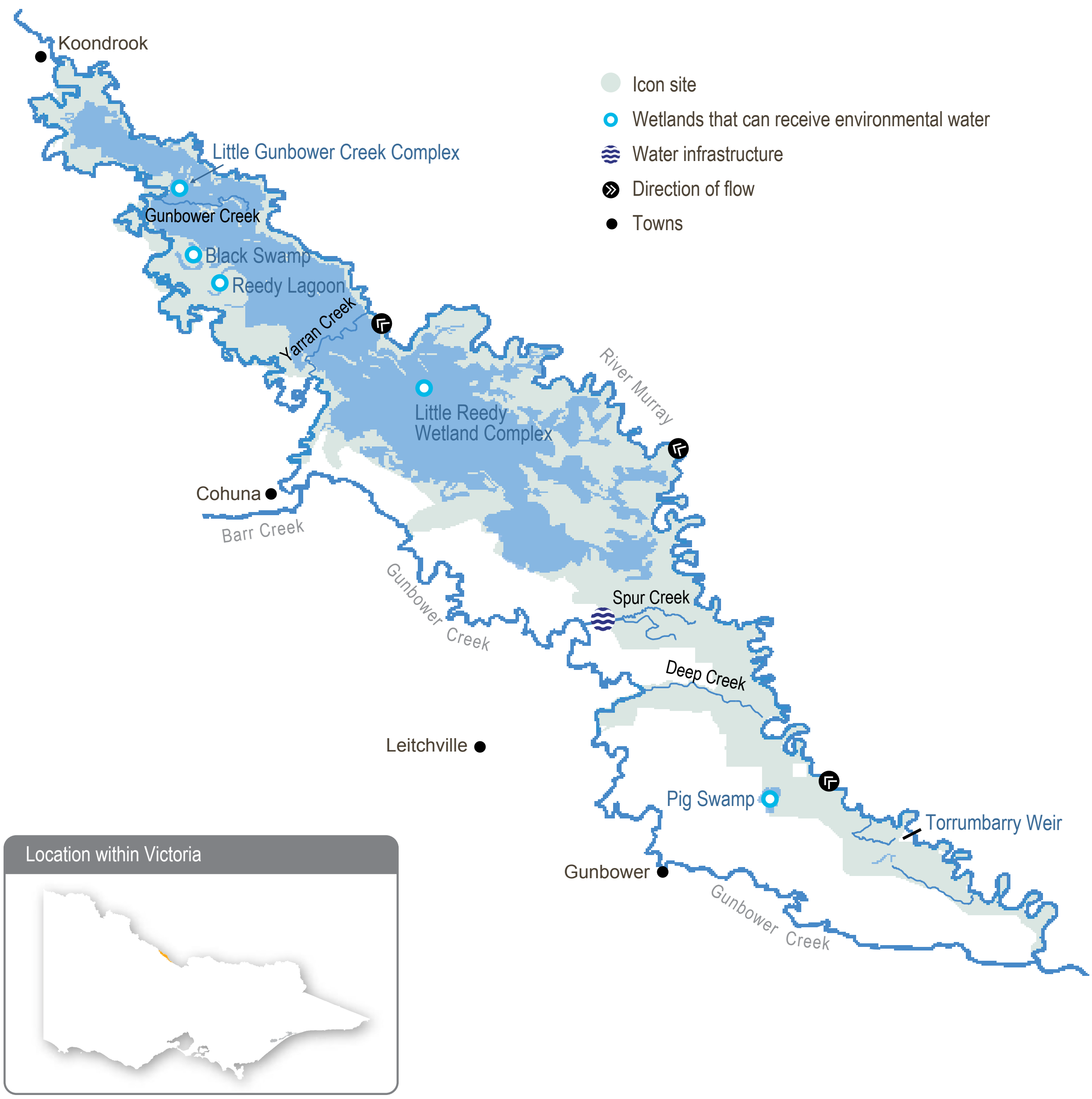
Gunbower Forest contains many important environmental values including rare and diverse wetland habitats, vulnerable and endangered plants (such as river swamp wallaby-grass and wavy marshwort) and animals, and large areas of remnant vegetation communities (such as river red gum forest). The forest provides habitat for many bird and small-bodied native fish species, and it is known to support internationally recognised migratory waterbirds, such as eastern great and intermediate egrets.

Gunbower Creek provides important habitat for native fish (such as Murray cod, golden perch and freshwater catfish). It is a valuable refuge for native fish, and it provides a source of fish to recolonise surrounding waterways.

Environmental objectives in Gunbower Creek and Forest

	Maintain and increase populations of large and small-bodied native fish (such as Murray cod)
	Increase the population of frogs in the forest by providing feeding and breeding habitat
	Maintain connections between the River Murray, Gunbower Forest floodplain, wetlands and floodrunners and Gunbower Creek
	Maintain the population of turtles
	Maintain the health and increase the abundance of native vegetation in priority permanent and semi-permanent wetlands Improve the health of river red gums, black box and grey box communities
	Provide feeding, breeding and refuge habitat for waterbirds including colonial nesting species, such as egrets, cormorants and herons
	Maintain and improve water quality in Gunbower Creek

Figure 5.2.2 Gunbower Creek and Forest



Recent conditions

Following two very hot and dry summers, 51.8 GL of water for the environment was delivered to Gunbower Forest from mid-June 2018 to the end of October 2018. The water inundated about 4,500 ha of the forest floodplain, floodrunners and wetlands, which included 25 percent (3,233 ha) of all river red gum areas and 87 percent (1,199 ha) of all wetlands within Gunbower Forest. The inundation supported the flood-dependent understorey and continued the long-term recovery of wetland plant communities from the Millennium Drought.

Flows into the forest improved the health of river red gum forest habitats. Understorey communities within inundated areas had greater coverage of aquatic, amphibious and mudflat plant species compared to areas that remained dry. Responses in wetlands were more varied, which may be partly due to the presence of large carp. Wetlands with small populations of adult carp (such as Reedy Lagoon) responded well, with dense cover of river swamp wallaby-grass, yellow bladderwort and wavy marshwort appearing during late spring and early summer. Vegetation responses were more limited at Black Swamp, which had a larger carp population.

Managed flows to Gunbower Forest supported many species of waterbirds to breed and successfully fledge their young, including ducks, Australasian grebes and black swans. The resident white-bellied sea eagle pairs at Little Reedy Lagoon and Little Gunbower Lagoon successfully bred in 2018, which is the third year in the row for the pair in Little Reedy Lagoon and the second time in three years for the pair in Little Gunbower. While surveys in September and October 2018 found limited signs of colonial waterbirds nesting, surveys in December 2018 at Long Lagoon found over 50 nests (about 150 juveniles present) including Australasian darter, Australian ibis, little pied cormorants, little black cormorants and great cormorant species. Most chicks fledged successfully by January 2019.

Fish surveys conducted in forest wetlands in autumn 2018 recorded less than half of the native species that would have historically used the wetlands. This result probably reflects recent drying patterns that were implemented since 2016 to remove large-bodied adult carp. Native fish communities are expected to improve in the forest wetlands if future watering events allow connections between the wetlands, Gunbower Creek and the River Murray.

Capacity constraints in Gunbower Creek mean it is not possible to simultaneously deliver large flows to Gunbower Forest and the lower reaches of Gunbower Creek. Environmental flows mainly targeted Gunbower Forest in 2018–19, and therefore flow in the lower reaches of Gunbower Creek was limited to a minimum rate that would still allow native fish to move throughout the system. The lower flow provided an opportunity to test whether native fish (including Murray cod) would spawn without the flow cues that have been provided in Gunbower Creek since 2013–14. Monitoring conducted in spring 2018 detected larvae of Murray cod, carp gudgeon, Australian smelt and flat-headed gudgeon in Gunbower Creek, but breeding rates were considerably lower than previous years. Importantly, most fish larvae were caught below Cohuna Weir, which was the reach that the flows targeted. Monitoring also detected a high abundance of waterbugs, which indicates the system is productive and likely supports the food resources that adult and larval fish need.

In May 2019, water for the environment was delivered to top up Reedy Lagoon in Gunbower Forest, to support the aquatic and amphibious wetland plants and maintain drought refugia for waterbirds, turtles and frogs.

Scope of environmental watering

Table 5.2.3 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

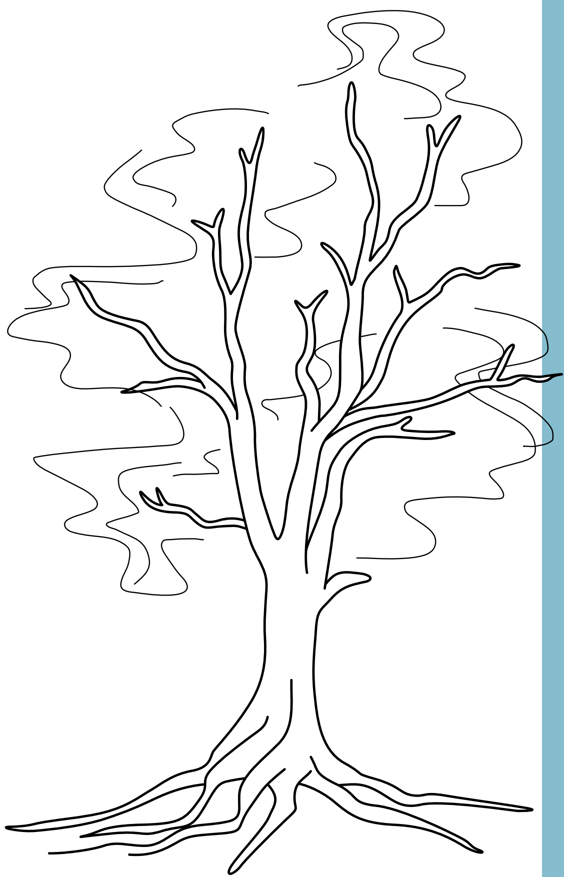


Table 5.2.3 Potential environmental watering actions and objectives for Gunbower Creek and Forest

Potential environmental watering action	Functional watering objective	Environmental objective
Gunbower Forest		
Reedy Lagoon (top-up in winter/spring 2019)	• Maintain the water depth to support wetland plants to flower, set seed and germinate • Maintain the water depth to provide feeding and refuge habitat for waterbirds, turtles and frogs • Maintain the water depth and quality to provide habitat for small-bodied native fish including Murray-Darling rainbowfish	
Little Gunbower wetland complex (fill in winter and provide top-ups if a significant bird-breeding event occurs)	• Maintain the water depth to support wetland plants to flower, set seed and germinate • Provide feeding and refuge habitat for waterbirds and frogs	
Black Swamp (fill in autumn 2020)	• Maintain the water depth to support wetland plants to flower, set seed and germinate • Provide feeding and refuge habitat for waterbirds and frogs	
Green Swamp, Corduroy Swamp and Little Reedy Lagoon (fill in winter 2019)	• Maintain the water depth to support wetland plants to flower, set seed and germinate • Provide feeding and refuge habitat for waterbirds and frogs • Provide habitat for small-bodied native fish	
Winter/spring fresh in Yarran Creek (variable flow rates and duration based on water levels in Gunbower Forest and flows in the River Murray and Gunbower Creek)	• Provide connectivity between Gunbower Creek and the River Murray through the Yarran Creek and Shillinglaws regulators, to increase flowing habitat for the lateral movement of native fish, turtles, carbon, nutrients and seed propagules • Provide migration and spawning opportunities for native fish	
Reedy Lagoon (top-up in autumn/winter 2020)	• Maintain the water depth to support wetland plants to flower, set seed and germinate • Maintain feeding and refuge habitat for waterbirds and frogs • Maintain habitat for small-bodied native fish including Murray-Darling rainbowfish	
Extend natural flooding in the Gunbower Forest floodplain, floodrunners and wetlands (with variable flow rates to maintain appropriate inundation extent)	• Inundate river red gum, black box and grey box communities • Provide access to breeding habitat and food resources for native fish (such as Murray cod) • Provide refuge habitat for waterbirds including colonial nesting species	

Table 5.2.3 Potential environmental watering actions and objectives for Gunbower Creek and Forest *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Gunbower Creek		
Winter low flows (above 300 ML/day during May to August)	• Provide access to habitat and food resources for native fish (such as Murray cod)	
Spring/summer/autumn high flows (targeting a gradual increase, stable flow period and decrease in flows ranging between 300–600 ML/day during August to May)	• Provide access to breeding habitat and food resources for native fish (such as Murray cod) • Provide cues for the migration and spawning of native fish	
Year-round low flows (above 300 ML/day)[1]	• Increase access to habitat and food resources for native fish	
Increased low flows (up to 550 ML/day year-round if unregulated conditions occur in the River Murray)[2]	• Increase recruitment from the River Murray populations into the creek by providing enough flow for native fish to migrate and spawn • Provide access to breeding habitat and food resources for native fish (such as Murray cod)	
Spring/summer/autumn freshes (up to 550 ML/day for two to four weeks during October to April)[2]	• Increase recruitment from the River Murray populations into the creek by providing cues for native fish to migrate and spawn • Dilute low-dissolved-oxygen water exiting Gunbower Forest below Koondrook Weir	

1 *Year-round low flows may be provided when delivery to Gunbower Forest through the Hipwell Road Channel regulator is occurring, to optimise the volume that can be delivered to the floodplain.*

2 *Increased low flows and freshes may be provided opportunistically in Gunbower Creek if unregulated conditions eventuate in the River Murray and the Hipwell Road Channel regulator is not being used.*

Scenario planning

Table 5.2.4 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The key objectives in 2019–20 are to build on the significant, positive ecological outcomes that were observed after floodplain watering in 2018–19 and provide refugia for wetland-dependent plants and animals. Unless naturally triggered, it is unlikely that large-scale floodplain watering will be delivered in winter/spring, and the focus of the delivery of water for the environment will be consolidating the outcomes of past watering actions in some wetlands in the forest.

In drought, dry and average conditions, the environmental watering priorities will be to maintain and improve the condition of semi-permanent and permanent wetlands across the forest and support local populations of waterbirds and small-bodied native fish. Delivering water to some permanent and semi-permanent wetlands in winter and spring 2019 will provide habitat for waterbirds and other wetland-dependent animals during the cooler months and prime the wetlands for a spring productivity boost. Topping up wetlands in autumn will help to maintain wetland vegetation and provide refuge over winter for water-dependent animals including waterbirds, if dry conditions persist into the first half of 2020 and beyond.

Under average or wet conditions, unregulated flows from the River Murray may inundate parts of the Gunbower Forest floodplain. Under these circumstances, water for the environment may be used to extend a flooding event in selected river red gum areas, to maintain and improve tree health.

If flow in the River Murray exceeds 15,000 ML per day for more than two weeks in winter/spring, a fresh may be delivered in Yarran Creek to allow carbon, fish, turtles and seed propagules to move between Gunbower Creek, Gunbower Forest and the River Murray. This event may be provided in dry to wet scenarios but is a lower priority under drought conditions.

Under all climatic conditions, water for the environment may be used to support a natural waterbird breeding event. This action would be based on the size of the breeding event and likelihood that chicks will fledge without additional water.

Gunbower Creek is a highly regulated system. As a result, natural conditions (such as flooding and rainfall) do not greatly influence the objectives or flow requirements in the system. Management of water for the environment will aim to support all aspects of native fish life cycles, ensuring there are sufficient habitat and food resources for native fish throughout the year.

The highest priority for water for the environment for Gunbower Creek is to maintain flowing habitat and access to feeding resources for native fish during winter, when historically, outside of the irrigation season, the creek was drawn down to pools. The second-highest priority is to smooth out flows during the irrigation season to provide opportunities for native fish (especially Murray cod) to breed and for their larvae to disperse.

In a wet climate scenario, water for the environment may be used to provide short freshes or increased low flows in Gunbower Creek. These flows may facilitate native fish movement between Gunbower Creek and the River Murray and cue spawning at a time when fish populations are likely to be responding to larger flows in the River Murray and other connected tributaries.

If water for the environment is used in 2019–20 to extend the duration or extent of a natural flood in Gunbower Forest, it may not be possible to deliver the full range of flows for large-bodied fish in Gunbower Creek. Under these circumstances, flow in Gunbower Creek will be managed to maintain habitat for the existing native fish population. A fresh may be delivered downstream of Koondrook Weir to dilute low-oxygen floodwater that drains from the floodplain into the river.

A minimum volume of 13,900 ML is planned to be carried over into 2020–21 to provide certainty of supply for low flows in Gunbower Creek during the winter period outside the irrigation season (between 15 May and 15 August each year), to maintain flowing habitat. Additionally, carryover volumes will support the winter/spring 2020 fills and top-ups of permanent wetlands in lower Gunbower Forest, to ensure habitat is available for small-bodied native fish, waterbirds and other aquatic plant and animal species.

Table 5.2.4 Potential environmental watering for Gunbower Creek and Forest under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No natural inflows into Gunbower Forest	• Minor natural inflows into Gunbower Forest may occur in winter/spring	• Some natural inflows into Gunbower Forest are likely in winter/ spring but unlikely to be significant	• Overbank flows are likely in winter/ spring
Potential environmental watering – tier 1 (high priorities)[1]	• Reedy Lagoon (winter/spring) • Little Gunbower wetland complex • Black Swamp • Gunbower Creek winter low flows • Gunbower Creek spring/summer/ autumn high flows	• Reedy Lagoon (winter/spring) • Little Gunbower wetland complex • Green Swamp, Corduroy Swamp and Little Reedy Lagoon • Black Swamp • Gunbower Creek winter low flows • Gunbower Creek spring/summer/ autumn high flows	• Reedy Lagoon (winter/spring) • Little Gunbower wetland complex • Green Swamp, Corduroy Swamp and Little Reedy Lagoon • Extend natural flooding by inundation of Gunbower Forest floodplain, floodrunners and wetlands (winter/ spring) • Yarran Creek winter/spring fresh • Black Swamp • Gunbower Creek winter low flows[2] • Gunbower Creek spring/summer/ autumn high flows[2]	• Reedy Lagoon (winter/spring) • Little Gunbower wetland complex • Green Swamp, Corduroy Swamp and Little Reedy Lagoon • Extend natural flooding by inundation of Gunbower Forest floodplain, floodrunners and wetlands (winter/ spring) • Yarran Creek winter/spring fresh • Black Swamp • Gunbower Creek winter low flows[2] • Gunbower Creek spring/summer/ autumn high flows[2]

Table 5.2.4 Potential environmental watering for Gunbower Creek and Forest under a range of planning scenarios *continued...*

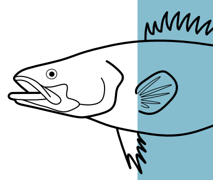
Planning scenario	Drought	Dry	Average	Wet
Potential environmental watering – tier 2 (additional priorities)	• Green Swamp, Corduroy Swamp and Little Reedy Lagoon • Reedy Lagoon (autumn/winter)	• Reedy Lagoon (autumn/winter) • Yarran Creek winter/spring fresh • Inundation of Gunbower Forest floodplain, floodrunners and wetlands (autumn/winter)	• Reedy Lagoon (autumn/winter) • Inundation of Gunbower Forest floodplain, floodrunners and wetlands (autumn/winter)	• Reedy Lagoon (autumn/winter) • Inundation of Gunbower Forest floodplain, floodrunners and wetlands (autumn/winter) • Gunbower Creek autumn/winter/spring increased low flows • Gunbower Creek spring/summer/autumn freshes
Possible volume of water for the environment required to meet objectives [3,4]	• 27,100 ML (tier 1) • 7,500 ML (tier 2)	• 35,000 ML (tier 1) • 29,000 ML (tier 2)	• 46,000 ML (tier 1) • 28,500 ML (tier 2)	• 46,000 ML (tier 1) • 34,500 ML (tier 2)
Priority carryover requirements	• 13,900 ML	• 13,900 ML	• 13,900 ML	• 13,900 ML

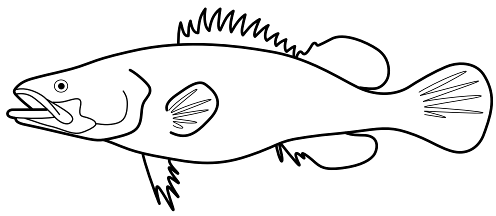
1 *Under tier 1 actions in all planning scenarios, an additional 900 ML (drought) and 1,500 ML (dry to wet) has been included to support a significant bird-breeding event that may be triggered by Gunbower floodplain inundation or wetland watering.*

2 *When the Hipwell Road Channel regulator is in operation, the highest-priority watering action will be to maintain a minimum year-round low flow of 300 ML per day, which will replace Gunbower Creek winter low flows and Gunbower Creek spring/summer/autumn high flows watering actions where this is the case.*

3 *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

4 *These estimates take account of the use of operational water en route to achieve watering action targets (except for discrete wetland watering actions), with water for the environment being required to underwrite the associated losses in Gunbower Creek and Gunbower Forest.*





5.2.3 Central Murray wetlands

System overview

The central Murray wetlands are located on the lower Loddon River and River Murray floodplains. The wetland system includes Round Lake, Lake Cullen, Lake Elizabeth, Lake Murphy, Johnson Swamp, Hird Swamp, Richardsons Lagoon, McDonalds Swamp, the Wirra-Lo wetland complex and Benwell and Guttrum state forests.

The central Murray wetlands are almost wholly contained within the Torrumbarry Irrigation Area and are all wetlands of regional or international significance. The area has experienced dramatic changes since European settlement with the construction of levees, roads and channels. Most of the wetlands are now cut off from natural flow paths and are rarely inundated by natural floods. They rely on water for the environment to maintain their ecological character and health.

Nine of the central Murray wetlands can receive water for the environment from permanent infrastructure: Lake Cullen, Hird Swamp, Johnson Swamp, Round Lake, McDonalds Swamp, Lake Elizabeth, Lake Murphy, Richardsons Lagoon and the Wirra-Lo wetland complex. Temporary pumps may be used to deliver water for the environment from the River Murray to some semi-permanent wetlands in the Guttrum and Benwell forests.

Environmental values

The wetlands in the central Murray system support vulnerable or endangered species including the Australasian bittern, Murray hardyhead, Australian painted snipe and growling grass frog. The wetlands provide habitat for many threatened and endangered bird species (including the eastern great egret and white-bellied sea eagle) listed under legislation and international agreements. Lake Cullen, Hird Swamp and Johnson Swamp are internationally recognised under the Ramsar Convention, while the other wetlands in the central Murray system have bioregional significance.

Environmental objectives in the central Murray wetlands

Restore the population of critically endangered Murray hardyhead

Maintain or increase the population of common, small-bodied native fish (such as carp gudgeon and flat-headed gudgeon)

Restore populations of endangered growling grass frog

Maintain the populations of common native frogs (such as barking marsh frog, Peron's tree frog and spotted grass frog)

Supply carbon to Pyramid Creek to boost the riverine foodweb

Maintain the population of native turtle species (such as the Murray River turtle and the common long-necked turtle)

Restore and maintain the health of riparian trees (such as river red gum and black box)

Restore and maintain mudflat vegetation communities (such as tall marsh, herblands, rushes and sedges)

Restore and maintain native aquatic vegetation species (such as tassel, milfoil and pondweed)

Reduce the extent and density of invasive plant species

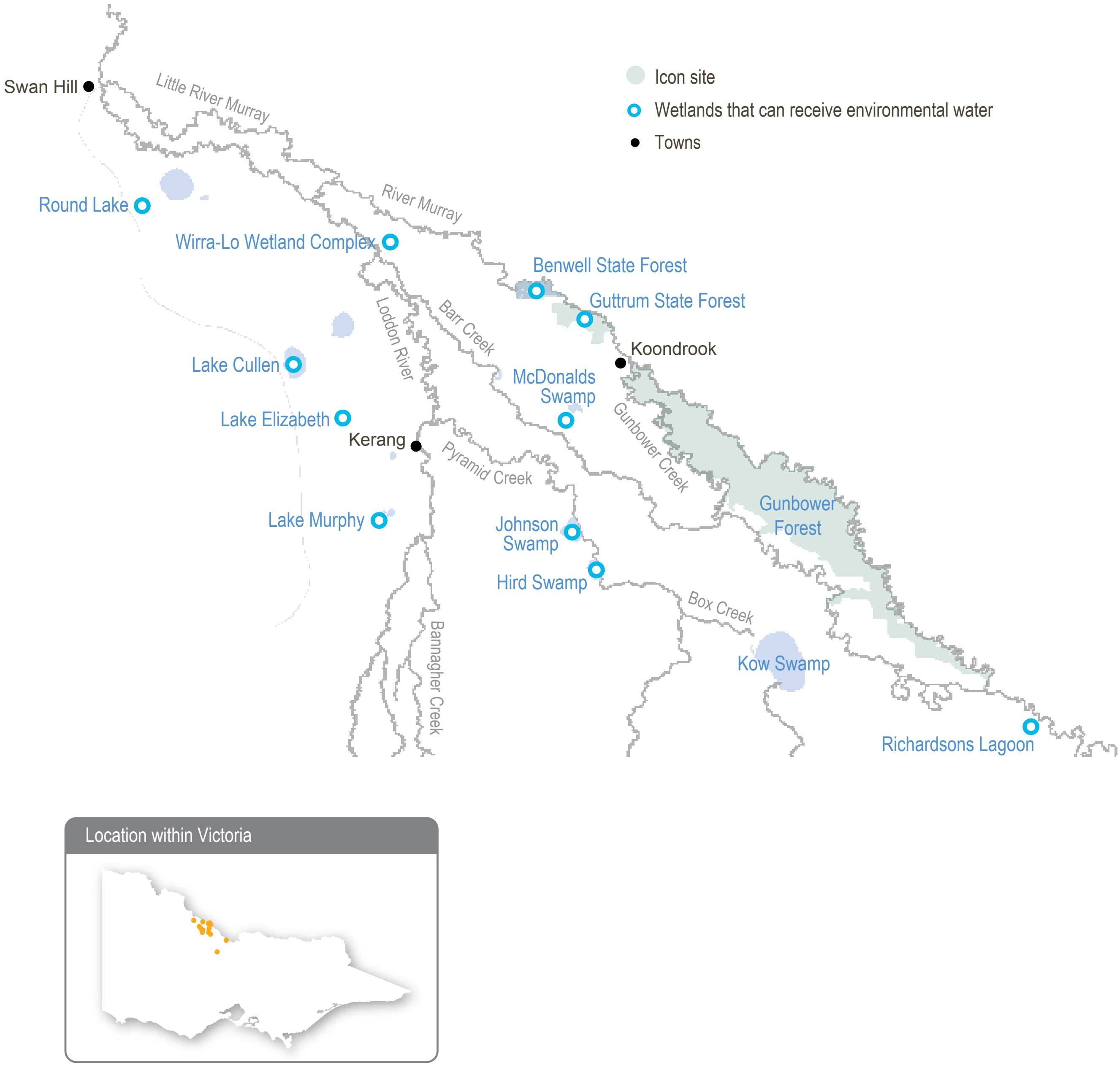
Support a mosaic of wetland plant communities across the region

Provide habitat for waterbird nesting, feeding and breeding for a variety of feeding guilds, including threatened species (such as Australasian bittern, little bittern and brolga)

Aboriginal environmental outcomes

Watering is planned to be delivered in partnership with Traditional Owners and achieve Aboriginal environmental outcomes

Figure 5.2.3 The central Murray wetlands



Recent conditions

Northern Victoria experienced drier and warmer conditions than average across 2018–19, with inflows to major storages tracking between dry to below average. Water for the environment was delivered to seven of the central Murray wetlands in 2018–19, as planned under a dry climate scenario.

In Round Lake and Lake Elizabeth, water for the environment was periodically used to maintain salinity within the target range for endangered Murray hardyhead, which were stocked in 2018 and 2016. Sampling at Lake Elizabeth in autumn 2018 found 24 Murray hardyhead (indicating successful recruitment, as the fish live for less than two years) and an additional 300 Murray hardyhead were released in Round Lake in October 2018 as part of a statewide translocation project.

Lake Cullen received water for the environment in spring 2018, which is the first time it has been watered independently of the Avoca Marshes. Until recently, it was thought that groundwater interactions forced saline water into the marshes when Lake Cullen was full. Recent investigations confirmed that this is not the case, which means water for the environment can be used as needed (irrespective of water levels in the Avoca Marshes) to support more environmental objectives in the lake. A waterbird survey conducted at Lake Cullen after the spring 2018 watering event recorded over 29,000 individual waterbirds, representing 60 waterbird species. Further monitoring was undertaken by Barapa Barapa and Wamba Wemba Traditional Owners in winter 2019.

Lignum Swamp North and Brolga Swamp, within the Wirra-Lo wetland complex, received water for the environment in 2018–19. Six frog species including the endangered growling grass frog were recorded at the wetland throughout spring/summer.

Water for the environment was also delivered to McDonalds Swamp, Lake Murphy and Johnson Swamp in 2018–19, to promote vegetation growth to support feeding and breeding for birds.

Scope of environmental watering

Table 5.2.5 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Two new wetlands within the Wirra-Lo wetland complex have been added to the environmental watering program in 2019–20. These wetlands have been created as part of the national Bringing Back the Bitterns project, which aims to restore local populations of the endangered Australasian bittern. These wetlands are not yet named, and they are referred to as Bittern East and Bittern West in this plan.

Table 5.2.5 Potential environmental watering actions and objectives for the central Murray wetlands

Potential environmental watering action	Functional watering objective	Environmental objective
Round Lake (top-ups as required to maintain water quality targets)	• Maintain salinity within 25,000–40,000 EC[1] to support suitable habitat and breeding conditions for Murray hardyhead and growing conditions for submerged aquatic plants	
Lake Elizabeth (top-ups as required to maintain water quality targets)	• Maintain salinity within 25,000–40,000 EC[1] to support suitable habitat and breeding conditions for Murray hardyhead and growing conditions for submerged aquatic plants • Provide permanent water as habitat for waterbirds	
Wirra-Lo wetland complex – Duck Creek North, Duck Creek South, Lignum Swamp North and Brolga Swamp (fill in spring)	• Maintain the health of open woodland vegetation, lignum and other aquatic vegetation • Provide feeding and breeding habitat for growling grass frog and other frog species • Provide foraging habitat for shallow-wading waterbirds and mudflat specialists • Provide refuge and recruitment sites for freshwater turtles	
Wirra-Lo wetland complex – Red Gum Swamp (fill in spring)	• Maintain the health of existing red gum trees	
Wirra-Lo wetland complex – Bittern West and Bittern East wetlands (partial fill in spring)	• Support the growth of newly-established reed beds to create nesting habitat for Australasian bittern	

Table 5.2.5 Potential environmental watering actions and objectives for the central Murray wetlands *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Guttrum Forest (fill in spring and autumn, with top-ups in summer if required to support waterbird breeding)	• Inundate the existing adult river red gums to support their growth and drown river red gum saplings in the open-water habitat • Promote the growth and re-establishment of aquatic and tall marsh vegetation • Maintain the depth of the wetland to support waterbird feeding and breeding	
Johnson Swamp (fill in spring – with through-flow to Pyramid Creek, with top-ups in summer/autumn to support bird breeding if required[2])	• Promote waterbird breeding and feeding • Restrict the growth of tall marsh vegetation by preventing otherwise favourable warm, shallow-water conditions • Promote the growth of aquatic herbland species • Provide refuge and recruitment sites for freshwater turtles • Provide carbon and nutrients to Pyramid Creek	
McDonalds Swamp (partial fill in autumn)	• Promote the growth of planted and naturally recruited river red gums • Support the germination of aquatic vegetation • Promote winter feeding conditions for waterbirds and frogs	
Lake Cullen (top-up in spring, and as required to support waterbird breeding[2])	• Maintain waterbird refuge • Promote the growth and recruitment of submerged aquatic plants • Maintain water levels to support waterbird breeding	
Wetland drying		
Lake Murphy, Hird Swamp and Richardsons Lagoon will not be actively watered in 2019–20	• Prevent drowning existing trees in the bed of wetlands • Promote herbland species and establish fringing vegetation around the edge of each wetland • Reduce the extent of water-dependent invasive species (such as cumbungi) • Allow for oxidation of the soil (Richardsons Lagoon)	

1 *EC stands for electrical conductivity, which is a measure of water salinity.*

2 *Top-ups to support waterbird breeding may occur if species of high conservation significance display breeding behaviour or nesting activity, or if large numbers of waterbirds have nests with live chicks.*

Scenario planning

Table 5.2.6 outlines the potential environmental watering and expected water use under a range of planning scenarios.

North Central CMA has undertaken landscape-scale planning for these wetlands to optimise the wetland watering regimes over multiple years. An important consideration in this planning is to ensure there is a large variety of habitat types available across the region to support waterbirds and other water-dependent animals at any time.

The highest environmental watering priorities under all planning scenarios are to water wetlands that protect the critically endangered Murray hardyhead, and provide habitat for nationally threatened species (such as the growling grass frog): that is, Round Lake, Lake Elizabeth and Wirra-Lo wetland complex. Watering Johnson Swamp is also a high priority under all climate scenarios, as it provides quality breeding and feeding habitat for a range of waterbird species across the landscape, and other nearby wetlands that rely on managed water deliveries are likely to experience drying phases. It is important to maintain some breeding and feeding habitat for waterbirds, irrespective of the climate scenario.

Watering Guttrum Forest in spring is a high priority under drought, dry and average planning scenarios, to rehabilitate and assist the recovery of the wetland vegetation community through a more-frequent flooding regime. Water may also be delivered to Guttrum Forest under any scenario, if there is a natural waterbird breeding event. Under wet conditions, natural inflows from the River Murray will likely inundate Guttrum Forest. If sufficient water is available in autumn/winter 2020, it may be prudent to re-fill Guttrum Forest to prime the wetland vegetation for the following spring, boost productivity and drown terrestrial vegetation in low-lying parts of the wetland to maintain important open-water habitat.

If sufficient water is available, water for the environment will be allowed to flow through Johnson Swamp to Pyramid Creek to boost the carbon supply to Pyramid Creek and increase the productivity of the riverine foodweb. The timing of the flow would coincide with a spring fresh in Pyramid Creek. This is a good example of how water for the environment can be used to support fundamental ecological processes and optimise ecological outcomes across multiple waterways. The potential watering actions for Pyramid Creek are detailed in section 5.7.1. A fresh may be delivered irrespective of a flow from the swamp: hence, providing a flow through Johnson Swamp is a secondary priority.

Lake Cullen provides important refuge during drought or dry condition for waterbirds, particularly species with restricted or small ranges. Lake Cullen may be watered in 2019–20 if there is limited waterbird habitat across the landscape (that is, in drought or dry conditions), but prolonged inundation may damage mudflat vegetation. The North Central CMA will evaluate these competing objectives before requesting water to fill Lake Cullen in 2019–20. Watering of Lake Cullen is therefore a secondary priority in wetter climate scenarios.

If sufficient water is available, McDonalds Swamp will receive a partial fill in autumn to promote growth of planted and naturally recruited river red gums, support plant germination and promote winter feeding conditions for waterbirds and frogs and prime the wetland to respond as weather warms up in spring 2020. Priming the wetland in this way will promote a greater environmental response to watering scheduled for 2020–21, however it is not critical to achieving outcomes in 2020–21, and therefore is a secondary priority for 2019–20.

There are no plans to deliver water for the environment to Lake Murphy, Hird Swamp and Richardsons Lagoon in 2019–20. These wetlands are due to experience a drying phase to promote the growth of herbland species and fringing vegetation, to control the extent of water-dependent invasive vegetation species, to allow existing trees in the bed of the wetland to breathe and to allow oxidation of the soil.

Priority carryover requirements have been calculated based on the required volume to support Murray hardhead sites in 2020–21.

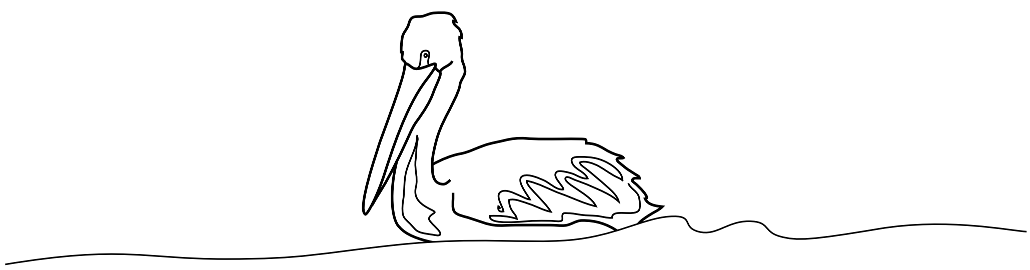


Table 5.2.6 Potential environmental watering for the central Murray wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected catchment conditions	• Catchment run off and unregulated flows into the wetland are unlikely	• Some catchment run off and unregulated flows into the wetlands are possible, particularly in winter/spring	• Low-to-moderate catchment run off and unregulated flows into the wetlands are likely, particularly in winter/spring	• Catchment run off and unregulated flows into the wetlands may significantly contribute to water levels in some wetlands, particularly winter/ spring
Potential environmental watering – tier 1 (high priorities)[1]	• Round Lake • Lake Elizabeth • Wirra-Lo wetland complex (Brolga Swamp, Red Gum Swamp, Bittern West and Bittern East) • Guttrum Forest (winter/spring) • Johnson Swamp • Lake Cullen	• Round Lake • Lake Elizabeth • Wirra-Lo wetland complex (Brolga Swamp, Red Gum Swamp, Bittern West and Bittern East) • Guttrum Forest (winter/spring) • Johnson Swamp • Lake Cullen	• Round Lake • Lake Elizabeth • Wirra-Lo wetland complex (Brolga Swamp, Red Gum Swamp, Bittern West and Bittern East) • Guttrum Forest (winter/spring) • Johnson Swamp • Johnson Swamp 'through flow'	• Round Lake • Lake Elizabeth • Wirra-Lo wetland complex (Brolga Swamp, Red Gum Swamp, Bittern West and Bittern East) • Guttrum Forest • Johnson Swamp • Johnson Swamp 'through flow'
Potential environmental watering – tier 2 (additional priorities)	• McDonalds swamp • Johnson Swamp 'through flow'	• McDonalds swamp • Johnson Swamp 'through flow' • Guttrum Forest (autumn/winter)	• Lake Cullen • Guttrum Forest (autumn/winter)	• Lake Cullen
Possible volume of water for the environment required to achieve objectives[2]	• 14,800 ML (tier 1) • 600 ML (tier 2)	• 14,800 ML (tier 1) • 1,000 ML (tier 2)	• 7,400 ML (tier 1) • 400 ML (tier 2)	• 7,400 ML (tier 1) • 0 ML (tier 2)
Priority carryover requirements	• 2,300–2,400 ML			

1 It is not possible to distinguish between tier 1a and 1b demands for the Central Murray wetlands as there is no individual entitlement (and therefore no expected supply volume) for them. Rather the water is shared and prioritised across several systems. Wetlands are listed in priority order for tier 1 and tier 2 under all climate scenarios.

2 Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.

5.2.4 Hattah Lakes

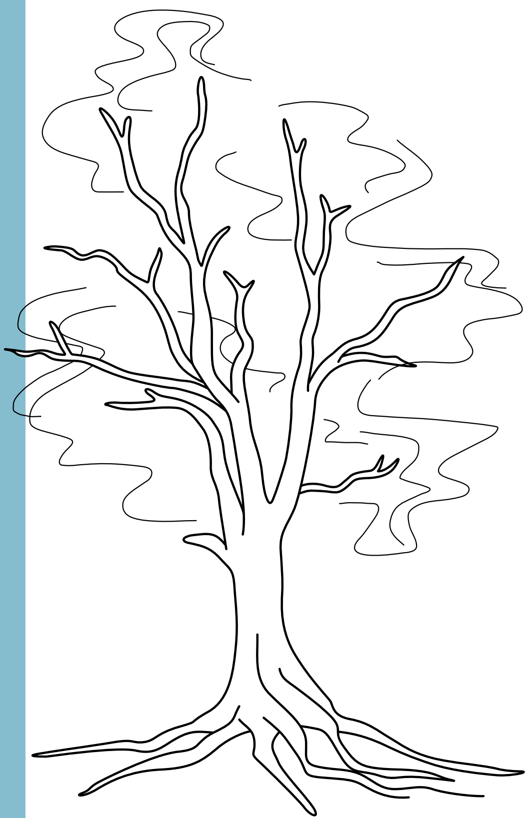
System overview

Hattah-Kulkyne National Park is situated in north-west Victoria adjacent to the River Murray, as Figure 5.2.4 shows. The national park contains a complex of more than 20 semi-permanent freshwater lakes known collectively as the Hattah Lakes.

The ecology of the Hattah Lakes and surrounding floodplain is strongly influenced by flooding regimes of the River Murray. The system fills when there are high flows in the River Murray, and some lakes hold water for numerous years after floods recede. Regulation of the River Murray has significantly reduced the frequency and duration of small- to medium-sized natural floods in the Hattah Lakes system. Over time, this has degraded vegetation communities and reduced the diversity and abundance of animals that use the vegetation and wetlands for habitat and food.

The Hattah Lakes complex can be broadly divided into the southern Hattah Lakes, which contain permanent to semi-permanent wetlands, and the higher-elevation northern Hattah Lakes, which are mostly ephemeral wetlands.

The Messenger, Oateys and Cantala regulators allow water to flow between the River Murray and the Hattah Lakes. When flows in the River Murray are about 26,000 ML per day, water begins to flow through the Messenger regulator into Chalka Creek and through to the Hattah Lakes complex. A permanent pump station has also been constructed that can deliver up to 1,000 ML per day to Hattah Lakes through Chalka Creek. The regulators and pump station are used in combination with several small constructed levees to restore a beneficial pattern of flooding to the lakes.



Lake Kramen in the south-east of Hattah-Kulkyne National Park is disconnected from the main Hattah Lakes complex. The Hattah Lakes pump station can deliver up to 145 ML per day to Lake Kramen to restore flooding regimes.

Environmental values

Hattah Lakes is home to a diverse range of flood-dependent vegetation that changes with the topography of the landscape. Vegetation types range from wetland communities in lower-lying areas that require almost annual flooding to lignum and black box communities situated higher on the floodplain that only need flooding once every four to five years on average.

A combination of natural flooding and the delivery of environmental flows since 2010 has improved tree canopy health and recruitment of black box and river red gum communities throughout the Hattah Lakes. Woodland birds (including the endangered regent parrot) have benefitted from the improved tree health.

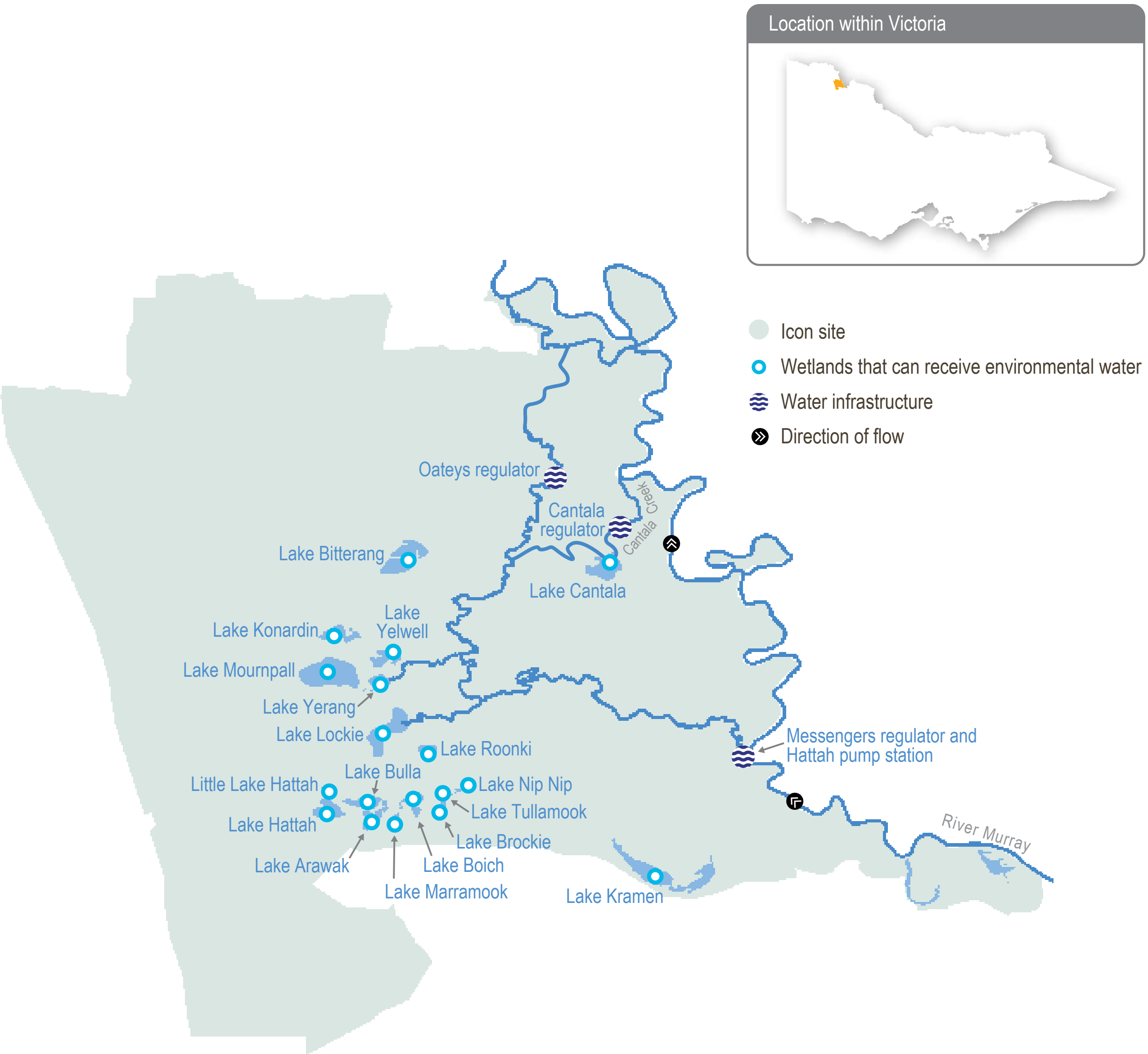
Hattah Lakes provides important waterbird breeding sites in an arid landscape. A total of 34 species of waterbirds are known to breed at the lakes when conditions are suitable. Another six species of waterbirds breed in the surrounding floodplain. Wetland drought-refuge sites are limited in the region, making Hattah Lakes critically important for waterbirds and terrestrial animals.

The Hattah Lakes support native fish species (such as golden perch and endangered freshwater catfish), which can move between the lakes and the River Murray when flows are suitable. Fish can also persist in permanent wetlands in the Hattah Lakes during dry years.

Environmental objectives in the Hattah Lakes

	Increase the fish population by supporting breeding
	Restore and maintain a mosaic of healthy wetland and floodplain plant communities
	Provide feeding and nesting habitat for the successful recruitment of waterbirds and woodland birds

Figure 5.2.4 The Hattah Lakes system



Recent conditions

Hattah Lakes last received natural inflows from the River Murray during spring 2016. Over 110 GL of water for the environment was delivered to Hattah Lakes between July and October 2017 via the Hattah pumps station, to build on environmental outcomes from the 2016 floods. Almost half the water pumped to the lakes flowed back into the River Murray, providing environmental benefits to high-priority environmental watering sites downstream.

Environmental flows in 2017 provided the most-extensive floodplain inundation at Hattah Lakes since the 1990s and supported the germination, growth and recovery of black box trees. Over several years, there has also been an increase in wetland plant diversity, demonstrated recruitment of small-bodied fish and an increased abundance of woodland birds.

The 2017–18 and 2018–19 summers were exceptionally hot and dry, and lakes within the Hattah complex completely dried, except Hattah Lake and Mournpall Lake. This drying pattern is important and has allowed floodplain and wetland plant communities to germinate, grow and reproduce a seedbank in preparation for the next flood.

Lake Kramen was last filled in 2014–15. It did not receive any inflow during the 2016 floods, and it has been completely dry since 2017. The dry phase allowed the growth of lake bed vegetation, which will provide an important source of carbon to support productive foodwebs when the wetland is next filled.

Scope of environmental watering

Table 5.2.7 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.2.7 Potential environmental watering actions and objectives for the Hattah Lakes

Potential environmental watering action[1]	Functional watering objective	Environmental objective
Lake Kramen (fill to 46.0 m AHD in winter/spring)	• Inundate fringing river red gums and black box trees to stimulate their growth and improve their condition • Provide refuge and feeding habitat for waterbirds • Provide conditions for lake bed herbaceous plants to grow in the drawdown phase after watering	
Southern Hattah Lakes[2] (partial fill to 42.5 m AHD in autumn/winter)	• Stimulate growth to improve the condition of river red gums • Provide refuge and feeding habitat for waterbirds • Stimulate the growth of aquatic vegetation in wetlands that are currently dry	
Hattah Lakes (floodplain inundation up to 45.0 m AHD at any time if there is a natural flood)	• Inundate river red gums and black box on the floodplain to stimulate the growth and improve the condition of mature trees • Provide suitable soil conditions for the germination of black box trees on the floodplain and support the growth of trees that germinated in the flows provided in 2017 • Provide suitable conditions to support waterbird and woodland bird breeding and feeding • Provide connections to allow native fish to move between Hattah Lakes and the River Murray • Provide spawning and recruitment habitat for small-bodied native fish and nursery habitat for large-bodied natives (such as golden perch)	

1 The Hattah Lakes pumps station may also be operated at any time of year to meet maintenance requirements.

2 Includes the following lakes: Bulla, Hattah, Little Hattah, Lockie, Yelwell and Yerang.

Scenario planning

Table 5.2.8 outlines the potential environmental watering and expected water use under a range of planning scenarios.

There are three watering actions planned for the Hattah Lakes in 2019–20: pumping water to Lake Kramen in spring; pumping water to provide a partial fill of the southern Hattah Lakes in autumn; and widespread floodplain inundation that may be achieved under a wet scenario from a combination of natural flows and managed environmental flows.

Lake Kramen has been dry for three years, and the river red gums and fringing black box vegetation are showing signs of water stress. It is proposed to fill Lake Kramen in winter/spring under dry and average scenarios to help the trees grow and recover. Under a drought scenario, Lake Kramen may be filled if the monitoring of tree condition indicates that water is needed[8]; otherwise it will be allowed to dry for another year. Under a wet scenario, widespread natural flooding may remove the need for environmental watering at Lake Kramen, but if floods do not reach the target inundation extent, supplementary pumping may be needed to meet the site objectives.

Unless there is a natural flood, Lake Hattah will likely dry by autumn 2020, leaving Lake Mournpall as the only water in the southern lakes system and therefore the only remaining refuge for carp. Environmental flows are normally delivered to Hattah Lakes during spring. However, under dry and average climate scenarios, the intention is to water the southern lakes in autumn (outside of peak carp reproduction time) to minimise the numbers of juvenile and larval carp that can enter the system through the pumps that draw water from the River Murray. The watering will not connect Lake Mournpall to the other lakes, so the remaining adult carp in Lake Mournpall will not be able to populate the newly-filled wetlands. Although the timing of the planned partial fill is not optimal for the spring regrowth of vegetation in 2019, water will remain in the lakes to support regrowth in the following spring/summer, when there is less aquatic plant damage as a result of fewer carp.

Under a drought scenario, the southern Hattah Lakes will be allowed to completely dry, unless routine tree condition monitoring indicates that river red gums fringing wetlands are severely stressed and are likely to die. Under a wet scenario, the lakes will be naturally inundated and therefore water for the environment may not be needed to achieve the planned partial fill. Water for the environment may be used to extend the magnitude and duration of a small-sized natural flood to support river red gum and black box trees on the floodplain. However, this objective is a low priority (tier 2) for 2019–20 because some areas of the floodplain at lower elevations will benefit from a drying phase that will help to maintain the diversity of wetland plant communities.

Table 5.2.8 Potential environmental watering for the Hattah Lakes under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Low flows year-round in the River Murray and no natural inflows to Hattah Lakes; substantial wetland drying will occur	• Rare high-flow events in the River Murray and no natural inflows to Hattah Lakes; substantial wetland drying will occur	• Short periods of high flows, most likely in late winter and spring, providing minor inflows to Hattah Lakes	• Lengthy periods of high flows with major spills from storages resulting in widespread inundation of Hattah Lakes and floodplain
Potential environmental watering – tier 1 (high priorities)[1]	• Trigger-based autumn/winter partial fill of southern Hattah Lakes • Trigger-based winter/spring fill of Lake Kramen	• Autumn/winter partial fill of southern Hattah Lakes • Winter/spring fill of Lake Kramen	• Autumn/winter partial fill of southern Hattah Lakes • Winter/spring fill of Lake Kramen	• N/A
Potential environmental watering – tier 2 (additional priorities)	• N/A	• N/A	• N/A	• Natural inundation of Hattah Lakes including Lake Kramen may be supplemented by pumping
Possible volume of water for the environment required to achieve objectives[2]	• 32,000 ML (tier 1)	• 32,000 ML (tier 1)	• 32,000 ML (tier 1)	• 0–100,000 ML (tier 2)

[1] It is not possible to distinguish between tier 1a and 1b demands for Hattah Lakes as there is no individual entitlement (and therefore no expected supply volume) for them. Rather the water is shared and prioritised across several systems.

[2] Water for the environment requirements for tier 2 are additional to tier 1 requirements.

[8] Observations of tree health will be used as a management trigger at Lake Kramen. Watering will occur under a drought scenario, if there is risk that five percent of the river red gum or black box fringing Lake Kramen will die.

5.2.5 Lower Murray wetlands

System overview

The lower Murray wetlands are found across the floodplain of the River Murray between Swan Hill and the South Australian border. The system includes a myriad of interconnected creeks, wetlands and floodplains that are ecologically important and reflect the natural character and attributes of the River Murray floodplain. While the number of wetlands across the lower Murray region are in their hundreds, 66 of them are considered part of the environmental watering program, and 54 of these have received water for the environment to date.

Regulation and diversion of River Murray flows have substantially reduced the frequency and duration of the high river flows that would naturally water the lower Murray wetlands. This change to the water regime has reduced the variety and condition of environmental values associated with billabongs and other floodplain habitats.

Water for the environment can be delivered to some wetlands in the region by direct pumping from the River Murray and/or use of irrigation supply infrastructure. Most wetlands that receive environmental flows can be managed independently of each other.

Some wetlands in the lower Murray area can receive water through weir-pool manipulation, for improved environmental outcomes. However, because they do not receive held water for the environment, they are not specified in this plan. Details of the environmental objectives associated with those wetlands can be found in the Mallee CMA's *Seasonal Watering Proposal for the Lower Murray Wetlands 2019–20*.

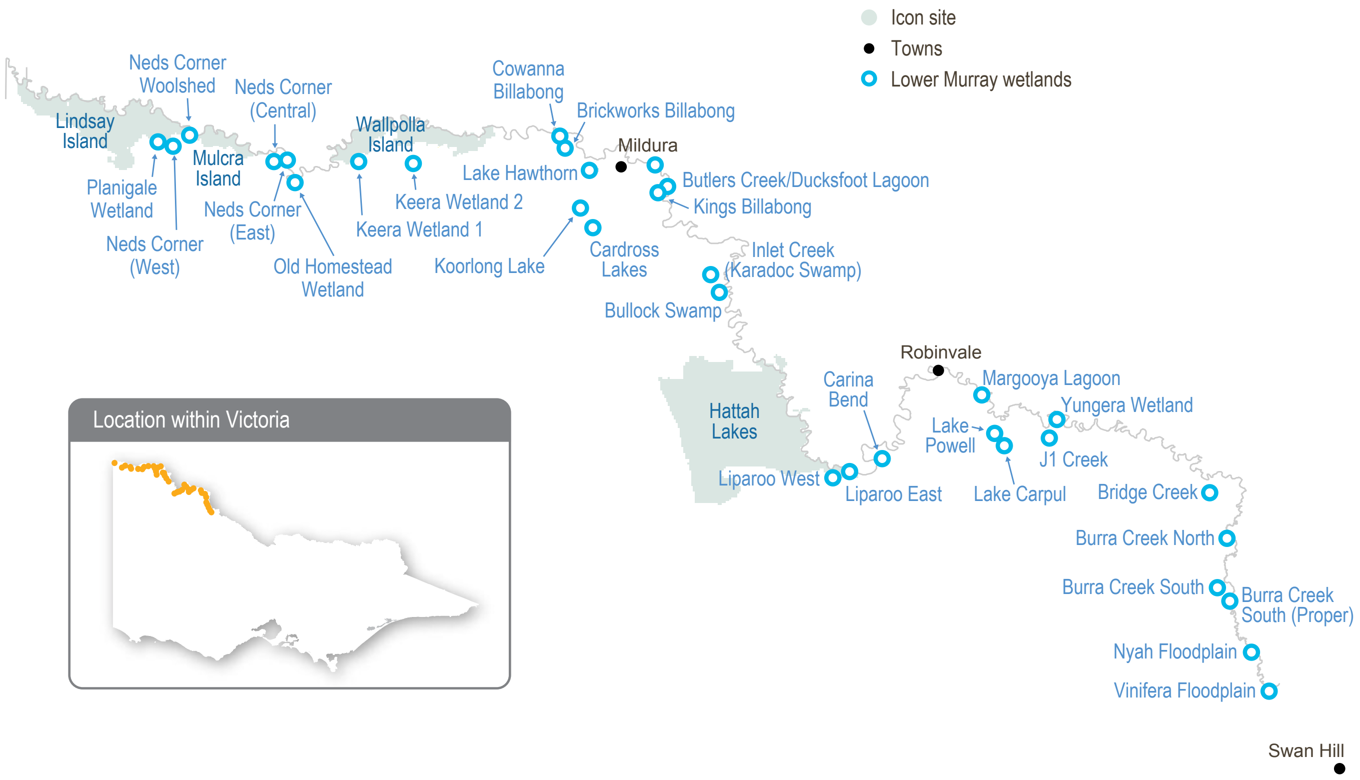
Environmental values

The lower Murray wetlands are comprised of multiple wetlands, creeks and billabongs. Depending on their location in the landscape, interactions with groundwater and their management history, the wetlands may be permanent or temporary, freshwater or saline. Differences in water regime and water quality between the wetlands provide a range of habitats for plants and animals. For example, permanent, saline wetlands (such as Brickworks Billabong) provide vital habitat for the endangered Murray hardyhead fish. Ephemeral wetlands support different ecological processes in their wet and dry phases. During the wet phase, they provide short-term boom periods when river red gum trees and wetland plants grow, spread and provide habitat for aquatic animals (such as waterbugs, birds, frogs and in some cases fish). During the dry phase, sediments are exposed to the air (which is important for carbon and nutrient cycles), and terrestrial plants grow and complete life cycles.

Environmental objectives in the lower Murray wetlands

Maintain and/or grow populations of native fish in permanent wetlands
Maintain and/or grow populations of native frogs including the endangered growling grass frog
Provide habitat for large terrestrial animals (such as lace monitors and bats)
Maintain and/or grow populations of native freshwater turtles including the endangered broad-shelled turtle
Increase the diversity, extent and abundance of wetland plants Improve the condition of river red gums, black box and lignum
Provide feeding and breeding habitat for a range of waterbird species including threatened and migratory species and colonial nesting species (such as egrets)

Figure 5.2.4 The lower Murray wetlands



Recent conditions

The lower Murray wetlands area experienced lower-than-average rainfall and higher-than-average temperatures in 2018–19. Although local rainfall is a contributing factor, flows in the River Murray primarily determine the inundation frequency and duration of the lower Murray wetlands. A small pulse in the River Murray in October 2018 inundated some of the low-lying wetlands in the area, but the flow was not sufficient to inundate any of the wetlands specified in the *Seasonal Watering Plan 2018–19*.

Environmental watering was managed under a dry scenario throughout 2018–19, prioritising watering actions that aimed to protect and maintain environmental values, avoid critical losses and maintain key refuges and key ecosystem functions at high-priority wetlands.

Water for the environment was delivered to nine wetlands in the lower Murray system. Most of this water was used to partially or completely fill wetlands in spring. Prolonged high temperatures over spring/summer resulted in increased evaporation, and water levels declining faster than normal. Top-ups were provided as needed to Lake Hawthorn, Koorlong Lake and Brickworks Billabong, to maintain water quality and ruppia aquatic habitat for Murray hardyhead.

Water for the environment was delivered to Lake Hawthorn in spring 2018 to provide optimal conditions for about 600 captive-bred Murray hardyhead that were released into the lake. Competing water demands prevented subsequent top-ups to the lake in January 2019: water for the environment uses the existing irrigation network for delivery and is subject to interruptible supply to meet irrigation demands. Monitoring in 2019 will determine if spawning and recruitment has been successful.

Following spring fills, the regulators to both Butlers Creek and Ducksfoot Lagoon were closed, allowing the wetlands to draw down over summer and autumn. Drying of the wetlands will help control local populations of carp. A large number of waterbirds including spoonbills and egrets were observed at both wetlands, after the wetlands filled and as they drew down.

In autumn, water for the environment was delivered to Lake Hawthorn, Burra Creek North, Burra Creek South and Vinifera floodplain. Except for Lake Hawthorn, these wetlands were allowed to completely dry over spring/summer. Drying killed carp that had moved into the wetlands and allowed clays in the bed of the wetlands to crack, which provided habitat for insects, reptiles and small mammals and allowed carbon/nutrients to accumulate in the soil. The input of carbon and nutrients during the dry phase will lead to increased productivity when the wetlands are next watered.

Scope of environmental watering

Table 5.2.9 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Environmental watering in 2019–20 will focus on maintaining critical wetland habitat for native animals by maintaining water quality, which helps create refuge, breeding and feeding habitat.

Table 5.2.9 Potential environmental watering actions and objectives for the lower Murray wetlands

Potential environmental watering action	Functional watering objective	Environmental objective
Wetland watering		
Brickworks Billabong (fill in spring, with top-ups as required to maintain water quality and water level targets)	• Fill in spring to 34.0 m AHD to inundate and grow ruppia to provide nursery habitat for Murray hardyhead and to provide high levels of aquatic productivity • Allow natural recession of a maximum 1 m AHD in late summer/autumn (to 33.0 m AHD), to provide shallow-water habitat and expose mudflats to support foraging and resting of small waders	
Bridge Creek (fill in winter/spring)	• Inundate existing river red gum, black box and lignum to maintain/improve their condition	
Bullock Swamp North (fill in winter/spring)	• Increase aquatic macrophyte diversity and area in the freshwater marsh habitats	
Burra Creek North (fill in winter/spring)	• Inundate existing river red gum, black box and lignum to maintain/improve their condition • Promote the growth of seasonal emergent and semi-emergent macrophytes • Provide seasonal connectivity along Burra Creek, wetlands and the floodplain in the target area to increase opportunities for native frogs and turtles and maintain riverine food chains	

Table 5.2.9 Potential environmental watering actions and objectives for the lower Murray wetlands *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Burra Creek South (fill in winter/spring)	• Inundate existing river red gum, black box and lignum to maintain/improve their condition • Promote the growth of seasonal emergent and semi-emergent macrophytes • Provide seasonal connectivity along Burra Creek, wetlands and the floodplain to increase the movement of turtles to support their recruitment and long-term population growth	
Burra Creek South Proper (fill in winter/spring)	• Inundate existing fringing river red gum, black box and lignum to maintain/improve their condition • Promote the growth of seasonal emergent and semi-emergent macrophytes	
Carina Bend (fill in winter/spring)	• Inundate the existing mature river red gum trees along the wetland perimeter to maintain their health • Inundate the floodway pond herbland EVC[1] within the creek to provide seasonal aquatic habitat that supports a diverse population of native fish and frogs • Inundate the intermittent swampy woodland EVC[1] to provide nesting and feeding habitat for waterfowl in winter and spring	
J1 Creek (fill in winter/spring)	• Inundate the existing river red gum communities to improve their health • Inundate the floodplain to increase the recruitment of floodplain plant communities including river red gum, lignum and black box	
Koorlong Lake (top-ups as required to maintain water quality and water level targets)	• Fill wetland to 38.0 m AHD in spring to support the growth of ruppia, to provide nursery habitat for Murray hardyhead and provide high levels of aquatic productivity • Allow water levels to drop over summer to 36.7 m AHD to increase salinity levels, providing a competitive advantage to Murray hardyhead	
Lake Carpul (fill in winter/spring)	• Inundate trees (including river red gum) bordering creeks and lakes to improve their condition • Fill Lake Carpul to capacity to support water-dependent vegetation and increase understorey productivity	
Lake Hawthorn (fill in spring, with top-ups as required to maintain water quality and water level targets)	• Fill wetland to 33.3 m AHD to encourage the germination and growth of ruppia, to provide nursery habitat for Murray hardyhead and visitation by shorebirds • Allow natural recession of a maximum 0.3 m (to 33.0 m AHD) to expose mudflats for foraging shorebirds before providing a top-up volume to return the water level to 33.3 m AHD	
Lake Powell (fill in winter/spring)	• Inundate trees (including river red gum) bordering creeks and lakes to improve their condition • Fill Lake Powell to capacity to support water-dependent vegetation and increase understorey productivity	
Liparoo East Billabong (fill in winter)	• Fill the billabong to encourage lignum growth and provide feeding habitat for large waders as well as temporary breeding habitat for waterbirds • Fill the billabong to support the growth of native vegetation and increase the understorey diversity and recruitment of river red gum saplings	
Liparoo West Billabong (fill in winter)	• Fill the billabong to encourage lignum growth and provide feeding habitat for large waders as well as temporary breeding habitat for waterbirds • Fill the billabong to support the growth of native vegetation and maintain a community of drought-tolerant emergent aquatic macrophytes at the wetland edge	

Table 5.2.9 Potential environmental watering actions and objectives for the lower Murray wetlands *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Neds Corner Central (fill in spring/summer)	• Fill the wetland to inundate the lignum swamp zone to stimulate the recruitment of native vegetation and improve species diversity • Fill the wetland to encourage lignum growth and increase the quantity and quality of nesting habitat for waterbirds	
Neds Corner East (fill in spring/summer)	• Fill the wetland to inundate the floodway pond herbland zone, to stimulate the recruitment of native vegetation and improve species diversity • Improve vegetation recruitment and diversity to meet EVC[1] benchmarks • Maintain the health and structure of the shrubby riverine woodland EVC[1]	
Neds Corner Woolshed (fill in winter/spring)	• Inundate the creek bed to enhance floodplain productivity and provide increased foraging areas to support the growling grass frog population • Fill the creek to increase the recruitment of river red gums and understory shrubs to improve breeding and nesting opportunities for native waterbirds	
Nyah Floodplain (fill in spring/summer)	• Water seasonal anabranches to restore the vegetation structure of wetland plant communities • Fill seasonal wetlands to re-establish resident populations of native frogs and support terrestrial animals • Inundate the red gum swamp forest and woodland to increase the recruitment of river red gum saplings and provide reliable breeding habitat for waterbirds including colonial nesting species • Deliver water onto the floodplain to improve the vegetation condition and support resident populations of vertebrate animals including carpet python, sugar glider and grey-crowned babbler	
Vinifera Floodplain (fill in spring/summer)	• Water seasonal anabranches to restore the vegetation structure of wetland plant communities • Fill seasonal wetlands to re-establish resident populations of native frogs and support terrestrial animals • Inundate the red gum swamp forest and woodland to increase the recruitment of river red gum saplings and provide reliable breeding habitat for waterbirds including colonial nesting species • Deliver water onto the floodplain to improve the vegetation condition and support the resident populations of vertebrate animals including carpet python, sugar glider and grey-crowned babbler	
Yungera Wetland (fill in winter/spring)	• Inundate the existing river red gum communities to improve their health • Inundate the floodplain to increase the recruitment of floodplain plant communities including river red gum, lignum and black box	
Wetland drying		
Margooya Lagoon	• Allow the lagoon to naturally recede and dry, to remove carp from the system and allow soils to consolidate and crack, to promote nutrient cycling. This promotes high levels of aquatic productivity upon rewetting, which support native frogs, fish recruitment and a range of habitat for waterbird feeding and breeding	

1 *Ecological Vegetation Classes (EVCs) are the standard unit for classifying vegetation types in Victoria. EVCs are described through a combination of floristics, lifeforms and ecological characteristics, and through an inferred fidelity to particular environmental attributes. Each EVC includes a collection of floristic communities (that is, lower level in the classification) that occur across a biogeographic range, and although differing in species, have similar habitat and ecological processes operating.*

Scenario planning

Table 5.2.10 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The highest-priority wetlands for environmental watering in 2019–20 under all climate scenarios, and particularly in a drought scenario, are those that provide critical refuge for native animals, including the critically endangered Murray hardyhead. As water availability increases, proposed watering extends to those wetlands that comprise a range of important vegetation communities, which provide breeding and feeding habitat for a diverse array of native species. Priority is given to those wetlands where the vegetation community has not been inundated for one or more years and is unlikely to withstand another dry year.

Depending on seasonal conditions and water availability, water deliveries to remaining wetlands are prioritised considering their recommended water regimes and the condition of the environmental values at each site. Under wetter scenarios, additional wetlands will be watered to mimic conditions that would naturally occur. In this way, the environmental responses are optimised, as plants and animals respond to natural environmental cues.

Table 5.2.10 Potential environmental watering for the lower Murray wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected catchment conditions	• No unregulated flows in the River Murray year-round and wetlands rely on delivery of water for the environment; very low rainfall year-round and extremely hot and dry conditions in summer/autumn causes substantial wetland drying	• Short periods of high flows in the River Murray are possible, however overbank flows to wetlands do not occur; low rainfall and very warm summer/autumn	• Sustained periods of high flows in the River Murray in late winter and early spring will provide some opportunity for low-lying wetlands to be naturally inundated but most wetlands will still rely on delivery of water for the environment • Local rainfall may be high and provide catchment flows to some wetlands	• Lengthy periods of high flows and floods with major spills from storages, resulting in widespread inundation of the floodplain and most wetlands • Some reliance on water for the environment to achieve target water levels • Local rainfall may be high and will provide catchment flows to most wetlands
Potential environmental watering – tier 1 (high priorities)[1]	• Brickworks Billabong • Lake Hawthorn • Koorlong Lake	• Brickworks Billabong • Lake Hawthorn • Koorlong Lake • Neds Corner East • Neds Corner Central • Neds Corner Woolshed • Liparoo East Billabong • Liparoo West Billabong • Carina Bend • Bridge Creek	• Brickworks Billabong • Lake Hawthorn • Koorlong Lake • Neds Corner East • Neds Corner Central • Neds Corner Woolshed • Liparoo East Billabong • Liparoo West Billabong • Carina Bend • Bridge Creek	• Brickworks Billabong • Lake Hawthorn • Koorlong Lake • Neds Corner East • Neds Corner Central • Neds Corner Woolshed • Liparoo East Billabong • Liparoo West Billabong • Carina Bend • Bridge Creek

Table 5.2.10 Potential environmental watering for the lower Murray wetlands under a range of planning scenarios *continued...*

Planning scenario	Drought	Dry	Average	Wet
Potential environmental watering – tier 2 (additional priorities)	• N/A	• N/A	• Burra Creek North • Burra South • Lake Powell • Lake Carpul	• Burra Creek North • Burra South • Lake Powell • Lake Carpul • Burra South Proper • Nyah Floodplain • Vinifera Floodplain • Yungera • J1 Creek • Bullock Swamp
Possible volume of water for the environment required to achieve objectives[2]	• 1,900 ML (tier 1)	• 5,120 ML (tier 1)	• 5,120 ML (tier 1) • 7,000 ML (tier 2)	• 5,120 ML (tier 1) • 11,520 ML (tier 2)

[1] *It is not possible to distinguish between tier 1a and 1b demands for the central Murray wetlands as there is no individual entitlement (and therefore no expected supply volume) for them. Rather the water is shared and prioritised across several systems. Instead, watering actions are listed in priority order. Wetlands are listed in priority order for tier 1 and tier 2 under all climate scenarios.*

[2] *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

5.2.6 Lindsay, Mulcra and Wallpolla islands

System overview

Lindsay, Mulcra and Wallpolla islands cover over 26,100 ha of Victorian floodplain in the Murray-Sunset National Park, as Figure 5.2.5 shows. They form part of the Chowilla Floodplain and Lindsay-Wallpolla islands icon site that straddles the Victoria and South Australia border in the mid-Murray river system.

The Lindsay, Mulcra and Wallpolla islands floodplain is characterised by a network of permanent waterways, small creeks and wetlands. The Lindsay River, Potterwalkagee Creek and Wallpolla Creek form the southern boundaries of the site and create large floodplain islands with the River Murray to the north.

In their natural state, these waterways and wetlands would regularly flow and fill in response to high water levels in the River Murray. Large floods still occur, but major storages in the upper reaches of the River Murray system have reduced the frequency of small- to moderate-sized floods.

Flows in the mid-Murray river system are regulated through a series of weir pools, generally referred to as locks. Water levels in the weir pools are managed primarily to provide safe navigation and adequate water levels for off-stream diversion via pumps. In recent years, the water level of weir pools 7 and 8 has also been managed to achieve ecological benefits in the River Murray channel, for example by lowering pool levels to increase the extent of fast-flowing habitat, which is preferred by large-bodied native fish (such as Murray cod).

Weir pool levels have a big effect on flows in Mullaroo Creek, the Lindsay River and Potterwalkagee Creek. When water levels in locks 7 and 8 are raised above the full supply level (FSL), flows to the Lindsay River and Potterwalkagee Creek increase; when weir pools are lowered, flows to both the Lindsay and Potterwalkagee reduce and eventually they stop flowing. Mullaroo Creek is less-affected by weir pool levels, because flows are controlled through the Mullaroo Creek regulator which connects the creek and the River Murray. Moderate lowering of the lock 7 weir pool level has little effect on Mullaroo Creek, but lowering to or beyond 0.5 m below FSL makes it difficult to deliver the recommended minimum flow of 600 ML per day that is required for native fish.

Fluctuation of weir pool levels is a major management consideration for jurisdictions that manage flows in the River Murray and the anabranch waterways of Lindsay, Mulcra and Wallpolla islands. Environmental objectives and associated water regimes for the River Murray sometimes conflict with those for the Lindsay, Mulcra and Wallpolla anabranch systems, so responsible agencies in Victoria and NSW and the Murray-Darling Basin Authority need to collaboratively plan how to manage weir pools and flows effectively.

Environmental values

The Lindsay, Mulcra and Wallpolla islands represent three separate anabranch systems including streams, billabongs, large wetlands and swamps. When flooded, waterways and wetlands within these systems provide habitat for native fish, frogs, turtles and waterbirds. Terrestrial animals (such as woodland birds) also benefit from improved productivity and food resources when the system floods. Large floodplain wetlands (such as Lake Wallawalla) can retain water for several years after inundation, and they provide important refuge for wetland-dependent species and support terrestrial animals (such as small mammals and reptiles).

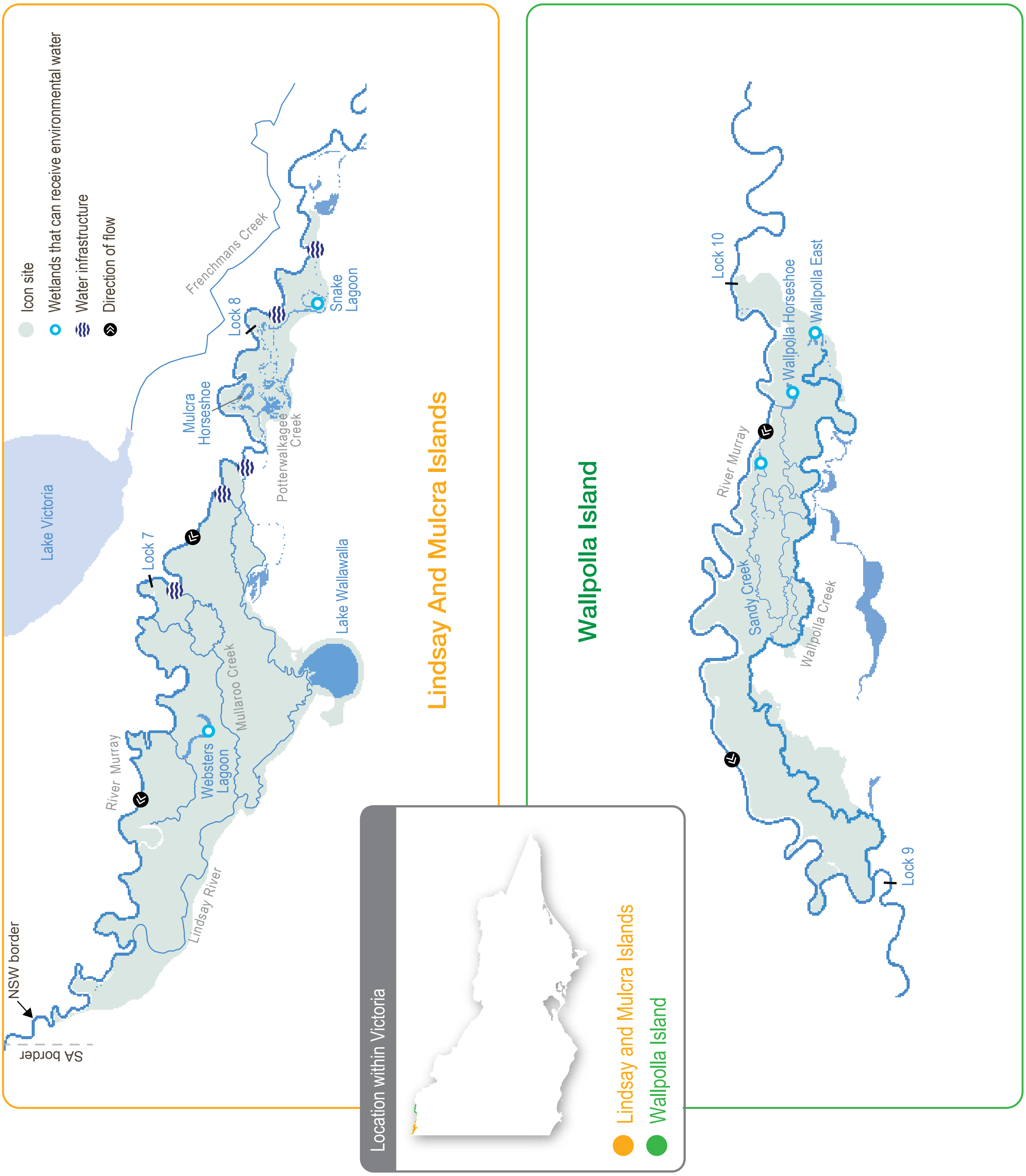
Mullaroo Creek and the Lindsay River support one of the most-significant populations of Murray cod in the lower River Murray. These waterways provide fast-flowing habitat that Murray cod favour, and contrast with the mostly slow-flowing and still habitats created by the nearby River Murray weir pools. Mature breeding fish in Mullaroo Creek and Lindsay River produce juveniles that subsequently colonise other parts of the Murray system. Waterways and wetlands throughout the icon site support several other fish species including freshwater catfish, silver perch, Murray-Darling rainbowfish and unspecked hardyhead.

The reduced frequency and duration of floods in the River Murray has degraded the water-dependent vegetation communities throughout the Lindsay, Mulcra and Wallpolla island system, which has in turn reduced the diversity and abundance of animals that rely on healthy vegetation for habitat.

Environmental watering objectives for the Lindsay, Mulcra and Wallpolla islands

	Increase the abundance, diversity and distribution of native fish
	Increase the abundance, diversity and distribution of wetland vegetation
	Increase the waterbird population by providing feeding and breeding habitat in floodplain wetlands

Figure 5.2.5 The Lindsay, Mulcra and Wallpolla islands



Recent conditions

Flows in the major Victorian and NSW tributaries of the southern Murray-Darling Basin were well-below average for the duration of 2018–19, and there was little to no inflow from the Darling River. As a result, there were no unregulated flows in the mid-Murray system in 2018–19.

The primary focus of environmental watering in the Lindsay, Mulcra and Wallpolla islands anabranch system in 2018–19 was to maintain flowing habitat in Mullaroo Creek, to help native fish survive and recruit. Flows in Mullaroo Creek varied between 400 and 1,200 ML per day throughout the year, with the higher-magnitude flows delivered in spring to support Murray cod.

The weir pool level in lock 8 was at FSL or lower all year round, which prevented any flows in Potterwalkagee Creek. The lock 7 weir pool level was too low for most of the year to provide flows to the upper Lindsay River. The exception was a short period in spring 2018 when the weir pool was raised to 0.3 m above FSL, which provided minor flows of 40 ML per day via the northern inlet. Water for the environment was delivered to Wallpolla Horseshoe, to provide feeding habitat for waterbirds and improve the condition of aquatic vegetation.

Scope of environmental watering

Table 5.2.11 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.2.11 Potential environmental watering actions and objectives for Lindsay, Mulcra and Wallpolla islands

Potential environmental watering action	Functional watering objective	Environmental objective
Lindsay Island – Mullaroo Creek		
Year-round low flows (minimum of 600 ML/day)	• Maintain fast-flowing habitat for native fish (such as Murray cod, silver perch and golden perch)	
Spring fresh (one fresh of up to 1,200 ML/day for up to three months during September to November)	• Initiate fish movement and spawning and improve recruitment opportunities for native fish	
Winter/spring/summer high flow (one high flow of more than 1,200 ML/day for a maximum of nine months during July to March)	• Extend the duration of higher flows to support dispersal, spawning and recruitment opportunities for native fish	
Lindsay Island – Lindsay River		
Winter/spring fresh (one fresh of up to 270 ML/day via the northern regulator and up to 120 ML/day via the southern regulator for a maximum of four months during August to November)	• Provide temporary flowing habitat to support dispersal, spawning and recruitment opportunities for native fish • Inundate the substrate and debris (snags) to promote the growth of biofilms, which provide a food source for animals higher in the food chain	
Winter/spring/summer high flow (one high flow of up to 450 ML/day via the northern regulator and up to 450 ML/day via the southern regulator for a maximum of nine months during July to March)	• Extend the duration of flowing habitat to support dispersal, spawning and recruitment opportunities for native fish	

Table 5.2.11 Potential environmental watering actions and objectives for Lindsay, Mulcra and Wallpolla islands *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Lindsay Island wetlands		
Websters Lagoon (complete fill in spring)	• Provide connection between Websters Lagoon and the River Murray to allow the exchange of carbon, nutrients and aquatic biota between the wetland and the river • Provide conditions for lake bed herbaceous plants to grow in the drawdown phase after watering • Provide variable water levels in the littoral zone to provide feeding habitat for shorebirds • Provide open-water habitat as refuge and feeding habitat for waterbirds	
Mulcra Island – Potterwalkagee Creek		
Spring fresh (one fresh of up to 450 ML/day via the Stoney Crossing regulator and up to 370 ML/day via the upper Potterwalkagee Creek regulator for a maximum of 3 months during September to November)	• Provide temporary flowing habitat to support dispersal, spawning and recruitment opportunities for native fish • Inundate the substrate and debris (snags) to promote the growth of biofilms, which provide a food source for animals higher in the food chain	
Winter/spring/summer high flow (one high flow of up to 1,000 ML/day via the Stoney Crossing and upper Potterwalkagee Creek regulators for a maximum of nine months during July to March)	• Extend the duration of flowing habitat to support dispersal, spawning and recruitment opportunities for native fish	
Wallpolla Island		
Finnigans Creek (complete fill in winter/spring)	• Provide connection between Wallpolla East, Sandy Creek and Finnigans Creek to allow nutrient exchange, increase wetland productivity and the dispersal of plant propagules • Inundate/drown river red gum saplings in the bed of Wallpolla Horseshoe to limit their coverage • Provide variable water levels in the littoral zone to improve wetland productivity and promote the growth of native aquatic and fringing plants • Provide variable water levels in the littoral zone to provide feeding habitat for shorebirds • Provide open-water habitat as refuge and feeding habitat for waterbirds	
Sandy Creek (complete fill in winter/spring)		
Wallpolla East (complete fill in winter/spring)		
Wallpolla Horseshoe (partial or complete fill any time)		

Scenario planning

Table 5.2.12 outlines the potential environmental watering actions and expected water use under a range of planning scenarios.

Mullaroo Creek requires year-round low flows of at least 600 ML per day under all climatic scenarios, to provide permanent habitat for large-bodied native fish, particularly Murray cod.

Under drought, dry and average scenarios, high flows are planned to be delivered to Mullaroo Creek, the Lindsay River (via the southern and northern regulators) and Potterwalkagee Creek (via Stoney Crossing and upper Potterwalkagee regulators) between August and November 2019 to cue the movement and spawning of large-bodied native fish.

Under a wet scenario, the high flows in all waterways will be extended for up to nine months between July 2019 and March 2020, to cue native fish spawning and to facilitate widespread movement between the River Murray, Lindsay River, Mullaroo Creek and Potterwalkagee Creek. It is expected these extended flows will be mostly provided by unregulated flows in the River Murray.

In summer and autumn, the water levels in lock 7 and lock 8 weir pools will be lowered to achieve environmental objectives in the River Murray. Weir pool lowering will prevent year-round low flows through the upper reaches of the Lindsay River and Potterwalkagee Creek.

Under drought, dry and average scenarios, environmental watering is planned for four wetlands at Wallpolla Island and at Websters Lagoon on Lindsay Island. In a wet scenario, long periods of high flows in the River Murray are expected to inundate large parts of the Lindsay, Mulcra and Wallpolla floodplains.

Table 5.2.12 Potential environmental watering for Lindsay, Mulcra and Wallpolla islands under a range of planning scenarios

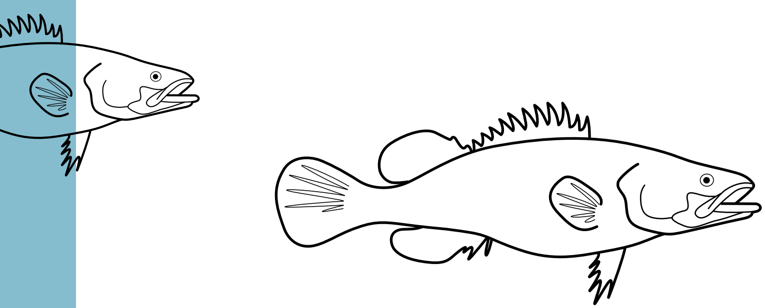
Planning scenario	Drought	Dry	Average	Wet
Expected conditions	• Year-round low flows in the River Murray and no natural floodplain inundation; substantial wetland drying will occur	• Rare high-flow events in the River Murray and no natural floodplain inundation; substantial wetland drying will occur	• Short periods of high flows, most likely in late winter and spring, providing minor inundation of the floodplain	• Long periods of high flows with major spills from storages resulting in widespread inundation of the floodplain and inundation of most wetlands
Lindsay Island				
Mullaroo Creek and Lindsay River potential environmental watering – tier 1 (high priorities)[1]	• Year-round low flows (Mullaroo Creek) • One spring fresh (Mullaroo Creek and Lindsay River) • Websters Lagoon (complete fill)	• Year-round low flows (Mullaroo Creek) • One spring fresh (Mullaroo Creek and Lindsay River) • Websters Lagoon (complete fill)	• Year-round low flows (Mullaroo Creek) • One spring fresh (Mullaroo Creek and Lindsay River) • Websters Lagoon (complete fill)	• Year-round low flows (Mullaroo Creek) • One winter/spring/summer high flow (Mullaroo Creek and Lindsay River) • Websters Lagoon (complete fill)
Possible volume of water for the environment required to achieve objectives[2]	• < 2,000 ML	• < 2,000 ML	• < 2,000 ML	• < 2,000 ML
Mulcra Island				
Potterwalkagee Creek potential environmental watering – tier 1 (high priorities)[1]	• One spring fresh	• One spring fresh	• One spring fresh	• One spring high flow

Table 5.2.12 Potential environmental watering for Lindsay, Mulcra and Wallpolla islands under a range of planning scenarios *continued...*

Planning scenario	Drought	Dry	Average	Wet
Possible volume of water for the environment required to achieve objectives[2]	• < 2,000 ML	• < 2,000 ML	• < 2,000 ML	• < 2,000 ML
Wallpolla Island				
Wallpolla Island wetlands potential environmental watering – tier 1 (high priorities) [1]	• Wallpolla Horseshoe (partial fill)	• Wallpolla Horseshoe (partial fill) • Sandy Creek (complete fill) • Wallpolla East (complete fill) • Finnigans Creek (complete fill)	• Wallpolla Horseshoe (partial fill) • Sandy Creek (complete fill) • Wallpolla East (complete fill) • Finnigans Creek (complete fill)	• All wetlands filled by unregulated flows
Potential environmental watering – tier 1 (high priorities)	• 1,000 ML	• 5,500 ML	• 5,500 ML	• 0 ML

1 *Tier 1b and tier 2 objectives have not been included in scenario planning due to the relatively low volume of water required to supply all environmental watering demands at Lindsay, Mulcra and Wallpolla islands.*

2 *These estimates take account of the use of operational water en route to achieve watering action targets, with water for the environment being required to underwrite the associated losses in locks 7 and 8, Mullaroo Creek, Lindsay River, Potterwalkagee Creek and Websters Lagoon.*



5.3 Ovens system

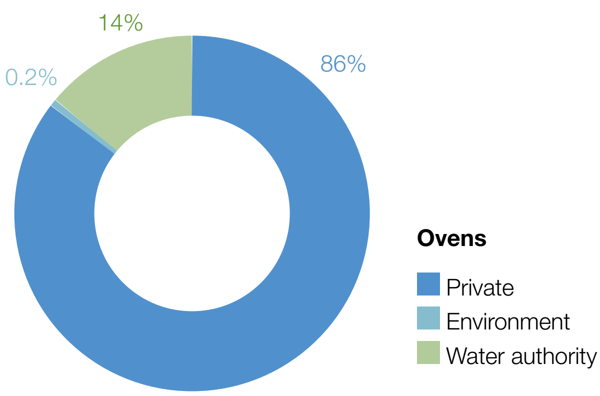
Waterway manager – North East Catchment Management Authority

Storage manager – Goulburn-Murray Water

Environmental water holder – Commonwealth Environmental Water Holder

Did you know ...?

The Ovens system is home to some of the healthiest riverbank and floodplain vegetation in Victoria, with fine examples of red gum forest and woodland thriving along river margins, benefitting from the relatively natural flow regime that persists in this system.



Proportion of water entitlements in the Ovens basin held by private users, water corporations or environmental water holders at 30 June 2018.

Top: Ovens River at Whorouly, by North East CMA
Centre: Lake Buffalo vegetation, by North East CMA
Above: Rocky river bed, Ovens River at Gapsted, by North East CMA

System overview

The Ovens River rises in the steep, forested mountains of the Great Dividing Range near Mount Hotham and flows about 150 km to join the River Murray in the backwaters of Lake Mulwala. The system contains two small water storages: Lake Buffalo on the Buffalo River and Lake William Hovell on the King River. The regulated reaches of the Ovens system include the Buffalo and King rivers downstream of these storages and the Ovens River from its confluence with the Buffalo River to the River Murray.

As its storages are quite small and spill regularly, the Ovens system maintains a large proportion of its natural flow regime, particularly in winter/spring. However, the storages and licensed water extractions throughout the system can restrict flow during low-flow periods, and parts of the system can become quite flow-stressed during summer and autumn.

The Ovens River flows into Lake Mulwala on the River Murray, the largest weir pool on the Murray regulated system. Ovens River flows contribute to the reliability and variability of the flow regime for the River Murray and support many downstream uses including irrigation, urban supply and watering of iconic floodplain sites (such as Barmah Forest).

Water for the environment is held in Lake Buffalo and in Lake William Hovell and can be released when the storages are not spilling. Five reaches in the Ovens system can benefit from releases of water for the environment. While all are important, there is a relatively small volume (123 ML) of water available, and it is well-short of the volume required to meet all environmental flow objectives. The available water is used selectively to deliver the greatest possible environmental benefit. Water for the environment is most-commonly used in the Ovens system to deliver critical flow events in reaches immediately downstream of the two main storages, or it is used in conjunction with operational water releases to influence flow in the lower Ovens River.

Environmental values

The diverse aquatic habitat and abundant food resources associated with the Ovens system support a wide range of native fish species including Murray cod, trout cod, golden perch and unspecked hardyhead. The Buffalo River provides valuable habitat for large-bodied fish species during part of their breeding cycle, while trout cod have a large range within the system and are found as far up the King River as Whitfield. A project to recover trout cod populations in the Ovens system has been successful, and efforts to reintroduce Macquarie perch are continuing.

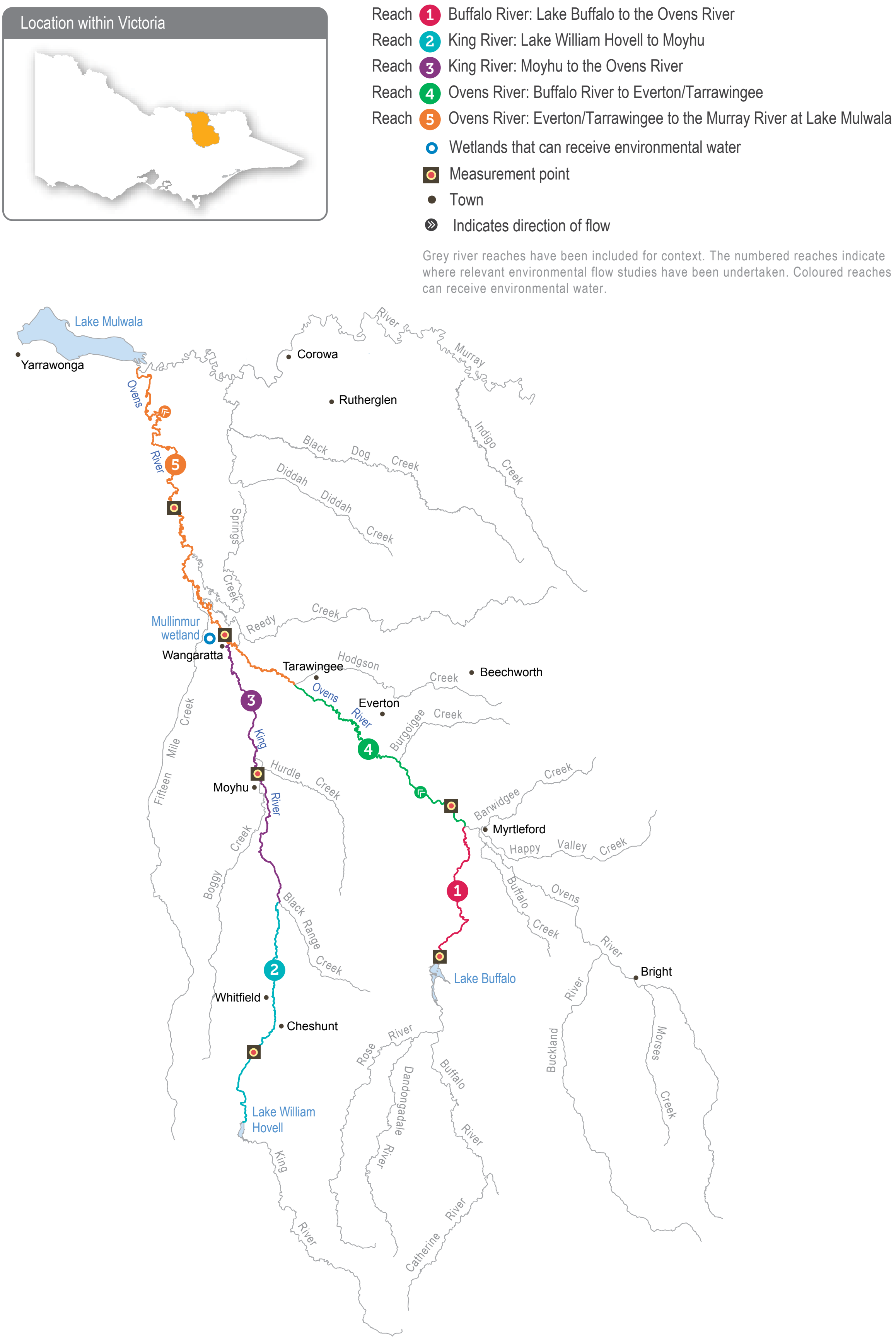
Frogs (such as the giant banjo frog and growling grass frog) are abundant in the lower reaches and associated wetlands of the Ovens River and in the King River upstream of Cheshunt. The lower Ovens wetland complex contains over 1,800 wetlands, is listed as nationally significant and is home to a variety of waterbirds including egrets, herons, cormorants and bitterns. The riparian zones of river channels throughout the Ovens system support some of Victoria's healthiest river red gum forests and woodlands, while the wetlands support a variety of aquatic and semi-aquatic vegetation communities.

The first trial delivery of water for the environment to a wetland on the Ovens floodplain is proposed for 2019–20. The target site is Mullinmur Wetland at Wangaratta, which has been the focus of several environmental improvement projects in recent years. Specific management actions include carp removal, a revegetation program and a project that is currently underway to determine whether the wetland can support a sustainable brood stock population of native freshwater catfish. Brood stock are important for catfish recovery (reintroduction) projects.

Environmental objectives in the Ovens system

	Maintain the size and distribution of native fish populations
	Maintain the form of the riverbank and channel and ensure river bed surfaces are in suitable condition to support all stream life
	Maintain the condition and extent of wetland vegetation communities
	Maintain an adequate abundance and diversity of waterbugs, to support river food webs and associated ecosystem processes
	Maintain water quality for all river life

Figure 5.3.1 The Ovens system



Recent conditions

A warm and dry 2018–19 resulted in relatively low flows throughout the Ovens system. Inflows into the storages were well-below average, although both Lake William Hovell and Lake Buffalo filled. The bulk transfer of water from Lake Buffalo to the Murray that normally occurs in autumn did not proceed in 2018–19, so water for the environment was used to briefly increase low flows below the storages in autumn. These flows helped to connect habitats within the channel that can become isolated during low-flow periods, and they also improved water quality.

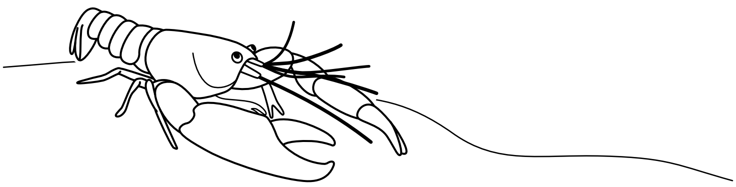
Scope of environmental watering

Table 5.3.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.3.1 Potential environmental watering actions and objectives for the Ovens system

Potential environmental watering action	Functional watering objective	Environmental objective
Autumn low-flow fresh in reaches 1, 4 and 5: one fresh of ≥ 430 ML/day for three days in reaches 1 and 4, > 130–260 ML/day in reach 5 (March/April)	• Provide flow cues to stimulate the movement of native fish • Maintain connectivity between pools for fish movement • Mix pools to improve the water quality • Provide small variations in river levels and velocity, to flush sediment from hard substrates and maintain waterbug habitat • Scour biofilm from the river bed	
Summer/autumn low-flow variability[1] in reaches 1, 2 and 3	• Maintain connectivity between pools for fish movement and water quality • Provide small variations in river levels to move sediment and maintain waterbug habitat	
Mullinmur Wetland (top-up during November to February)	• Maintain the water level to support the growth and recruitment of aquatic vegetation • Maintain habitat for native catfish	

[1] *Operational releases from storage can vary, with water for the environment used to provide some variability over one or two days.*



Scenario planning

Table 5.3.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Climatic conditions and inflows into storages have a large effect on how water for the environment is likely to be used. Under dry conditions, water for the environment aims to provide low-flow variability and avoid cease-to-flow events in the river reaches immediately below the storages. Mullinmur Wetland will also likely require water to maintain water levels and habitat for aquatic biota under dry to average conditions. As conditions become wetter, there will be more opportunities to piggyback environmental releases on operational water bulk transfers from Lake Buffalo to deliver larger freshes and achieve environmental outcomes over a much greater length of river. Water for the environment cannot be released if the storages are spilling or if there is a risk that private land will be flooded. The recommended environmental flows through the Ovens system are likely to be achieved naturally through storage spills and unregulated tributary inflows under wet conditions. The water for the environment holdings in the Ovens system have a high level of security and are expected to be fully available under all scenarios.

Table 5.3.2 Potential environmental watering for the Ovens system under a range of planning scenarios

Planning scenario	Dry	Average	Wet
Expected river conditions	• Possible winter/early spring unregulated flows • Highly likely low summer/autumn flows • Bulk water release unlikely	• High winter/spring unregulated flows • Possible summer/autumn low flows • Bulk water release likely	• High unregulated flows throughout most of the year • Bulk water release likely • All flow objectives achieved naturally
Expected availability of water for the environment	• 50 ML Lake William Hovell • 73 ML Lake Buffalo • 123 ML total		
Potential environmental watering – tier 1a (high priorities)	• Summer/autumn low flow variability • Mullinmur Wetland top-up	• Autumn fresh • Summer/autumn low flow variability • Mullinmur Wetland top-up	• None required
Possible volume of water for the environment required to achieve objectives	• 123 ML	• 123 ML	• 0 ML

5.4 Goulburn system

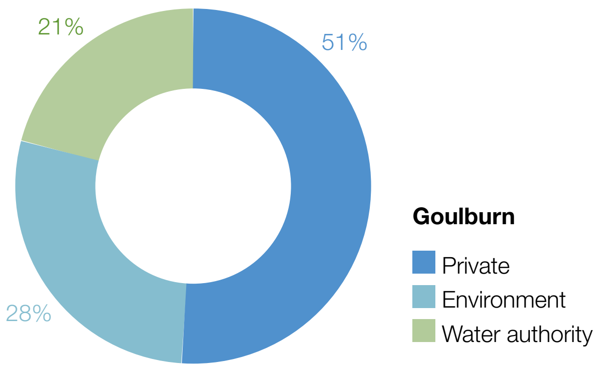
Waterway manager – Goulburn Broken Catchment Management Authority

Storage manager – Goulburn-Murray Water

Environmental water holders – Victorian Environmental Water Holder (including the Living Murray program), Commonwealth Environmental Water Holder

Did you know ...?

Taungurung people know the Goulburn River as *Waring*. The waters of *Waring* have a special connection with Taungurung, including its tributaries such as the Broken River, Hughes Creek, Seven Creeks, Yea River, Acheron River, King Parrot Creek, Rubicon River, Jamieson River, and the Howqua and Delatite rivers.



Proportion of water entitlements in the Goulburn basin held by private users, water corporations or environmental water holders at 30 June 2018.

Top: Goulburn River, by Goulburn Broken CMA
Centre: Cormorant on the Goulburn River, by Bruce Paton, VEWH
Above: River red gum, near Shepparton on the Goulburn River, by Bruce Paton, VEWH

5.4.1 Goulburn River

System overview

The Goulburn is Victoria's largest river basin, covering over 1.6 million ha or 7.1 percent of the state. The Goulburn River flows for 570 km from the Great Dividing Range upstream of Woods Point to the River Murray east of Echuca. It is an iconic heritage river because of its environmental, Aboriginal cultural heritage and recreational values.

There are several environmental water holders in the Goulburn system. The Commonwealth Environmental Water Holder holds the largest volume and use of Commonwealth water for the environment is critical to achieving outcomes in the Goulburn River, as well as priority environmental sites further downstream. Water for the environment held on behalf of the Living Murray program may assist in meeting objectives in the Goulburn system en route to icon sites in the Murray system (see subsection 1.4.2). Water held by the VEWH in the Goulburn system is used to meet environmental objectives in the Goulburn River and the Goulburn wetlands.

The construction and operation of Lake Eildon and Goulburn Weir have significantly altered the natural flow regime of the Goulburn River. Water-harvesting during wet periods and regulated releases to meet irrigation and other consumptive demands during dry periods mean that flow downstream of these structures is typically low in winter and spring and high in summer and autumn. This effectively reverses the natural seasonal flow pattern. Land use changes and the construction of small dams and drainage schemes have further modified the Goulburn River's flow regime. Levees and other structures prevent water inundating the floodplain and filling many of the natural wetlands and billabongs. If the opportunity arose to deliver water for the environment above current river thresholds at the right time to support improved environmental outcomes, water managers would consider it. Several tributaries including the Acheron and Yea rivers and the Broken River outfall downstream of Lake Eildon add some flow variation on top of the regulated flow regime in the Goulburn River. Large floods that cause the Goulburn River storages to fill and spill are also important for the overall flow regime and its associated environmental values.

The priority environmental flow reaches in the Goulburn River are downstream of Goulburn Weir (reaches 4 and 5), which are collectively referred to as the lower Goulburn River. The mid-Goulburn River extends from Lake Eildon to Goulburn Weir (reaches 1 to 3). From early spring to late autumn, large volumes of water are delivered from Lake Eildon to Goulburn Weir to supply the irrigation system. During that period, flow in the mid-Goulburn River is usually well above the recommended environmental flow targets. Deliveries of water for the environment have the most benefit in the mid-Goulburn River (especially in reach 1 immediately downstream of Lake Eildon) outside the irrigation season, when flow is much lower than natural.

Environmental flow targets can sometimes be met by the coordinated delivery of operational water being transferred from Lake Eildon to the River Murray. These transfers are known as inter-valley transfers (IVTs). These transfers occur during the irrigation season between spring and autumn, and they may meet environmental flow objectives without the need to release water for the environment. In recent years, operational transfers in the Goulburn River have significantly exceeded the environmental flow recommendations for summer and early autumn and have damaged bank vegetation and eroded the riverbanks.

Environmental values

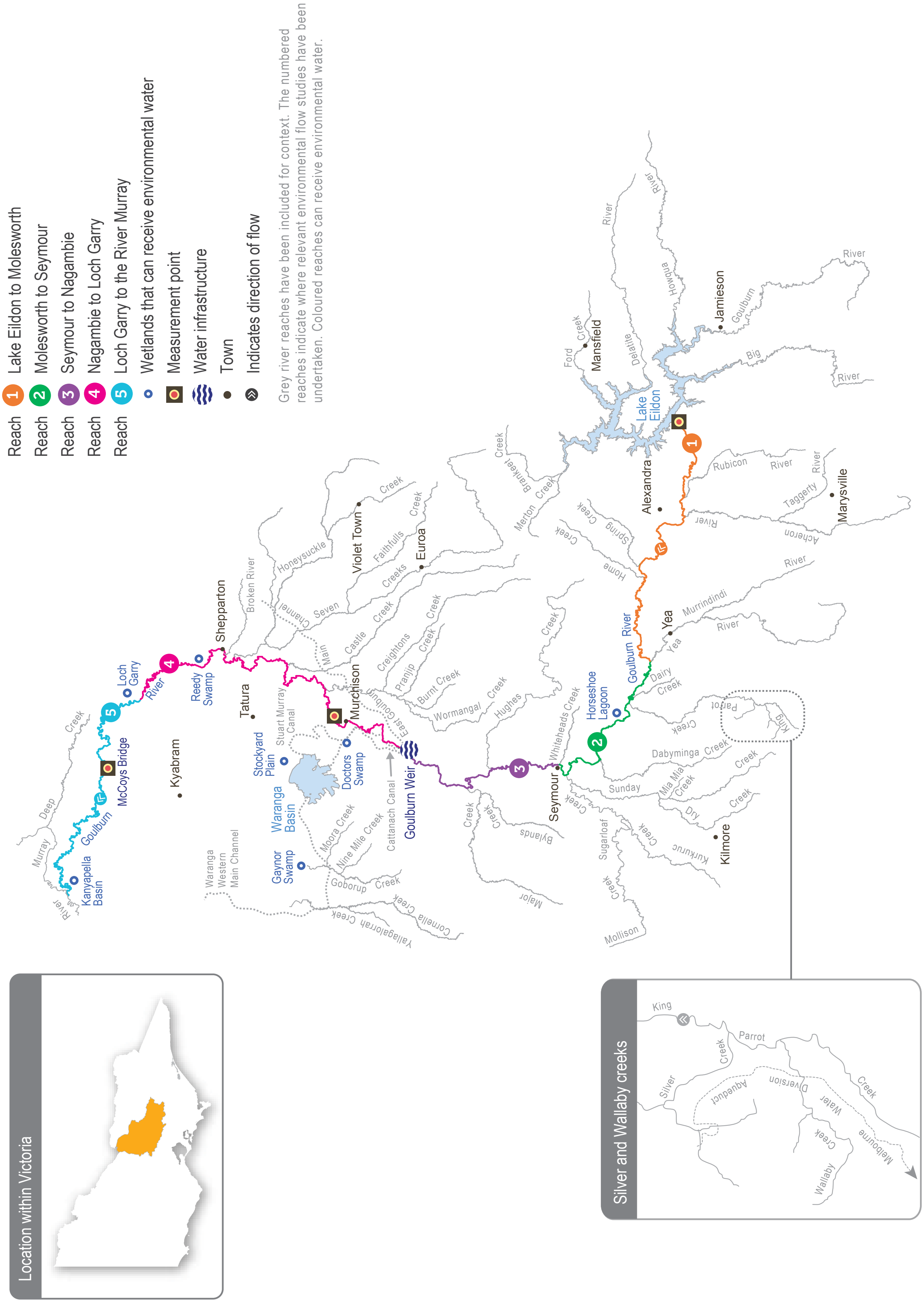
The Goulburn River and its tributaries support a range of native fish species including golden perch, silver perch, Murray cod, trout cod, Macquarie perch and freshwater catfish. Aquatic vegetation, scour holes and woody debris within the channel provide high-quality habitat for adult and juvenile fish. River red gums are a dominant feature of the riparian zone along the length of the Goulburn River. These trees shade the river and provide habitat for many species including the squirrel glider. Leaves that fall from the river red gums provide carbon that supports riverine foodwebs, and dead trees that fall into the river provide a substrate for biofilms and macroinvertebrates and habitat for fish. Birds (such as egrets, herons and cormorants) use trees along the river to roost and feed, while frogs benefit from shallowly inundated vegetation at the edge of the river channel and in adjacent wetlands.

The Goulburn River system is an important conservation area for threatened species. Several wetlands in the Goulburn catchment are formally recognised for their conservation significance. Tributaries of the mid-Goulburn River between Lake Eildon and Goulburn Weir host some of the last remaining Macquarie perch populations in the Murray-Darling Basin, while freshwater catfish can be found in lagoons connected to reach 3 of the Goulburn River. Monitoring over recent years shows that environmental flows in the lower Goulburn River can trigger golden perch, silver perch and trout cod to spawn. However, these larvae do not appear to survive or remain in the Goulburn River and contribute to the local population.

Environmental objectives in the Goulburn River

- Protect and boost populations of native fish
- Maintain the form of the riverbank and channel including maintaining a high diversity of river bed surfaces to support all stream life
- Provide sufficient rates of carbon and nutrient production and processing, to support native fish and waterbug communities
- Increase aquatic and flood-tolerant plants in the river channel and on the lower banks, to provide shelter and food for animals and to stabilise the riverbank
- Maintain abundant and diverse waterbug communities, to support the riverine foodweb
- Minimise the risk of hypoxic blackwater after natural events

Figure 5.4.1 The Goulburn system



Recent conditions

The Goulburn catchment has experienced drier-than-average conditions for most of the last six years. The main exception was 2016, when unregulated spring flows caused overbank flooding. This preceded another very dry summer and autumn in 2016–17, and since then the trend has been dry.

In the lower Goulburn River, most of the flow variation in 2018–19 was due to releases of water for the environment and IVTs, rather than natural (unregulated) flows. An exception was one small, unregulated flow event in August 2018, which reached about 1,500 ML per day at Murchison and 2,000 ML per day at McCoys Bridge. Water for the environment was used when necessary throughout the year to meet minimum low-flow requirements and to provide some high flows in winter and spring to support specific environmental outcomes.

Water for the environment was used to deliver a winter fresh in mid-June to mid-July 2018 to improve the bank vegetation, water quality and habitat for waterbugs and native fish. Improving the condition of the bank vegetation in winter/spring increases the resilience of plant communities and enables them to better withstand the effects of high river flows in the following summer and autumn. The VEWH is funding the Goulburn Broken CMA to undertake a monitoring project to investigate the impact of high summer and autumn flows in 2018–19. The outcomes of this project will inform future management decisions to improve environmental outcomes.

A combination of water for the environment and IVTs was used to deliver a spring fresh from late September to late October 2018, to allow the bank vegetation to establish and grow. Healthy bank vegetation helps to protect the riverbank from erosion, and vegetation at the water's edge provides habitat for waterbugs and small fish.

In late August 2018, an IVT pulse up to 3,000 ML per day was delivered down the Goulburn River, which is the earliest an IVT has ever been delivered in the water year. IVT demand increased in mid-December 2018 and after Christmas, and releases from the Goulburn Weir near Murchison remained above 2,000 ML per day throughout January and February 2019. From late February and for the first week of March 2019, the river flow dropped to about 1,000 ML per day before again increasing above 2,000 ML per day as autumn irrigation demands increased. The total volume of IVT delivered down the Goulburn River in 2018–19 was the highest on record, and has tripled over the last four years. The duration of IVT has also increased in the last two years, with releases starting as early as August and ending as late as June.

A study commissioned in 2018 recommended that flow in the lower Goulburn River should not exceed 1,000 ML per day for more than a few weeks in spring and summer/autumn, to protect the bank vegetation. Despite collaboration between the Goulburn Broken CMA and Goulburn-Murray Water to try to limit environmental damage, it was not possible to achieve these flow recommendations and also supply downstream consumptive demand in 2018–19.

The vast majority of water for the environment delivered in the Goulburn River is reused at downstream sites along the River Murray. In 2018–19, Goulburn water was reused to meet native fish objectives in Gunbower Creek, inundate wetlands and significant floodplain habitats in Gunbower Forest and support ecological objectives in South Australia. Water for the environment that is delivered from the Goulburn system makes a significant contribution to environmental objectives further downstream, which helps to achieve environmental outcomes at the Murray-Darling Basin scale.

Scope of environmental watering

Table 5.4.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.4.1 Potential environmental watering actions and objectives for the Goulburn River

Potential environmental watering action	Functional watering objective	Environmental objective
Winter fresh (during July to August 2019, up to 15,000 ML/day with more than 14 days above 6,600 ML/day in reaches 4 and 5)	• Improve macroinvertebrate habitat by improving water quality (reducing turbidity and mixing stratified water) and by increasing the wetted perimeter • Provide carbon (e.g. leaf litter) to the channel • Inundate bench habitats to encourage plant germination • Remove terrestrial vegetation and trigger the recruitment of native bank vegetation	
Year-round low flows (500–830 ML/day in reach 4 and 540–940 ML/day in reach 5)	• Provide slow, shallow habitat required for recruitment of larvae/ juvenile fish and habitat for adult small-bodied fish • Provide deep-water habitat for large-bodied fish • Submerge snags to provide habitat for fish and waterbugs and a substrate for biofilms to grow • Maintain habitat for aquatic vegetation and water the root zone of low bank vegetation • Vary flow within a specified range to encourage planktonic production (for food), disrupt biofilms and maintain water quality	
Winter/spring variable low flows (between 800–2,000 ML/day in reach 4 during July to October)	• Increase sediment and seed deposition on banks and benches • Support nutrient cycling	
Spring/autumn/winter low flows (400 ML/day in reach 1 during July to September and April to June)	• Wet and maintain riffles to provide habitat for biofilms and waterbugs • Scour fine sediment from the gravel bed and riffle substrate • Maintain the wetted perimeter of the channel and habitat for aquatic vegetation • Maintain existing beds of in-channel vegetation • Maintain habitat for small-bodied native fish	
Spring fresh (> 6,000 ML/day for 14 days in August – September in reaches 4 and 5)	• Inundate and water vegetation on the benches and lower banks, to support existing plants and facilitate recruitment • Increase soil moisture on the benches and banks, to sustain growth and increase vigour, flowering and seed development • Increase the extent of vegetation by distributing seed to riverbanks	
Flows should not exceed 1,000 ML/day for five to six weeks after a spring fresh (in late spring and summer) in reaches 4 and 5	• Allow newly grown littoral emergent and amphibious plants to become established and persist • Provide bank stability • Provide habitat for small-bodied fish and macroinvertebrates	
Provide slower recession to unregulated flows, or add pulses following natural cues/ unregulated flows (in reaches 1 and 4)	• Minimise the risk of bank erosion associated with rapid drawdown • Minimise the risk of hypoxic blackwater after natural events	

Table 5.4.1 Potential environmental watering actions and objectives for the Goulburn River *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Winter fresh (in 2020, up to 15,000 ML/day with more than 14 days above 6,600 ML/day in reaches 4 and 5)	• Improve macroinvertebrate habitat by improving water quality (reducing turbidity and mixing stratified water) and by increasing the wetted perimeter • Provide carbon (e.g. leaf litter) to the channel • Inundate bench habitats to encourage plant germination • Remove terrestrial vegetation and trigger the recruitment of native bank vegetation	
Autumn fresh (one fresh of up to 6,000 ML/day for two days in March or April in reaches 4 and 5)[1]	• Encourage the germination of new seed on the lower banks and benches • Improve water quality by reducing turbidity and mixing stratified water • Flush fine sediment from hard substrates to allow new biofilm growth and to improve food and habitat for macroinvertebrates	
Flows should not exceed 1,000 ML/day for more than 20 consecutive days, with a minimum of seven days between pulses in summer/ autumn in reaches 4 and 5	• Maintain for more than one season a littoral fringe of emergent or amphibious plants • Provide bank stability • Provide habitat for small-bodied fish and macroinvertebrates	

1 *This autumn fresh will only be delivered if the average weekly flows in summer are less than 1,500 ML/day.*

Scenario planning

Table 5.4.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Various triggers for action are applied as part of the adaptive management of water for the environment in the Goulburn system. For example, carrying over water to provide low flows in winter and spring 2020 is only required in below-average, dry or drought conditions to enable low flows to continue from the 2019–20 water year into July to September 2020. The need to carry over water is lessened in wetter scenarios, because high reservoir inflows increase the likelihood of high water allocation at the start of 2020–21. This means that instead of carrying over water into the next season, it can be used to contribute to environmental watering events planned for 2019–20.

The highest-priority watering actions in 2019–20 aim to sustain the growth, flowering and seed development of emergent and bank vegetation. The long duration of high IVT flows in consecutive summers (2017–18 and 2018–19) means that lower bank and fringing vegetation has been under water for much of the past two years, severely affecting the health of plants and the condition of the banks.

Under drought conditions, the highest-priority watering actions are to deliver low flows throughout the year and a winter fresh in 2019. Under below-average conditions, all watering actions including low flows, winter and spring freshes and recession flow management are a high priority. However, in a below-average scenario, the magnitude and duration of the winter 2020 fresh may need to be reduced, and there may be less opportunity to build on naturally occurring events. Under average and wet conditions, the full suite of watering actions is recommended, although in a wet scenario unregulated flows (rather than managed flows) would provide the spring fresh and part of the winter 2020 fresh.

All environmental watering actions in Table 5.4.2 (apart from the autumn fresh) are a high priority for the Goulburn system. Delivering these actions in full would increase the likelihood that the functional watering objectives in Table 5.4.1 would be achieved. The key factor separating tier 1a and tier 1b actions is the anticipated supply of water for the environment for 2019–20. Under drought to below-average scenarios, it is expected that actions like the spring 2019 fresh (drought) or winter 2020 fresh (dry and below-average scenarios) cannot be delivered in full, so they are in tier 1b. The autumn 2019 fresh is a lower-priority action (i.e. tier 2) that may be implemented if more water becomes available than is needed to achieve all the tier 1 objectives and if various triggers are met over the summer period.

In some previous years, deliveries of water for the environment focused on supporting native fish spawning and migration. Flows to trigger fish spawning or migration are not specifically planned for 2019–20 for two reasons: to enable vegetation that has been under water for long durations due to IVT deliveries to establish and grow along the banks, and because these flows do not need to be delivered annually to maintain golden perch populations, because they are a long-lived species.

The recommended year-round low flows below Goulburn Weir (reaches 4 and 5) will maintain fish habitat and facilitate fish passage. These low flows will also help the growth of aquatic and amphibious vegetation and provide habitat and food for waterbugs and small-bodied fish by submerging snags and encouraging plankton production.

Table 5.4.2 Potential environmental watering for the Goulburn River under a range of planning scenarios

Planning scenario	Drought	Dry	Below average	Average	Wet
Expected river conditions	• No unregulated flows • Blackwater could be an issue in the warmer months	• Unregulated flows are expected to provide some low flows for half a month from winter to mid-spring and are likely to provide small, short winter/spring freshes • Blackwater could be an issue in the warmer months	• Unregulated flows are expected to provide some low flows for a few months from winter to mid-spring and are likely to provide winter/spring freshes • Blackwater could be an issue in the warmer months	• Unregulated flows are expected to provide low flows for most of the year and are likely to provide medium winter/spring freshes • Blackwater could be an issue in the warmer months	• Unregulated flows are expected to provide low flows and multiple overbank flows events in winter/spring
Normal minimum passing flows at reach 5 of 400 ML/day during July to October and 350 ML/day during November to June					
Expected availability of water for the environment[1]	• 250,000 ML	• 344,000 ML	• 483,000 ML	• 516,000 ML	
Potential environmental watering – tier 1a (high priorities)	• Year-round low flows • Winter/spring variable low flows • Spring/autumn/winter low flows (reach 1) • Winter 2019 fresh	• Year-round low flows • Winter/spring variable low flows • Spring/autumn/winter low flows (reach 1) • Winter 2019 fresh • Spring fresh (partial)	• Year-round low flows • Winter/spring variable low flows • Spring/autumn/winter low flows (reach 1) • Winter 2019 fresh • Spring fresh • Winter 2020 fresh (partial) • Recession flow management	• Year-round low flows • Winter/spring variable low flows • Spring/autumn/winter low flows (reach 1) • Winter 2019 fresh • Spring fresh • Winter 2020 fresh • Recession flow management	• Year-round low flows • Winter/spring variable low flows • Spring/autumn/winter low flows (reach 1) • Winter 2019 fresh • Winter 2020 fresh (partial) • Recession flow management
Potential environmental watering – tier 1b (high priorities)	• Spring fresh (partial) • Recession flow management	• Winter 2020 fresh (full) • Recession flow management	• Winter 2020 fresh (full)	• N/A	• N/A

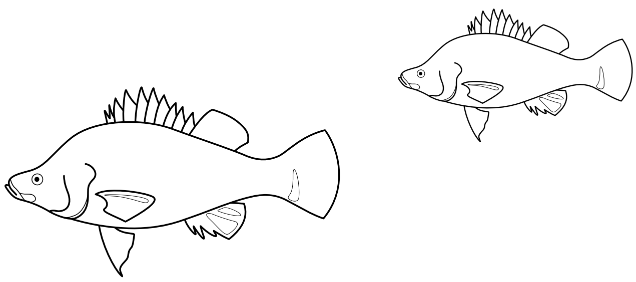
Table 5.4.2 Potential environmental watering for the Goulburn River under a range of planning scenarios *continued...*

Planning scenario	Drought	Dry	Below average	Average	Wet
Potential environmental watering – tier 2 (additional priorities)	• N/A	• N/A	• N/A	• Autumn fresh (partial) *Note:* triggers must be met before this flow is considered	• Autumn fresh *Note:* triggers must be met before this flow is considered
Possible volume of water for the environment required to achieve objectives[2]	• 214,000 ML (tier 1a) • 104,000 ML (tier 1b)	• 298,000 ML (tier 1a) • 150,000 (tier 1b)	• 434,000 ML (tier 1a) • 130,000 ML (tier 1b)	• 472,000 ML (tier 1a) • 20,000 ML (tier 2)	• 316,000 ML (tier 1a) • 47,000 ML (tier 2)
Priority carryover requirements	• 23,000 ML[3]	• 23,000 ML	• 23,000 ML	• 0 ML	• 0 ML

1 *When trading opportunities are available, additional water for the environment allocations from the Murray can be transferred in to meet Goulburn demand.*

2 *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

3 *Additional water is required to meet this priority carryover requirement under an extreme dry scenario.*



5.4.2 Goulburn wetlands

System overview

Of some 2,000 natural wetlands in the Goulburn Broken area, only three — Reedy Swamp, Gaynor Swamp and Doctors Swamp — have received water for the environment through VEWH or CEWH entitlements. Several other small wetlands in the Goulburn catchment have been watered under a separate arrangement through the Murray-Darling Wetlands Working Group. Recent modifications to the irrigation supply network and other water delivery options will enable water for the environment to be delivered to Loch Garry, Kanyapella Basin and Horseshoe Lagoon from 2019–20 onwards. These wetlands have strong cultural significance to the Yorta Yorta and Taungurung Traditional Owners.

Gaynor Swamp, Reedy Swamp, Loch Garry, Doctors Swamp and Kanyapella Basin wetlands can all receive water for the environment via irrigation supply infrastructure in the Shepparton and Central Goulburn irrigation districts. The volume of water that can be delivered to each wetland depends on the available capacity in the irrigation supply network, which varies with irrigation demand. Water for the environment will be delivered from the Goulburn River to Horseshoe Lagoon via a temporary pump.

Environmental values

Many natural wetlands across the Goulburn catchment including Reedy Swamp, Loch Garry, Gaynor Swamp, Kanyapella Basin and Doctors Swamp are formally recognised for their conservation significance. The Goulburn wetlands support a variety of plant communities ranging from river red gum swamps to treeless cane grass wetlands.

Reedy Swamp contains a mosaic of vegetation types including tall marsh, floodway pond herbland and rushy riverine swamp. It is an important drought refuge and nesting site for colonial waterbirds and an important stopover feeding site for migratory birds (such as sharp-tailed sandpiper and marsh sandpiper).

Doctors Swamp is considered one of the most-intact red gum swamps in Victoria, supporting over 80 wetland plant species.

Gaynor Swamp is a cane grass wetland situated on paleosaline soils – soils formed from historic oceans. The wetland supports thousands of waterbirds including brolga and intermediate egrets when wet. Gaynor Swamp has a higher salt concentration than other wetlands in the region, and it attracts a different suite of feeding waterbirds as it draws down. One of the most significant species that feed on exposed mudflats at Gaynor Swamp is the red-necked avocet.

Loch Garry supports large areas of deep, open water fringed by giant rush and dominated by tall marsh. It is an important site for waterbird feeding and roosting and is a drought refuge for eastern great egrets, musk ducks, nankeen night herons and royal spoonbills.

Kanyapella Basin is a shallow freshwater marsh that provides habitat for numerous plant and animal species including the threatened intermediate egret. It has historically been a popular site for ibis, heron and cormorants.

Horseshoe Lagoon, a former channel of the Goulburn River, comprises vegetation mainly of tall marsh, floodway pond herbland and floodplain riparian woodland.

Environmental objectives in the Goulburn wetlands

	Maintain or increase the diversity and abundance of frog species
	Maintain the population of turtles
	Increase the diversity of native wetland plants consistent with the EVC[1] benchmarks Reduce the cover and diversity of exotic plants Maintain the population of rigid water milfoil
	Provide breeding habitat for waterbirds Provide feeding and roosting habitat for waterbirds
Aboriginal environmental outcomes	
	Watering is planned to be delivered in partnership with Traditional Owners and achieve Aboriginal environmental outcomes

1 *Ecological vegetation classes (EVCs) are the standard unit for classifying vegetation types in Victoria. EVCs are described through a combination of floristics, lifeforms and ecological characteristics, and through an inferred fidelity to particular environmental attributes. Each EVC includes a collection of floristic communities (that is, lower level in the classification) that occur across a biogeographic range, and although differing in species, have similar habitat and ecological processes operating.*

Recent conditions

The Goulburn system experienced dry conditions and some of its highest temperatures on record during 2018–19.

Water for the environment was delivered to Reedy Swamp in spring 2018, to provide refuge for thousands of bird species including the threatened white-bellied sea eagle and glossy ibis. The wetland was allowed to draw down and dry over summer.

Gaynor Swamp received water for the environment for the first time in April 2018 and quickly became a feeding site for thousands of waterbirds including brolga. Observations of breeding behaviour in whiskered terns and brolga led to a subsequent top-up delivery in spring 2018, to support waterbird breeding.

Doctors Swamp was not actively watered during 2018–19, to allow it to dry and reduce exotic aquatic vegetation at the site.

Horseshoe Lagoon partially filled in December 2017 from natural flows in the Goulburn River, but the wetland, along with Kanyapella Basin, has not been fully inundated since 2011–12, and both are currently dry. Loch Garry was partially filled during natural floods in 2016 and dried in January 2019.

Scope of environmental watering

Table 5.4.3 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.4.3 Potential environmental watering actions and objectives for the Goulburn wetlands

Potential environmental watering action	Functional watering objective	Environmental objective
Doctors Swamp (fill in autumn)	• Promote vegetation growth • Provide habitat for waterbird roosting and feeding	
Horseshoe Lagoon (fill in winter)	• Maintain wetland vegetation by supporting growth and recruitment • Promote the growth of river swamp wallaby-grass • Provide habitat for turtle and frog populations	
Kanyapella Basin (partial fill in spring or autumn)	• Promote different vegetation communities to establish	
Loch Garry (partial fill in autumn)	• Increase wetland vegetation growth and recruitment • Provide feeding/breeding habitat for a range of waterbirds	
Reedy Swamp (fill in autumn)	• Limit the growth of aquatic weeds by keeping the wetland dry in summer • Promote the growth of native wetland vegetation • Provide refuge and food/habitat for waterbirds	
Wetland drying		
Gaynor Swamp	• Reduce the extent of typha	

Scenario planning

Table 5.4.4 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Goulburn Broken CMA has planned wetland watering to maintain a range of habitat types to support waterbirds and other water-dependent animals in the region at any point in time.

Doctors Swamp, Reedy Swamp and Horseshoe Lagoon have been identified as high-priority watering sites in 2019–20 under all climatic scenarios. If there are no natural flows, Doctors Swamp and Reedy Swamp will require water in autumn 2020 to maintain their existing wetland vegetation and to encourage recruitment. Horseshoe Lagoon has not received water for the environment before, and the interval since its last natural fill is threatening the condition of native plant communities. Water for the environment delivered to Horseshoe Lagoon in winter will aim to improve the condition of native wetland vegetation communities and provide habitat for native animals.

It is expected that sufficient water will be available to meet all priority watering actions, and hence no tier 1b actions are noted.

Loch Garry and Kanyapella Basin have been identified as tier 2 priorities for 2019–20. If the desired drying period (6–18 months) is met at Loch Garry, water may be delivered in autumn 2020. However, if the water is not available in 2019–20 and the wetland remains dry, the vegetation communities are likely to tolerate another year without water. Bathymetric survey work needs to be completed at Kanyapella Basin, to enable appropriate delivery volume estimates before a potential partial trial filling could be delivered in spring 2019 or autumn 2020.

Gaynor Swamp received water for the environment for the first time in autumn 2018 and an additional top-up in late spring/early summer 2018. The wetland will not be actively watered in 2019–20 and will be allowed to dry. The dry phase will reduce the extent of exotic weeds.

Table 5.4.4 Potential environmental watering for the Goulburn wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Catchment run off and unregulated flows into the wetlands are highly unlikely	• Catchment run off and unregulated flows into the wetlands are unlikely	• Some catchment run off and unregulated flow into some of the wetlands are likely, particularly in winter/spring	• Catchment run off and unregulated flow into the wetlands may significantly contribute to their water levels, particularly in winter/spring
Potential environmental watering – tier 1a (high priorities)	• Doctors Swamp • Horseshoe Lagoon • Reedy Swamp	• Doctors Swamp • Horseshoe Lagoon • Reedy Swamp	• Doctors Swamp • Horseshoe Lagoon • Reedy Swamp	• Doctors Swamp • Horseshoe Lagoon • Reedy Swamp
Potential environmental watering – tier 2 (additional priorities)	• Kanyapella Basin • Loch Garry	• Kanyapella Basin • Loch Garry	• Kanyapella Basin • Loch Garry	• Kanyapella Basin • Loch Garry
Possible volume of water for the environment required to achieve objectives[1]	• 1,300 ML (tier 1) • 1,000 ML (tier 2)	• 1,300 ML (tier 1) • 1,000 ML (tier 2)	• 1,000 ML (tier 1) • 1,000 ML (tier 2)	• 700 ML (tier 1) • 1,000 ML (tier 2)

[1] *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

5.5 Broken system

The Broken system includes the Broken River, upper Broken Creek, lower Broken Creek and various wetlands.

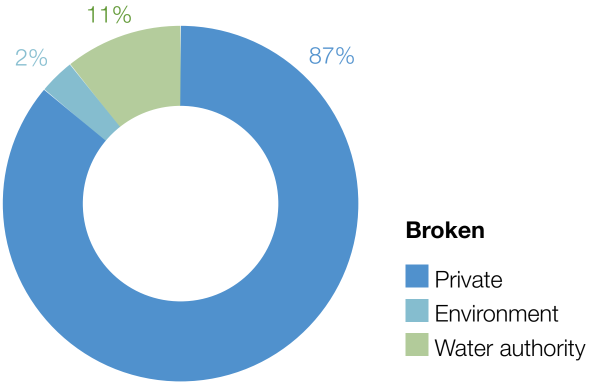
Waterway manager – Goulburn Broken Catchment Management Authority

Storage manager – Goulburn-Murray Water

Environmental water holders – Victorian Environmental Water Holder, Commonwealth Environmental Water Holder

Did you know ...?

Recent fish monitoring in sections of the Broken River and Broken Creek for the Victorian Environmental Flows Monitoring and Assessment Program shows that Murray cod of all ages, golden perch, Murray river rainbow fish and silver perch are all benefiting from environmental flows.



Proportion of water entitlements in the Broken basin held by private users, water corporations or environmental water holders at 30 June 2018.

Top: Lower Broken Creek, by Goulburn Broken CMA
Centre: Graeme Hackett, ARI, with a tagged Murray cod at Broken River, by Goulburn Broken CMA
Above: Common spadefoot toad at Moodie Swamp, by Jo Wood

5.5.1 Broken River and upper Broken Creek

System overview

The Broken River is a tributary of the Goulburn River, rising in the Wellington–Tolmie highlands and flowing north-west to Benalla and then west for a total distance of 190 km before it joins the Goulburn River near Shepparton. Lake Nillahcootie is the main storage on the Broken River. It is about 36 km upstream of Benalla and diverts water from the river to support stock and domestic supply and irrigated agriculture. The main tributaries of the Broken River are Hollands Creek, Ryans Creek and Lima East Creek.

Lake Nillahcootie has a storage capacity that is about half the mean annual flow of its upstream catchment, so it fills in most years. The operation of Lake Nillachootie has modified the river's natural flow pattern; winter/spring flows are less than natural because a large proportion of inflows are harvested, while summer/autumn flows are higher than natural because water is released to meet downstream irrigation demands. These impacts are most pronounced in the reach between Lake Nillahcootie and Hollands Creek. Downstream of Hollands Creek, the river retains a more-natural flow pattern due to the contribution of tributary inflows. The catchment has been extensively cleared for agriculture including dryland farming (such as livestock grazing and cereal cropping) and irrigated agriculture (such as dairy, fruit and livestock).

Water is released from Lake Nillahcootie to meet downstream demand and minimum-flow requirements specified under the bulk entitlement for the Broken River system. Releases from storage may be less than 30 ML per day as tributary inflows immediately below the storage (such as from Back Creek) can supply much of minimum-flow requirements specified in the bulk entitlement.

The upper Broken Creek is defined as the 89-km stretch of creek from the Broken River (at Caseys Weir) to the confluence with Boosey Creek near Katamatite. The upper Broken Creek flows across a flat, riverine plain and has naturally low run off from its local catchment. It receives flood flows from the Broken River, although the frequency of these floods has been reduced by earthworks and road construction.

Upper Broken Creek has been regulated for more than a century. Before 2007, water was diverted into upper Broken Creek at Casey's Weir to meet local demand, but recent water-savings projects have reduced the demand on the creek. There are now low flows throughout the year between Caseys Weir and Waggarandall Weir. Flows downstream of Waggarandall Weir are mainly influenced by rainfall and catchment run off. These changes have reduced the amount of permanent aquatic habitat.

Delivery of water for the environment to the Broken River is primarily constrained by the availability of water. Usually, the available volume of water for the environment is well short of the volume required to deliver the desired flow components. Deliveries of water for the environment to the upper Broken Creek are also restricted by channel capacity and by the need to avoid flooding low-lying adjacent land.

Environmental values

The Broken River retains one of the best examples of healthy in-stream vegetation in a lowland river in the region. A range of native submerged and emergent plant species including eelgrass, common reed and water ribbons populate the bed and margins of the river. These plants provide habitat for a range of animals including small- and large-bodied native fish species. Murray cod, Macquarie perch, golden perch, silver perch, river blackfish, mountain galaxias and Murray-Darling rainbowfish all occur in the Broken River. The river also supports a large platypus population.

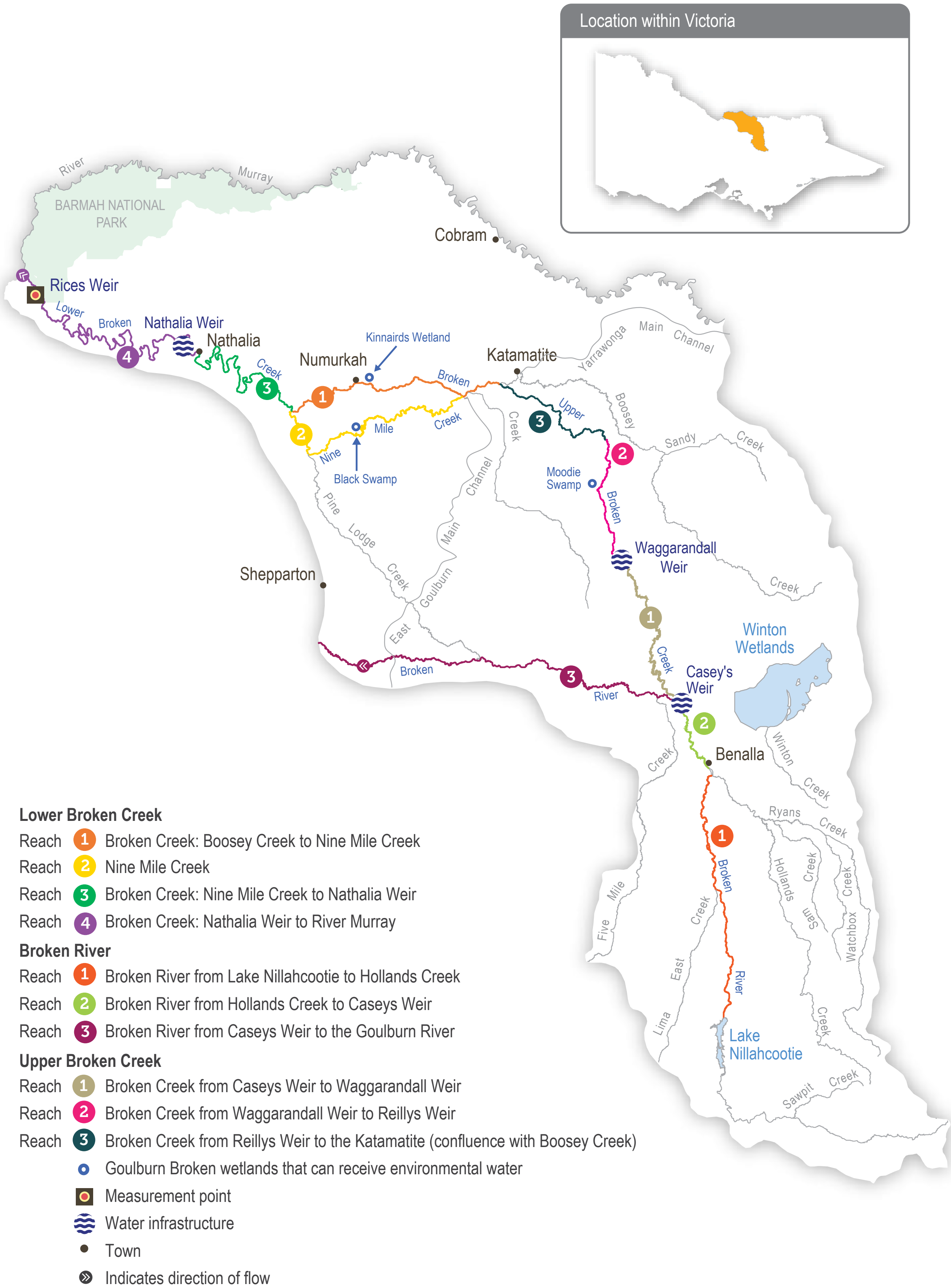
The upper Broken Creek area is dominated by unique box riparian vegetation and remnant plains grassy woodland. It supports numerous threatened species including brolga, Australasian bittern, buloke and rigid water milfoil. Much of the high-quality native vegetation in the region is set aside as a natural features reserve. Upper Broken Creek supports a variety of native fish species including carp gudgeon, Murray cod, golden perch and Murray-Darling rainbowfish, as well as platypus and common long-necked turtle.

Both the Broken River and upper Broken Creek are listed in the *Directory of Important Wetlands in Australia*.

Environmental objectives in the Broken River and upper Broken Creek

	Increase native fish populations
	Maintain platypus populations
	Maintain in-stream vegetation
	Support a wide range and high biomass of waterbugs, to break down dead organic matter and support the river's food web
	Maintain water quality

Figure 5.5.1 The Broken system



Grey river reaches have been included for context. The numbered reaches indicate where relevant environmental flow studies have been undertaken. Coloured reaches can receive environmental water.

Recent conditions

Dry conditions were the dominant feature of flows in the Broken River and upper Broken Creek in 2018–19. Isolated rainfall events between August and December 2018 delivered a few small, natural freshes in the Broken River downstream of Lake Nillahcootie, which benefitted native fish and in-stream vegetation. Winter/spring flows in the upper Broken Creek were below minimum-flow requirements for most of the time, although two small, natural freshes helped maintain water quality and broad environmental values.

Environmental flows commenced in May 2019, to help maintain minimum-flow levels in the Broken River under ongoing dry conditions. These flows aim to maintain habitat and prevent the loss of aquatic vegetation, waterbugs and native fish leading into winter 2019.

Scope of environmental watering

Table 5.5.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.5.1 Potential environmental watering actions and objectives for the Broken River and upper Broken Creek

Potential environmental watering action	Functional watering objective	Environmental objective
Summer/autumn fresh in upper Broken Creek (one fresh of up to 100 ML/day for 10 days during December to May)	• Maintain water quality, particularly dissolved oxygen levels, in refuge pools	
Summer/autumn low flows in upper Broken Creek (up to 10 ML/day for 30–60 days during December to May)	• Maintain pool and riffle habitat for native fish populations and waterbugs • Maintain access to habitat and food resources for platypus • Maintain habitat for in-stream vegetation	
Winter/spring low flows in upper Broken Creek (up to 15 ML/day for 30–60 days during June to November)	• Maintain pool and riffle habitat for native fish populations and waterbugs • Maintain access to habitat and food resources for platypus • Maintain habitat for in-stream vegetation	
Year-round low flows in the Broken River (up to 30 ML/day for 40–100 days)	• Maintain riffles, slackwater and pools to provide diverse hydraulic habitat for native fish, aquatic plants, platypus and waterbugs • Maintain habitat for in-stream and fringing aquatic vegetation and prevent terrestrial vegetation colonising the stream bed	
Summer/autumn freshes in the Broken River (one fresh of 400–500 ML/day for two to five days during December to May)	• Scour sediment around large wood and turn over bed sediments to replenish biofilms and increase productivity • Provide flow cues to stimulate native fish breeding and migration • Provide flow to maintain in-stream and fringing aquatic vegetation • Maintain longitudinal connectivity for native fish passage	

Scenario planning

Table 5.5.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Environmental flow requirements for the upper Broken Creek and Broken River are greater than the volume of water for the environment expected to be available in the Broken system. Natural catchment run off and operational deliveries including mandated passing flows are expected to meet some of the recommended environmental flow requirements for these systems. Water for the environment will be used where possible to meet the highest-priority flows that are not met from consumptive deliveries or natural flows.

Priority is given to upper Broken Creek watering actions in summer and autumn under all scenarios to maintain water quality, although this is more likely to be required under drought and dry conditions than average to wet conditions. Flow targets in upper Broken Creek are less likely to be met by catchment run off and managed releases than in the Broken River, and a lack of flow in the creek poses a significant risk to native fish, platypus and macroinvertebrate populations.

If additional water for the environment is available, tier 1b actions can be delivered if required. Low flows and water quality freshening flows are potential demands throughout the year under most scenarios.

Any remaining water for the environment may be used in the Broken River. Minimum baseflows are planned to be maintained under drought and dry conditions, if not met through irrigation releases or catchment run off. A summer/autumn fresh in the Broken River is an additional demand, noting this may be met by the delivery of inter-valley transfers from the Broken system to the Goulburn system under some scenarios.

Table 5.5.2 Potential environmental watering for the Broken River and upper Broken Creek under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No unregulated winter and spring flows in Broken River • No unregulated flows in upper Broken Creek • Minimal volume transferred to the Goulburn River • Low and cease-to-flow events in summer/autumn below Waggarandall Weir on upper Broken Creek	• Low unregulated flows and some freshes in Broken River • No unregulated flows in the Upper Broken Creek • Up to 1,500 ML of consumptive water delivered via the Broken River in summer/autumn	• High winter and spring flows in the Broken River • Some contribution of unregulated winter and spring flows and freshes in upper Broken Creek • Up to 1,500 ML of consumptive water delivered via the Broken River in summer/autumn	
Expected availability of water for the environment	• 0–267 ML	• 304 ML	• 534 ML	
Potential environmental watering – tier 1a (high priorities)	• Summer/autumn fresh in upper Broken Creek (partial)	• Summer/autumn fresh in upper Broken Creek (partial)	• Summer/autumn fresh in upper Broken Creek (partial)	• Summer/autumn fresh in upper Broken Creek (partial)
Potential environmental watering – tier 1b (high priorities with shortfall)	• Summer/autumn fresh in upper Broken Creek (remaining demand) • Summer/autumn low flows in upper Broken Creek • Winter/spring low flows in upper Broken Creek • Year-round low flows in the Broken River	• Summer/autumn fresh in upper Broken Creek (remaining demand) • Summer/autumn low flows in upper Broken Creek • Winter/spring low flows in upper Broken Creek • Year-round low flows in the Broken River	• Summer/autumn fresh in upper Broken Creek (remaining demand) • Summer/autumn low flows in upper Broken Creek • Winter/spring low flows in upper Broken Creek	• Summer/autumn fresh in upper Broken Creek (remaining demand)
Potential environmental watering – tier 2 (additional priorities)		• Summer/autumn fresh in Broken River	• Summer/autumn fresh in Broken River	
Possible volume of water for the environment required to achieve objectives[1]	• 267 ML (tier 1a) • Up to 4,000 ML (tier 1b)	• 304 ML (tier 1a) • Up to 2,500 ML (tier 1b) • Up to 5,800 ML (tier 2)	• 534 ML (tier 1a) • Up to 1,180 ML (tier 1b) • Up to 5,800 ML (tier 2)	• 534 ML (tier 1a) • Up to 1.000 ML (tier 1b)

[1] *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

5.5.2 Lower Broken Creek

System overview

The lower Broken Creek system includes the section of Broken Creek that flows from the confluence of Boosey Creek near Katamatite to the River Murray, and Nine Mile Creek, which is an anabranch that leaves lower Broken Creek at the East Goulburn Main Channel and re-joins downstream of Numurkah.

Lower Broken and Nine Mile creeks have been regulated for over a century. Before regulation, the creeks would have had most of their flow in winter and spring and then contracted to isolated pools or dried out during summer and autumn. The adjacent floodplain would have also flooded regularly. The creeks now have numerous weirs that maintain a relatively constant flow from mid-August until mid-May to support irrigated agriculture. These modifications have changed the way native animals use the creek. Previously, native fish would have moved into the creek when it was flowing and returned to the River Murray as it dried. Both creeks now provide year-round habitat for native fish, and fish passage structures allow fish to move between weir pools. Water for the environment is used to support these permanent fish habitats, by providing flows to trigger fish movement and support fish passage, control water quality and flush azolla as necessary.

The lower Broken Creek is operated separately to the upper Broken Creek and the Broken River, because regulated water is delivered to the lower Broken Creek from the Goulburn and Murray systems via the irrigation channel network.

Water for the environment can be provided to the lower Broken Creek from the Goulburn system through the East Goulburn Main Channel and from the Murray system through the Yarrawonga Main Channel. Water is released into the lower Broken Creek from several irrigation area regulators along the length of the lower Broken Creek. The main priority for environmental watering in the lower Broken Creek system is to maintain minimum flows throughout the year. Particular attention is given to reaches 1 and 2 during the non-irrigation season, when flow can stop. The next priority is to deliver freshes in winter and spring to trigger fish movement and spawning, maintain water quality and manage azolla blooms in reaches 3 and 4. The measurement point for environmental flows in the lower Broken Creek is at Rices Weir.

Some of the environmental flow targets for the lower Broken Creek are partly or wholly met by operational water releases (inter-valley transfers [from the Goulburn to the Murray] or choke bypass flows [when bypassing the Barmah choke in the Murray]) that are delivered to meet downstream demands. These operational deliveries mainly occur during peak irrigation demand between spring and autumn. Water for the environment may be used to supplement these operational releases and to deliver recommended flow components that are not met by the operational releases.

Environmental values

The lower Broken Creek and Nine Mile Creek support a diverse and abundant native fish community including the threatened Murray cod, golden perch, silver perch, unspecked hardyhead and crimson-spotted rainbowfish (also known as the Murray-Darling rainbowfish). Sections of the lower Broken and Nine Mile creeks have been reserved as state park and natural feature reserves. The associated floodplain and wetland habitats support box-dominated grassy woodland communities and numerous species of state and national conservation significance including river swamp wallaby-grass and the Australasian bittern.

Environmental objectives in the lower Broken Creek

Protect and increase native fish populations including the threatened Murray cod, golden perch and silver perch
Protect platypus populations, particularly outside the irrigation season Protect rakali (water rat) populations, particularly outside the irrigation season
Protect turtle populations, particularly outside the irrigation season
Avoid the excessive build-up of azolla Maintain the cover and condition of native in-stream and littoral vegetation communities
Maintain the diversity and abundance of waterbug populations
Maintain dissolved oxygen levels suitable for aquatic animals

Recent conditions

The lower Broken Creek system experienced below-average rainfall, record high temperatures and little unregulated flow during 2018–19. Water for the environment was used in combination with operational water to maintain flow in the creek, where possible.

Lower Broken Creek had particularly low flow during June and July 2018, due to lower-than-average rainfall and maintenance works at Katandra Weir and surrounding irrigation areas. Goulburn-Murray Water was forced to close the fish ladders in lower Broken Creek for a number of weeks during this period, to maintain critical weir pool habitat.

The low winter flow led to a build-up of azolla downstream of Nathalia in July 2018. Six blockages were identified, where azolla blanketed whole sections of the creek. Water for the environment was used to deliver a fresh at the start of the irrigation season in August. The fresh peaked at 450 ML per day at Rices Weir and successfully flushed azolla and stimulated fish movement.

Flows between September and December 2018 varied from 206 ML per day to 332 ML per day and often failed to meet the minimum-flow target of 250 ML per day, which is what is needed to maintain adequate fish habitat.

A combination of water for the environment and operational water maintained dissolved oxygen levels in the lower Broken Creek through summer 2018–19. This was particularly important in the wake of record high temperatures in January 2019, which increased the risk of low dissolved-oxygen levels in the weir pools.

The environmental flow study for the lower Broken Creek was updated in 2019. The study improved the scientific rationale for the current environmental flow regime and developed new objectives and flow recommendations for the flowing reaches upstream of Nathalia. One of the main amendments is a recommendation for minimum flows in reaches 1 and 2 over the non-irrigation season, to provide critical habitat for aquatic animals and protect in-stream vegetation.

There is limited formal and ongoing monitoring of ecological conditions in the lower Broken Creek, but the Broken Environmental Water Advisory Group observed when it met in February 2018–19 that:

- lower Broken Creek is looking better than it has since the 1990s
- golden perch and large Murray cod are being caught, and fishing has improved
- a platypus was recently sighted in a permanent weir pool in the Nine Mile Creek at Wunghu.

The platypus sighting was verified by several fishers and community members and is the first sighting in the reach.

Scope of environmental watering

Table 5.5.3 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

The rakali (water rats) have been included as an environmental objective for the year-round low flows in 2019–20. According to the 2019 Lower Broken Creek Environmental Flows study, a flow management regime that supports the survival and recruitment of platypus should also favour rakali (water rats), given that both species consume macroinvertebrates, have similar requirements with respect to the timing of lactation and juvenile dispersal and are vulnerable to the same range of predators.

Table 5.5.3 Potential environmental watering actions and objectives for the lower Broken Creek

Potential environmental watering action	Functional watering objective	Environmental objective
Year-round low flows of up to 200 ML/day in reaches 3 and 4 and 100 ML/day in reaches 1 and 2[1]	• Provide native fish passage through fish ladders • Provide suitable foraging habitat for platypus and rakali (water rats), and support the movement of juvenile platypus and rakali • Provide habitat for turtles including protection from exposure to cold in winter • Provide flowing water habitat and avoid winter drawdown of weir pools for fish, vegetation, waterbugs, platypus and turtles • Limit suspended sediment and maintain suitable dissolved oxygen conditions	
Winter/spring/summer/autumn high flows (up to 300 ML/day in reaches 3 and 4 during July to May)	• Provide habitat for fish and support fish movement, spawning and recruitment • Flush and mobilise azolla and maintain oxygen levels in summer	
Winter/spring freshes (up to three freshes of 450 ML/day during July to October)	• Flush and mobilise azolla, if it blooms • Trigger fish migration and movement	

[1] *Primarily planned for the irrigation season between mid-August and mid-May, but it may be delivered year-round subject to supply constraints. Constraints may mean these flows may not be delivered in the non-irrigation season.*

Scenario planning

Table 5.5.4 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Due to regulation of the lower Broken and Nine Mile creeks, which creates highly modified and relatively uniform conditions, environmental flow recommendations are relatively constant from year to year and independent of annual climatic conditions.

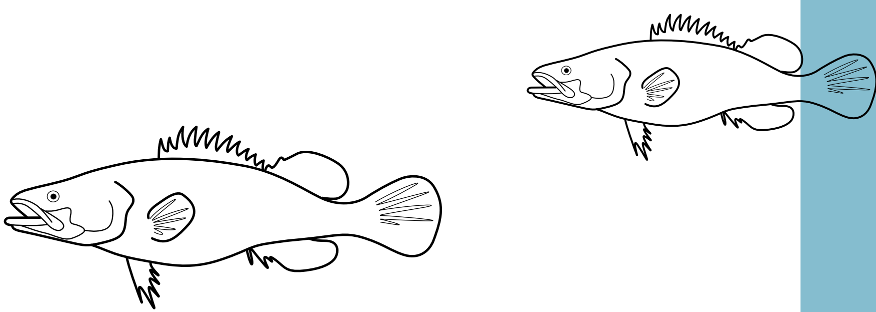
During 2019–20, environmental flows in the lower Broken Creek will be adjusted as needed to optimise the quantity of habitat and movement opportunities for native fish, maintain water quality and flush azolla through the system. The environmental flow objectives may be partly or wholly met by regulated flows to meet irrigation demand and by natural unregulated flows and therefore water for the environment will only be used to make up shortfalls. During dry conditions, water for the environment will be mainly used to deliver high flows and freshes, because irrigation demand and the associated operational water flows are likely to meet many of the environmental low-flow requirements. During wet conditions, there will be less demand for operational water, so more water for the environment may be needed to meet the low-flow requirements.

The potential environmental watering actions in Table 5.5.4 are all considered to be high priorities and are expected to meet the environmental requirements of the system. No second-tier priority watering actions have been identified for 2019–20.

In addition to the deliveries of water for the environment outlined in this seasonal watering plan, downstream demands (environmental or operational) may result in higher flows being delivered in the lower Broken Creek in 2019–20. Higher flows through the lower Broken Creek system generally provide positive environmental outcomes.

Table 5.5.4 Potential environmental watering for the lower Broken Creek under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No unregulated flows in winter • No flows throughout the irrigation season (mid-August to May) • No diversion of unregulated River Murray flows available	• Some unregulated flows in winter • No flows throughout the irrigation season (mid-August to May) • No diversion of unregulated River Murray flows available	• Unregulated flows in winter/spring • No unregulated flows during October to May (except for an occasional unregulated fresh in spring) • Diversion of unregulated River Murray flows available during mid-August to October	• Unregulated flows in winter/spring • No unregulated flows during November to May • Diversion of unregulated River Murray flows available during mid-August to November
Potential environmental watering (tier 1 – high priorities)	• Year-round low flows • Winter/spring/summer/autumn high flows • Winter/spring freshes			
Possible volume of water for the environment required to achieve objectives	• 56,500 ML	• 56,500 ML	• 54,500 ML	• 57,600 ML



5.5.3 Broken wetlands

System overview

Of some 2,000 natural wetlands in the Goulburn Broken area, only three in the Broken catchment have infrastructure that allow them to receive water for the environment: Black Swamp, Kinnairds Wetland and Moodie Swamp. Kinnairds Wetland and Black Swamp are red gum swamps near Numurkah. Moodie Swamp is a cane grass wetland adjacent to Broken Creek at Waggarandall that provides excellent breeding habitat for brolga.

The water regimes of these wetlands are influenced by their position in the landscape. The development and operation of the Shepparton, Central Goulburn and Murray Valley irrigation districts have changed the natural flow paths and the timing, frequency, volume and duration of natural flooding to these and other wetlands in the region. Existing irrigation system infrastructure enables water for the environment to be delivered to the three nominated wetlands, but irrigation deliveries have priority within the channel system. This limits the volume of water that can be delivered to the wetlands, often when it is most needed.

Environmental values

Moodie Swamp, Kinnairds Wetland and Black Swamp support a high diversity of vegetation communities ranging from river red gum-dominated swamps to cane grass wetlands. The wetlands contain state and nationally threatened vegetation communities and species including ridged water milfoil and river swamp wallaby-grass. The wetlands also provide food resources and breeding habitat for bird species of high conservation significance (such as eastern great egret, Latham's snipe, white-bellied sea eagle, Australasian bittern, brolga, royal spoonbill, yellow-billed spoonbill, Australasian shoveler and glossy ibis). Many of these species are listed in international agreements and conventions.

Environmental objectives in the Broken wetlands

	Provide breeding habitat for waterbirds Provide feeding and roosting habitat for waterbirds
	Increase the diversity of native wetland plants consistent with the EVC[1] benchmarks Reduce the cover and diversity of exotic plant species Increase and maintain populations of rigid water milfoil and slender water milfoil

[1] *Ecological vegetation classes (EVCs) are the standard unit for classifying vegetation types in Victoria. EVCs are described through a combination of floristics, lifeforms and ecological characteristics, and through an inferred fidelity to particular environmental attributes. Each EVC includes a collection of floristic communities (that is, lower level in the classification) that occur across a biogeographic range, and although differing in species, have similar habitat and ecological processes operating.*

Recent conditions

The Broken River catchment received below-average rainfall and some of its highest recorded temperatures during 2018–19. Water for the environment was delivered to Black Swamp and Kinnairds Wetland in spring, to support the growth of native vegetation and provide refuge for birds and other water-dependent animals. Both wetlands responded with increased wetland plant cover including threatened species (such as river swamp wallaby-grass). Both wetlands dried over summer and autumn.

Moodie Swamp was allowed to dry during 2018–19, to reduce competition from exotic plants. Drying cycles are critical for supporting a healthy, productive wetland environment.

Scope of environmental watering

Table 5.5.5 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.5.5 Potential environmental watering actions and objectives for the Broken wetlands

Potential environmental watering action	Functional watering objective	Environmental objective
Black Swamp (fill in autumn)	• Promote the growth of river swamp wallaby-grass • Provide waterbird habitat	
Kinnairds Wetland (fill in autumn)	• Promote the germination and growth of rigid and slender water milfoil • Prime the wetland for waterbird breeding	
Moodie Swamp (partial fill in autumn)	• Promote cane grass growth • Promote the germination and growth of rigid water milfoil • Provide habitat for brolga nesting	

Scenario planning

Table 5.5.6 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Goulburn Broken CMA has undertaken landscape-scale planning for these wetlands to maintain a high diversity of habitat types in the region to support waterbirds and other water-dependent animals. Plans have been made under a range of climate scenarios to guide decision-making, but decisions to deliver water for the environment to the Broken wetlands will be based largely on their hydrological condition and observed waterbird breeding activity and on the potential impact of environmental watering on wetland vegetation communities.

Moodie Swamp has been identified as a high priority in all planning scenarios, as it remained dry throughout 2018–19. A partial fill in autumn will provide habitat for waterbirds and promote wetland vegetation growth for threatened and vulnerable species (such as rigid and slender milfoil).

It is expected that sufficient water will be available to meet all priority watering actions, so no tier 1b actions are noted.

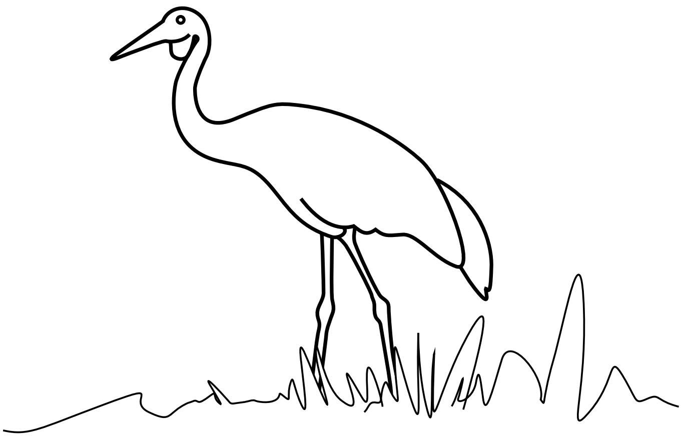
Black Swamp and Kinnairds Wetland are secondary priorities in all planning scenarios. Both wetlands received water for the environment in 2018–19, and their vegetation communities are likely to tolerate a year without additional water. Water for the environment may be used to fill these wetlands in autumn, if sufficient water resources are available. This would build on positive vegetation and waterbird responses to watering in 2018–19.

All three wetlands will be likely to fill naturally in winter or spring under a wet climate scenario. Small volumes of water for the environment may be required under these circumstances, to extend the duration or extent of natural flooding, helping to support a significant waterbird breeding event.

Table 5.5.6 Potential environmental watering for the Broken wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Catchment run off and unregulated flows into the wetlands are highly unlikely	• Catchment run off and unregulated flows into the wetlands is unlikely	• Some catchment run off and unregulated flows into some of the wetlands is likely, particularly in winter/spring	• Catchment run off and unregulated flows into the wetlands may significantly contribute to water levels in the wetlands, particularly in winter/spring
Potential environmental watering – tier 1a (high priorities)	• Moodie Swamp	• Moodie Swamp	• Moodie Swamp	• Moodie Swamp
Environmental watering – tier 2 (additional priorities)	• Black Swamp • Kinnairds Wetland	• Black Swamp • Kinnairds Wetland	• Black Swamp • Kinnairds Wetland	• Black Swamp • Kinnairds Wetland
Possible volume of water for the environment required to achieve objectives[1]	• 500 ML (tier 1) • 580 ML (tier 2)	• 500 ML (tier 1) • 580 ML (tier 2)	• 500 ML (tier 1) • 580 ML (tier 2)	• 500 ML (tier 1) • 580 ML (tier 2)

[1] *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*



5.6 Campaspe system

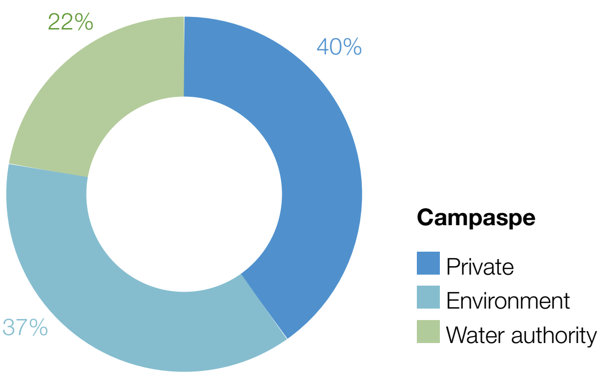
Waterway manager – North Central Catchment Management Authority

Storage manager – Goulburn-Murray Water, Coliban Water

Environmental water holders – Victorian Environmental Water Holder (including the Living Murray program), Commonwealth Environmental Water Holder

Did you know ...?

The Campaspe River forms a boundary between Dja Dja Wurrung Country and Taungurung Country, and is known to both peoples as *Yerrin*. Taungurung also know the Campaspe River between Kyneton and Heathcote as *Boregam*.



Proportion of water entitlements in the Campapse basin held by private users, water corporations or environmental water holders at 30 June 2018.

Top: Coliban River, by North Central CMA
Centre: Recreation on the Campaspe River, by North Central CMA
Above: Platypus at English's Bridge, by Paula Markey

The Campaspe catchment extends from the Great Dividing Range in the south and outfalls to the River Murray in the north, a total distance of about 150 km. The Campaspe River is the main waterway in the catchment and flows through urban, peri-urban and rural town including Kyneton, Elmore, Rochester and Echuca. The second-largest waterway is the Coliban River, which also rises in the Great Dividing Range to the west of the Campaspe River before joining it at Lake Eppalock.

5.6.1 Campaspe River

System overview

Natural inflows in the upper Campaspe River catchment are harvested into Lake Eppalock, which is located near the townships of Axedale and Heathcote. The main tributaries of the Campaspe River are the Coliban River, McIvor and Pipers creeks upstream of Lake Eppalock and Mount Pleasant, Forest and Axe creeks downstream of Lake Eppalock. Below Lake Eppalock, the major in-stream structure is the Campaspe Weir, which was built to divert water to the Campaspe Irrigation District. It is no longer used for water diversion, but is a barrier to fish migration. Higher flows usually spill over the weir. The Campaspe Siphon, just downstream of Rochester, is part of the Waranga Western Channel, which carries water from the Goulburn system to western Victoria. Water can be released from the Waranga Western Channel into the lower reaches of the Campaspe River, but the siphon is another barrier to fish migration at low-to-moderate flows.

Flows downstream of Lake Eppalock are largely influenced by releases from storage and the operation of the Campaspe Weir and the Campaspe Siphon near Rochester. The Campaspe's major tributary — the Coliban River — flows through the three Coliban Water storages — the Upper Coliban, Lauriston and Malmsbury reservoirs — before reaching Lake Eppalock. Water for the environment is held and released from Lake Eppalock, with some limited ability to regulate flows further downstream at the Campaspe Weir.

Water for the environment is released from Lake Eppalock to support aquatic plants and animals in and along the river. It can be supplemented by water for the environment delivered via the Waranga Western Channel at the Campaspe Siphon, which provides important flexibility to meeting reach 4 demands. Water for the environment is primarily used to improve the magnitude and variability of flows during the winter and spring. Primary flow measurement points are at Barnadown (reach 2) and downstream of the Campaspe Siphon (reach 4).

Goulburn-Murray Water transfers operational water from Lake Eppalock to customers in the River Murray and to downstream storages (such as Lake Victoria). These inter-valley transfers (IVTs) usually occur in summer/autumn and can significantly increase flows in the Campaspe River at a time when flows would naturally be low. High IVT flows may reduce the amount of suitable habitat for juvenile fish, which rely on protected, shallow areas of water near the edge of the river channel. They can also drown streamside vegetation. Storage managers and the CMA have been working cooperatively to enhance the positive effects and limit any negative effects IVTs may have on native plants and animals. For example, IVTs have been released in a pattern to support native fish migration from the River Murray into reach 4 of the Campaspe River, without affecting delivery to downstream users.

Environmental values

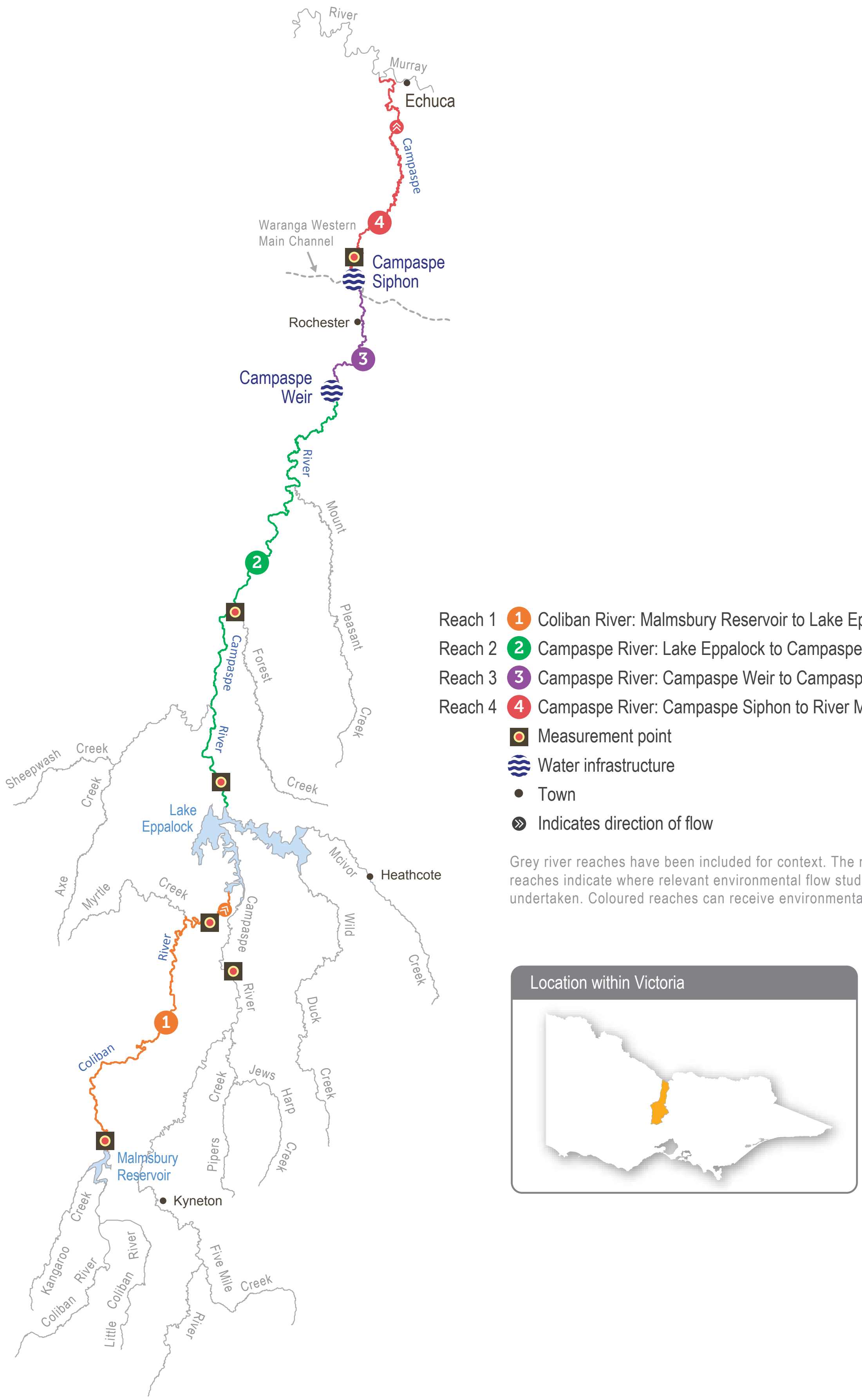
The Campaspe River downstream of Lake Eppalock provides important habitat for several native fish species including Murray cod, silver perch, golden perch, Murray-Darling rainbowfish and flat-headed gudgeon. Murray-Darling rainbowfish were presumed lost from the system during the Millennium Drought, but since 2011 they have been recorded at many sites on the Campaspe River and are now abundant downstream of Elmore. Maintaining flows is important for migration opportunities and dispersal of native fish species throughout the Campaspe system.

Platypus, rakali (water rats), turtles and frogs are also present along the length of the Campaspe River. The streamside vegetation zone is narrow and dominated by large, mature river red gum trees that support wildlife (such as the swift parrot and squirrel glider).

Environmental objectives in the Campaspe River

Provide habitat to help protect and increase populations of native fish
Maintain the resident platypus population by providing places to rest, breed and feed, as well as opportunities for juveniles to disperse
Maintain adult river red gums and provide opportunities for successful recruitment Maintain the extent and increase the diversity of riparian vegetation Increase the extent of in-stream aquatic plants
Increase waterbug productivity
Maintain water quality in deep pools and prevent stratification in summer Reduce the risk of blackwater events in summer

Figure 5.6.1 The Campaspe system



Recent conditions

The Campaspe system had below-average rainfall and above-average temperatures throughout 2018–19. January 2019 was especially hot across the system.

There were few unregulated flows from tributaries in 2018–19, and Lake Eppalock did not spill. The dry conditions led to high operational water demand in the Murray and Goulburn systems. Large volumes of IVTs were delivered from the Campaspe system to meet these demands; and despite few unregulated flows in the Campaspe River, the high operational flow meant that conditions were more like average in summer/autumn. The North Central CMA worked with ecologists to advise storage managers about minimising risks to environmental values throughout this period.

The Campaspe River received several planned environmental flows in 2018–19. Water for the environment was used to deliver winter low flows from 1 July 2018, with a small break (cease-to-flow) for three days in early August due to maintenance works at the Eppalock outlet tower. IVTs were delivered from mid-August to mid-September. A winter/spring high flow of 1,500 ML per day for six days commenced in mid-September, before resuming the low flow of 200 ML per day. The winter/spring high flow was delivered in September, to ensure low and stable flows during the critical Murray cod nesting period in October. IVTs resumed in late October and continued through summer and autumn. Water for the environment was used to deliver several summer/autumn freshes, to maintain water quality.

Monitoring of native fish and vegetation continued in the Campaspe River in 2018–19 as part of the Victorian Environmental Flows Monitoring Assessment Program (VEFMAP). Murray cod larvae were detected for the second year in a row, and eggs or larvae of Australian smelt, flat-headed gudgeon, carp gudgeon, redfin and carp were also detected. Very few young-of-year fish were caught in the surveys, which indicates a lack of recent recruitment. Rapid changes in river flows and lower water temperatures as a result of IVTs during the spawning period could be having an adverse affect on the survival and recruitment of young native fish.

Scope of environmental watering

Table 5.6.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.6.1 Potential environmental watering actions and objectives for the Campaspe River

Potential environmental watering action	Functional watering objective	Environmental objective
Summer/autumn low flows (10–40 ML/day during December to May)	• Maintain backwater habitat for zooplankton and nursery habitat for native fish • Maintain habitat for native in-stream vegetation to colonise the channel margins • Promote the growth of biofilms to support macroinvertebrates and provide habitat for fish • Maintain the water quality and depth in deep pools in summer • Allow platypus to safely move between pools while foraging and ensure adequate food for lactating females	
Winter/spring low flows (up to 20–70 ML/day during June to November)	• Maintain pool and riffle habitat to support macroinvertebrate communities and feeding habitat for fish and platypus • Allow localised fish movement by maintaining adequate depth between pool habitat • Facilitate the long-distance movement of male platypus, especially in the August to October breeding season • Provide foraging opportunities across a wide range of habitats for female platypus to develop fat reserves before breeding • Maintain water quality by preventing pools stratifying	

Table 5.6.1 Potential environmental watering actions and objectives for the Campaspe River *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Winter/spring freshes (up to two freshes of 1,000-1,500 ML/day for two to five days during June to November)	• Flush accumulated leaf litter from the bank and low benches, to reduce the risk of blackwater events during managed flow releases in summer • Maintain soil moisture for established river red gum and woody shrubs • Maintain connectivity to allow fish movement, which in turn allows them to optimise their habitat and perhaps breed • Encourage female platypus to select a nesting burrow higher up the bank to reduce the risk of high flow later in the year flooding the burrow when juveniles are present[1]	
Higher winter/spring low flows (50–200 ML/day during June to November)	• Maintain pool and riffle habitat to support macroinvertebrate communities and feeding habitat for fish and platypus • Allow localised fish movement by maintaining adequate depth between pools • Facilitate the long-distance movement by male platypus, especially in the August to October breeding season • Provide foraging opportunities across a wide range of habitat for female platypus to develop fat reserves before breeding • Maintain water quality by preventing pools stratifying • Prevent terrestrial plants colonising the lower sections of the riverbank and low benches in the channel • Maintain soil moisture in the riverbank for established river red gum and woody shrubs • Help establish littoral vegetation	
Summer/autumn freshes (three freshes of 100-200 ML/day for two to three days during December to May)	• Promote the local movement of adult fish, to access alternative habitat • Wet submerged wood and flush fine silt and old biofilms, to promote new biofilm growth and increase macroinvertebrate productivity • Facilitate the downstream dispersal of juvenile platypus in April and May to colonise other habitat areas • Inundate low bars, benches and low portions of the bank to maintain fringing and emergent vegetation	

[1] *Deliver before the platypus' egg-laying season, ideally in August.*

Scenario planning

Table 5.6.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

For 2019–20, the highest-priority flows that are expected to be met with supply of water for the environment are low flows and freshes throughout the year, represented as tier 1a actions in Table 5.6.2. This includes additional 'emergency' freshes that can be delivered in a low-dissolved-oxygen situation to avoid critical loss of habitat and species. In a drought scenario, the winter/spring low flow in tier 1a would be reduced, which would increase the risk of low water quality and would mean fewer opportunities for fish and platypus movement and foraging. Additional water in a drought scenario is needed to achieve important higher-magnitude winter/spring low flows (tier 1b) to increase opportunities for fish and platypus movement and foraging and to reduce the risk of low water quality.

If more water becomes available than that needed to meet tier 1 objectives, higher low flows, more freshes and potentially fish-attractant flows in summer (tier 2) could be delivered. Note however that the fish-attractant flows in summer are a low priority, because a lack of large-scale breeding in the River Murray last year has meant that there are likely to be few potential fish recruits.

Carryover into 2020–21 is not a priority this year, because sufficient allocation from a very high-reliability entitlement is expected to be available on 1 July 2020 to meet minimum critical demands.

Table 5.6.2 Potential environmental watering for the Campaspe River under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Few or no unregulated flows • High operational water deliveries • No passing flows in winter • No spills from storage	• Some unregulated flows • High operational water deliveries • Increased passing flows • No spills from storage	• Some unregulated flows • Increased passing flows	• Unregulated flows • Increased passing flows • Spills from storage
Expected availability of environmental water	• 17,000 ML	• 21,000 ML	• 36,400 ML	• 38,400 ML
Potential environmental watering – tier 1a (high priorities)	• Summer/autumn low flow • Winter/spring low flow (reduced) • Winter/spring fresh • One to three summer/autumn freshes • Additional freshes may be required to avoid critical loss of species/habitat if a low-dissolved-oxygen event occurs	• Summer/autumn low flow • Winter/spring low flow • Winter/spring fresh • One to three summer/autumn freshes • Additional freshes may be required to avoid critical loss of species/habitat if a low-dissolved-oxygen event occurs	• Summer/autumn low flow • Higher winter/spring low flow • Winter/spring fresh • One to three summer/autumn freshes • Additional freshes may be required to avoid critical loss of species/habitat if a low-dissolved-oxygen event occurs	• Summer/autumn low flow • Higher winter/spring low flow • Winter/spring fresh • One to three summer/autumn freshes • Additional freshes may be required to avoid critical loss of species/habitat if a low-dissolved-oxygen event occurs
Potential environmental watering – tier 1b (high priorities)	• Winter/spring low flow	• N/A	• N/A	• N/A
Potential environmental watering – tier 2 (additional priorities)	• Higher winter/spring low flow • Winter/spring fresh (one additional event) • Increased magnitude of summer/autumn freshes • Provide fish-attracting flows in summer	• Higher winter/spring low flow • Winter/spring fresh (one additional fresh) • Increased magnitude of summer/autumn freshes • Provide fish-attracting flows in summer	• Winter/spring fresh (one additional fresh) • Increased magnitude of freshes • Provide fish-attracting flows in summer	• Higher winter/spring low flow • Winter/spring fresh (one additional fresh) • Increased magnitude of freshes • Provide fish-attracting flows in summer
Possible volume of water for the environment required to achieve objectives[1]	• 14,700 ML (tier 1a) • 5,000 ML (tier 1b) • 9,700 ML (tier 2)	• 20,300 ML (tier 1) • 5,000 ML (tier 2)	• 26,700 ML (tier 1) • 6,900 ML (tier 2)	• 28,600 ML (tier 1) • 10,000 ML (tier 2)

[1] *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

5.6.2 Coliban River

The Coliban River is the major tributary of the Campaspe River and flows into Lake Eppalock. It is highly regulated with three storages harvesting water primarily for urban use.

Flows in the Coliban River downstream of Malmsbury Reservoir are regulated by the operation of the Malmsbury, Lauriston and Upper Coliban storages. An important distinction between the Coliban River and other regulated Victorian systems is the lack of irrigation demand. Therefore, flows in the river are influenced by the passing-flow entitlement, which depends on catchment inflows, transfers of water to Lake Eppalock and major flood events in the catchment.

Reach 1 of the Coliban River below Malmsbury Reservoir to Lake Eppalock can benefit from environmental watering. The VEWH does not have any environmental entitlements in the Coliban system, but passing flows can be managed — for example, they can be accumulated and released when most needed — to help mitigate some risks associated with critically low summer/autumn flows including low-dissolved-oxygen levels. A small volume of Commonwealth water for the environment is held in the system, but the high cost of delivery means there is no plan to use it in 2019–20.

Environmental values

The Coliban River provides important habitat for platypus, rakali (water rats) and small-bodied native fish (such as flat-headed gudgeon and mountain galaxias). The Coliban River also contains a diverse range of waterbugs supported by stands of emergent and submergent aquatic vegetation. It is bordered by remnant patches of stream bank shrubland vegetation and woodland containing river red gum, callistemon, woolly tea-tree and inland wirilda, which provide habitat for terrestrial animals.

Environmental objectives in the Coliban River

Increase the abundance and diversity of small-bodied native fish
Clean fine sediment from substrates to support biofilms
Increase platypus communities by providing opportunities for successful breeding and dispersal
Increase the cover and diversity of aquatic plants Increase the cover and diversity of fringing vegetation, while limiting encroachment into the middle of the channel
Maintain adequate diversity and biomass of waterbugs, to break down dead organic matter and support the river's food chain
Improve water quality and maintain healthy levels of dissolved oxygen in pools

Recent conditions

Rainfall in the Coliban River catchment during 2018–19 has been variable although generally below average. Rainfall between August and November is essential for filling the Coliban storages, and it was about 75 percent of the long-term average in 2018. For most of the year, there were little to no unregulated flows from catchment run off, so flows in the Coliban River were generally well-below minimum environmental flow recommendations.

Passing flows from Malmsbury Reservoir were reduced from up to 8 ML per day to 4 ML per day during winter/spring, to build a reserve that could maintain continuous flows through parts of the Coliban River over summer. Without this action, most of the Coliban River would have likely stopped flowing in summer. Even with the release of these accumulated passing flows, the lowest reaches of the Coliban River contracted to a series of isolated pools in March 2019.

Accumulated passing flows were used to deliver a summer/autumn fresh of 50 ML per day for three days from Malmsbury Reservoir in early March 2019, to support fish and platypus movement, maintain aquatic and fringing vegetation, improve water quality and waterbug habitat and flush organic material and sediment from in-stream substrates. The timing of this fresh was amended to align with a Dja Dja Wurrung field trip for a series of Aboriginal waterways assessments. Dja Dja Wurrung representatives were able to witness the progress of the fresh through the system and observe the transition from a series of disconnected pools into a flowing river.

Scope of environmental watering

Table 5.6.3 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.6.3 Potential environmental watering actions and objectives for the Coliban system

Potential environmental watering action	Functional watering objective	Environmental objective
Pulsed summer/autumn low flow (5–15 ML/day for up to two weeks during December to May as required)	• Maintain water quality including dissolved oxygen levels • Maintain refuge habitat for aquatic animals including fish and platypus	
Summer/autumn low flow (1–10 ML/day during December to May)	• Maintain aquatic habitat that can support waterbugs, native fish, platypus and aquatic and fringing vegetation • Maintain water quality including dissolved oxygen levels	
Summer/autumn freshes (two freshes of up to 160 ML/day for up to three days during December to May)[1]	• Maintain the water depth through riffle-run habitats of 5–20 cm for a 25–50 ML/day event to maintain water quality and habitat for waterbugs • Maintain the water depth through riffle-run habitats of 45–55 cm for a 160 ML/day event to: • increase the water depth to facilitate fish and platypus movement • clean river substrates • inundate the low benches to support the fringing vegetation • clear sediment and biofilms from hard substrates in the bottom of the channel	

[1] *Summer freshes should be delivered once the 2020–21 critical water reserves have been provided.*

Scenario planning

Table 5.6.4 outlines the potential environmental watering and expected water use under a range of planning scenarios. Watering actions have only been considered for drought to average scenarios, because under a wet scenario the storages are likely to spill and therefore it will not be possible to accumulate passing flows. There is insufficient water available to meet all the requirements for water for the environment of the Coliban system, and managers must prioritise actions annually.

Under drought conditions, the priority will be to provide pulsed or continuous low flows for as long as possible in summer and autumn, to maintain aquatic habitat and water quality for as much of the reach downstream of Malmsbury Reservoir as possible. Under dry and average conditions, it should be possible to provide low flows for longer periods. Water is not likely to be available to provide summer/autumn freshes, except under average conditions or when a sufficient volume has been carried over and has not been lost to spill. The target flows and duration of freshes to mitigate a potentially catastrophic water quality incident will vary depending on water availability, the severity of the conditions and the incident, and the amount of flow and water in the river at the time.

The tier 1a watering actions will not prevent cease-to-flow events in the lower sections of the Coliban River during a hot and dry summer. Such conditions represent a risk to native plant, fish and platypus populations. Any additional water that becomes available under a drought scenario should be carried over to help deliver critical low flows in summer/autumn 2020–21, but under other scenarios it may be used to increase the magnitude of low flows or provide additional freshes in summer/autumn 2019–20.

Table 5.6.4 Potential environmental watering for the Coliban River under a range of planning scenarios

Planning scenario	Drought	Dry	Average
Expected river conditions	• Little or no unregulated flows	• Some unregulated flows from tributary inflows	• Some unregulated river flows from tributary inflows
Expected availability of water for the environment	• Minimal passing flows and low volume to withhold for use at other times in the season	• Slightly increased passing flows	• Moderate-to-high passing flows but reduced ability to reserve flows due to possible storage spills • Withheld flows for use at other times in the season
Potential environmental watering – tier 1a (high priorities – expected to be delivered in 2019–20)	• Pulsed or continuous summer/autumn low flows	• Summer/autumn low flows • Summer/autumn freshes	
Potential environmental watering – tier 1b (reliant on additional water becoming available in 2019–20)	• Set aside reserve for critical needs in 2020–21	• N/A	
Potential environmental watering – tier 2 (additional priorities)[1]	• Increased magnitude of summer/autumn low flows • Provide summer/autumn freshes	• Increased magnitude of summer/autumn low flows • Provide additional summer/autumn freshes	• Increased magnitude of summer/autumn low flows • Increased magnitude of summer freshes
Possible volume of water for the environment required to achieve objectives[2]	• 1,200 ML (tier 1a) • 720 ML (tier 1b) • Tier 2 – dependent on water resources and river conditions	• 1,600 ML (tier 1a) • Tier 2 – dependent on water resources and river conditions	• 2,200 ML (tier 1a) • Tier 2 – dependent on water resources and river conditions
Priority carryover requirements	• Reserve passing flows for 2020–21		

1 *Only a priority after 2019–20 critical carryover requirements have been set aside.*

2 *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

5.7 Loddon system

Waterway manager – North Central Catchment Management Authority

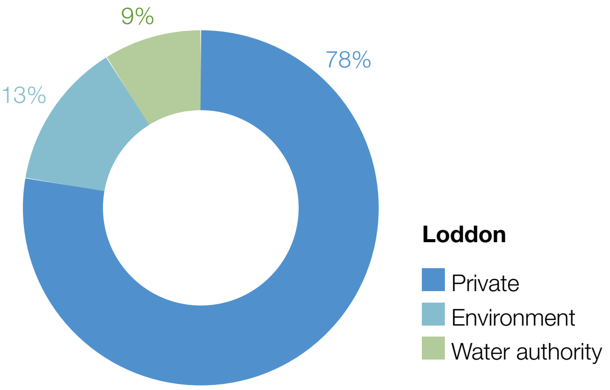
Storage manager – Goulburn-Murray Water

Environmental water holders – Victorian Environmental Water Holder, Commonwealth Environmental Water Holder

Did you know ...?

Dja Dja Wurrung people know the Loddon River as *Bulutjang*.

Environmental flows can provide a cue for native fish to move within a system. When environmental flows were released in the Loddon River and Pyramid Creek in 2017, 40 percent of tracked fish moved at least 40 kilometres upstream, and one even travelled 140 kilometres!



Proportion of water entitlements in the Loddon basin held by private users, water corporations or environmental water holders.

Top: Loddon River, by North Central CMA
Centre: Rakali at Longs Rd, Loddon River, by North Central CMA
Above: Golden perch release, Pyramid Creek, by Arthur Rylah Institute

5.7.1 Loddon River system (including Tullaroop, Serpentine and Pyramid creeks)

System overview

The Loddon River flows from the Great Dividing Range in the south to the River Murray in the north. Tullaroop Creek is the main tributary in the upper Loddon River system. The middle section of the Loddon River is characterised by many distributary streams and anabranches that carry water away from the river onto the floodplain. The lower Loddon River is joined by Pyramid Creek at Kerang, at which point the Loddon becomes part of the River Murray floodplain.

Three main storages are located on the Loddon River: Cairn Curran, Tullaroop and Laanecoorie reservoirs. Downstream of Laanecoorie Reservoir, river flows are regulated by the operation of the Bridgewater, Serpentine, Loddon and Kerang weirs.

Water for the environment can be delivered to the Loddon River from Cairn Curran or Tullaroop reservoirs or from the Goulburn system via the Waranga Western Channel, which intersects with the Loddon River at Loddon Weir. Water is provided to Pyramid Creek through releases from Kow Swamp, which receives water diverted from the River Murray at Torrumbarry Weir. Water is diverted from the Loddon River to Serpentine Creek and to the Loddon Valley Irrigation Area to supply agriculture.

The highly regulated nature of the Loddon system provides both challenges and opportunities for effective management of water for the environment. The ability to manipulate the timing of releases at multiple locations provides opportunities to accomplish environmental outcomes at discrete locations. However, coordinating environmental flows and consumptive flows is difficult through the irrigation season, especially when irrigation demand is high. This can lead to constraints in the timing and delivery of water for the environment or higher-than-recommended flows upstream of Loddon Weir. The structures used for managing irrigation water form barriers in the waterway, restricting continuity and the ability to achieve outcomes for native fish and possibly platypus.

Environmental values

The Loddon River system supports platypus, rakali (water rats) and several species of native fish. Streamside vegetation varies in condition depending on the recent water regime, the extent of clearing and historic and current land management practices. Those areas remaining relatively intact support a variety of woodland birds and other native animals. Important plant species across the system include cane grass, tangled lignum, black box and river red gum.

Although fish populations in the Loddon system are affected by the many barriers caused by weirs and reservoirs, a large range of species are still found through the catchment. Native fish are most abundant and diverse in the upper catchment. River blackfish are found in Serpentine Creek and rare Murray-Darling rainbow fish are found in the middle and lower sections of the Loddon River.

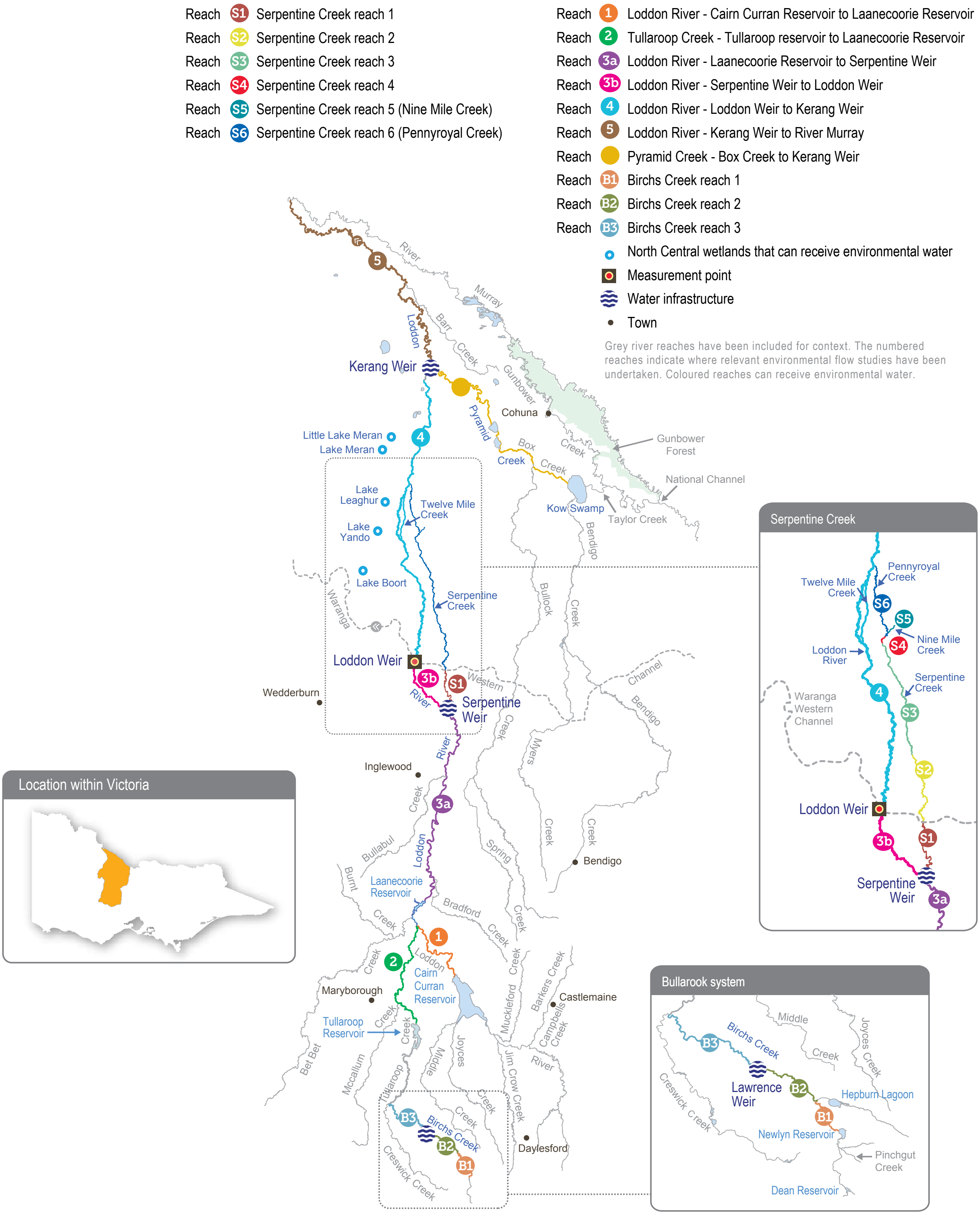
The highest-priority reach for environmental watering is from Loddon Weir to Kerang Weir. The reach does not carry irrigation water, and it relies heavily on environmental flows to maintain its environmental condition. Environmental flows to this reach aim to improve the condition of riparian vegetation, maintain water quality and increase the abundance and diversity of native fish. Environmental flows are delivered to the upper Loddon River, Tullaroop Creek and Serpentine Creek to maintain or increase populations of river blackfish and platypus.

Pyramid Creek and the lower Loddon River support large-bodied fish (such as golden perch, Murray cod and silver perch) and are important corridors for fish migration between the Loddon and Murray systems. Engineering works to provide fish passage at the Chute, Box Creek regulator, Kerang Weir, Fish Point Weir and Little Murray Weir on the Little Murray River in recent years have been important in reopening these migration routes. The Arthur Rylah Institute has monitored fish movement and populations in Pyramid Creek and the lower Loddon River since 2017, and results have indicated that the combined Loddon-Pyramid flow is stimulating native fish movement through the fishways.

Environmental objectives in the Loddon River system

Increase populations of small and large-bodied native fish and opportunities for movement between habitats
Maintain and enhance the channel form and features including deep pools and benches Maintain the condition of suitable substrate, to maintain ecosystem processes Engage floodrunners, distributary channels, anabranches and backwaters
Increase the population and recruitment of resident platypus Maintain the rakali (water rat) population
Maintain the riparian and floodplain vegetation and facilitate the recruitment of woody and non-woody vegetation Maintain and increase the extent of in-stream vegetation Limit the encroachment of fringing vegetation into the stream channel
Maintain/increase the diversity and productivity of waterbugs and waterbug functional feeding groups, to drive productive and dynamic foodwebs
Maintain water quality, to support aquatic animals and minimise the risk of blackwater events

Figure 5.7.1 The Loddon system



Recent conditions

Rainfall in the Loddon catchment was much lower than average throughout most of 2018–19, although several storms in December meant rainfall for that month was above average. Natural streamflow and inflows to storages were very low throughout 2018–19, as most rainfall was absorbed by soils and did not generate much run-off. Despite the very dry conditions, there was adequate water available to deliver all planned flows for the Loddon River, Pyramid Creek and Serpentine Creek under a dry scenario, but the presence of blue-green algae in Loddon and Kerang weirs prevented delivery of freshes to the Loddon River in autumn.

While only one summer fresh could be delivered in the Loddon River, low flows were delivered throughout the year, meeting targets in the priority reach (reach 4). A fresh of up to 400 ML per day was delivered to reach 4 in spring, and it was timed to coincide with an environmental flow in Pyramid Creek to cue native fish movement.

Water for the environment was used to deliver two summer/autumn freshes and one winter/spring fresh to Serpentine Creek in 2018–19. A minimum operational flow of 7 ML per day was provided at other times. The summer freshes helped alleviate low-dissolved-oxygen levels in reach S1 during prolonged hot weather in January 2019. Environmental flows delivered to Serpentine Creek subsequently flowed through to Nine Mile Creek, where they supported vegetation and aquatic animals.

Two environmental flows were provided to Pyramid Creek during 2018–19, to support North Central CMA's *Native Fish Recovery Plan – Gunbower and Lower Loddon*. The first was delivered in spring and involved coordinated releases through Pyramid Creek and reach 4 of the Loddon River, to attract fish from the lower Loddon and River Murray to move through Kerang Weir and the Box Creek regulator fishway at Kow Swamp. The second environmental flow to Pyramid Creek was delivered at the end of the irrigation season in mid-May to prevent fish becoming stranded when the irrigation system was drained. Target environmental flows in Pyramid Creek could not be achieved without the cooperation and expertise of the storage manager, Goulburn-Murray Water.

Scope of environmental watering

Table 5.7.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

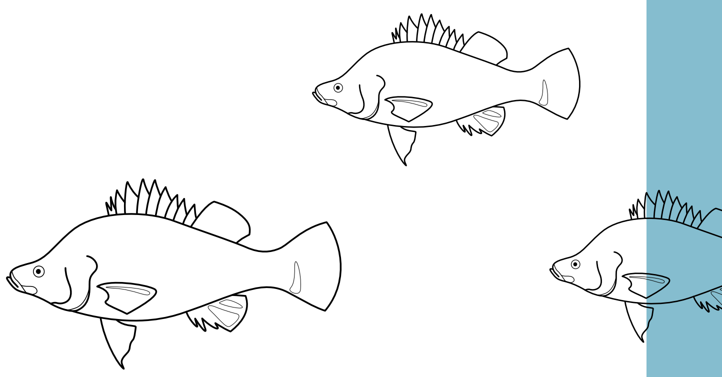


Table 5.7.1 Potential environmental watering actions and objectives for the Loddon River system

Potential environmental watering action	Functional watering objective	Environmental objective
Loddon River (reach 1)		
Summer/autumn fresh (one to four freshes of 35–80 ML/day for one to three days during December to May)	• Flush fine sediment from hard surfaces • Increase the water level, to promote the growth of fringing emergent macrophytes • Increase connectivity to promote the local movement of adult fish and encourage juvenile fish and platypus dispersal in autumn • Wet submerged wood to flush old biofilms and promote new biofilm growth	
Spring fresh (one fresh of 400–700 ML/day for four to five days during September to October)	• Redistribute fine sediment on bars and benches • Flush accumulated leaf litter, to increase productivity and reduce the risk of hypoxic blackwater event in summer • Increase the wetted area, to promote the recruitment and maintenance of riparian vegetation on the banks and benches • Stimulate the movement of Murray cod, to encourage breeding	
Tullaroop Creek (reach 2)		
Summer/autumn fresh (one to four freshes of 30–40 ML/day for one to three days during December to May)	• Flush fine sediment from hard surfaces • Increase the water level, to promote the growth of fringing emergent macrophytes • Increase connectivity, to promote the local movement of adult fish and encourage juvenile fish and platypus dispersal in autumn • Wet submerged wood to flush old biofilms and promote new biofilm growth	
Spring fresh (one fresh of 200–400 ML/day for one to five days during September to October)	• Redistribute fine sediment on bars and benches • Flush accumulated leaf litter, to increase productivity and reduce the risk of hypoxic blackwater event in summer • Increase the wetted area, to promote the recruitment and maintenance of riparian vegetation on the banks and benches • Stimulate the movement of Murray cod, to encourage breeding	
Loddon River (reach 4)		
Summer/autumn fresh (one to three freshes of 50–100 ML/day for three to four days during December to May)	• Flush fine sediment from hard surfaces • Increase the water level, to promote the growth of fringing emergent macrophytes • Increase connectivity, to promote the local movement of fish and platypus including juvenile dispersal in autumn	
Winter/spring high flow (one high flow of 450–750 ML/day for six to 10 days during August to November)[1]	• Provide flow through flood runners • Scour accumulated sediment from pools • Flush accumulated organic matter from the bank and benches, to increase productivity and reduce the risk of hypoxic blackwater event in summer • Increase the wetted area, to promote the recruitment and growth of riparian and emergent vegetation • Stimulate native fish movement and breeding	

Table 5.7.1 Potential environmental watering actions and objectives for the Loddon River system *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Summer/autumn low flow (25–50 ML/day during December to May)	• Maintain an adequate depth in pools for aquatic plants and to provide habitat for waterbugs, fish and rakali (water rats) • Provide continuous flow through the reach, to maintain water quality • Maintain connecting flows to support in-stream and fringing non-woody vegetation	
Winter/spring low flow (50–100 ML/day during June to November)	• Increase the water depth for fish, platypus and rakali (water rats) dispersal and to provide foraging habitat • Prevent silt and fine sediment settling on submerged wood and other hard surfaces • Prevent the growth of terrestrial plants in the river channel	
Autumn high flow (up to one high flow of 400 ML/day for 6–10 days during March to May)	• Trigger and facilitate the upstream movement of golden perch, silver perch and Murray cod older than one year	
Serpentine Creek (reach S1)[2]		
Winter/spring fresh (one fresh of 40–150 ML/day for two days during August to November)	• Maintain the channel form and scour pools • Provide connectivity for fish and waterbugs to access different habitat areas • Transport organic matter that has accumulated in the channel • Provide a cue for adult platypus to construct burrows above the higher water level	
Summer/autumn fresh (one to three freshes of 30–40 ML/day for one to three days during December to May)	• Maintain the channel form by engaging benches • Flush fine sediment and scour biofilms, to replenish the food supply • Transport organic matter that has accumulated in the channel • Provide flow variability to maintain the diversity of fringing vegetation • Provide a sufficient depth of water and variability of flow to maintain microbial biofilms	
Summer/autumn low flow (10–20 ML/day during December to May)	• Prevent notching of riverbanks by providing flow variability • Provide connectivity between pools to allow the dispersal of small-to-medium-bodied native fish • Wet exposed roots, leaf packs and woody debris, to provide habitat for aquatic animals • Provide sufficient flow to maintain water quality by re-oxygenating pools and preventing stagnation • Maintain foraging habitat for platypus • Maintain the wetted area to support in-stream aquatic vegetation (e.g. water ribbons, eel weed and milfoil)	

Table 5.7.1 Potential environmental watering actions and objectives for the Loddon River system *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Winter/spring low flow (20–30 ML/day during June to November)	• Maintain spawning habitat for native fish • Wet exposed roots, woody debris, emergent vegetation and leaf packs, to provide habitat for aquatic animals • Maintain water quality by preventing stagnation • Provide flow variability, to maintain diversity of fringing vegetation • Provide a sufficient depth of water and variability of flow to maintain microbial biofilms	
Pyramid Creek and Loddon River (reach 5)		
Spring high flow (one high flow of 700–900 ML/day for 10 days during September to October)	• Trigger the migration, spawning and recruitment of native fish species including Murray cod • Maintain connectivity between habitats and improve water quality	
Autumn/winter low flow (90–200 ML/day during May to August)	• Maintain connectivity between pools and provide habitat for fish and waterbugs outside of the irrigation season • Improve water quality by reducing salinity levels • Enhance the wetted area to maintain and promote the growth of fringing emergent (non-woody) vegetation along the lower banks of the channel • Redistribute fine sediment on benches and bars	
Autumn high flow (up to one high flow of 700–900 ML/day for 10 days during March to May)	• Trigger the migration, spawning and recruitment of native fish species including Murray cod • Facilitate the upstream movement of golden perch, silver perch and Murray cod older than one year • Maintain connectivity between habitats and improve water quality • Facilitate platypus dispersal	

1 *Due to potential inundation of private land, environmental flows above 450 ML per day in reach 4 will not be provided without the agreement of potentially affected landholders.*

2 *Flows in Serpentine Creek will be allowed to either return to the Loddon River via the channel system or continue down Pennyroyal Creek, Bannacher Creek and Nine Mile Creek with the agreement of landholders.*

Scenario planning

Table 5.7.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The highest-priority reach for environmental flows in the Loddon system is the Loddon River between Loddon Weir and Kerang Weir (i.e. reach 4). Reach 4 is a high priority because it receives little to no consumptive water and therefore completely relies on passing flows, unregulated spills from storage and environmental flows. There are also many system constraints that limit the ability to deliver flows when a lot of water is available. Pyramid Creek is also a priority reach, because it provides a corridor for large-bodied native fish to move between critical habitat in the River Murray, Kow Swamp and Gunbower Creek.

Under drought and dry conditions, the highest-priority watering actions in both reaches will aim to maintain the quality and quantity of aquatic habitat for native fish. In reach 4, this will involve supplementing passing flows, particularly under a drought scenario. Passing flows for reach 4 are reduced when the combined storage volumes in Cairn Curran and Tullaroop reservoirs are less than 60,000 ML according to rules in the VEWH's Loddon River bulk entitlement. This is likely to occur in the first half of the year under a drought scenario, and in that case water for the environment will help meet minimum environmental low-flow requirements. Occasional freshes in summer and autumn are also planned under all scenarios, to flush pools and prevent adverse water quality.

Pyramid Creek carries a large volume of consumptive water during the irrigation season, but flows can drop significantly outside the irrigation season. Under all scenarios, water for the environment will be used in Pyramid Creek to supplement flows in autumn and winter, so flows of at least 200 ML per day will be maintained to ensure there is sufficient habitat for fish and other aquatic animals outside the irrigation season.

Under average and wet conditions, water for the environment will be used to provide high flows in the Loddon River in spring and possibly autumn, to cue the movements, spawning and recruitment of large-bodied native fish (such as Murray cod, golden perch and silver perch). These flows will coincide with similar releases in Pyramid Creek, which help to achieve the required flow magnitude at Kerang Weir needed to encourage fish to move upstream into the system from the River Murray, and to allow some fish to access habitats in reach 4.

The Loddon River upstream of Serpentine Weir and Serpentine Creek carry operational low flows for most of the year. Water for the environment will be mainly used in these reaches to provide occasional freshes to maintain water quality and support riparian vegetation.

Up to 5,100 ML is prioritised for carryover into 2020–21. This water is needed for summer/autumn freshes and for a spring high flow if conditions remain dry in 2019–20.

While there is expected to be enough water available to meet the tier 1a potential watering actions under all scenarios, deliveries of water for the environment in the Loddon system can also be constrained by the physical capacity of the infrastructure and capacity-share rules. For example, water for the environment can only be delivered through the Waranga Western Channel when there is spare capacity after irrigation demands have been met. The VEWH and North Central CMA work with Goulburn-Murray Water to optimise environmental outcomes within system constraints. These cooperative arrangements include adjusting the timing of deliveries of water for the environment to avoid capacity constraints and modifying the rate and timing of irrigation deliveries and transfers, to support environmental outcomes.

Table 5.7.2 Potential environmental watering for the Loddon River system under a range of planning scenarios

<table>
<tr><th>Planning scenario</th><th>Drought</th><th>Dry</th><th>Average</th><th>Wet</th></tr>
<tr><td>Expected river conditions</td><td>• Negligible contributions from unregulated reaches and tributaries of the Loddon River, consumptive water deliveries in the irrigation season
• Reduced passing flows in autumn and winter likely</td><td>• Small contributions from unregulated reaches and tributaries of the Loddon River contributing to low flows, consumptive water deliveries in the irrigation season</td><td>• Unregulated flows will provide low flows and multiple freshes, most likely in winter and spring
• Consumptive water deliveries in the irrigation season
• No spill likely</td><td>• Spills from Loddon system storages will provide extended-duration high flows and overbank flows most likely in late winter to spring</td></tr>
<tr><td>Expected availability of water for the environment</td><td>• Up to 13,800 ML</td><td>• Up to 16,200 ML</td><td>• Up to 21,100 ML</td><td>• Up to 21,100 ML</td></tr>
<tr><td colspan="5">Loddon River (reach 1) and Tullaroop Creek</td></tr>
<tr><td>Potential environmental watering – tier 1a (high priorities)</td><td colspan="4">• One to four summer/autumn freshes
• One spring fresh</td></tr>
<tr><td colspan="5">Loddon River (reach 4)</td></tr>
<tr><td>Potential environmental watering – tier 1a (high priorities)</td><td colspan="2">• One to three summer/autumn freshes
• Summer/autumn low flows
• Winter/spring low flows</td><td>• Three summer/autumn freshes
• One winter/spring high flow
• Summer/autumn low flows
• Winter/spring low flows</td><td>• Three summer/autumn freshes
• One winter/spring high flow
• Summer/autumn low flows
• Winter/spring low flows
• One autumn high flow</td></tr>
<tr><td>Potential environmental watering – tier 1b (high priorities with shortfall)</td><td colspan="2">• One winter/spring high flow
• Increased magnitude of summer/autumn fresh</td><td>• One autumn high flow
• Summer low flow magnitude delivered at upper range</td><td>• N/A</td></tr>
<tr><td>Potential environmental watering – tier 2 (additional priorities)</td><td>• Low flow magnitudes delivered at upper ranges</td><td>• Winter low flow magnitude delivered at upper range
• One autumn high flow</td><td>• N/A</td><td>• N/A</td></tr>
<tr><td colspan="5">Serpentine Creek (reach S1)</td></tr>
<tr><td>Potential environmental watering – tier 1a (high priorities)</td><td colspan="4">• One winter/spring fresh
• One to three summer/autumn freshes
• Summer/autumn low flows
• Winter/spring low flows</td></tr>
</table>

Table 5.7.2 Potential environmental watering for the Loddon River system under a range of planning scenarios *continued...*

Planning scenario	Drought	Dry	Average	Wet
Potential environmental watering – tier 1b (high priorities with shortfall)	• Increased magnitude of winter/spring fresh		• Low flow magnitudes delivered at upper ranges	• N/A
Potential environmental watering – tier 2 (additional priorities)	• Low flow magnitudes delivered at upper ranges		• N/A	
Pyramid Creek and Loddon River (reach 5)				
Potential environmental watering – tier 1a (high priorities)	• Autumn/winter low flows		• One spring high flow • Autumn/winter low flows	
Potential environmental watering – tier 1b (high priorities with shortfall)	• One spring high flow		• Autumn high flow	
Possible volume of water for the environment required to achieve objectives[1]				
Loddon River (reach 1 and reach 4), Tullaroop Creek and Serpentine Creek	• 8,800 ML (tier 1a) • 3,800 ML (tier 1b) • 7,700 (tier 2)	• 6,000[2] ML (tier 1a) • 6,500 ML (tier 1b) • 7,300 (tier 2)	• 12,500 ML (tier 1a) • 7,300 ML (tier 1b) • 6,900 (tier 2)	• 9,000 ML (tier 1a)
Pyramid Creek and Loddon River (reach 5)	• 2,000 ML (tier 1a)[3] • 1,000 ML (tier 1b)		• 3,000 ML (tier 1a) • 1,000 ML (tier 1b)	
Priority carryover requirements	• 4,500–5,100 ML			

1 *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

2 *Environmental watering demands under a dry scenario are lower than under a drought scenario because it is expected that combined storage levels of Tullaroop and Cairn Curran reservoirs will remain above 60 GL, meaning passing flows will not be reduced and less water for the environment will be required for supplementing passing flows.*

3 *Represents the estimated volume of water required to underwrite losses associated with the delivery of consumptive water en route through Pyramid Creek.*

5.7.2 Boort wetlands

System overview

The Boort wetlands are on the floodplain west of the Loddon River, downstream of Loddon Weir. They consist of temporary and permanent freshwater lakes and swamps: Lake Boort, Lake Leaghur, Lake Yando, Little Lake Meran and Lake Meran. Together, the Boort wetlands cover over 800 ha. There are several other wetlands in the district, but they are currently not managed with water for the environment.

The natural watering regimes of wetlands throughout the broader Loddon system have been substantially modified by the construction of levees and channels across the floodplain and by the construction and operation of reservoirs and weirs along the Loddon River. Water is delivered to the Boort wetlands through Loddon Valley Irrigation Area infrastructure.

The availability of water for the environment for the Boort wetlands is closely linked to water available for the Loddon River system. The ability to deliver water for the environment to the wetlands is sometimes limited by channel-capacity constraints. The VEWH and North Central CMA work with the storage manager (Goulburn-Murray Water) to best meet environmental objectives within capacity constraints.

Environmental values

The Boort wetlands provide habitat for a range of plant and animal species. At Lake Yando, 12 rare plant species have been recorded including the jerry-jerry and water nymph. Bird species recorded at Lake Boort, Lake Leaghur and Lake Meran include the white-bellied sea eagle, Latham's snipe and eastern great egret. Little Lake Meran is a swampy woodland with black box trees on the highest wet margins and river red gums fringing the waterline.

Environmental watering objectives in the Boort wetlands

	Increase the population of large and small-bodied fish species
	Increase the diversity and population of native frogs including by enhancing breeding opportunities
	Maintain the population of freshwater turtles, in particular Murray River turtles
	Rehabilitate and increase the extent of emergent and aquatic vegetation (aquatic herblands, tall marsh), intermittent swampy woodland and riverine chenopod woodland Maintain the health and restore the distribution of river red gums and associated floristic community across the wetland bed Maintain the extent and restore the health of black box vegetation
	Support a high diversity of wetland birds by enhancing feeding and breeding conditions

Recent conditions

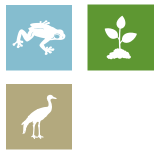
Rainfall throughout the Loddon catchment and the Boort wetlands was drier than average throughout 2018–19, but summer storms resulted in above-average rainfall in December. The Boort wetlands received no natural inflows, and the very hot and dry conditions over summer and autumn accelerated drying in the wetlands that held water from previous years.

Lakes Boort, Leaghur, Yando and Meran were all naturally flooded in spring 2016 and water levels are continuing to recede, allowing wetland plants an opportunity to establish. Little Lake Meran was the only lake in the Boort wetlands system to receive water for the environment in 2018–19. Little Lake Meran is normally disconnected from the Loddon floodplain, except during exceptionally high floods (such as in 2011). After flooding in 2011, river red gums germinated around the edges of the lake. Water for the environment was delivered to Little Lake Meran in May 2018, and follow-up watering was delivered in August and September, to promote the growth of naturally recruited river red gums and fringing vegetation.

Scope of environmental watering

Table 5.7.3 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.7.3 Potential environmental watering actions and objectives for the Boort wetlands

Potential environmental watering action	Functional watering objective	Environmental objective
Loddon River (reach 1)		
Lake Meran (top-up in spring to maintain critical water level)	• Increase the water depth to maintain an appropriate water temperature for aquatic animals and provide a refuge for freshwater turtles, waterbirds and fish, helping to support recruitment • Promote the growth and increase the extent of lake bed herbland vegetation by wetting the wetland fringe	
Lake Yando (fill in spring, with top-ups as required to support waterbird breeding) Lake Yando (partial fill in autumn, if fill in spring is not possible)[1]	• Provide moisture to promote the germination and recruitment of river red gums and maintain the existing mature trees • Support the growth of aquatic and semi-aquatic plant species, providing habitat for aquatic animals	
Lake Leaghur (partial fill in autumn)	• Prime the wetland for spring watering in 2020–21 by stimulating the early germination of wetland vegetation, attracting waterbirds to feed and breed in early spring/summer 2020 as the weather warms up • Promote winter feeding conditions for waterbirds and frogs • Reduce the volume of water required to fill the wetland in spring 2020–21	
Wetland drying		
Little Lake Meran and Lake Boort (promote natural drawdown/drying)	• These wetlands will be in a drying phase in 2019–20 • Promote the establishment and growth of fringing vegetation and herbland species	

[1] *A partial fill in autumn will be triggered if a fill in spring is not possible due to supply shortfall or delivery constraints.*

Scenario planning

Table 5.7.4 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Supplying a top-up to Lake Meran is prioritised under all scenarios. This is to ensure the wetland remains at a level between 77.3 and 77.8 m AHD. The wetland needs to be permanently maintained within this range to prevent the irreversible loss of significant species, in particular Murray River turtles. Lake Yando has been dry for about 20 months and filling it in 2019–20 is a priority under dry-wet scenarios, to support vegetation outcomes. A partial fill of Lake Leaghur is recommended in autumn under average to wet scenarios, to prime the wetland for a complete fill in spring of the following water year.

All other wetlands will be allowed to draw down to a minimum level or to dry completely. This will provide an important dry period, to promote the growth of herbland plants and fringing vegetation.

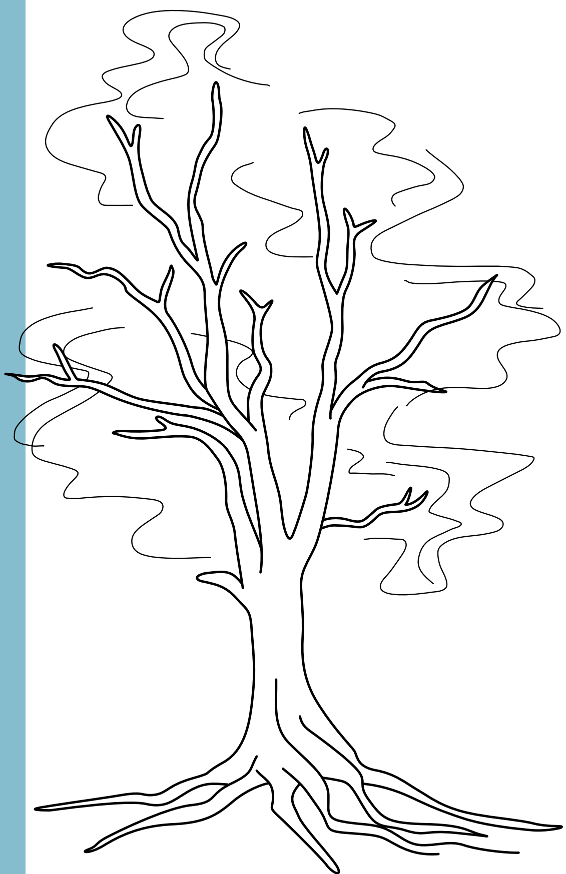
Most wetlands are expected to fill naturally from large overland floods under a wet scenario.

Table 5.7.4 Potential environmental watering for the Boort wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No natural inflows to wetlands	• Minimal natural inflows to wetlands	• Periods of high flows combined with localised catchment contributions, which are expected to provide minor inflows to wetlands	• Extended durations of high flows and overbank flows from creeks and flood runners, which fill most wetlands
Potential environmental watering – tier 1 (high priorities)[1]	• Lake Meran	• Lake Meran • Lake Yando	• Lake Meran • Lake Yando • Lake Leaghur	• Lake Meran • Lake Yando • Lake Leaghur
Potential environmental watering – tier 2 (additional priorities)	• Lake Yando • Lake Leaghur	• Lake Leaghur	• N/A	• N/A
Possible volume of water for the environment required to achieve objectives[2]	• 2,000 ML (tier 1a) • 2,200 ML (tier 2)	• 3,200 ML (tier 1a) • 1,000 ML (tier 2)	• 4,200 ML (tier 1a)	• 4,200 ML (tier 1a)

1 *It is not possible to distinguish between tier 1a and 1b demands for the Boort Wetlands as there is no individual entitlement (and therefore no expected supply volume) for them. Rather the water is shared and prioritised across several systems. Wetlands are listed in priority order for tier 1 and tier 2 under all climate scenarios.*

2 *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*



5.7.3 Birch Creek

System overview

Birch Creek is a tributary of the Loddon River located in the southernmost part of the catchment. The creek rises in the ranges north-east of Ballarat and flows north-west through Newlyn and Smeaton before joining Tullaroop Creek near Clunes. The lower parts of the catchment are extensively cleared where the creek meanders through an incised basaltic valley. The creek contains a regionally significant platypus community and a vulnerable river blackfish population.

Birch Creek is part of the broader Bullarook system which contains two small storages — Newlyn Reservoir and Hepburn Lagoon — which provide water for irrigation and urban supply. The storages fill and spill during winter or spring in years with average or above-average rainfall.

Birch Creek receives tributary inflows from Rocky Lead, Langdons, Lawrence and Tourello creeks. In the downstream reaches, Birch Creek is highly connected to groundwater, which provides baseflows to the creek in most years.

The VEWH is allocated 100 ML in Newlyn Reservoir on 1 December each year, provided that seasonal determinations in the Bullarook system are at least 20 percent. Any unused allocation from 1 December can be carried over until 30 November of the following water year, but if Newlyn Reservoir spills from 1 July to 30 November, the volume held in carryover is lost. Any water remaining on 30 November is forfeited. When seasonal determinations are below 20 percent, the VEWH does not receive an allocation, and the system's resources are shared equitably to protect critical human and environmental needs.

Environmental values

Birch Creek supports threatened aquatic plants and its deep pools provide habitat for aquatic animals during dry periods. The creek contains native fish including regionally significant populations of river blackfish and mountain galaxias as well as flat-headed gudgeon and Australian smelt. Recent monitoring indicates that platypus are present throughout the entire creek.

The removal of willows along the creek in 2018 has led to observed improvements in in-stream vegetation and presence of small-bodied fish.

Environmental objectives in Birch Creek

Increase the population and diversity of small-to-medium-bodied native fish including river blackfish, mountain galaxias, flat-headed gudgeon and Australian smelt, and provide opportunities for movement between pool habitats
Maintain the breeding population of platypus and provide opportunities for its dispersal to Creswick Creek and Tullaroop Creek
Maintain and improve the diversity and abundance of in-stream aquatics Maintain a diverse variety of fringing and riparian native vegetation communities
Increase the population of waterbugs and the diversity of functional groups
Maintain water quality to support aquatic life and ecological processes

Recent conditions

The Birch Creek catchment had below-average rainfall in winter and spring 2018–19, with October being well-below average. Despite the dry winter and spring, flows in the creek were maintained from groundwater baseflow, consumptive water and small releases from Hepburn Lagoon. Summer and autumn were warmer and drier than average, and flows in Birch Creek throughout these seasons were low, but sufficient to maintain aquatic habitat and water quality.

Newlyn Reservoir did not spill in 2018–19, but tributary inflows and groundwater discharge contributed to meeting environmental flow objectives in Birch Creek throughout the year; and no environmental flows were delivered in 2018–19.

The system allocation was above 20 percent on 1 December 2018, meaning the 2018 allocation of water for the environment became available. The 2018 reserve will be available for use until 30 November 2019.

Significant willow removal occurred along Birch Creek in 2018, particularly in the Smeaton area. This may have increased flow rates, but this has not been confirmed. Processes such as scouring and sediment transport are more evident since the removal of the trees, and observations indicate the recolonisation of in-stream vegetation and small-bodied fish.

Scope of environmental watering

Table 5.7.5 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.7.5 Potential environmental watering actions and objectives for Birch Creek

Potential environmental watering action	Functional watering objective	Environmental objective
Spring fresh (one fresh of 30 ML/day for three days during September to November)	• Maintain and support the growth of streamside vegetation by providing moisture and sediment to the bank and benches • Scour organic matter that has accumulated in the channel and cycle nutrients throughout the creek • Wet benches and smaller channels, to provide increased habitat and refuge for small fish • Freshen refuge pools and provide connectivity between pools for fish and platypus movement	
Summer/autumn freshes (up to three freshes of 10 ML/day for three days during March to April)	• Increase the water depth, to maintain and support the growth of in-stream aquatic vegetation • Expand riffle/run areas to provide waterbug habitat • Top up pools to refresh water quality (particularly dissolved oxygen) and enhance connectivity between pools for fish and platypus movement	

Scenario planning

In drought or dry scenarios, seasonal determinations in the Bullarook system (which supports allocations for Birch Creek) will likely be less than 20 percent on 1 December 2019. Under these scenarios, the VEWH will not receive an allocation.

The water that was allocated to the VEWH on 1 December 2018 will be retained until 30 November 2019 in accordance with entitlement rules. In this case, delivery of a spring fresh using carryover is a priority, to bolster the condition of the creek in the lead-up to summer. Entitlement rules do not allow the carryover volume to be held beyond 30 November, so they cannot be used for higher-priority flows in summer and autumn. If the seasonal determination is less than 20 percent on 1 December 2019, the VEWH will be entitled to an equitable share of the available water resources in the Bullarook system, which will be managed to consider both critical human and environmental needs.

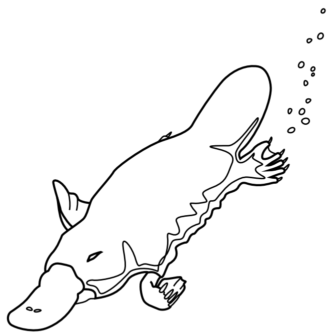
Under an average-to-wet scenario, high rainfall will provide flows to Birch Creek throughout winter and spring, recharging groundwater aquifers. Any water allocated to the VEWH on 1 December 2019 may be used to provide a summer/autumn fresh during March or April 2020. However, it is more likely that there will be sufficient flows in Birch Creek provided by groundwater discharge, and the unused water for the environment will probably be carried over for use in the following water year.

Table 5.7.6 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Table 5.7.6 Potential environmental watering for Birch Creek under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Reservoir spill unlikely • Flows extremely low in winter/spring • Limited irrigation releases due to low allocations	• Reservoir spill possible • Low flows in winter/spring if no spills occur • Moderate irrigation releases	• Reservoir spills certain in winter/spring • Some unregulated flows through summer/autumn	
Expected availability of water for the environment	• 100 ML (carryover)	• 100–200 ML (carryover and allocation)	• 100 ML (allocation)[1]	
Potential environmental watering – tier 1a (high priorities)	• One spring fresh	• One spring fresh • One to three summer/autumn freshes	• One to three summer/autumn freshes	
Possible volume of water for the environment required to achieve objectives	• 100 ML (tier 1a)	• 100–200 ML (tier 1a)	• 100 ML (tier 1a)	
Priority carryover requirements	• If the 100 ML allocation is received on 1 December 2019 and Birch Creek is in good condition over summer/autumn, carry over 100 ML allocation into 2020–21 water year, for use by 30 November 2020			

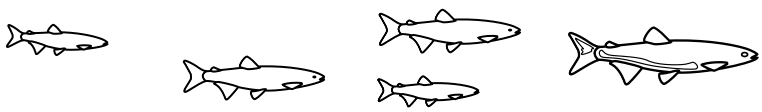
1 *Under an average-wet scenario, it is likely that Newlyn Reservoir will spill before 30 November 2019, losing the 100 ML carryover from December 2018.*



Moorabool River at Fyansford, by Saul Vermeeren

SECTION 6

Further information



6.1 Acronyms and abbreviations

AHD – Australian Height Datum (also see Glossary entry)

BGLC – Barengi Gadjin Land Council Aboriginal Corporation

BLCAC – Bunurong Land Council Aboriginal Corporation

CEWH – Commonwealth Environmental Water Holder

CMA – Catchment management authority

DELWP – Department of Environment, Land, Water and Planning

EVC – Ecological Vegetation Class

FSL – Full supply level

GLaWAC – Gunaikurnai Land and Waters Aboriginal Corporation

GWMWater – Grampians Wimmera Mallee Water

IVT – Inter-valley transfer

MDBA – Murray-Darling Basin Authority

MDWWG – Murray Darling Wetlands Working Group

ML – Megalitre (also see glossary entry)

NVIRP – Northern Victoria Irrigation Renewal Project

NVRM – Northern Victoria Resource Manager

RMIF — River Murray Increased Flows

SAC – Snowy Advisory Committee

VEFMAP – Victorian Environmental Flows Monitoring Assessment Program

VEWH – Victorian Environmental Water Holder

WetMAP – Wetland Monitoring Assessment Program

WMPP – Wimmera-Mallee Pipeline Project

6.2 Glossary

Acid sulphate soils – Naturally occurring soils containing high quantities of iron sulphates. When these soils remain underwater they are stable, but if they are exposed to air, sulphuric acid is generated and can result in severe environmental impacts.

Adaptive management – An iterative decision-making process based on continuous learning that aims to reduce uncertainty over time.

Allocation (of water) – The specific volume of water allocated to water entitlements in a given water year or allocated as specified in a water resource plan.

Australian Height Datum (AHD) – Height above sea level.

Azolla – A native aquatic fern which grows in waterways in dense patches. Its presence usually indicates high levels of nutrients.

Bank erosion – The wearing-away of the banks of a stream or river (as distinct from erosion of the bed) that can occur in extensively dry conditions.

Bank slumping – A form of mass wasting in a river or stream that occurs when a coherent mass of loosely consolidated materials or rock layers moves a short distance down a slope.

Bankfull flows – Flows of sufficient size to reach the top of the riverbank, with little flow spilling onto the floodplain.

Baseflows – A relatively stable, sustained and low flow in a river, generally being its minimum natural level.

Biodiversity – The variety or abundance of plant and animal species in a particular habitat or environment.

Biofilms – Slimy films of bacteria, other microbes and organic materials that cover underwater surfaces including rocks and snags.

Biota – The animal or plant life of a particular area, habitat or geological period.

Blackwater – A natural occurrence caused by the breakdown of plant matter causing the water to discolour. The water turns black and can have very low dissolved-oxygen levels, which can stress or kill fish and other animals that breathe underwater.

Brackish water – Water that is moderately salty but not as salty as sea water. It may result from the mixing of seawater with freshwater, as in estuaries.

Carryover – Unused water of which entitlement holders are allowed to retain ownership into the following season, according to specified rules.

Catchment management authority – A statutory authority established to manage river health and regional and catchment planning and to manage waterways, floodplains, salinity and water quality.

Cease-to-flow – The period in which there is no discernible flow in a river and partial or total drying of the river channel.

Cold water pollution – A phenomena caused by cold water being released into rivers, primarily from large dams, in warmer months.

Commonwealth Environmental Water Office – An office that manages water entitlements recovered by the Australian Government through a combination of investments in water-saving infrastructure, water purchases and other water recovery programs. The entitlements are held by the CEWH.

Confluence – The point where a tributary joins a larger river (called the main stem) or where two streams meet to become the source of a river of a new name.

Consumptive water – Water owned by water corporations or private entitlement holders held in storages and actively released to meet domestic, stock, town and irrigation needs.

Diadromous fish – Fish that migrate between freshwater and saltwater.

Drawdown – Water released from a body of water (such as a reservoir) at the end of the irrigation season for dam operation and maintenance purposes.

Ecological vegetation communities – Components of a vegetation classification system, these are groups of vegetation communities based on floristic, structural and ecological features.

En route – Water that is on its way to being delivered to urban, rural and irrigation water users.

Environmental flow study – A scientific study of the flow requirements of a particular basin's river and wetland systems used to inform decisions about the management and allocation of water resources.

Environmental objectives – Measurable target outcomes sought for each environmental value in the system, to be achieved by ongoing implementation of one or more watering actions as well as complementary actions (such as controlling invasive species or installing fishways). Target outcomes may take years or several decades to achieve.

Environmental water entitlement – An entitlement to water to achieve environmental objectives in waterways. It covers an environmental entitlement, environmental bulk entitlement, water share, section 51 licence or supply agreement.

Environmental water management plan – A plan developed by a waterway manager outlining long-term environmental objectives and based on consultation with key stakeholders, local community and advisory groups to inform the seasonal watering proposal for the particular system.

Estuary – A partially enclosed body of water along the coast where freshwater from rivers and streams meets and mixes with saltwater from the sea.

Fishway – A series of pools built like steps to enable fish to travel through a waterway, dam or waterfall.

Fledging – The care of a young bird until it can fly.

Flow components – Components of a river system's flow regime that can be described by magnitude, timing, frequency and duration (for example, cease-to-flow and overbank flows).

Freshes – Small or short-duration, peak-flow events which exceed the baseflow and last for a few days.

Functional watering objective – The physical or biological effect that a particular watering action aims to achieve.

Geomorphology – The scientific study of landforms and the processes that shape them.

Groundwater – Water held underground in the soil or in pores and crevices in rock.

Headwater – A tributary stream of a river close to or forming part of its source.

Headworks system – A system including various storage infrastructure (such as reservoirs and diversion weirs) to enable connection of multiple waterways.

Heritage rivers – Rivers listed under the Heritage Rivers Act 1992 and parts of rivers and river catchment areas in Victoria which have significant nature conservation, recreation, scenic or cultural heritage attributes.

High-reliability entitlement – A legally recognised, secure entitlement to a defined share of water. Full allocation of a high-reliability entitlement is expected in most years.

Hydrology – The study of the properties of the water and its movement in relation to land.

Inter-valley transfers – The transfer of water between river systems to meet demands as a result of water trade between river systems.

Irrigation releases – The release of water for irrigation purposes.

Juvenile – A stage of life at which an animal or plant is not yet fully mature.

Land manager – An agency or authority responsible for conserving natural and cultural heritage on public land including parks and reserves (such as Parks Victoria and DELWP).

Low-reliability entitlement – A legally recognised, secure entitlement to a defined share of water. Full allocation of a low-reliability entitlement is expected only in some years.

Macroinvertebrates – Animals without a backbone and which can be seen with the naked eye including worms, snails, mites, bugs, beetles, dragonflies and freshwater crayfish. They are also referred to as waterbugs.

Macrophytes – Aquatic plants that are either emergent (growing out of the water, for example phragmites), submergent (growing under the water, for example ribbonweed) or floating (for example floating pond weed).

Managed release – A release of water for the environment which is stored in major reservoirs and used for potential watering actions to achieve environmental outcomes.

Megalitre – One million (1,000,000) litres.

Midden – A site of cultural significance where Aboriginal people left the remains of their meals and other domestic waste.

Millennium Drought – One of the worst droughts recorded since settlement, it went from about 1995 to 2012.

Operational releases – Releases made from major storages to enable the water distribution system to operate or to make water available to consumptive water users.

Overbank flows – The portion of a flood flow that flows outside the main river channel at relatively small depths over part of or the full width of the waterway and in a direction essentially parallel with the direction of the main channel.

Passing flows – Water released from storages to operate river and distribution systems (often to help deliver water for environmental or consumptive uses) and maintain environmental values and other community benefits. The volume of passing flows is generally determined by inflows to those storages.

Permanent trade – The transfer of ownership of a water share or licence.

Potential environmental watering – Environmental flow components that have been identified for a particular system in a particular year.

Pulse – A gradual build in the flow of water, typically to replicate the most-suitable conditions for water species (such as fish to travel and spawn).

Ramsar-listed wetland – A wetland listed as internationally significant under the Convention on Wetlands signed in Ramsar, Iran in 1971.

Reach – A stretch or section of a river, generally defined in an environmental flow study.

Recruitment – The increase in plants or animals when they survive to the settlement or maturity stage.

Regional waterway strategy – An eight-year action plan prepared by a CMA for the rivers, wetlands and estuaries in its area. It provides a single regional planning document for waterways in the area.

Remnant vegetation – Patches of native trees, shrubs and grasses still remaining following disturbance.

Return flows – Any flows delivered for environmental purposes and then returned to the downstream system to be reused for other purposes. Returned flows may be captured and stored downstream for later reuse, although most commonly they remain within the waterway for in-stream reuse.

Riffle – A relatively shallow section of stream where water flows at a higher velocity with increased turbulence, causing many ripples to be formed in the water surface.

Riparian vegetation – Vegetation located in the area of land that adjoins, regularly influences or is influenced by a river.

Salt wedge – The transition zone of saltwater and freshwater environments which occurs when a freshwater river flows directly into saltwater.

Seasonal watering plan – The VEWH's annual operational document which outlines potential environmental watering across the state in the forthcoming water year.

Seasonal watering proposal – An annual proposal outlining the regional priorities for the use of water for the environment in each water year and submitted by waterway managers to the VEWH for consideration in its seasonal watering plan.

Seasonal watering statement – A statement by the VEWH authorising a CMA to apply or use water from its water for the environment entitlements consistently with the seasonal watering plan.

Shared benefits – The many cultural, economic, recreational, social and Traditional Owner benefits of environmental watering.

Slackwater habitat – Habitat in a body of water that has little or no flow, typically formed in areas where the current is restricted by obstructions.

Spawning – The process of species releasing eggs and sperm to reproduce.

Storage manager – Appointed by the Minister for Water to operate major water storages in a particular river basin, to deliver water to entitlement holders.

System operating water – Water managed by storage managers, held in storages and actively released to ensure the system can deliver consumptive water and water to meet other needs.

Temporary trade – Transfer of a seasonal allocation.

Terrestrial vegetation – Land-based plants.

The Living Murray program – An intergovernmental program which holds an average of 500,000 ML of water for the environment a year for use at six iconic sites along the River Murray.

Tier 1a – High-priority potential environmental watering actions that could be achieved with the assumed supply of water.

Tier 1b – High-priority potential environmental watering actions that are unlikely to be achieved with the assumed supply of water, and may require additional water to meet demands.

Tier 2 – Environmental watering actions identified as being necessary to support the environmental objectives, but which are not essential to deliver this year.

Trade – Water shares, allocations and take-and-use licences that can be traded in Victoria under rules the Minister for Water sets.

Translocation – The movement of living organisms from one area to another area where they are given free release.

Tributary – A smaller river or creek that flows into a larger river.

Unregulated (entitlement) – An entitlement to water declared in periods of unregulated flow in a river system (that is, flows that cannot be captured in storages).

Unregulated flows – Natural streamflows that cannot be captured in major reservoirs or storages.

Victorian Environmental Water Holder (VEWH) – An independent statutory body responsible for holding and managing Victorian water for the environment entitlements and allocations.

Victorian environmental watering program – The overarching program by which all environmental watering actions are planned and delivered and in which all environmental watering partners are involved.

Water Act 1989 – The legislation that governs water entitlements and establishes the mechanisms for managing Victoria's water resources.

Water entitlement – The right to a volume of water that can (usually) be stored in reservoirs and taken and used under specific conditions.

Water trade – The process of buying, selling or exchanging water allocation or entitlements.

Water allocation – See Allocation (of water).

Water for the environment – Water available for environmental purposes including entitlements held by the VEWH, passing flows and unregulated flows.

Water year – The same as a financial year: from 1 July to 30 June the next year.

Waterway manager – The agency or authority (such as a CMA or Melbourne Water) responsible for the environmental management of a catchment or waterway.

Waterways – Rivers, wetlands, creeks, floodplains, estuaries and other bodies of water.

6.3 Contact details

For further information about the *Seasonal Watering Plan 2019-20*, please contact the VEWH.

Victorian Environmental Water Holder
Ground floor, 8 Nicholson St, East Melbourne, Victoria 3002
PO Box 500, East Melbourne, Victoria 3002
(03) 9637 8951
general.enquiries@vewh.vic.gov.au
www.vewh.vic.gov.au

For specific information about each system and details about specific seasonal watering proposals, please contact the relevant waterway manager.

Corangamite CMA
64 Dennis Street, Colac, Victoria 3250
PO Box 159, Colac, Victoria 3250
(03) 5232 9100
info@ccma.vic.gov.au
www.ccma.vic.gov.au

East Gippsland CMA
574 Main Street, Bairnsdale, Victoria 3875
PO Box 1012, Bairnsdale, Victoria 3875
(03) 5152 0600
egcma@egcma.com.au
www.egcma.com.au

Glenelg Hopkins CMA
79 French Street, Hamilton, Victoria 3300
PO Box 502, Hamilton, Victoria 3300
(03) 5571 2526
ghcma@ghcma.vic.gov.au
www.ghcma.vic.gov.au

Goulburn Broken CMA
168 Welsford Street, Shepparton, Victoria 3630
PO Box 1752, Shepparton, Victoria 3630
(03) 5822 7700
reception@gbcma.vic.gov.au
www.gbcma.vic.gov.au

Mallee CMA
DPI Complex, Corner Koorlong Avenue and Eleventh Street, Irymple, Victoria 3498
PO Box 5017, Mildura, Victoria 3502
(03) 5051 4377
reception@malleecma.com.au
www.malleecma.vic.gov.au

Melbourne Water
990 La Trobe Street, Docklands, Victoria 3008
PO Box 4342, Melbourne, Victoria 3001
131 722
enquiry@melbournewater.com.au
www.melbournewater.com.au

North Central CMA
628–634 Midland Highway, Huntly, Victoria 3551
PO Box 18, Huntly, Victoria 3551
(03) 5448 7124
info@nccma.vic.gov.au
www.nccma.vic.gov.au

North East CMA
Level 1, 104 Hovell Street, Wodonga, Victoria 3690
PO Box 616, Wodonga Victoria 3689
1300 216 513
necma@necma.vic.gov.au
www.necma.vic.gov.au

West Gippsland CMA
16 Hotham Street, Traralgon, Victoria 3844
PO Box 1374, Traralgon, Victoria 3844
1300 094 262
westgippy@wgcma.vic.gov.au
www.wgcma.vic.gov.au

Wimmera CMA
24 Darlot Street, Horsham, Victoria 3400
PO Box 479, Horsham, Victoria 3402
(03) 5382 1544
wcma@wcma.vic.gov.au
www.wcma.vic.gov.au

For specific information about the other environmental water holders in Victoria, please contact one of the following organisations.

Murray–Darling Basin Authority
Level 4, 51 Allara Street, Canberra City, ACT 2601
GPO Box 1801, Canberra City, ACT 2061
(02) 6279 0100
inquiries@mdba.gov.au
www.mdba.gov.au

Commonwealth Environmental Water Office
John Gorton Building, King Edward Terrace, Parkes, ACT 2600
GPO Box 787, Canberra, ACT 2061
1800 218 478
ewater@environment.gov.au
www.environment.gov.au/water/cewo

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Regent parrots at Hattah Lakes, by Mallee CMA

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Brolga seen during water delivery at Gaynor Swamp, by Goulburn Broken CMA

Inside back cover:
Great cormorant, Mt William Creek, by Greg Fletcher, Wimmera CMA

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VICTORIAN ENVIRONMENTAL WATER HOLDER

VICTORIA State Government