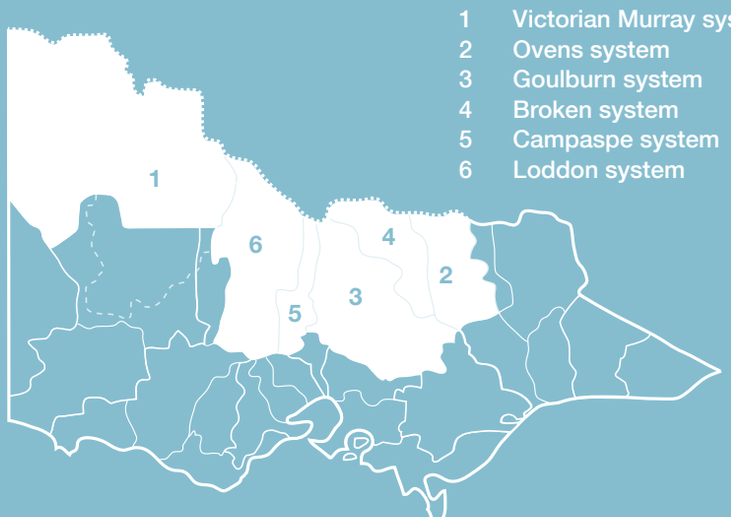
Section 5

Northern Region



1 Victorian Murray system
2 Ovens system
3 Goulburn system
4 Broken system
5 Campaspe system
6 Loddon system

5.1 Northern Region overview

The Northern Region has a vital network of rivers, wetlands and floodplains that provide homes for ancient river red gums and a diversity of other plants and animals. Priority sites include the Goulburn, Broken, Loddon and Campaspe rivers as well as wetlands and floodplains on these systems and on the Victorian Murray system, including Barmah Forest, Gunbower Forest, Hattah Lakes and Lindsay, Wallpolla and Mulcra islands.

Local Aboriginal communities have an enduring connection to these sites, many of which have important heritage values (such as scar trees, middens, burial sites, artefacts and ovens). Waterways across the Northern Region provide highly valued amenity and recreational opportunities for residents and visitors as well as business opportunities from tourism. Importantly, these waterways also support irrigated agriculture which contributes significantly to Australia's prosperity through food and fibre production.

Environmental water available for use in the northern Victorian systems is held in the Ovens, Murray, Goulburn, Broken, Loddon and Campaspe storages, which also hold water for consumptive water entitlements. The water systems of the Northern Region are highly connected. Infrastructure and water trading allows water to move from one system to another. This allows environmental water to move between systems for delivery to priority environmental sites across northern Victoria, if needed. However, most environmental water in these systems is prioritised to provide benefits in the regions in which the water is held.

Seasonal outlook 2016-17

Each year on 15 May, the Northern Victoria Resource Manager 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 2016–17 outlook suggests water availability will most likely be lower than in recent years, with allocations against high-reliability entitlements unlikely to reach 100 percent unless near-average inflows into storages occur. Under a dry inflow scenario (for example, assuming inflows remain similar to the lowest 10 percent of inflows on record), the Goulburn and Murray systems are expected to reach around 50 percent

Nyah-Vinifera floodplain, by Mallee CMA

allocations against high-reliability entitlements for the year, which is around half of the allocations available in 2015–16. If inflows are worse than this, allocations could be lower.

For the Campaspe, Loddon, Broken and Bullarook systems, dry conditions will see zero or very low allocation. Under very dry conditions, there is a risk that no environmental water will be able to be delivered, including any water carried over and already held in storage. This significant risk of delivery constraints has been factored into environmental water planning for 2016–17. Average inflows should result in these four systems reaching 100 percent allocation against high-reliability entitlements.

Environmental water demands in northern Victoria are generally highest in winter and spring. As the outlook indicates, water availability early in the season may be relatively low, so carryover from 2015–16 will be important to help meet early-season demands. The VEWH's carryover into 2016–17 is expected to be sufficient to support priority demands. Small transfers may occur between systems to support potential shortfalls under some planning scenarios, notwithstanding possible delivery constraints.

If conditions remain very dry across the region, environmental watering will mainly focus on delivery of actions planned under a drought or dry scenario. Carryover planning for 2017–18 will also be essential under continuing dry conditions.

The VEWH coordinates with other environmental water holders in northern Victoria, New South Wales and South Australia to deliver environmental outcomes at the broader Murray–Darling Basin scale.

The VEWH liaises with the MDBA and the Commonwealth Environmental Water Office to maximise the benefits of environmental water delivery in Victorian systems. Delivery of Living Murray and Commonwealth environmental water to meet Victorian environmental water objectives is covered in the following sections.

Environmental water delivered through northern Victorian waterways can sometimes be reused to achieve further environmental benefits downstream (see section 1.4.2 on return flows). If return flows are not to be reused at Victorian environmental sites, the VEWH, Living Murray and CEWH return flows may continue to flow across the border to South Australia where they will be used to provide environmental benefits at sites such as those in the Coorong, Lower Lakes and Murray Mouth region.

The VEWH may also authorise waterway managers to order Living Murray and Commonwealth water for downstream sites, provided there are no adverse impacts on Victorian waterways.

What is the Murray–Darling Basin Plan?

Northern Victoria is a part of the Murray–Darling Basin and environmental water deliveries in the Northern Region are subject to the requirements of the Murray–Darling Basin Plan. The plan was developed by the MDBA under the *Commonwealth Water Act 2007* and became law in November 2012. The 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 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 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 Murray–Darling Basin Plan.

5.2 Victorian Murray system

Waterway managers – Goulburn Broken, North Central and Mallee catchment management authorities

Storage managers – Goulburn-Murray Water, Lower Murray Water, Murray–Darling Basin Authority (River Murray Operations)

Environmental water holders – Victorian Environmental Water Holder, Murray–Darling Basin Authority (the Living Murray program), Commonwealth Environmental Water Holder

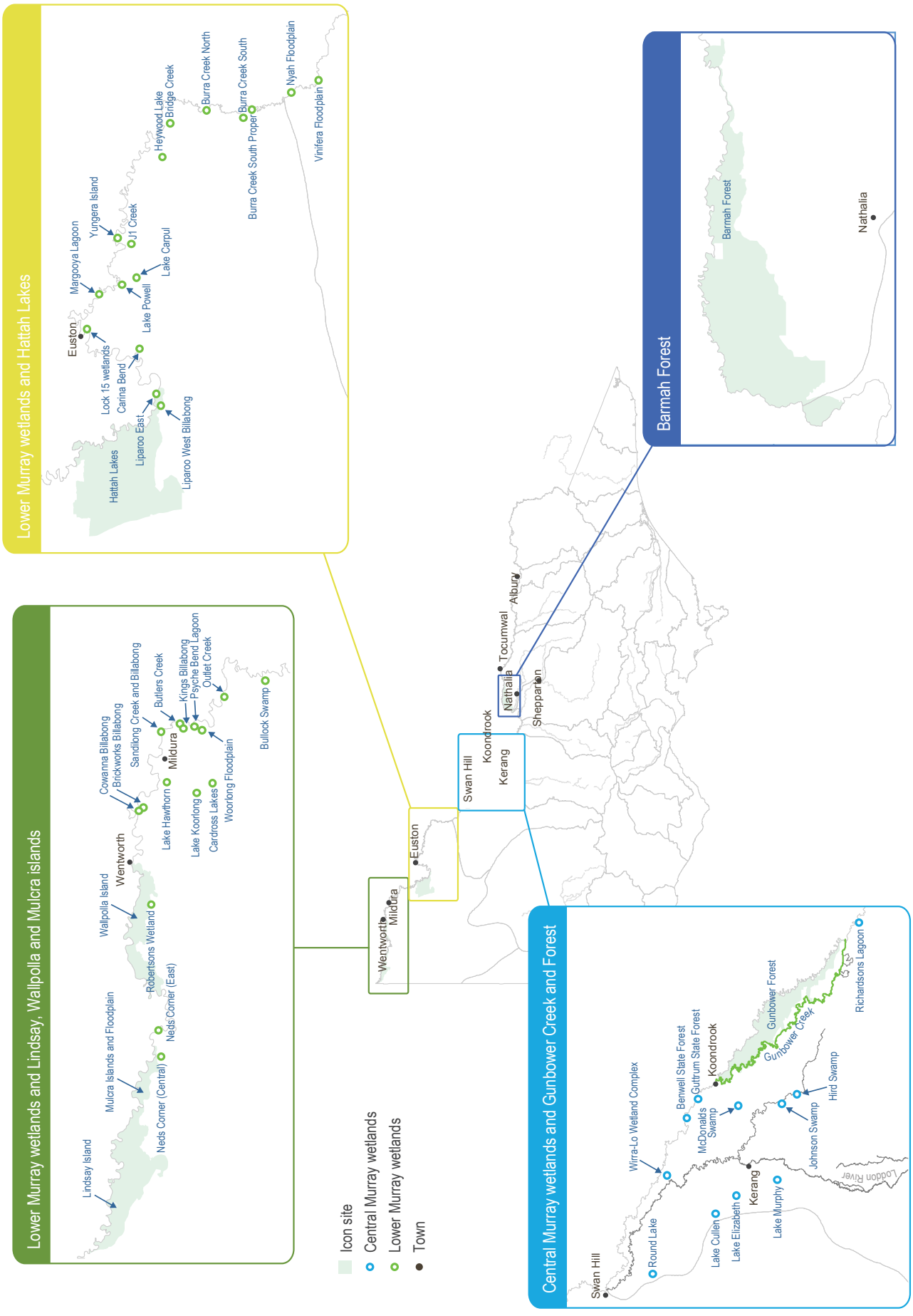
Region overview

As Figure 5.2.1 shows, the Victorian Murray system contains many significant floodplains and wetland systems covering the Goulburn Broken, North Central and Mallee CMA areas. The system contains floodplains and wetlands that are of international importance and include the iconic Hattah Lakes, Barmah Forest and Kerang wetlands, as well as other nationally and regionally significant sites. The system provides a wide range of habitat types that support rare and threatened waterbird species including the painted snipe, brolga, royal spoonbill and white-bellied sea eagle. They are also home to the endangered Murray hardyhead fish. The Victorian Murray system supports a variety of recreational activities (such as camping, fishing, water sports, bird watching and recreational hunting) and Aboriginal cultural heritage values (such as scar trees, middens, burial sites, artefacts and ovens).

Environmental water can be supplied from a range of sources to meet demands in the Victorian Murray system. This includes entitlements held by the VEWH, the Living Murray program and the CEWH; reuse of return flows; and in some instances use of consumptive water en route. The source of the water and ability to deliver all watering actions will depend on water availability, water commitments by other environmental water holders and operational conditions. As a result, the following Victorian Murray system sections do not specify the expected environmental water availability.

Australian little bittern, Johnson Swamp, by Simon Starr

Figure 5.2.1 The Victorian Murray system



5.2.1 Barmah Forest

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 is a significant feeding and breeding site for waterbirds including bitterns, ibis, egrets, spoonbills and night herons, as well as for significant fish, frog and turtle populations.

The forest also supports a broad range of floodplain vegetation communities including river red gum forest, river red gum woodland, wetlands and the threatened Moira grass plains.

Social and economic values

The Barmah Forest supports a variety of recreational and tourism activities such as camping, bushwalking, fishing, river cruises and bird watching.

The forest is valued for its part in Australia's heritage and for its natural and Aboriginal and European cultural heritage values. Aboriginal sites of significance include scar trees, middens, burial sites, artefacts and ovens. The Barmah Forest continues to be a place of significance for Traditional Owners and their Nations in the region. Non-Aboriginal artefacts are largely associated with past forestry and grazing in the forest.

Environmental watering objectives in Barmah Forest	
	Enhance the health of river red gum communities and aquatic vegetation within the wetlands and watercourses and on the floodplain Encourage germination and growth of Moira grass
	Provide feeding locations and allow colonial waterbirds to successfully fledge their young
	Use flows to connect floodplains to the river, enabling carbon transfer, providing drought refuge, boosting floodplain animal and bird habitats and providing bugs and other food resources for native fish species, waterbirds, frogs and turtles
	Protect and boost populations of native fish by providing flows to encourage fish to spawn

System overview

The Barmah–Millewa Forest covers 66,000 hectares and straddles the Murray and Edwards rivers between the townships of Tocumwal, Deniliquin and Echuca. The Victorian component is the Barmah National Park and River Murray Reserve covering 28,500 hectares of forest and wetlands.

Water management in the Barmah–Millewa Forest depends on gravity distribution from the River Murray. When river flows are above 15,000 ML per day downstream of Yarrawonga Weir, both sides of the forest are managed as a whole. When flows are below this, each side of the forest can be managed separately by operating the regulators individually. Below flows of about 10,500 ML per day downstream of Yarrawonga Weir, all regulators usually remain closed.

River regulation and water extraction from the River Murray has reduced the frequency, duration and magnitude of flood events in the Barmah–Millewa Forest. This has affected the diversity, extent and condition of vegetation communities and the habitat and health of dependent animal species.

Environmental water releases seek to protect critical habitat under dry conditions and build on unregulated flows and the delivery of consumptive water en route to maximise environmental outcomes when possible. As Barmah Forest is located in the upper reaches of the River Murray, environmental water delivered to the forest can often be used again at sites further downstream as part of multi-site watering events.

Recent conditions

Rainfall was lower-than-average for the majority of winter-spring in 2015. A few small natural peaks above choke capacity occurred that provided water to the lower wetlands before high consumptive water deliveries through the Barmah choke were combined with environmental water to provide a flood event across the floodplain from August to November.

Millewa Forest on the New South Wales side of the Murray was the primary focus of environmental water delivery in 2015–16. This was agreed as part of a reciprocal arrangement between New South Wales and Victorian program partners to maximise environmental benefits and minimise risks to the forest each year, given the constraints that restrict the ability to manage floodplain watering of both forests concurrently. Some low-level watering did occur in Barmah in 2015–16 (including shallow flooding of wetlands in late winter/early spring), in addition to some flows connecting the River Murray and the creeks through the forest. Within Barmah, environmental watering was extended through to the end of January in Boals Deadwood Wetland to support a successful colonial waterbird breeding event.

Wetland plants and river red gums responded very well to the shallow flooding in Barmah Forest. There was a clear contrast in plant health between the areas flooded and those that remained dry. The watering allowed wetland plants to reproduce and river red gums to put on a flush of new growth. Waterbirds bred successfully, with about 750 nests of ibis and 20 of royal spoonbills as well as multiple colonies of cormorants in Barmah Forest. In Millewa Forest, a similar numbers of ibis, around 200 pairs of royal spoonbills and 100 pairs of eastern great egrets also bred. About 45 male Australasian bitterns–a nationally endangered bird–were heard calling and are believed to have also bred as well as numerous other wetland-dependent bird species.

Native fish continued to be monitored but despite the watering southern pygmy perch were again not found: this has been the case since the millennium drought.

While this species appears to have become locally extinct, protecting their habitat is still a high priority in case there are still remnant populations. Deliberate flow pulses in the River Murray channel through Barmah–Millewa Forest resulted in spawning of silver and golden perch. The pulses provide flow variability which is necessary to trigger perch spawning. Frogs, turtles, reptiles and other animals in the forest also benefited from the environmental water deliveries in 2015–16.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.2.1.

Table 5.2.1 Potential environmental watering actions and objectives for Barmah Forest

Potential environmental watering	Environmental objectives
Spring/summer pulsed flows in the River Murray channel (3 pulses of up to 500 ML/day for 8 days each in October–December)[1]	• Provide flow variability within the main river channel to encourage spawning of native fish species, primarily the golden and silver perch
Spring/summer freshes to Gulf and Boals creeks (100 ML/day for 3–5 days as required in September–March)	• Maintain critical drought refuge areas within Barmah Forest • Protect fish and turtle populations in permanent waterways
Spring/summer baseflows to Gulf and Boals creeks (100 ML/day for 30–60 days as required in September–December)	• Maintain general drought refuge areas within Barmah Forest • Maintain fish and turtle populations in permanent waterways • Maintain connectivity to the river • Remove accumulated organic matter (cycling carbon to the river system and minimising anoxic blackwater development) • Maintain water quality
Spring inundation of floodplain marshes (variable flow rates to extend the duration and inundation extent of natural flooding in September–November)[2]	• Provide flooding of sufficient duration to promote growth of floodplain marsh vegetation in open plains
Targeted wetland watering to Boals Deadwood and Top Island wetlands (100–250 ML/day for 4 months in October–January)	• Support breeding of colonial nesting and flow-dependent waterbirds

1 This action may be achieved through management of river operations and not require environmental water.
2 Environmental water is restricted to 18,000 ML per day downstream of Yarrawonga to September and 15,000 ML per day after September.

Scenario planning

Table 5.2.2 outlines the potential environmental watering and expected water usage under a range of planning scenarios.

Environmental water requirements vary significantly for Barmah Forest in response to natural conditions. Under drier conditions, objectives focus on maintaining the condition of permanent creeks to sustain fish and turtle populations.

As conditions become wetter, the focus shifts to the provision of larger-scale outcomes (such as extending the duration of natural flooding to promote the germination of wetland plants such as Moira grass in floodplain marshes, providing benefits to broader floodplain vegetation communities including river red gum forests).

Targeted wetland watering may occur under a range of conditions to support the breeding of colonial nesting waterbirds and other flood-dependent birds.

Table 5.2.2 Potential environmental watering for 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 • Small 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 winte	• High probability of moderate-to-large unregulated flows in winter/spring • Expected large overbank flows
Potential environmental watering	• Spring/summer pulsed flows in the River Murray channel • Spring/summer freshes	• Spring/summer baseflows • Targeted wetland watering	• Spring/summer baseflows • Spring inundation of floodplain marshes • Targeted wetland watering	• Spring/summer baseflows • Spring inundation of floodplain marshes • Targeted wetland watering
Possible volume of environmental water required to achieve objectives[1]	• 2,000 ML (no return flows)	• 37,000 ML (no return flows)	• 463,000 ML (with 360,000 ML return flows)[2]	• 484,000 ML (with 360,000 ML return flows)[2]

1 The possible volumes of environmental water required in Barmah Forest are estimates; the actual volumes required are highly dependent on natural conditions.
2 The volumes identified include the volume required to achieve floodplain marsh vegetation objectives in both the Barmah and Millewa forests and may be met by unregulated flows.

Risk management

In preparing its seasonal watering proposal, the Goulburn Broken CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

Engagement

The Goulburn Broken CMA consulted key stakeholders when preparing the seasonal watering proposal for Barmah Forest. Table 5.2.3 shows these stakeholders.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies which incorporate environmental, cultural, social and economic considerations.

Table 5.2.3 Partners and stakeholders engaged in developing the Barmah Forest seasonal watering proposal

Partners engagement
• Department of Environment, Land, Water and Planning
• Murray–Darling Basin Authority (River Murray Operations and Living Murray program)
• NSW National Parks and Wildlife Service
• NSW Office of Environment and Heritage
• Parks Victoria
• Yorta Yorta Nation Aboriginal Corporation
• Commonwealth Environmental Water Office
• Victorian Environmental Water Holder

5.2.2 Gunbower Creek and Forest

Environmental values

Gunbower Forest contains a range of important environmental values including diverse and rare wetland habitats, vulnerable and endangered plants and animals and large areas of remnant vegetation communities (such as river red gum forest). The forest provides a diversity of habitats for birds and is known to support internationally recognised migratory waterbirds.

Gunbower Creek provides important habitat for native fish such as Murray cod, trout cod and freshwater catfish. Due to the diversity of fish in the creek, it is considered to be a valuable refuge and source of fish for the recolonisation of surrounding waterways.

Social and economic values

Gunbower Creek and Forest are both valuable sites from a cultural and socioeconomic perspective. Local Aboriginal communities have a strong connection to the Gunbower Forest area. The forest provides social and economic values through timber production, apiculture (bee keeping), recreation and tourism. The creek supports recreational activities (such as boating, fishing and bird watching) and is the major carrier for the delivery of irrigation supply to the surrounding productive lands.

Environmental watering objectives in Gunbower Creek and Forest
Improve the resilience of wetland plant life and help river red gums recover from damage they experienced in the millennium drought
Maintain populations of small-bodied fish species in forest wetlands and rehabilitate large- and small-bodied native fish communities in Gunbower Creek Use flows to connect Gunbower Forest to Gunbower Creek enabling fish, insects, crustaceans, molluscs, worms and carbon to move between them, supporting the life cycle of Gunbower's native fish
Provide feeding, breeding and refuge habitat for waterbirds including colonial nesting species
Maintain the form of the creek bank and channel, and a diversity of creek-bed surface to support all stream life

System overview

Gunbower Forest is a large flood-dependent forest situated on the River Murray floodplain in northern Victoria between Torrumbarry and Koondrook. Covering 19,450 hectares, 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 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 over the long term. This has affected the extent and condition of habitat and the health of dependent animal communities.

Gunbower Creek is managed primarily as an irrigation carrier and supplies the Torrumbarry Irrigation Area from the River Murray. The daily variation in the creek through spring, summer and autumn is much higher now than under natural conditions due to irrigation demand. This results in significant ecological impacts including impacts on native fish populations. Environmental water is used to smooth out the variation by filling the gaps in flows caused by irrigation demand within the creek. This supports fish migration and breeding and promotes other ecological processes while maintaining water delivery for irrigation needs. Flows linking the creek to the Gunbower Forest floodplain and the River Murray can be restored through environmental watering and are vital to enhance ecosystem functioning (such as carbon exchange).

The Living Murray structural works program in the middle and lower forest was completed in 2013. The works allow up to 3,800 hectares of the wetlands and floodplain to be watered with considerably less water than would be required under natural conditions. The works enable efficient watering through Gunbower Creek of the forest to maintain wetland and floodplain condition.

Recent conditions

Gunbower Forest has received four years of consecutive flooding as a result of natural and managed events. From early September to mid-November 2015, nearly 29,000 ML of environmental water was delivered through Gunbower Forest. It was mainly delivered through the Hipwell Road Channel Regulator but for the first time water was also delivered through newly refurbished regulators in the lower landscape (the Yarran Creek, Black Swamp, Reedy Lagoon and Little Gunbower Lagoon regulators) to inundate areas of permanent and semipermanent wetlands. Environmental water was delivered to enhance the resilience of wetland vegetation, provide feeding habitat for waterbirds and enable native fish movement and carbon and nutrient cycling between the creek and forest.

The water delivered in 2015–16 inundated over 2,800 hectares of the forest including about 1,720 hectares of river red gums and 1,112 hectares of wetlands. Field observations showed that river red gums have responded with a flush of new growth and are in a better condition to withstand future dry conditions.

A diversity of aquatic plants germinated in the wetlands in response to the watering, with an excellent response in those areas that received water in the early spring delivery. For the second year in a row river swamp wallaby grass (a threatened plant species) germinated, which is important to replenish the wetland seed bank across the forest.

The high-value permanent and semipermanent wetlands in the lower part of Gunbower Forest have provided critical refuge areas in the landscape for waterbirds and source populations of vegetation. The importance of these areas was shown in the strong response to the 2015 environmental watering. A number of waterbirds utilised the

resources in the wetlands for feeding and breeding during the 2015 watering event including large numbers of black swans, Australian wood ducks, white-bellied sea eagles, yellow-billed spoonbills and great egrets. A small colony of cormorants (40 nests) was recorded breeding in the Little Reedy Wetland complex.

Environmental water was provided through Gunbower Creek to support native fish in autumn and winter, during the off-irrigation season. Traditionally, the creek was drawn down to a series of disconnected deep pools at the end of the irrigation season: this is now recognised as a major limiting factor to the survival of juvenile fish, particularly Murray cod. Providing environmental flows during this period enables continued connectivity between habitats and food resources to support native fish species.

Strong recruitment of Murray cod in Gunbower Creek was observed through monitoring in 2014, corresponding to the delivery of environmental watering designed specifically to trigger spawning of Murray cod in spring and early summer in 2013–14. In 2015–16 the North Central CMA received many anecdotal reports of juvenile Murray cod being caught downstream of Cohuna, indicating that juvenile and adult Murray cod are benefiting from the creek management with winter, spawning and movement flow components. Despite this, the overall Murray cod population in Gunbower Creek requires ongoing environmental management for it to recover and become self-sustaining in the long term.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.2.4.

Table 5.2.4 Potential environmental watering actions and objectives for Gunbower Creek and Forest

Potential environmental watering	Environmental objectives
Gunbower Forest	
Winter/spring watering of Reedy Lagoon and Black Swamp (top-up flows as required in July–December)	• Maintain the health and resilience of vegetation communities in permanent wetlands • Maintain suitable feeding and refuge habitat for waterbirds • Support a significant bird breeding event if one is triggered naturally
Provide top-ups in autumn/winter for Reedy Lagoon and Black Swamp	• Maintain/enhance the health and resilience of vegetation communities in permanent wetlands • Maintain suitable feeding, breeding and refuge habitat for waterbirds including colonial nesting species
Winter/spring watering of Pig Swamp and associated floodrunners	• Improve the health of vegetation communities (including river red gums, sedgy riverine and tall marsh) in the semipermanent wetland • Improve suitable feeding, breeding and refuge habitat for waterbirds, frogs and other water-dependant animals
Winter/spring connectivity flows between Gunbower Creek and River Murray through Yarran Creek and Shillinglaws regulators	• Promote lateral movement of fish, turtles and seed propagules between the River Murray and Gunbower Creek
Provide an extension of natural flooding in Gunbower Forest floodplain, floodrunners and wetlands (with variable flow rates to maintain appropriate inundation extent)	• Improve the health of river red gum communities • Maintain/enhance healthy populations of native fish in wetlands and increase opportunities for riverine fish to access floodplain resources • Maintain suitable feeding, breeding and refuge habitat for waterbirds including colonial nesting species • Support a significant bird breeding event if one is triggered naturally
Gunbower Creek	
Winter baseflows (up to 400 ML/day between July–August and May–June)	• Maintain food and habitat resources for native fish including the recently recruited Murray cod in Gunbower Creek • Maintain native fish access to resources
Spring/summer high flows (targeting a gradual increase in flows up to 700 ML/day including various periods of stable flows in August–January)	• Promote conditions for spawning and larvae survival • Maintain native fish access to habitat and food resources, including recently recruited juvenile fish
Summer/autumn high flows (above 300 ML per day, between January to May)	• Maintain native fish access to habitat and food resources including recently recruited juvenile fish

Scenario planning

Table 5.2.5 outlines the potential environmental watering and expected water usage under a range of planning scenarios.

The scale of the floodplain watering in Gunbower Forest will be determined by climatic conditions, delivery capacity and environmental water availability.

The main objective for 2016–17 is to provide a drying regime to the majority of the permanent and semipermanent wetlands. Drying aims to reduce the number of carp across the forest: they have bred in large numbers in the last two seasons of environmental watering after a large carp invasion in the natural floods between 2010–2012.

Therefore in drought conditions, watering is only planned to occur at two very high-priority wetlands (Reedy Lagoon and Black Swamp). The two wetlands will provide drought refuge for waterbirds and other water-dependent animals and also maintain wetland vegetation. Top-up flows to ensure the wetland vegetation remains in good health may be provided in autumn/winter if another very dry season is predicted in 2017–18: there would also be planning for carryover water into the next season to meet the permanent wetland demands.

Watering of Pig Swamp is a priority under all possible conditions except drought. Located in upper Gunbower Forest, this semipermanent wetland was disconnected from the irrigation network as part of a Goulburn-Murray Water water savings project in 2007 and no longer receives irrigation outfalls or natural flooding except in very large events when flows in the River Murray are above 50,000 ML per day. Watering will support stressed river red gums and wetland vegetation that have not received any water since the 2011 floods.

In wet years, higher flows (above 20,000 ML per day for two weeks) in the River Murray may result in natural flooding and could provide opportunities to support lateral connectivity between the forest, creek and the Murray system. If the duration of higher flows exceeds three weeks in the River Murray, moderate levels of flooding will naturally occur in the forest. Environmental water may be used to extend the duration and extent of flooding to improve the health of the floodplain ecosystem still recovering from the millennium drought.

If a significant bird breeding event is triggered, environmental water may be delivered to assist in maintaining an appropriate inundation depth and area to support the waterbirds to fledging.

Gunbower Creek is a highly regulated system. As a result, natural conditions do not greatly influence the objectives or flow requirements in the system. Environmental water management will aim to support all aspects of native fish life cycles, ensuring there is sufficient habitat and food resources for native fish throughout the year.

The highest priority for watering in Gunbower Creek is maintaining flowing habitat to support juvenile native fish through winter when there is no irrigation water and improvement works over winter are occurring in the system. Additionally, delivery of environmental water to smooth out flows during the irrigation period and provide summer stable flows will be prioritised to promote opportunities for breeding and larval dispersal, particularly for Murray cod which can abandon their nests in response to sudden changes in flow height (a common feature of irrigation water delivery patterns). If sufficient water is available, additional flow components (such as increased baseflows) will be targeted to support fish movement and enable native fish to access different habitats.

Table 5.2.5 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	• Natural inflows into Gunbower Forest unlikely	• Natural inflows into Gunbower Forest are likely in winter/spring but unlikely to be significant	• Overbank flows may occur in winter/spring
Potential environmental watering – tier 1 (high priorities)	• Top-up watering of Reedy Lagoon and Black Swamp • Gunbower Creek winter baseflows • Gunbower Creek spring/summer high flows	• Top-up watering of Reedy Lagoon and Black Swamp • Gunbower Creek winter baseflows • Gunbower Creek spring/summer high flows • Gunbower Creek summer/autumn high flows	• Top-up watering of Reedy Lagoon and Black Swamp • Winter/spring watering Pig Swamp • Gunbower Creek winter baseflows • Gunbower Creek spring/summer high flows • Gunbower Creek summer/autumn high flows	• Winter/spring watering Pig Swamp • Winter/spring connectivity flows • Gunbower Creek winter baseflows • Gunbower Creek spring/summer high flows • Gunbower Creek summer/autumn high flows
Potential environmental watering – tier 2 (additional priorities)	• Top-up watering of Reedy Lagoon and Black Swamp (autumn) • Gunbower Creek summer/autumn high flows	• Top-up watering of Reedy Lagoon and Black Swamp (autumn) • Winter/spring watering Pig Swamp	• Top-up watering of Reedy Lagoon (autumn) • Winter/spring connectivity flows	• Extension of natural inundation of Gunbower Forest floodplain, floodrunners and wetlands • Gunbower Creek spring increased flows
Possible volume of environmental water required to meet objectives[1, 2]	• 23,000 ML (tier 1) • 6,000 ML (tier 2)	• 28,000 ML (tier 1) • 1,550 ML (tier 2)	• 28,000 ML (tier 1) • 4,050 ML (tier 2)	• 50,000 ML (tier 1) • 6,500 ML (tier 2)
Priority carryover requirements	• 4,000 ML	• 4,000 ML	• 2,000 ML	• N/A

1 Represents the estimated volume of water required to underwrite the losses associated with the delivery of consumptive water en route (except for discrete wetland watering actions).
2 Environmental water requirements for tier 2 are additional to tier 1 requirements.

Risk management

In preparing its seasonal watering proposal, North Central CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

Engagement

Table 5.2.6 shows the partners and stakeholder organisations with which North Central CMA engaged when preparing the Gunbower Creek and Forest seasonal watering proposal.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies, which incorporate environmental, cultural, social and economic considerations.

Table 5.2.6 Partners and stakeholders engaged in developing the Gunbower Creek and Forest seasonal watering proposal

Stakeholder engagement
• Commonwealth Environmental Water Office
• Gannawarra Shire Council, Campaspe Shire Council, Cohuna Progress Association and Murray Tourism Board
• Gunbower Island Community Reference Group (with representation from the Cohuna Progress Association, bird observers, Field and Game Australia, BirdLife Australia, Gunbower Landcare Group, irrigators and general community members)
• Gunbower Operations Advisory Group (with representation from Goulburn-Murray Water, Parks Victoria, Department of Environment, Land, Water and Planning [regional], Vic Forests, State Forests New South Wales, North Central CMA, MDBA, CEWH and the VEWH)
• Gunbower Technical Working Group (with representatives of Department of Environment, Land, Water and Planning [Threatened Flora and Fauna]; Goulburn Broken CMA; and specialist fish, vegetation and bird consultants and ecologists)
• North Central CMA Natural Resource Management Committee, an advisory group to the North Central CMA Board comprising regional community members
• Victorian Environmental Water Holder
• Yorta Yorta and Barapa Barapa Traditional Owners

5.2.3 Central Murray wetlands

Environmental values

The wetlands within the central Murray system are highly significant, supporting vulnerable or endangered species including the Australasian bittern, Murray hardyhead, Australian painted snipe and growling grass frog. The wetlands provide habitat for many threatened bird species (including the great egret and white-bellied sea eagle) listed under a range of legislation and international agreements. There are internationally recognised, Ramsar-listed wetlands within the system including Lake Cullen, Hird Swamp and Johnson Swamp, while the others are of bioregional significance.

Social, cultural and recreational values

The Barapa Barapa, Yorta Yorta and Wamba Wamba Nations are the Traditional Owner groups of the central Murray wetlands. The area is considered one of the most archaeologically important areas of Victoria with numerous middens, mounds, artefacts, scar trees and surface scatters documented.

The wetlands are used extensively for various recreational activities including bird watching, bushwalking and duck hunting in some wetlands. Tourism to the region supports the local economy and other indirect economic benefits are derived from groundwater recharge and carbon storage that the wetlands support.

Environmental watering objectives in central Murray wetlands
Maintain river red gum, black box, lignum woodland and wetland plant communities
Provide appropriate wetting and drying conditions that support seed germination, seedling survival and recruitment including of semi-aquatic plant species in damp areas of wetlands
Maintain habitat for the critically endangered Murray hardyhead
Provide habitat for waterbird resting, feeding and breeding
Provide habitat for the endangered growling grass frog

System overview

The central Murray wetland system consists of ten wetlands on the River Murray floodplain. Nine of these can receive environmental water: Lake Cullen, Hird Swamp, Johnson Swamp, Round Lake, McDonalds Swamp, Lake Elizabeth, Lake Murphy, Richardsons Lagoon and the Wirra–Lo wetland complex. These are all wetlands of regional significance.

The central Murray wetlands are almost wholly contained within the Torrumbarry Irrigation Area. This 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 flooding and rely on the provision of environmental water to maintain their ecological character and health.

Guttrum and Benwell forests are a regionally significant wetland system and border the River Murray. Neither forest has permanent infrastructure to deliver environmental water although some semipermanent wetlands can be watered via temporary pumping from the River Murray.

Recent conditions

Significantly low rainfall, high temperatures and barriers—channels, roads and levees—that prevent natural run-off meant that minimal natural inflows were received in the central Murray wetlands in 2015–16. Environmental water was the primary water source provided in 2015–16.

Environmental watering in 2015–16 included top-up flows to Round Lake and Lake Elizabeth to maintain and establish suitable conditions for Murray hardyhead; and to Johnson Swamp, Richardson's Lagoon and Wirra–Lo wetland complex to support a diversity of waterbirds, plants and other animals typical of temporary freshwater marshes.

Four of the wetlands in the central Murray system did not receive environmental water in 2015–16 including McDonalds Swamp, Hird Swamp, Lake Cullen and Lake Murphy. A partial fill of McDonalds Swamp planned for autumn 2016 did not go ahead due to the risk of introducing high levels of toxic blue-green algae from the irrigation system into the wetland. The delivery to McDonalds Swamp is now planned to occur in late winter to early spring 2016. A drying regime was implemented for Hird Swamp, Lake Cullen and Lake Murphy: this helps promote germination and establishment of vegetation in and around the wetland and also promotes productivity and provides an important food source for wading waterbirds.

The drying of Lake Murphy resulted in a very productive mudflat and shallow water habitats that supported a diversity of feeding and breeding waterbirds into mid-summer including at least 1,000 individuals of 25 different waterbird species.

Round Lake remained permanently inundated during the season to support the resident Murray hardyhead population. While fish surveys in spring 2015 did not catch any Murray hardyhead individuals, surveyors observed some of the fish congregating in the shallower areas of the wetland. A low catch rate reflects the difficulties sampling for this species and its natural boom-and-bust population cycles.

In Lake Elizabeth the coverage of aquatic plant species favoured by Murray hardyhead have become more widespread since the first environmental watering in 2014. The plants should provide ideal habitat for the Murray hardyhead that were translocated into the wetland in autumn 2016.

A large variety and number of waterbirds were recorded at Wirra–Lo wetland complex, Johnson Swamp and Richardsons Lagoon in 2015–16. This included significant

species listed in the *Victorian Flora and Fauna Guarantee Act 1988*: the intermediate egret, Australasian bittern, little bittern, blue-billed duck, royal spoonbill, Baillon's crake, Latham's snipe, painted snipe and brolga. Successful breeding of Australasian bittern, Australian little bittern and brolga was recorded at Johnson Swamp. Other threatened species such as the sharp-tailed sandpiper, marsh sandpiper and whiskered tern were also recorded at some of these wetlands.

Wirra–Lo wetland complex was part of a former irrigation property that has been prioritised for rehabilitation with the strong support of the landholders. The landholders used irrigation water run-off and altered irrigation infrastructure to maintain the wetland's integrity for years. The wetland now has an environmental covenant to protect the land from farming and has been voluntarily disconnected from the irrigation network. Environmental water was first delivered to the Wirra–Lo wetland complex in 2014 and follow-up watering occurred in 2015–16. Each watering has triggered the rapid growth of aquatic and amphibious plant species (such as wavy marshwort, robust milfoil and spiny mud-grass). Environmental water in combination with land rehabilitation works and a native vegetation planting program is supporting a diverse range of wetland animal species including frogs and waterbirds.

Guttrum and Benwell forests have not received natural inflows since the heavy rains and consequent high flows in the River Murray in 2010–11. Although the natural inundation assisted the forest to partly recover from the millennium drought, recent observations suggest that the forests are still in relatively poor condition and require a more natural watering regime and reduced grazing pressure to support their recovery.

Scope of environmental watering

Potential environmental watering actions (including wetland drying) and their environmental objectives are shown in Table 5.2.7.

Table 5.2.7 Potential environmental watering actions and objectives for central Murray wetlands

Potential environmental watering	Environmental objectives
Wetland watering	
Round Lake (top-up flows as required to maintain water quality targets)	• Maintain habitat for Murray hardyhead • Maintain suitable waterbird habitat
Lake Elizabeth (top-up flows as required to maintain water quality targets)	• Maintain habitat for translocated Murray hardyhead • Support submerged salt-tolerant aquatic plant assemblage and a diversity of waterbirds
Wirra–Lo wetland complex (fill in winter/spring and provide top-ups if required)	• Rehabilitate river red gum and aquatic vegetation communities, providing habitat for the growling grass frog and a diversity of waterbirds
Guttrum and Benwell forests (semipermanent wetlands only; fill in winter/spring and provide top-ups if required)[1]	• Promote a variety of aquatic vegetation, semi-aquatic vegetation and river red gum communities in semipermanent wetlands • Provide feeding and breeding habitat for waterbirds
McDonalds Swamp (fill in winter/spring and provide top-ups if required)	• Maintain a diverse vegetation community by supporting juvenile river red gums and reducing coverage of common reed and cumbungi communities through environmental water management
Richardsons Lagoon (top up in winter/spring and provide top-ups if required)	• Promote a variety of aquatic plant species that support a variety of water-dependent species including fish, waterbirds, frogs and turtles
Hird Swamp West and East (partial fill in autumn/winter)	• Maintain a variety of vegetation communities (including open-water habitat) to support waterbird feeding and breeding habitats
Lake Cullen (top up in spring if natural flooding occurs)	• Maintain a viable stock of submerged salt-tolerant aquatic plants to support waterbird feeding and breeding habitats
Wetland drying	
Johnson Swamp and Lake Murphy (drawdown and drying)	• These wetlands will not be actively watered in 2016–17 • The drying will assist in maintaining a diversity of habitats to support a wide range of wetland-dependent birds and animals and to promote the growth and establishment of vegetation in and surrounding the wetland

1 Guttrum and Benwell forest may receive environmental water in 2016–17 pending further investigation by North Central CMA. Infrastructure projects for Guttrum and Benwell forests are being assessed as part of the Sustainable Diversion Limit Offset component of the Murray–Darling Basin Plan. Until works are approved and completed, environmental watering will only consider semipermanent wetlands that can receive water that is pumped from the River Murray.

Scenario planning

Table 5.2.8 outlines the potential environmental watering and expected water usage under a range of planning scenarios.

Landscape-scale planning for these wetlands has been undertaken by the North Central CMA to optimise the wetland watering regimes over multiple years. An important consideration in this planning includes ensuring that there is a diversity of habitat types available across the region to support waterbirds and other water-dependent animals at any point in time.

In a given year, multiple wetlands may require environmental water at the same time. Inter-annual planning helps to manage this risk of increased pressure on environmental water resources, particularly if there is a return to drought conditions. It also helps support waterbird populations by ensuring that suitable habitat for breeding, feeding and nesting is available across northern Victoria.

The wetlands of highest priority for environmental water management in the central Murray wetlands in 2016–17 are Round Lake and Lake Elizabeth. Round Lake supports what is considered to be the only stable population of the critically endangered Murray hardyhead in the Kerang region. Murray hardyhead were also recently translocated to Lake Elizabeth and the lake will be prioritised to receive environmental water in 2016–17 to support the new population. It is important that these wetlands are maintained for future stocking and translocation programs to prevent the regional loss of the species.

In drier conditions, environmental water is planned to be delivered to fill and maintain water depth in some wetlands, to support the needs of wetland-dependent vegetation, fish and bird species. Water availability may increase if catchment conditions become wetter, which would support delivery to more wetlands within the central Murray to help meet native plant, animal and waterbird objectives. Under very wet conditions natural floods may partially or completely fill some of the central Murray wetlands, but environmental water will be required to maintain water depth to support waterbird breeding and vegetation condition.

While environmental water is planned to be delivered to Lake Cullen in 2016–17, its significant size and potential groundwater issues means that delivery depends on a degree of natural inundation of the wetland which in 2016–17 would only occur under extremely wet conditions. If natural flooding does occur, environmental water may be used to top up and maintain water levels to reduce the potential detrimental impact from a short, shallow inundation and groundwater intrusion. Further assessment will be undertaken to inform the most appropriate management option considering the timing, extent and duration of any natural inundation.

No environmental water is planned to be delivered to Johnson Swamp and Lake Murphy in 2016–17. These wetlands are undergoing a drying phase to promote habitat diversity for waterbirds and also to support young river red gums that established after recent environmental watering.

Table 5.2.8 Potential environmental watering for 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 wetlands is unlikely	• Catchment run-off and unregulated flows into the wetlands is unlikely	• Some catchment run-off and unregulated flows into 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 1 (high priorities)	• Round Lake • Lake Elizabeth	• Round Lake • Lake Elizabeth	• Round Lake • Lake Elizabeth • Wirra–Lo wetland complex • Guttrum and Benwell forests • McDonalds Swamp • Richardsons Lagoon	• Round Lake • Lake Elizabeth • Wirra–Lo wetland complex • Guttrum and Benwell forests • McDonalds Swamp • Richardsons Lagoon
Potential environmental watering – tier 2 (additional priorities)	• Wirra–Lo wetland complex • Guttrum and Benwell forests • McDonalds Swamp • Richardsons Lagoon	• Wirra–Lo wetland complex • Guttrum and Benwell forests • McDonalds Swamp • Richardsons Lagoon	• Hird Swamp	• Hird Swamp • Lake Cullen
Possible volume of environmental water required to meet objectives1	• 3,850 ML (tier 1) • 5,175 ML (tier 2)	• 3,100 ML (tier 1) • 4,300 ML (tier 2)	• 7,400 ML (tier 1) • 1,500 ML (tier 2)	• 7,400 ML (tier 1) • 19,000 ML (tier 2)
Priority carryover requirements	• 3,900 ML	• 3,100 ML	• 5,800 ML	• 5,800 ML

1 Possible environmental water requirements for tier 2 are additional to tier 1 requirements.

Risk management

In preparing its seasonal watering proposal, North Central CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

Engagement

Table 5.2.9 shows the partners, stakeholder organisations and individuals with which North Central CMA engaged when preparing the central Murray wetlands seasonal watering proposal.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies, which incorporate environmental, cultural, social and economic considerations.

Table 5.2.9 Key stakeholders engaged in the development of the central Murray wetlands seasonal watering proposal

Stakeholder engagement
• Birdlife Australia
• Central Murray Wetlands Environmental Water Advisory Group (made up of community members, private landholders, interest groups including Game Management Authority, North Central CMA project staff, Board and Community Consultative Committee representation)
• Commonwealth Environmental Water Office
• Community members
• Department of Environment, Land, Water and Planning
• Field and Game Australia
• Gannawarra Shire Council
• Goulburn-Murray Water
• North Central CMA Board
• North Central CMA Community Consultative Committee, an advisory group to the North Central CMA Board made up of regional community members
• Parks Victoria
• Swan Hill Rural City Council
• Victorian Environmental Water Holder

McDonalds swamp, by North Central CMA

5.2.4 Hattah Lakes

Environmental values

Hattah Lakes provides immense waterbird breeding habitat, particularly for colonial nesting waterbirds including several species of cormorant. Being located in a remote and arid landscape, Hattah Lakes also provides large-scale drought refuge for waterbirds and other vertebrate animals. Nine fish species have been reported in the lakes and five of these have conservation significance in Victoria, including the freshwater catfish and fly-specked hardyhead.

Flood-dependent vegetation at Hattah Lakes ranges from wetland communities that require frequent flooding to communities that require inundation every few years (such as lignum and black box). The lakes support more than 100 plant species that are considered rare or threatened in Victoria. One of these rare plants, the winged peppercress, is listed as nationally endangered under the *Environmental Protection and Biodiversity Conservation Act 1999*.

Social and economic values

Hattah Lakes is a popular location for camping, canoeing, birdwatching and photography. The lakes are also valued by Traditional Owners in the region, who have a continuing connection to the land. There are more than 1,000 registered sites of importance including burial sites, scar trees and shell middens.

Environmental watering objectives for the Hattah Lakes

- Restore a healthy and diverse mix of wetland and floodplain plant life to maintain the ecological character of this internationally protected site
- Maintain high-quality habitat for native fish in wetlands
- Use flows to connect the lakes to the river so large-bodied fish (including Murray cod and perch) can move, feed and breed
- Provide feeding and breeding habitat for a range of waterbird species including threatened and migratory species and colonial species (such as the spoonbill and egret)

System overview

Hattah Lakes is a complex of more than 20 semipermanent freshwater lakes over an area of 48,000 hectares. The lakes complex forms part of the Hattah–Kulkyne National Park. Located adjacent to the River Murray in north-west Victoria, the ecology of the lakes and floodplain is strongly influenced by flooding regimes.

The Hattah Lakes system is naturally filled when there are high flows in the River Murray. When floods recede some individual lakes hold water for years. The high flows that cause floods in the lakes are less than they were before, when the Murray system was unregulated.

In the absence of regular high flows in the River Murray, large-scale engineering works were completed under the Living Murray program to improve water regimes at Hattah Lakes under low-flow conditions. Pumps and regulators are used to deliver, retain and discharge water from the floodplain, to provide the water regimes that support the environmental values in the system.

Recent conditions

Natural flooding at Hattah Lakes has been absent since 2011. To replicate natural floods and assist commissioning of new water delivery infrastructure, environmental water has been delivered to Hattah Lakes three times since 2013. The first two deliveries reached high elevations on the floodplain and supported black box woodlands. Most recently, in spring 2015 water was used to top up semipermanent wetlands. The inundation extent was reduced compared to previous years, allowing a drying phase to favour vegetation on the drying beds of lakes and recruitment of river red gums.

The environmental watering over the last three years saw a range of positive results. Most notably, the condition of river red gum and black box woodlands has improved. After environmental watering, botanists recorded 80 new locations of rare or threatened plants, with a low abundance of exotic weeds. The wetlands have also benefited through nutrient exchange and release of carbon, which makes plants grow rapidly and provides optimal conditions for fish and birds to feed and reproduce.

The watering in spring 2015 provided connectivity between the lakes and the River Murray. During the watering event, golden perch that were present in the lakes were observed moving in response to environmental flows in Chalka Creek and exiting the wetlands to the River Murray. The release also provided a chance for little pied cormorants to breed and improved habitat for woodland birds including threatened regent parrots.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.2.10.

Table 5.2.10 Potential environmental watering actions and objectives for the Hattah Lakes

Potential environmental watering[1]	Environmental objectives
Winter/spring inundation of semipermanent wetlands (provide top-up flows as required targeting a water level of 42.5 m AHD July–November)	• Maintain deeper water for waterbird breeding events • Maintain potential breeding habitat for fish including golden perch • Provide connectivity between the Hattah Lakes system and the River Murray channel
Winter/spring inundation of temporary wetlands (fill wetlands above 42.5 m AHD July–November)	• Provide inundation of red gum forest and woodland for growth and reproduction

1 The Hattah Lakes pump station will also be operated to meet annual maintenance requirements.

Scenario planning

Table 5.2.11 outlines potential environmental watering and expected water usage under a range of planning scenarios.

In recent years the watering requirements for the red gum forest, woodlands and semipermanent wetlands at Hattah Lakes have been met, and these communities now need time to dry and allow new understorey to develop. Additional watering is not required in 2016–17 and the priority for Hattah Lakes is to provide widespread and substantial drawdowns to allow vegetation to grow and establish. As the water in wetlands evaporates it also provides lots of shallow water, which is the preferred habitat for wading birds.

Under a drought or dry scenario there are low environmental water demands in the lakes system, and water is only required to undertake annual operational maintenance of the Hattah Lakes pump station.

Natural flow cues will be used to help inform decisions to undertake larger-scale watering at Hattah Lakes if conditions are average to wet, aiming to replicate watering events that would have occurred before major dams and weirs were built.

Table 5.2.11 Potential environmental watering for the Hattah Lakes under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No unregulated flows in the River Murray year-round • No natural inflows expected into wetlands or floodplain		• Short periods of high flows in the River Murray in late winter and early spring will provide minor filling of wetlands and the floodplain	• Lengthy periods of high flows and floods with major spills from storages, resulting in widespread inundation of the floodplain and inundating most wetlands
Potential environmental watering	• Operational maintenance of pump station and infrastructure commissioning		• Winter/spring fresh in Chalka Creek south • Winter/spring inundation of semipermanent wetlands	• Winter/spring fresh in Chalka Creek south • Winter/spring inundation of temporary wetlands
Possible volume of environmental water required to meet objectives	• 2,000 ML		• Up to 22,000 ML	• Up to 35,000 ML

Risk management

In preparing its seasonal watering proposal, Mallee CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

Engagement

Table 5.2.12 shows the partners and stakeholder organisation with which Mallee CMA engaged when preparing the Hattah Lakes seasonal watering proposal.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies, which include environmental, cultural, social and economic considerations.

Table 5.2.12 Partners and stakeholders engaged in developing the Hattah Lakes seasonal watering proposal

Partner and stakeholder engagement
• Commonwealth Environmental Water Office
• Goulburn-Murray Water
• Murray–Darling Basin Authority
• Parks Victoria
• Department of Environment, Land, Water and Planning
• Victorian Environmental Water Holder
• Mallee CMA Water Technical Advisory Committee (an advisory group to Mallee CMA comprising community members)

5.2.5 Lower Murray wetlands

Environmental values

The lower Murray wetlands are comprised of multiple wetlands, creek and billabongs on the floodplain of the River Murray. Depending on their location in the landscape, interactions with groundwater and their management history, the wetlands may be permanent, temporary, freshwater or saline. The differences in water regime and water quality among 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. Unlike permanent wetlands, temporary freshwater wetlands fill and dry intermittently. During the filling phase they provide short-term boom periods when river red gum trees and wetland plants grow, spread and provide habitat for aquatic animals.

Social and economic values

There are several irrigation districts in the Sunraysia region that are supplied by the River Murray and contribute significant wealth to the local economy. Camping, fishing and other water-based recreational activities are popular along the River Murray including at some wetlands in the lower Murray system. Waterbirds provide opportunities for bird watching and hunting. Aboriginal culture is strongly linked to the floodplain of the River Murray, which for many thousands of years would have maintained a concentrated population due to the abundant resources it provided.

Environmental watering objectives in the lower Murray wetlands
Increase the diversity, extent and abundance of wetland plant life
Provide feeding and breeding habitat for a range of waterbird species including threatened and migratory species and colonial species (such as the egret)
Improve water quality and increase habitat for fish
Improve the condition of river red gums, black box and lignum to provide habitat for large animals (such as lace monitors and bats)

System overview

The lower Murray wetlands span more than 700 kilometres of linear floodplain along the River Murray between Swan Hill and the South Australian border. This includes creeks, wetlands and floodplains that are ecologically important and reflect the natural character and attributes of the River Murray floodplain.

The regulation and diversion of River Murray flows has dramatically altered the hydrology of the lower Murray wetlands. River regulation has substantially reduced the frequency and duration of the high river flows that are needed to water billabongs and floodplains. This change to the water regime has caused a decline in the environmental values of floodplain wetland sites.

Environmental water can be delivered to some wetlands in the region through a combination of direct pumping from the River Murray and through use of irrigation supply infrastructure. All the wetlands can be managed independently of each other.

Recent conditions

The last time that sustained high flows in the River Murray were sufficient to inundate vast areas of lower Murray wetlands and floodplains was in 2010 and 2011. Since 2011 high river flows have mostly been absent so wetlands have relied on the delivery of environmental water to support aquatic life.

Environmental water was delivered to some wetlands in 2015–16 including to Burra Creek North, Neds Corner East and Central, Butlers Creek, Brickworks Billabong, Cardross Lake, Cowanna Billabong, Lakes Powell and Carpul, Nyah and Vinifera floodplains and Lake Hawthorn. This watering achieved a range of positive outcomes for native fish, birds and terrestrial animals.

In 2014–15 Lakes Powell and Carpul received environmental water for the first time since 2011–12. The filling complemented the gains made from the previous watering by improving the condition of black box vegetation that had regenerated around the lakes. The watering also provided habitat and feeding opportunities for many thousands of waterbirds.

At Brickworks Billabong environmental watering supported a population of critically endangered Murray hardyhead. In March 2015, 2,500 Murray hardyhead were translocated to Brickworks Billabong, adding to the existing population. Since that time, watering of the billabong has maintained the condition of ruppia, an aquatic plant that provides habitat for the fish. Monitoring in January 2016 has demonstrated that Murray hardyhead are thriving and breeding in the wetland, with high numbers of adult and juvenile fish present.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.2.13.

Environmental watering will focus on maintaining and improving vegetation condition, habitat quality and availability throughout the wetlands, floodplains and waterways in the lower Murray region, and in some cases, rehabilitating salt-affected wetlands.

Table 5.2.13 Potential environmental watering actions and objectives for the lower Murray wetlands

Potential environmental watering	Environmental objectives
Wetland watering	
Brickworks Billabong (spring, autumn and top-ups as required to maintain water quality targets and minimum water level)	• Maintain and improve the condition of aquatic vegetation and water quality for Murray hardyhead
Cardross Lakes (top up as required to maintain water quality targets and minimum water level)	
Lake Koorlong (top up as required to maintain water quality targets and minimum water level)	
Burra Creek South (winter/spring)	• Provide productive lake habitat for waterbirds • Restore floodplain productivity to maintain resident populations of vertebrate animals including carpet pythons and insectivorous bats • Promote emergent and semi-emergent aquatic vegetation
Burra Creek South Proper (spring)	
Burra Creek North (winter/spring)	
Nyah floodplain (spring/summer)	• Improve condition and structure of wetland vegetation • Provide seasonal feeding and reproductive opportunities for native fish • Provide breeding habitat for waterbirds including colonial nesting species • Restore floodplain productivity to maintain resident populations of vertebrate animals including carpet pythons, sugar gliders and grey-crowned babblers
Vinifera floodplain (spring/summer)	
Liparoo East (winter/spring)	• Improve condition of the lignum swampy woodland vegetation community and provide habitat for waterbird breeding
Liparoo West (winter/spring)	
Woorlong floodplain (winter/spring/autumn)	• Improve wetland productivity • Reinstate submerged and semi-emergent aquatic plants • Improve nesting opportunities in flooded lignum surrounding the wetlands • Improve the health of surrounding river red gum and black box
Carina Bend (winter/spring)	• Maintain and improve the health of river red gum, black box and lignum
J1 wetland (winter/spring/autumn)	
Yungera wetland (winter/spring/autumn)	
Bridge Creek (spring)	
Cowanna Billabong (winter/spring)	• Support fish and birds • Increase wetland productivity • Provide opportunities for fish to move between wetlands and the River Murray
Butlers Creek (spring/summer)	
Neds Corner East and Central (spring)	• Provide breeding and roosting habitat for colonial waterbirds
Margooya Lagoon (winter/spring/summer)	• Improve river red gum condition • Improve the native fish assemblage of the lagoon • Restore submerged aquatic vegetation in the open-water areas of the wetland
Lock 15 wetlands (all year)	• Improve the productivity of connected riparian zones and wetlands • Restore floodplain productivity to maintain resident populations of vertebrate animals including carpet python and insectivorous bats • Contribute to the carbon requirements of the River Murray channel ecosystem
Lake Hawthorn (spring, and top-ups as required to maintain water level targets)	• Restore aquatic vegetation, particularly ruppia • Provide habitat for waterbirds
Psyche Bend Lagoon (autumn, winter or spring)	• Provide freshwater inflows and flushing flows to reduce salinity levels and improve the condition and diversity of wetland vegetation, improving ecological function
Bullock Swamp (autumn, winter or spring)	
Outlet Creek (Karadoc Swamp) (spring)	
Wetland drying	
Kings Billabong, Heywood Lake, Robertsons wetland, Lakes Powell and Carpul, Sandilong Creek and wetland	• These wetlands will not be actively watered in 2016–17 • Drying will assist in maintaining a diversity of habitats to support a wide range of wetland-dependent birds and animals and to promote the growth and establishment of vegetation in and surrounding the wetland

Scenario planning

Table 5.2.14 outlines the potential environmental watering and expected water usage under a range of planning scenarios.

It has been more than five years since the drought-breaking floods of 2011, but conditions have been very dry ever since. Despite the gains made as a result of the widespread floods five years ago, many wetlands require environmental watering. The approach in 2016–17 is to continue recovery and build resilience in fish and wetland vegetation communities so they can better endure current and future dry conditions.

The highest-priority wetlands for environmental watering in 2016–17 are Cardross Lakes, Lake Koorlong and Brickworks Billabong, as these sites support the critically endangered Murray hardyhead.

Depending on seasonal conditions and water availability, remaining wetlands are prioritised in line with their recommended watering regimes and considering the condition of the environmental values at each site. If conditions become average or wet, additional wetlands will be watered to mimic conditions that would naturally occur in wetter years. In this way the environmental responses are maximised as plants and animals respond to natural environmental cues.

For some temporary wetlands, the desired wet phase has been achieved consistently in recent years. Some wetlands will not be actively watered in 2016–17 and will be allowed time to dry. This will allow time for vegetation to germinate and establish, to increase the diversity of habitats available for aquatic plants and animals during the next wet phase. At the same time, the dry phase will provide opportunities for terrestrial animals to access resources within a temporarily dry wetland.

Table 5.2.14 Potential environmental watering for 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 • Wetlands rely on environmental water delivery		• 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 environmental water delivery	• Lengthy periods of high flows and floods with major spills from storages, resulting in widespread inundation of the floodplain and inundating most wetlands • Some reliance on environmental water delivery to achieve target water levels
Potential environmental watering – tier 1 (high priorities)	• Brickworks Billabong • Cardross Lake • Lake Koorlong	• Brickworks Billabong • Cardross Lake • Lake Koorlong • Lock 15 wetlands • Lake Hawthorn • Burra Creek South	• Brickworks Billabong • Cardross Lake • Lake Koorlong • Lock 15 wetlands • Lake Hawthorn • Burra Creek South • Nyah floodplain • Vinifera floodplain • Burra Creek South Proper • Neds Corner East and Central • Carina Bend • Liparoo East • Liparoo West • Margooya Lagoon • Cowanna Billabong	• Brickworks Billabong • Cardross Lake • Lake Koorlong • Lock 15 wetlands • Lake Hawthorn • Burra Creek South • Nyah floodplain • Vinifera floodplain • Burra Creek South Proper • Neds Corner East and Central • Carina Bend • Liparoo East • Liparoo West • Margooya Lagoon • Cowanna Billabong • Bullock Swamp • Psyche Bend Lagoon • Woorlong floodplain • Burra Creek North • Butlers Creek • J1 Wetland • Yungera Wetland • Outlet Creek (Karadoc Swamp) • Bridge Creek
Potential environmental watering – tier 2 (additional priorities)	• Lake Hawthorn	• Nyah floodplain • Vinifera floodplain • Carina Bend • Liparoo East • Liparoo West • Margooya Lagoon • Cowanna Billabong	• Bullock Swamp • Psyche Bend Lagoon • Woorlong floodplain • Burra Creek North • Butlers Creek	• N/A
Possible volume of environmental water required to meet objectives[1]	• 950 ML (tier 1) • 1,500 ML (tier 2)	• 3,750 ML (tier 1) • 6,000 ML (tier 2)	• 10,200 ML (tier 1) • 2,300 ML (tier 2)	• 15,050 ML (tier 1)
Priority carryover requirements	• 2,450 ML	• 9,750 ML	• 12,500 ML	• 15,050 ML

1 Environmental water requirements for tier 2 actions are additional to tier 1 requirements.

Risk management

In preparing its seasonal watering proposal, Mallee CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

Engagement

Table 5.2.15 shows the partners and stakeholder organisations with which Mallee CMA engaged when preparing the lower Murray wetlands seasonal watering proposal.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies, which include environmental, cultural, social and economic considerations.

Table 5.2.15 Partners and stakeholders engaged in developing the lower Murray wetlands seasonal watering proposal

Partner and stakeholder engagement
• Goulburn-Murray Water
• Commonwealth Environmental Water Office
• Murray–Darling Basin Authority
• Department of Environment, Land, Water and Planning
• Parks Victoria
• Lower Murray Water
• Mildura Rural City Council
• Swan Hill Rural City Council
• Victorian Environmental Water Holder
• Mallee CMA Water Technical Advisory Committee (an advisory group to Mallee CMA comprising community members)

5.2.6 Lindsay, Wallpolla and Mulcra islands

Environmental values

The Mullaroo and Potterwalkagee creeks are renowned for holding very large Murray cod. These creeks provide superior fish habitat compared to the nearby weir pools in the River Murray, and large breeding fish in the creeks are an important source of juveniles to the Murray system. The waterways also support several other threatened fish species, such as the freshwater catfish, silver perch, Murray–Darling rainbowfish and unspeckled hardyhead.

The vast scale of the Lindsay, Mulcra and Wallpolla islands site is noteworthy because it provides very large expanses of habitat to support wetland-dependent and terrestrial species. Several rare and threatened vegetation types occur on the floodplain and in the wetlands as well as more common types of woodlands (such as black box and river red gum).

When flooded, waterways and wetlands within this system provide excellent habitat for waterbirds, 40 species of which are threatened in Victoria including the great egret and red-necked stint. Terrestrial animals also benefit from the improved productivity and food resources when flooding occurs.

Social and economic values

The islands offer recreation opportunities in a remote location with camping, boating and fishing popular for residents of nearby communities and long-distance travellers.

The floodplain and wetland systems have many sites with valuable Aboriginal heritage including shell middens, burial sites and scar trees. Lindsay Island is noteworthy due to the presence of many archaeological sites and the floodplain and wetland systems continue to be places of importance for Traditional Owners and their Nations in the region.

Environmental watering objectives in Lindsay, Wallpolla and Mulcra islands	
	Increase the diversity, extent and abundance of wetland plant life
	Provide feeding and breeding habitat for a range of waterbird species including threatened and migratory species and colonial species (such as the egret)
	Increase abundance, diversity and movement of native fish Provide flows for large-bodied fish (including Murray cod and perch) to swim, feed and breed

System overview

Lindsay, Mulcra and Wallpolla islands cover over 26,100 hectares of River Murray floodplain, forming part of the Chowilla floodplain and Lindsay–Wallpolla Island Living Murray icon site. The floodplain is characterised by a network of permanent waterways, small creeks and wetlands. The larger, permanent waterways–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.

Naturally, these waterways and wetlands would flow and fill in response to high water levels in the River Murray. However, the regulation of the River Murray has reduced its influence on the Lindsay, Mulcra and Wallpolla system.

Although large floods can still occur, flows through the system are mostly regulated by the River Murray locks 6 to 9. Regulators and containment structures have been built throughout the Lindsay, Mulcra and Wallpolla floodplain and are used to help protect the environmental values at the site.

Recent conditions

Floods in 2010 and 2011 provided the first large-scale floodplain watering event in 15 years, but there have not been flows high enough for widespread floodplain watering since. Local conditions have been hot and dry in recent years, causing high evaporation and wetland drying.

The weir pools at River Murray locks 6 to 9 have been managed to add greater variability in water levels to improve environmental outcomes in the waterways, floodplains and wetlands in the system. The raising and lowering of these weir pools has been managed to facilitate delivery of preferred baseflows and freshes to Potterwalkagee and Mullaroo creeks in 2015–16. The events also facilitated the commissioning of newly completed infrastructure on Mullaroo Creek.

High flows and flushes in the Lindsay River were provided to stimulate fish movement and to facilitate pumping of water into surrounding floodplain wetlands. During these high flows, 8,000 ML was pumped into Lake Wallawalla and 600 ML into Wallpolla East Wetland to improve vegetation condition and provide habitat for waterbirds to feed and breed.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.2.16.

Table 5.2.16 Potential environmental watering actions and objectives for Lindsay, Wallpolla and Mulcra islands

Potential environmental watering	Environmental objectives
Lindsay Island	
Year-round baseflows in Mullaroo Creek (greater than 400 ML/day)	• Maintain flowing water habitat for native fish species such as the Murray cod, silver perch and golden perch
Year-round baseflows in the northern Lindsay River (greater than 40 ML/day year-round)	
Spring freshes in Mullaroo Creek (up to 1,000 ML/day in September to November)	• Stimulate golden perch spawning and movement, and seasonal Murray cod movement • Maintain flows to assist in recruitment and survival of fish
Spring and summer high flows in the northern and southern Lindsay River (up to 450 ML/day in September–February)	
Year-round high flows in Mullaroo Creek (up to 1,000 ML/day year-round)	
Mulcra Island	
Year-round baseflows in lower Potterwalkagee Creek (up to 100 ML/day year-round)	• Maintain flowing water habitat for large-bodied native fish, particularly golden perch
Spring freshes and high flows in lower and upper Potterwalkagee Creek (up to 500 ML/day year-round)	• Stimulate large-bodied native fish movement and spawning
Floodplain inundation of lower Potterwalkagee Creek	• Improve condition of lignum shrublands • Provide floodplain habitat for small-bodied fish to reproduce
Wallpolla Island	
Spring inundation of Wallpolla East, Sandy Creek and floodplain, Finnegans Creek and Wallpolla Horseshoe (filling flows in September–November)	• Provide temporary habitat for plants and animals and increase wetland productivity
Wetland drying	
Lake Wallawalla	• Lake Wallawalla will not be actively watered in 2016–17 • Drying will assist in maintaining a diversity of habitats to support a wide range of wetland-dependent birds and animals and promote the growth and establishment of vegetation in and surrounding the wetland

Scenario planning

Table 5.2.17 outlines the potential environmental watering and expected water usage under a range of planning scenarios.

Watering at Lindsay, Mulcra and Wallpolla islands in 2016–17 will focus on providing variable flows in the major waterways and anabranches of the systems (including Lindsay River) and Mullaroo and Potterwalkagee creeks. These flow events will again be coordinated with weir pool operations.

Baseflows are generally provided in these waterways by consumptive water. Under drought and dry conditions spring freshes will also be provided to maintain habitat and provide migration opportunities for native fish. Wetland watering actions are not planned under drought conditions but will become a priority for delivery as conditions improve.

Table 5.2.17 Potential environmental watering for Lindsay, Wallpolla and Mulcra islands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected catchment conditions	• No unregulated flows in the River Murray year-round • No natural inflows expected into wetlands or floodplain		• Short periods of high flows in the River Murray in late winter and early spring will provide minor filling of wetlands and the floodplain	• Lengthy periods of high flows and floods with major spills from storages resulting in widespread inundation of the floodplain and inundating most wetlands
Potential environmental watering – Lindsay and Mulcra Islands	• Year-round baseflows in Mullaroo Creek and Potterwalkagee Creek • Spring freshes in Mullaroo Creek	• Year-round baseflows in Mullaroo Creek and Potterwalkagee Creek • Spring freshes in Mullaroo Creek	• Spring freshes and high flows in Mullaroo Creek and Potterwalkagee Creek • Spring and summer high flows in northern and southern Lindsay River	• Year-round high flows in Mullaroo Creek • Spring and summer high flows in northern and southern Lindsay River • Floodplain inundation above the lower Potterwalkagee regulator
Possible volume of environmental water required to meet objectives	• 2,000 ML[1]			
Potential environmental watering – Wallpolla Island	• N/A	• Spring inundation of Wallpolla East, Sandy Creek and floodplain, Finnegans Creek and Wallpolla Horseshoe	• Spring inundation of Wallpolla East, Sandy Creek and floodplain, Finnegans Creek and Wallpolla Horseshoe	• Spring inundation of Wallpolla East, Sandy Creek and floodplain, Finnegans Creek and Wallpolla Horseshoe • Increased flows in all systems and large-scale floodplain inundation
Possible volume of environmental water required to meet objectives	• N/A	• 2,100 ML	• 2,700 ML	• 4,000 ML

1 Volume includes the estimated volume of environmental water required to underwrite the losses associated with the delivery of consumptive water en route (for flows within the Mullaroo Creek, Lindsay River and Potterwalkagee Creek).)

Risk management

In preparing its seasonal watering proposal, Mallee CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

Engagement

Table 5.2.18 shows the partners and stakeholder organisation with which Mallee CMA engaged when preparing the Lindsay, Wallpolla and Mulcra islands seasonal watering proposal.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies, which include environmental, cultural, social and economic considerations.

Table 5.2.18 Partners and stakeholders engaged in developing the Lindsay, Wallpolla and Mulcra islands seasonal watering proposal

Partner and stakeholder engagement
• Commonwealth Environmental Water Office
• Goulburn-Murray Water
• Murray–Darling Basin Authority
• Parks Victoria
• Department of Environment, Land, Water and Planning
• Victorian Environmental Water Holder
• Mallee CMA Water Technical Advisory Committee (an advisory group to Mallee CMA comprising community members)

Potterwalkagee creek, by Mallee CMA

5.3 Ovens system

Waterway manager – North East Catchment Management Authority

Storage manager – Goulburn-Murray Water

Environmental water holder – Commonwealth Environmental Water Holder

Environmental values

The Ovens system supports a wide range of native fish species including the Murray cod, trout cod, golden perch and fly-specked hardyhead. The Buffalo River is important for large fish species during part of their breeding cycle while trout cod are found as far up the King River as Whitfield. The Ovens system has been the focus of a successful recovery project for trout cod, with efforts to reintroduce Macquarie perch underway.

Frogs (such as the giant bullfrog and growling grass frog) are abundant in the lower Ovens River and associated wetlands and in the King River upstream of Cheshunt. The lower wetlands support birds such as egrets, herons, cormorants, bitterns and treecreepers while the vegetation along the rivers is mostly river red gums and is among the healthiest examples in north-east Victoria.

Social and economic values

Recreational activities include fishing, boating, kayaking, waterskiing, swimming and bushwalking while irrigation supports the food and wine industries that attract many tourists to the region. The lower Ovens/ River Murray weir pool associated with Lake Mulwala is another tourist drawcard. There are also significant Aboriginal cultural heritage values with scar trees and artefact scatters as the physical evidence of Aboriginal people living along the river. The Ovens River continues to be a place of significance for Traditional Owners and their Nations in the region.

Environmental watering objectives in the Ovens system
Provide flows for native fish to move between pools and over rocky or shallow parts of the river
Maintain the form of the river bank and channel plus a range of different river bed surfaces to support all stream life
Scour silt build-up and clean cobbles in river bed pools to maintain habitat for native plants and animals
Maintain water quality for all river life
Provide habitat for a wide range of waterbugs which provide energy, break down dead organic matter and support the river's food chain

System overview

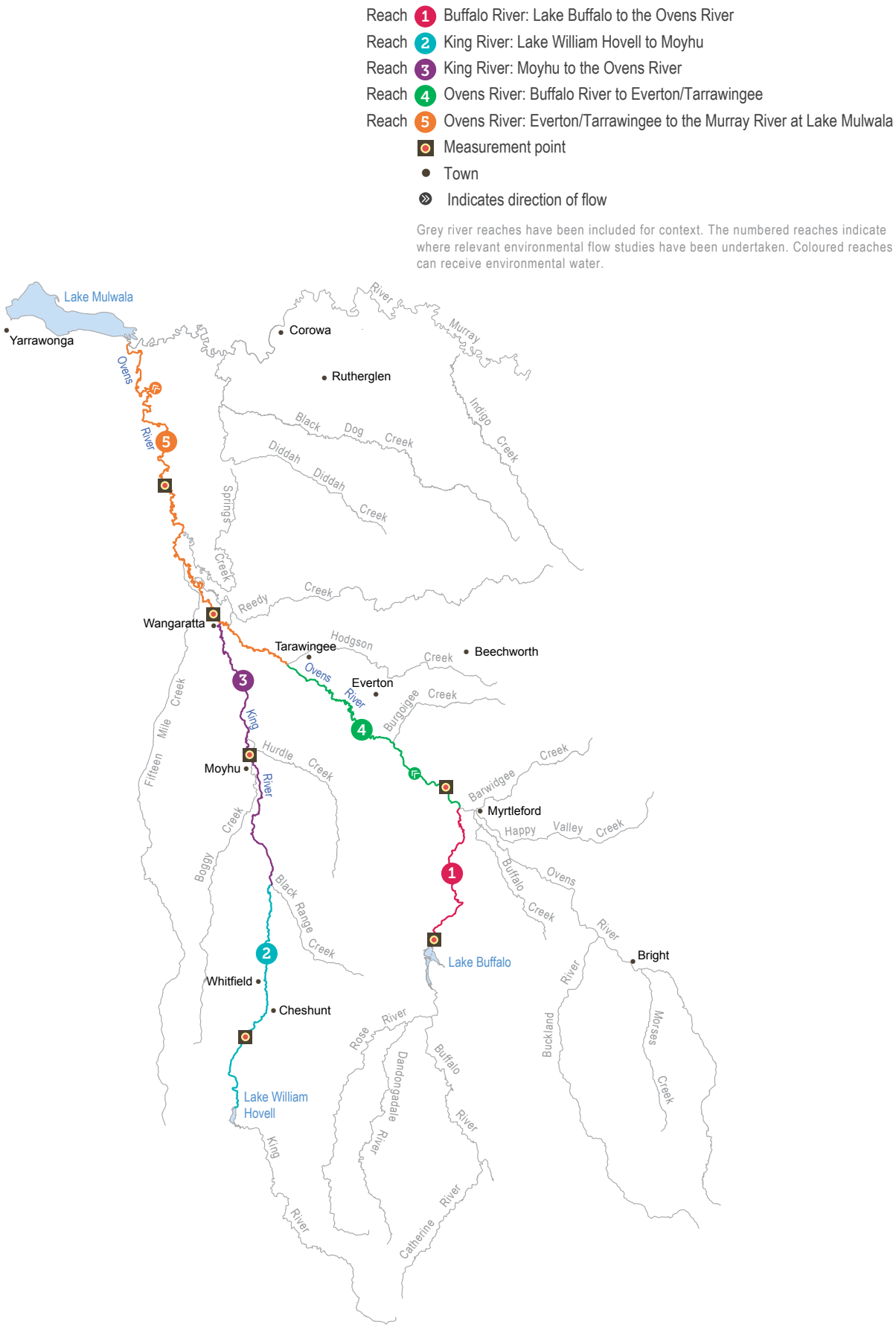
The Ovens system rises in the Great Dividing Range near Mount Hotham and flows about 150 km to join the River Murray in the backwaters of Lake Mulwala. Two small water storages have been constructed in the system: Lake Buffalo on the Buffalo River and Lake William Hovell on the King River. The regulated reaches of the Ovens system include the Buffalo River below Lake Buffalo, the King River below Lake William Hovell and the Ovens River from its confluence with the Buffalo River to the River Murray (as shown in Figure 5.3.1).

The Ovens system maintains quite good natural flows (particularly in winter-spring), compared to other regulated rivers. This is a result of relatively small storages that spill regularly and allow unregulated flows to the rivers.

The Ovens system contributes significantly to the water resources of the River Murray. The water that flows out of the Ovens River is regulated by the largest weir pool (Lake Mulwala) on the Murray regulated system. Ovens River flows contribute to the reliability and the variability of the flow regime for the River Murray and support many downstream uses including irrigation, urban supply and watering of iconic sites (such as Barmah Forest).

Environmental water is held in Lake Buffalo and in Lake William Hovell and can be released under regulated conditions when the storages are not spilling. Five reaches in the Ovens system can benefit from environmental water releases. While all are important, there are relatively small environmental holdings available in the system to meet the needs of all reaches. When water is only available from the holdings, outcomes in the reaches immediately downstream of the storages are targeted. When paired with consumptive water on its way to the Murray system, additional benefits are likely to be achieved downstream in the lower Ovens River.

Figure 5.3.1 The Ovens system



Recent conditions

Some unregulated flows occurred in the Ovens system in winter and spring 2015. Climatic conditions continued the recent trend of the past four years of reduced rainfall: consequently, inflows to the storages were also very low. Releases from storage generally remained at low, stable levels during the irrigation season.

The releases from Lake William Hovell presented an opportunity to add some flow variability by releasing 50 ML of water over two days in early April.

The bulk drawdown of water—a large release from Lake Buffalo to deliver consumptive water downstream and make additional space in the storage—did not occur due to the dry conditions in 2015–16. Consequently, 20 ML of water was released at the end of April to provide some variability downstream of the storage.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.3.1.

Table 5.3.1 Potential environmental watering actions and objectives for the Ovens system

Potential environmental watering	Environmental objectives
Summer/autumn low-flow fresh in reach 5 (1 fresh of 130–260 ML/day for at least 3 days in April–May)	• Maintain flow cues to stimulate movement of native fish • Maintain short-term fluctuations in discharge to move sediment and maintain waterbug habitat • Maintain connectivity between pools and riffles • Scour biofilm from river bed
Supporting variability[1] of summer/autumn low flows targeting reaches 1, 2 and 3	• Maintain natural connectivity between pools and riffles • Maintain short-term fluctuations in discharge to move sediment and maintain waterbug habitat

1 Operational releases from storage can vary, with environmental water used to provide some variability over one or two days.

Scenario planning

Table 5.3.2 outlines the potential environmental watering and expected water usage under a range of planning scenarios.

The climatic conditions and inflows into storages have a large effect on how environmental water is likely to be used. Under dry conditions, environmental water aims to provide low-flow variability below the storages.

As conditions become wetter, there are increased opportunities to piggyback environmental releases on the bulk drawdown of water from Lake Buffalo and achieve environmental outcomes for the length of the regulated river. Environmental water cannot be released if the storages are spilling and under wet conditions the additional risk of overbank flows may result in environmental water not being released at all. However, the desired flows through the Ovens system are likely to be achieved naturally under wet conditions. The Commonwealth environmental water holdings in the Ovens system have a high level of security and are expected to be available under all scenarios except for an extreme dry scenario, where perhaps rights to environmental water could be qualified and therefore not available for release.

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
Expected availability of environmental water		• 50 ML Lake William Hovell • 20 ML Lake Buffalo • 70 ML total	
Potential environmental watering	• Summer/autumn low flows	• Summer/autumn low-flow freshes	• All objectives achieved naturally • Spill conditions and/or risk of overbank flows mean environmental water may not be released
Possible volume of environmental water required to meet objectives	• 70 ML	• 70 ML	• 70 ML

Risk management

In preparing its seasonal watering proposal, North East CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

Engagement

Table 5.3.3 shows the partners with which North East CMA engaged when preparing the Ovens system seasonal watering proposal.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies, which incorporate environmental, cultural, social and economic considerations

Table 5.3.3 Partners engaged in developing the Ovens system seasonal watering proposal

Partner engagement
• Commonwealth Environmental Water Office • Goulburn-Murray Water • Victorian Environmental Water Holder

5.4 Goulburn system

Waterway manager – Goulburn Broken Catchment Management Authority

Storage manager – Goulburn-Murray Water

Environmental water holders – Commonwealth Environmental Water Holder, Victorian Environmental Water Holder, Murray–Darling Basin Authority (the Living Murray program)

The Goulburn is Victoria's largest river basin, covering over 1.6 million hectares or 7.1 percent of the state. The Goulburn River flows for 570 kilometres 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, recreational and Aboriginal cultural heritage values. It supports large areas of intact river red gum forest and provides habitat for threatened and endangered bird and fish species. It also contains important cultural heritage sites, provides water for Victoria's largest irrigation district and supports recreational activities such as fishing and canoeing. There are several wetlands within the Goulburn Broken catchment formally recognised for their conservation significance.

Engagement

Table 5.4.1 shows the partners and stakeholder organisation with which Goulburn Broken CMA engaged when preparing the Goulburn system seasonal watering proposal.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies, which incorporate environmental, cultural, social and economic considerations.

Table 5.4.1 Partners and stakeholders engaged in developing the Goulburn system seasonal watering proposal

Partner and stakeholder engagement
• Commonwealth Environmental Water Office
• Goulburn-Murray Water
• Parks Victoria
• Victorian Environmental Water Holder
• Yorta Yorta Nation Aboriginal Corporation
• Goulburn Environmental Water Advisory Group (includes recreational users, local environment groups and landholders)

5.4.1 Goulburn River

Environmental values

The Goulburn River supports a range of native fish species including golden perch, silver perch, Murray cod, trout cod, Macquarie perch and freshwater catfish. Its aquatic vegetation and submerged logs provide great diversity of habitat to support adult and juvenile fish. The bank vegetation is dominated by river red gums which provide habitat for many species including the squirrel glider. Birds such as egrets, herons and cormorants use trees along the river to roost and feed while frogs benefit from shallow areas.

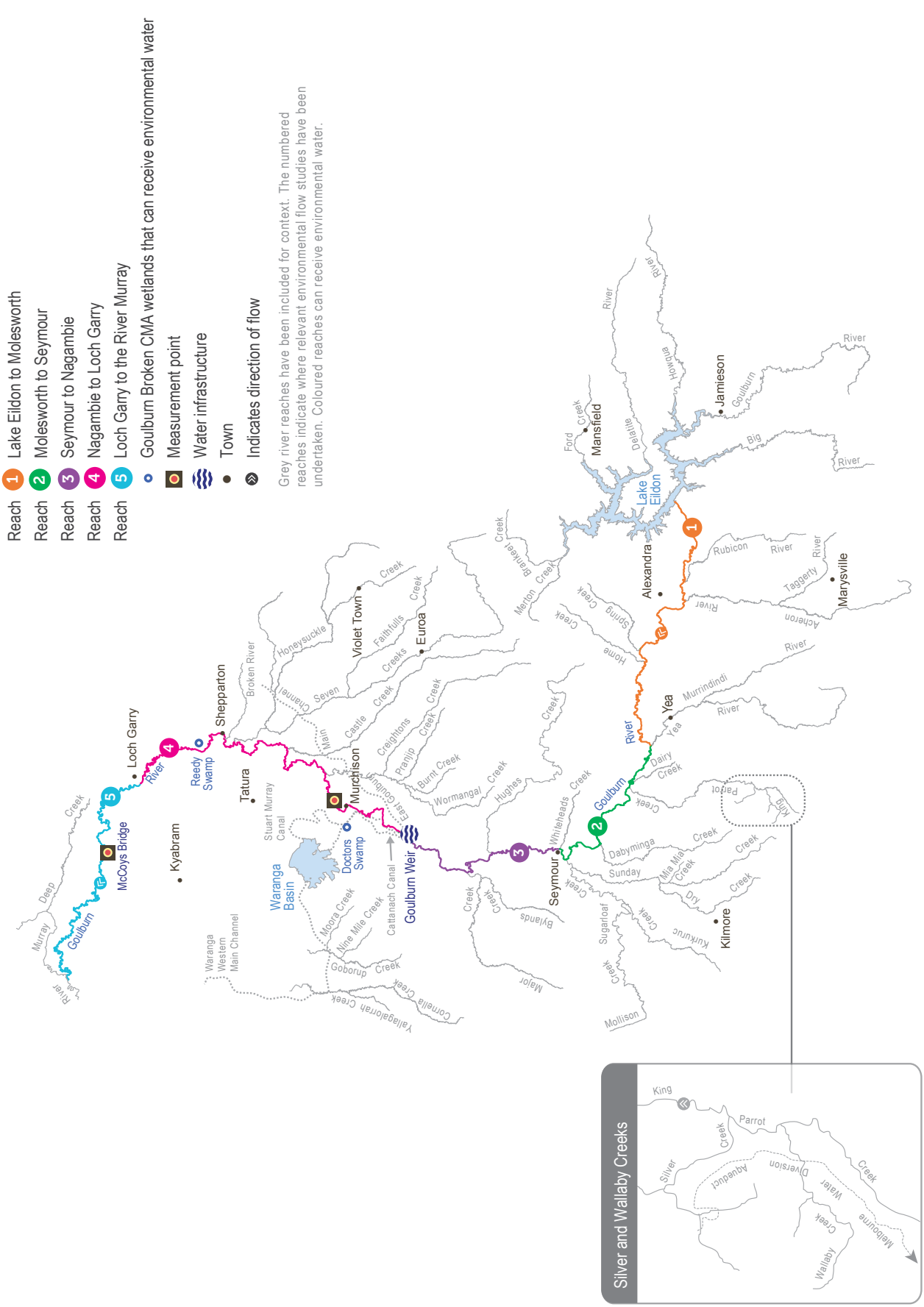
Mid-Goulburn River tributaries between Lake Eildon and Goulburn Weir are important for Macquarie perch habitat while freshwater catfish can be found in lagoons connected to the Goulburn River. The lower Goulburn River below the Goulburn Weir is a significant source of golden perch recruitment, and monitoring shows successful spawning in response to environmental flows.

Social and economic values

The Goulburn River contributes a large proportion of water for use in the Murray–Darling Basin. As part of the Goulburn Broken catchment, it covers two percent of the area of the basin and contributes 11 percent of the water for use in the basin. The majority of this water is used by irrigated agriculture. The Goulburn River is popular for recreation, fishing and boating. Fishing in particular provides substantial economic and social benefits to the region and the river supplies water for towns and stock and domestic users. The river's floodplain also has many important Aboriginal cultural heritage sites such as scar trees, mounds, stone artefact scatters and middens. The Goulburn River continues to be a place of importance for Traditional Owners and their Nations.

Environmental watering objectives in the Goulburn River	
	Increase aquatic and flood-tolerant plants within the river channel and lower banks to provide shelter and food for organisms further up the food chain and to stabilise the river bank
	Protect and boost populations of native fish (including golden perch) by providing habitat flows and encouraging fish to migrate and spawn
	Maintain the form of the river bank and channel and a diversity of riverbed surfaces to support all stream life
	Provide habitat and nourishment for waterbugs which provide energy, break down organic matter and support the river's food chain

Figure 5.4.1 The Goulburn River system



System overview

Lake Eildon and Goulburn Weir have significantly modified the Goulburn River's flow pattern. Due to the impact of water harvesting, lower flows now occur in the Goulburn River in winter and spring while higher flows occur in summer and autumn due to releases to meet irrigation and consumptive demands. This reverses what would happen naturally. The river flow regime is also affected by land use changes and by the construction of small dams and drainage schemes. Levees and other structures prevent water inundating the floodplain. Tributaries downstream of major infrastructure (such as Seven Creeks and the Broken River) help contribute natural flows to the Goulburn River in the lower reaches downstream of Goulburn Weir.

Environmental water in the Goulburn system is held by the VEWH, CEWH and MDBA as part of the Living Murray program. The CEWH is the largest holder of environmental water in the Goulburn system. Availability and use of Commonwealth environmental water is critical to achieving outcomes in the Goulburn River. Environmental water held on behalf of the Living Murray program may also assist in meeting objectives in the Goulburn system en route to icon sites in the Murray system (see section 1.4.2).

Environmental water may need to be delivered through the Goulburn system to meet a downstream environmental objective. Where possible, these releases are managed to achieve outcomes in the Goulburn system before being reused downstream.

Environmental targets can also be met by water delivered from Lake Eildon to meet downstream demands in the River Murray (known as inter-valley transfers). Goulburn inter-valley transfers occur at times during the irrigation season, from spring to autumn. These flows may assist in achieving the desired environmental objectives without the need to release environmental water.

The priority reaches are reaches 4 and 5 in the lower Goulburn River as they are the most flow-stressed sections of the river. Delivery of environmental flows to these target reaches also provides benefits and meets some environmental targets in upstream reaches. The use of environmental water to target objectives above the Goulburn Weir (reaches 1–3) is limited as they receive significant flows for the purpose of transferring consumptive water from Lake Eildon to Waranga Basin. These flows often meet or exceed environmental flow targets in this part of the system for most of the year.

Recent conditions

The dry conditions of 2014–15 became even more severe in 2015–16. Only very small fluctuations in river level occurred from unregulated flows, meaning environmental water deliveries provided the only significant higher flows and flow variability in the lower Goulburn River (reaches 4 and 5). Water released from Lake Eildon and extracted from the river at Goulburn Weir met or exceeded some environmental targets in the mid-Goulburn River (reaches 1, 2 and 3).

Environmental water was delivered downstream of Goulburn Weir through winter and spring to provide baseflows which supported fish and waterbug habitat. One spring fresh and one autumn fresh were delivered to support the recovery of bank vegetation, and some significant improvements in vegetation growth on the lower bank were observed. Some of the environmental water delivered down the Goulburn River was primarily targeted to meet environmental needs in Gunbower Forest and South Australia. No environmental water was released between November and mid-March due to the delivery of consumptive (mainly irrigation) water to the River Murray. Close collaboration between waterway and storage managers resulted in these flows also meeting environmental flow targets.

Monitoring found continued improvement of bank vegetation with an excellent response of mostly native plants establishing on the lower bank. A second spring fresh was not delivered in 2015–16 as a result of reduced water availability and consequently spawning of golden and silver perch was not recorded. However, perch are a long-lived fish and spawning was achieved in the previous two years so this was a lower priority under drier conditions and lower water availability.

Fish surveys continued to record native species such as the Murray cod, Australian smelt, golden and silver perch, trout cod and Murray–Darling rainbowfish. The introduced European carp are also prevalent. Of note, while in past years perch spawning has been successful, recruitment has not been found in the Goulburn River, with an absence of young fish (one to two years old). The reason for this is unclear, though there is a high possibility that the eggs/juvenile fish move into the River Murray. If wet conditions occur in 2016–17, a trial of a summer pulse is proposed to determine if increased flows at this time will attract perch into the Goulburn.

All environmental water deliveries are managed to protect damage to the river banks. This is done by adding variation to stable flows and carefully controlling the rate of rise and fall of freshes. Monitoring of bank condition is showing very positive results with some areas showing thin layers of sediment left on the banks from the delivery of environmental water. This material is supporting the germination and growth of new bank vegetation.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.4.2.

Table 5.4.2 Potential environmental watering actions and objectives for the Goulburn River

Potential environmental watering[1]	Environmental objectives
Year-round baseflows (500 ML/day in reach 4 and/or 540 ML/day in reach 5)	• Maximise habitat and movement opportunities for large- and small-bodied native fish • Provide conditions that support waterbug habitat and food resources including maintaining suitable water quality, encouraging the establishment of aquatic vegetation, submerging snags and encouraging planktonic production
Spring fresh (1 fresh of up to 15,000 ML/day with flows above 5,600 ML/day for 14 days in reach 4 and reach 5 in September–November)	• Support establishment of flood-tolerant bank vegetation • Maintain macrophyte, waterbug and fish habitat by mobilising fine sediments, submerging snags and replenishing slackwater habitat • Initiate spawning and pre-spawning migration and support recruitment of golden perch
Winter fresh (1 fresh of up to 15,000 ML/day with flows above 6,600 ML/day for 14 days in reach 4 and reach 5 in June–August 2017)	• Maintain macrophyte, waterbug and fish habitat by mobilising fine sediments, submerging snags and replenishing slackwater habitat
Summer/autumn fresh (1 fresh of up to 5,600 ML/day for 2 days in reach 4 and reach 5 in February–April)	• Maintain macrophyte, waterbug and fish habitat by mobilising fine sediments, submerging snags and replenishing slackwater habitat • Support establishment of flood-tolerant bank vegetation
Spring/summer fresh (1 fresh of up to 15,000 ML/day for 2 days in reach 4 and reach 5 in November–December)	• Initiate spawning and pre-spawning migrations and recruitment of golden perch • Maintain macrophyte, waterbug and fish habitat by mobilising fine sediments, submerging snags and replenishing slackwater habitat
Increased baseflows (830 ML/day in reach 4 and/or 940 ML/day in reach 5 year-round)	• As for 500–540 ML/day baseflows, plus ... • Submerge additional snags for waterbug food and habitat • Maintain pool depths and sediment distribution • Provide area of slackwater habitat in spring/summer to support spring-spawned larvae and juvenile fish
Summer/autumn pulse (up to 5,000 ML/day in reach 4 and/or reach 5 for 10 days between January–March)	• Attractant flows for fish migration

1 Environmental water may be used to slow the recession of unregulated flows or operational releases to reduce damage to banks and vegetation from rapid drops in water levels. This also helps prevent waterbugs and fish from being stranded in small pools on river banks or benches following higher flows.

Scenario planning

Table 5.4.3 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 environmental water in the Goulburn system. For example, the second of the two proposed spring freshes that target golden perch spawning may not be delivered if monitoring shows spawning was achieved during the first, longer-duration spring fresh.

The highest priority for environmental watering in 2016–17 will be providing year-round baseflows and the long-duration spring fresh and summer/autumn fresh. These provide improved habitat for animals in the river channel and support vegetation on the river banks and margins. Under drought or dry conditions the freshes are likely to be smaller due to less water being available. If better conditions occur, additional freshes and increased baseflows become achievable, targeting spawning and migration of golden and silver perch, waterbug and fish habitat and additional enhancement of bank vegetation.

Under drier scenarios, environmental water objectives focus on maintaining the health of the system. Under wetter scenarios, unregulated flows and water allocations are expected to increase, providing a greater opportunity to improve the health of the river as additional objectives can be achieved. Tier 2 actions are included as desirable objectives if more water becomes available.

In determining potential watering actions for 2016–17, consideration was given to critical carryover into 2017–18. Under a dry or below-average scenario, carryover is a priority to ensure baseflows can be provided from July–September 2017. Under drought conditions the benefits of using all available water to maintain the health of the river are greater than keeping some for the next year. If average or wet conditions occur, the increase in water availability for 2017–18 would mean this carryover would not be essential.

Table 5.4.3 Potential environmental watering for the Goulburn system under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No unregulated flows	• Unregulated flows expected to provide some baseflows between winter to mid-spring and likely winter-spring freshes	• Unregulated flows expected to provide baseflows in winter to mid-spring and likely winter-spring freshes	• Unregulated flows expected to provide high baseflows and multiple overbank flows events in winter/spring
	• Normal minimum passing flows at reach 5 of 400 ML/day from July–October and 350 ML/day from November–June			
Expected availability of environmental water	• 74,000 ML carryover • 15,000 ML VEWH • 58,000 ML CEWH • 8,000 ML Living Murray • 155,000 ML total	• 74,000 ML carryover • 15,000 ML VEWH • 149,000 ML CEWH • 21,000 ML Living Murray • 259,000 ML total	• 74,000 ML carryover • 15,000 ML VEWH • 276,000 ML CEWH • 39,000 ML Living Murray • 404,000 ML total	• 74,000 ML carryover • 15,000 ML VEWH • 276,000 ML CEWH • 39,000 ML Living Murray • 404,000 ML total
Potential environmental watering – tier 1 (high priorities)	• Year-round baseflows • Spring fresh (partial event) • Summer/autumn fresh (partial event)	• Year-round baseflows • Spring fresh • Summer/autumn fresh (partial event)	• Year-round baseflows • Spring fresh • Summer/autumn fresh • Increased baseflows (year-round) • Spring/summer fresh • Recession flow management	• Year-round baseflows • Spring fresh • Summer/autumn fresh • Increased baseflows (year-round) • Spring/summer fresh • Summer/autumn pulse • Recession flow management • Winter 2017 fresh (partial-full event)
Potential environmental watering – tier 2 (additional priorities)	• Increased baseflows (year-round) • Spring/summer fresh • Summer/autumn pulse • Recession flow management • Winter 2017 fresh	• Increased baseflows (year-round) • Spring/summer fresh • Summer/autumn pulse • Recession flow management • Winter 2017 fresh	• Summer/autumn pulse • Winter 2017 fresh	• Winter 2017 fresh (full event)
Possible volume of environmental water required to achieve objectives[1]	• 135,000 ML (tier 1) • 400,000 ML (tier 2)	• 237,000 ML (tier 1) • 400,000 ML (tier 2)	• 378,000 ML (tier 1) • 193,000 ML (tier 2)	• 378,000 ML (tier 1) • 0–120,000 ML (tier 2)
Critical carryover into 2017–18	• 0 ML	• 23,000 ML	• 23,000 ML	• 0 ML

1 Environmental water requirements for tier 2 actions are additional to tier 1 requirements.

Risk management

In preparing its seasonal watering proposal, Goulburn Broken CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

5.4.2 Goulburn wetlands

Environmental values

There are a large number of natural wetlands across the Goulburn catchment including a number that are formally recognised for their conservation significance (such as Reedy Swamp and Doctors Swamp). The wetlands contain vegetation communities ranging from swamps dominated by river red gums to 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. It is also an important stopover site for migratory birds (such as sharp-tailed and marsh sandpipers).

Doctors Swamp is a bioregionally significant swamp and is considered one of the most intact red gum swamps in Victoria.

Social and economic values

Visitor activities enjoyed at the wetlands include bird watching, picnicking, camping and walking. Doctors Swamp is a state game reserve.

The Goulburn wetlands are identified as a culturally sensitive area under the *Victorian Aboriginal Heritage Act 2006*. The Goulburn wetlands have been, and continue to be, places of significance for Traditional Owners. The area traditionally supported a rich and diverse supply of plant and animal resources for food, medicines, shelter, clothing and tools.

Environmental watering objectives in the Goulburn wetlands

Improve the range of native plant life including river red gum and grassy wetland species

Provide drought refuge, habitat and breeding and feeding opportunities for migratory and colonial nesting waterbirds

System overview

Both Doctors Swamp and Reedy Swamp can receive environmental water via irrigation supply infrastructure within the Shepparton and Central Goulburn irrigation districts. The volume delivered at any one time depends on available capacity in the irrigation supply network.

Reedy Swamp is naturally inundated during high flows (of about 20,000 ML per day) in the Goulburn River. Doctors Swamp can only receive environmental water if the Cattanach Canal is running at 2,500 ML per day and there is available capacity after irrigation demand is met, which is also influenced by the operation of Waranga Basin. Due to this the opportunity to deliver environmental water is greater in autumn and winter.

Recent conditions

Significantly low rainfall and high temperatures meant that there were minimal natural inflows to Reedy Swamp and Doctors Swamp in winter and early spring of 2015.

In 2015–16 environmental water was delivered to Reedy Swamp and Doctors Swamp to support a large diversity of waterbirds and wetland plant species. Large rainfall events between October and December 2015 produced some natural flows into Reedy Swamp, which supported the outcomes of the spring watering.

Wetland plants including river red gums responded very well to the spring watering. Monitoring showed an increase in waterbird species (including ducks, swans, yellow-billed spoonbills and ibis) feeding and roosting at both swamps. This included some species listed in the *Victorian Flora and Fauna Guarantee Act 1988* (such as the eastern great egret).

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.4.4.

Table 5.4.4 Potential environmental watering actions and objectives for the Goulburn wetlands

Potential environmental watering	Environmental objectives
Reedy Swamp (fill in late winter/spring and provide top-ups in spring/summer as required)	• Maintain as a drought refuge for waterbirds • Improve the diversity of wetland vegetation • Provide waterbird breeding and feeding habitat particularly for migratory and colonial nesting species
Doctors Swamp (fill in autumn/winter 2017)	• Maintain the diversity of wetland vegetation • Provide waterbird breeding and feeding habitat

Scenario planning

Table 5.4.5 outlines potential environmental watering and expected water usage under a range of planning scenarios.

Goulburn Broken CMA has planned wetland watering to ensure there is a diversity of habitat types to support waterbirds and other water-dependant animals in the region at any point in time.

Reedy Swamp has been identified as a significant drought refuge for waterbirds. It has a high ecological value due to the diverse community of water-dependent plants and animals it supports. It is known to be a large rookery for Australian white ibis, straw-necked ibis and royal spoonbills. In wetter conditions Reedy Swamp will mostly fill from natural inflows, although it is planned to receive environmental water in autumn if it doesn't fill naturally in winter/spring.

Doctors Swamp is a highly valued site for waterbird habitat and wetland plant diversity. Under wetter conditions Doctors Swamp is planned to receive environmental water either in winter/spring 2016 or late autumn/winter 2017. If Doctors Swamp does not fill from natural inflows in winter/spring the priority is to fill the wetland in late autumn/winter to support the optimum watering regime for river red gums.

In drier periods (when irrigation demand is high), there may be capacity constraints in the irrigation networks that may affect environmental water deliveries in the Goulburn wetlands. These potential constraints will be assessed to inform delivery.

In wetter periods, the ecological and hydrological objectives of these wetlands may be largely met by natural inflows. Only small volumes of environmental water may be required to extend the duration or extent of natural flooding.

The decision to deliver environmental water to Goulburn wetlands will be based on their hydrological condition and waterbird breeding activity, and on the potential effect of environmental watering on wetland vegetation communities.

Table 5.4.5 Potential environmental watering for the Goulburn wetlands under a range of planning scenarios

Planning scenario[1]	Drought	Dry	Average	Wet
Expected catchment conditions	• Catchment run-off and unregulated flows into the wetlands is 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 1 (high priorities	• Reedy Swamp	• Reedy Swamp	• Doctors Swamp (winter/spring)	• Doctors Swamp (winter/spring)
Potential environmental watering – tier 2 (additional priorities)[2]	• N/A	• N/A	• Doctors Swamp • (autumn/winter) • Reedy Swamp	• Doctors Swamp • (autumn/winter) • Reedy Swamp
Possible volume of environmental water required to achieve objectives[3]	• 1,235 ML (tier 1)	• 1,235 ML (tier 1)	• 500 ML (tier 1) • 1,120 ML (tier 2)	• 500 ML (tier 1) • 1,120 ML (tier 2)
Priority carryover requirements	• 1,235 ML	• 1,235 ML	• 500 ML	• 500 ML

1 If any of the wetlands support significant waterbird breed events in spring/summer environmental water deliveries may be considered to support bird habitat until fledging.
2 If tier 2 wetlands have exceeded their optimum drying periods within the 2016–17 water year and not received any natural inflows, they would be increased to a tier 1 priority for autumn/winter in 2017 to protect their ecological values.
3 Environmental water requirements for tier 2 actions are additional to tier 1 requirements.

Risk management

In preparing its seasonal watering proposal, Goulburn Broken CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

5.5 Broken system

Waterway manager – Goulburn Broken Catchment Management Authority

Storage manager – Goulburn-Murray Water

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

The Broken system (including the Broken River, lower Broken Creek, upper Broken Creek and wetlands) supports threatened plant and animal species. These include six native fish species of Victorian and national conservation significance (such as the iconic Murray cod). The system also supports a diverse range of habitats for fish and waterbirds, especially in cane grass wetlands that provide important brolga breeding habitat. The lower Broken Creek forms an important part of the irrigation distribution system, delivering water from the Murray and Goulburn systems into the Murray Valley and Shepparton irrigation districts. It contains important Aboriginal cultural heritage sites and is also popular for recreation.

Engagement

Table 5.5.1 shows the partners and stakeholder organisations with which Goulburn Broken CMA engaged when preparing the Broken system seasonal watering proposal.

Seasonal watering proposals are informed by longer-term plans such as regional waterway strategies and environmental water management plans. These longer-term plans incorporate a range of environmental, cultural, social and economic perspectives.

Table 5.5.1 Partners and stakeholders engaged in developing the Broken system seasonal watering proposal

Partner and stakeholder engagement
• Broken Environmental Water Advisory Group (comprising community members)
• Commonwealth Environmental Water Office
• Goulburn Broken Catchment Wetland Advisory Group (with representation from Goulburn Valley Landcare, Field and Game Australia, Goulburn-Murray Water, Moira Shire, Council of Greater Shepparton, Turtles Australia, Parks Victoria, Trellys Fishing and Hunting and Kinnairds Wetland Advisory Committee)
• Murray–Darling Basin Authority (River Murray Water)
• Victorian Environmental Water Holder
• Yorta Yorta Nation Aboriginal Corporation

5.5.1 Upper Broken Creek

Environmental values

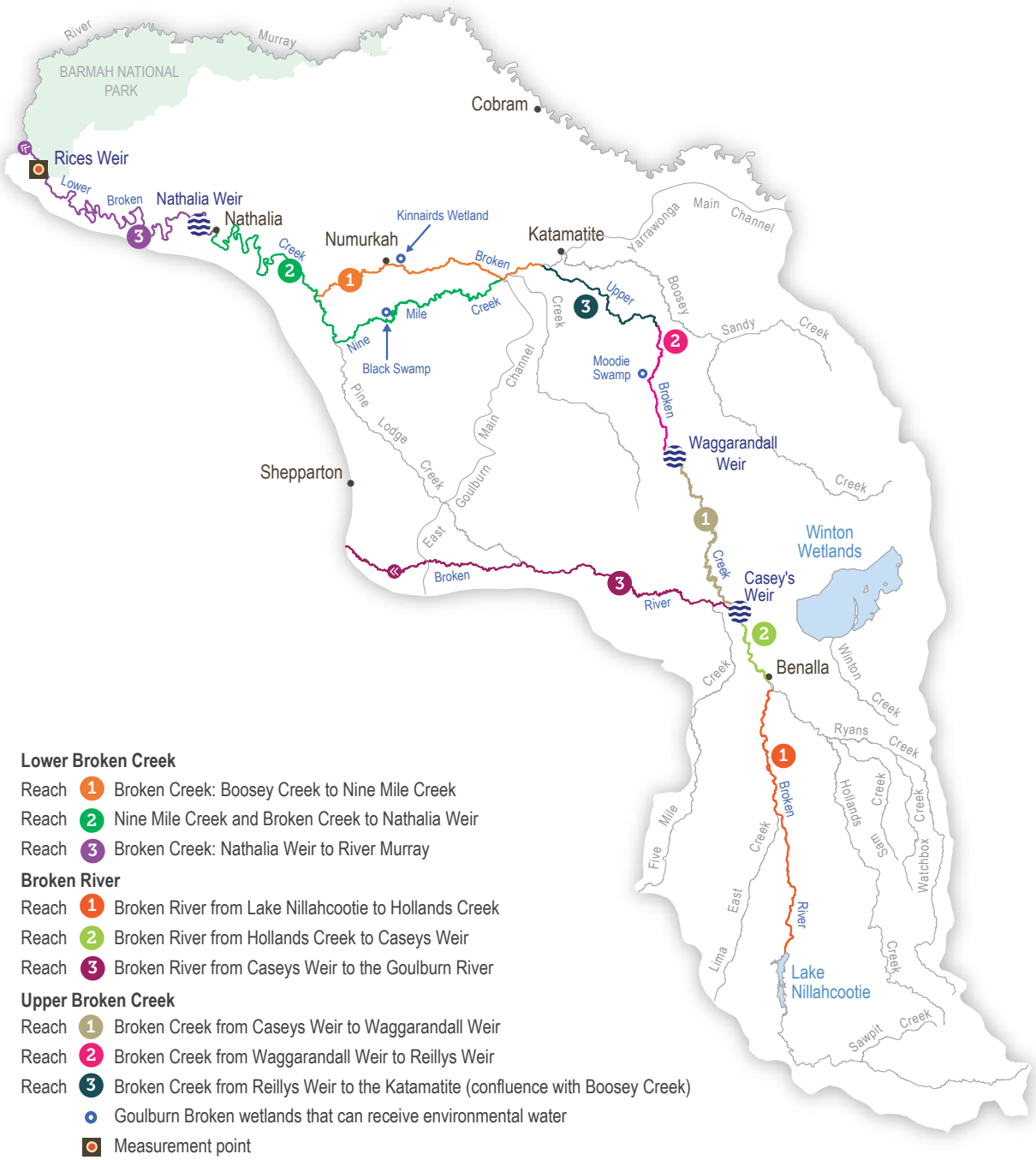
The upper Broken Creek area is dominated by unique box riparian vegetation and supports remnant plains grassy woodland. Much of this area also lies in the Broken–Boosey State Park, which contains high-quality native vegetation. The creek supports a variety of threatened animals including fish species such as the carp gudgeon, Murray cod, golden perch and Murray–Darling rainbowfish.

Social and economic values

Most of upper Broken Creek is in the Broken–Boosey State Park which contains a range of Aboriginal cultural heritage values including scar trees and sites of significance for Traditional Owners. The system also support a range of recreational and tourism values, providing opportunities for bushwalking, fishing and bird watching. Upper Broken Creek is an important source of water and a delivery mechanism for some stock and domestic and irrigation customers.

Environmental watering objectives in the upper Broken Creek system	
	Move built-up sand and clay material to restore deep pools and provide habitat for water animals
	Improve and maintain plants on the riverbank and in the river channel
	Protect and boost populations of native fish (including threatened Murray cod and golden perch) by improving pool habitat
	Maintain water quality
	Support a wide range of waterbugs to provide energy, break down dead organic matter and support the river's food chain

Figure 5.5.1 The Broken system



Lower Broken Creek

Reach 1 Broken Creek: Boosey Creek to Nine Mile Creek
Reach 2 Nine Mile Creek and Broken Creek to Nathalia Weir
Reach 3 Broken Creek: Nathalia Weir to River Murray

Broken River

Reach 1 Broken River from Lake Nillahcootie to Hollands Creek
Reach 2 Broken River from Hollands Creek to Caseys Weir
Reach 3 Broken River from Caseys Weir to the Goulburn River

Upper Broken Creek

Reach 1 Broken Creek from Caseys Weir to Waggarandall Weir
Reach 2 Broken Creek from Waggarandall Weir to Reillys Weir
Reach 3 Broken Creek from Reillys Weir to the Katamatite (confluence with Boosey Creek)

Goulburn Broken wetlands that can receive environmental water
Measurement point
Water infrastructure
Town
Indicates direction of flow

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.

System overview

The Broken Creek diverges from the Broken River downstream of Benalla and flows to the River Murray near Barmah Forest. The creek is located on a flat riverine plain and has naturally low run-off from its local catchment. It also receives flood flows from the Broken River, although these are much less frequent than occurred naturally due to earthworks and road construction.

Upper Broken Creek is the section of creek from Caseys Weir to Katamatite which extends about 65 kilometres. The creek has been used for water supply from the Broken River for more than 100 years, although irrigation entitlements have been significantly reduced (by more than 80 percent) as part of water savings projects in the last ten years. There are now low flows all year round at the top of the creek (Caseys Weir to Waggarandal Weir) as water can only be supplied from Broken River based on orders from customers in the creek. In the lower reaches (Waggarandal Weir to Reillys Weir and Reillys Weir to Katamatite), the system is most influenced by rainfall and catchment run-off which provides infrequent flow variability. Diverting water from the Broken River to the top reach may achieve some environmental objectives.

Recent conditions

Over the last ten years, flows in the upper Broken Creek have not exceeded 70 ML per day with minimal high-flow variability. No environmental water was delivered to the upper Broken Creek in 2015–16, although an autumn delivery to Moodie Swamp provided some benefit to the creek through increased flows on the way to the wetland.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.5.2.

Table 5.5.2 Potential environmental watering actions and objectives for the upper Broken Creek system

Potential environmental watering	Environmental objectives
Summer/autumn fresh (1 fresh of up to 200 ML/day for 2 days in December–May)	• Rehabilitate deep pool habitats and facilitate the movement of sediments • Maintain and enhance riparian and in-channel vegetation (water ribbons and river red gum communities) with variable wet and dry zones • Maintain water quality, particularly in refuge pools • Maintain and restore waterbug habitat by providing occasional freshes to complete life cycles

Scenario planning

Table 5.5.3 outlines the potential environmental watering and expected water usage under a range of planning scenarios.

If there is any allocation made available in the Broken system, the use of Commonwealth environmental water is considered available for use in the creek, but it may need to be prioritised against delivery to Moodie Swamp (see section 5.5.3). More water is required to achieve the identified potential watering actions with an extra 147 ML required to deliver a summer/autumn fresh.

Table 5.5.3 Potential environmental watering for the upper Broken Creek system under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No unregulated flows	• Minimal unregulated flows	• Some contribution of unregulated flows in upper Broken Creek, particularly in winter/spring	
Expected availability of environmental water	• 0 ML	• 10 ML	• 253 ML	
Potential environmental watering	• Summer/autumn fresh			
Possible volume of environmental water required to achieve objectives	• Up to 400 ML			

Risk management

In preparing its seasonal watering proposal, Goulburn Broken CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

5.5.2 Lower Broken Creek

Environmental values

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 Murray–Darling rainbowfish. The associated floodplain and wetland habitats support box-dominated grassy woodland communities and numerous threatened species of state and national conservation significance including buloke, the bush stone-curlew and the brolga.

Social and economic values

The lower Broken and Nine Mile creeks and associated floodplain and wetland habitats contain many important Aboriginal cultural heritage sites, provide water for agriculture and urban centres and support a variety of recreational activities such as fishing and bushwalking.

Environmental watering objectives in the lower Broken Creek system

	Control excessive build-up of azolla, a native aquatic plant that can lower water quality in the creek when significant blooms occur
	Protect and boost populations of native fish (including the threatened Murray cod, golden perch and silver perch) by providing habitat flows and encouraging fish to migrate and spawn
	Maintain healthy water oxygen levels

System overview

The lower Broken and Nine Mile creeks have been regulated for over 100 years, significantly altering their flow regimes. Pre-regulation, the creeks would have mainly flowed in winter and spring and the adjacent floodplain would have received more regular flooding from overbank flows. In summer and autumn, the creeks would have had much less flow, even reducing to pools and drying out completely. The creeks now flow at a relatively constant level from mid-August until mid-May with numerous weirs that support adjacent irrigated farming. This has resulted in changes to the way native animals use the creek. Previously, native fish would have moved into the creek when it was flowing and moved back out into the River Murray when it dried. The creek now provides year-round habitat for native fish, permanently holding water and with fish passage structures through all the weirs. Consequently, environmental water is used to support this permanent native fish habitat.

The lower Broken Creek is operated separately to the upper Broken Creek and Broken River because regulated water is delivered to the lower Broken Creek from the Goulburn and Murray systems via the irrigation channel network, rather than from the Broken River.

Environmental water provided in the lower Broken Creek can be sourced from both the Goulburn and Murray systems. Environmental water is released from the Goulburn system through the East Goulburn main channel and from the Murray system through the Yarrawonga main channel. The priority river reach for environmental watering is reach 3 (from Nathalia Weir Pool to the River Murray), with flows to this reach expected to also deliver the desired flows in reaches 1 and 2. The measurement point for target flows in lower Broken Creek is at Rices Weir.

Recent conditions

Unregulated winter flows were significantly lower in July–August 2015 than in the previous winter. There were no further significant rainfall events that triggered unregulated flows in the systems for the remainder of the irrigation season.

Between the opening of the irrigation season on 15 August and the end of August, flows at Rices Weir averaged 240 ML per day. This was higher than normally targeted at this time of year and was a result of the delivery of the Goulburn system water quality reserve to dilute and flush irrigation channels of residual herbicide applied for the treatment of arrowhead, an aquatic weed. There were no negative effects recorded and the flows helped flush a build-up of azolla from the creek that developed during the low pre-irrigation-season flows.

Environmental watering commenced slightly later than normal in early September following the completion of the delivery of water from the Goulburn system water quality reserve. Flows reduced in September, averaging 162 ML per day, which helped minimise further azolla build-up.

Between October and the end of April the flow target was 250 ML per day, and flows generally ranged between 200 ML per day and 350 ML per day. As well as environmental water, Goulburn inter-valley transfer and Murray choke bypass flows contributed a significant proportion of the flows. The coordination of environmental and operational water deliveries helped achieve both environmental outcomes and delivery of water to downstream users.

In February a blue-green algae outbreak occurred in the Murray and made its way into the lower Broken Creek. In early March, a local heatwave increased water temperatures to close to 30oC. These two factors combined to result in low dissolved oxygen levels at Rices Weir for about a week. A proactive fish relocation project was initiated, capturing native fish and relocating them downstream of Rices Weir. All fish moved were in good condition and no other signs of stress (such as fish gulping for air at the surface) were observed. This indicates that either the fish were able to move to find better water quality in the immediate area or up and down the creek—there are fish ladders allowing passage along the creek and into the River Murray—or they were able to cope with the low dissolved oxygen levels until they improved.

The target flow at Rices Weir was reduced to 150 ML per day in May but with local rain and reduced irrigation demand it remained around 250 ML per day before ceasing at the end of the irrigation season on 15 May.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.5.4.

Table 5.5.4 Potential environmental watering actions and objectives for the lower Broken Creek

Potential environmental watering	Environmental objectives
Year-round low flows (40 ML/day)[1]	• Provide native fish passage
Winter/spring medium flows (120 ML/day in August–November)	• Minimise azolla growth
Spring/summer/autumn medium flows (150–250 ML/day in October–May)	• Maintain water quality, including dissolved oxygen levels above 5 mg/L
Winter/spring freshes (120–250 ML/day for up to 14 days in August–November)	• Remove large azolla blooms
Spring/summer high flows (250 ML/day in September–December)	• Increase native fish habitat during migration and breeding seasons

1 Primarily during the irrigation season between mid-August and mid-May, but it may be delivered year-round subject to supply constraints.

Scenario planning

Table 5.5.5 outlines the potential environmental watering and expected water usage under a range of planning scenarios.

Due to regulation of the lower Broken and Nine Mile creeks, their environmental water needs are relatively fixed from year to year and independent of annual climatic conditions.

During the season, the environmental water flows of the lower Broken Creek can vary and focus on maximising the habitat and movement of fish, maintaining water quality and flushing azolla through the system. The required volume to meet these objectives decreases from a dry to a wet scenario as unregulated flows would contribute a greater amount under wetter conditions.

Risk management

In preparing its seasonal watering proposal, Goulburn Broken CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

Table 5.5.5 Potential environmental watering for the lower Broken Creek under a range of planning scenarios

Planning scenario	Dry	Average	Wet
Expected river conditions	• Some unregulated flows in winter • No unregulated flows throughout the irrigation season (mid-August–May) • No diversion of unregulated River Murray flows available	• Unregulated flows in winter/spring • No unregulated flows from October–May • Diversion of unregulated River Murray flows available mid-August–October	• Unregulated flows in winter/spring • No unregulated flows from November–May • Diversion of unregulated River Murray flows available mid-August–November
Potential environmental watering	• Year-round low flows • Winter/spring medium flows • Summer/autumn medium flows • Winter/spring freshes	• Year-round low flows • Winter/spring medium flows • Summer/autumn medium flows • Winter/spring freshes • Spring/summer high flows	
Possible volume of environmental water required to achieve objectives	• 62,000 ML	• 61,000 ML	• 50,000 ML

5.5.3 Broken wetlands

Environmental values

The Broken wetlands (which include Moodie Swamp, Kinnairds Wetland and Black Swamp) support a diversity of vegetation communities ranging from swamps dominated by river red gums to cane grass wetlands. The wetlands contain state and nationally threatened species and communities including rigid water milfoil and river swamp wallaby grass. The wetlands also provide food resources and breeding habitat for bird species listed in international agreements and conventions (such as the brolga and royal spoonbill).

Social and economic values

The Broken wetlands have been and continue to be places of significance for the Traditional Owners of the Yorta Yorta Nation. The wetlands traditionally provided a rich and diverse supply of plant and animal resources for food, medicines, shelter, clothing and tools. Some of the sites have artefacts and scar trees recorded in or adjacent to them.

The wetlands support a range of recreational activities including bird watching, bike riding, bush walking and camping. Moodie Swamp and Black Swamp are state game reserves.

Environmental watering regime objectives in the Broken wetlands

- Maintain or improve the diversity of wetland vegetation
- Maintain populations of nationally threatened plant species (such as ridged water milfoil, slender water milfoil and river swamp wallaby grass)
- Promote feeding and breeding habitat for waterbirds, particularly for brolga

System overview

Of some 2,000 natural wetlands in the Goulburn Broken area, only three in the Broken catchment (Black Swamp, Kinnairds Wetland and Moodie Swamp) can receive environmental water. The natural water regimes of these wetlands have been greatly influenced by their positions in the surrounding Shepparton, Central Goulburn and Murray Valley irrigation districts, which have changed the timing, frequency, volume and duration of inundation. Environmental watering aims to replace some of the more natural patterns of wetting and drying of the wetlands. Water is delivered to the wetlands using irrigation supply infrastructure.

Recent conditions

Significantly low rainfall and high temperatures meant that there were no natural inflows to Black Swamp, Kinnairds Wetland and Moodie Swamp in winter and early spring of 2015.

Environmental watering in 2015–16 included a winter/spring fill in Black Swamp and Kinnairds Wetland to promote a diversity of wetland vegetation following fires in 2014 and also to support waterbird breeding and feeding. A late-autumn fill was provided to Moodie Swamp to promote the growth of wetland vegetation to provide habitat for brolga and Australasian bittern.

Black Swamp watering resulted in significant growth of the river swamp wallaby grass, listed in the *Environmental Protection and Biodiversity Conservation Act 1999*. A state-listed rare water nymph was also found for the first time at Black Swamp. The near-threatened magpie geese also roosted at Black Swamp for the first time on record following the spring watering. Unfortunately, the delivery regulator at Black Swamp was tampered with several times (in October 2015 and March 2016) which resulted in the drowning of young plants that had germinated in spring following environmental water delivery and also the drowning of newly planted wetland vegetation.

Native vegetation at Kinnairds Wetland responded positively to the watering, and for the second time magpie geese were recorded at the wetland. Additional top-ups were provided in late spring and summer to maintain habitat to support magpie geese feeding, roosting and breeding.

Moodie Swamp received a delivery in late autumn 2016. The delivery was to encourage the growth of important wetland vegetation species including southern cane grass and rigid water milfoil and to provide feeding and breeding habitat for waterbirds including brolga and Australasian bittern.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.5.6.

Table 5.5.6 Potential environmental watering actions and objectives for the Broken wetlandss

Potential environmental watering	Environmental objectives
Moodie Swamp (fill in late winter/spring and provide top-ups as required)	• Maintain the diversity of wetland vegetation • Maintain populations of the nationally threatened rigid water milfoil • Provide waterbird feeding and breeding habitat, particularly for Brolga
Kinnairds Wetland (fill in late autumn/winter if it has remained dry and the maximum drying regime has been reached; provide top-ups as required)	• Improve the diversity of wetland vegetation • Maintain populations of the nationally threatened rigid water milfoil and slender water milfoil • Provide waterbird feeding and breeding habitat, particularly for royal spoonbills and the Australasian shoveler
Black Swamp (fill in late autumn/winter if it has remained dry and the maximum drying regime has been reached; provide top-ups as required)	• Improve the diversity of wetland vegetation • Maintain populations of the nationally threatened rigid water milfoil and slender water milfoil • Provide waterbird feeding and breeding habitat, particularly for royal spoonbills and the Australasian shoveler

Scenario planning

Table 5.5.7 outlines potential environmental watering and expected water usage under a range of planning scenarios.

Landscape-scale planning for these wetlands has been undertaken by the Goulburn Broken CMA to ensure a diversity of habitat types are available to support waterbirds and other water-dependant animals in the region.

Moodie Swamp has been identified as very high priority in all planning scenarios as it supports important cane grass habitat for brolga and Australasian bittern. It also supports a diverse community of water-dependent plants and animals. Watering in winter/spring of 2016–17 is important to build on the vegetation outcomes from the 2016 autumn watering.

Both Kinnairds Wetland and Black Swamp have been identified as providing important habitat for waterbirds and wetland vegetation communities (including ridged water milfoil and river swamp wallaby grass). If natural inflows do not occur in the wetlands in autumn/winter 2016, environmental water is planned to be delivered to inundate the wetlands to provide conditions that promote vegetation growth and feeding and breeding opportunities for waterbirds.

In wetter conditions, the ecological objectives at these wetlands are typically met by natural inflows, and only small volumes of environmental water are required to extend the duration or extent of natural flooding. In average to wet conditions autumn top-ups in Moodie Swamp, Kinnairds Wetland and Black Swamp are a priority to support the ecological characteristics of the wetlands.

The decision to deliver environmental water to Broken wetlands will be based on their hydrological condition and waterbird breeding activity, and on the potential impact of environmental watering on wetland vegetation communities.

Risk management

In preparing its seasonal watering proposal, Goulburn Broken CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

Table 5.5.7 Potential environmental watering for the Broken wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected catchment conditions	• Catchment run-off and unregulated flows into the wetlands is 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 1 (high priorities)	• Moodie Swamp	• Moodie Swamp	• Moodie Swamp (winter/ spring)	• Moodie Swamp (winter/ spring)
Potential environmental watering – tier 2 (additional priorities)[2]	• N/A	• N/A	• Moodie Swamp (autumn/winter) • Kinnairds Wetland • Black Swamp	• Moodie Swamp (autumn/ winter) • Kinnairds Wetland • Black Swamp
Possible volume of environmental water required to achieve objectives[1]	• 500 ML (tier 1)	• 500 ML (tier 1)	• 500 ML (tier 1) • 1,060 ML (tier 2)	• 500 ML (tier 1) • 1,060 ML (tier 2)

1 Environmental water requirements for tier 2 actions are additional to tier 1 requirements.
2 If tier 2 wetlands have exceeded their optimum drying periods within the 2016–17 water year and have not received any natural inflows, they would be increased to a tier 1 priority for autumn/winter in 2017 to protect their ecological values.

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, Commonwealth Environmental Water Holder, the Murray-Darling Basin Authority (the Living Murray program)

The Campaspe River catchment extends from the Great Dividing Range in the south to the River Murray in the north, a total distance of about 150 kilometres. The major waterways of the catchment are the upper Campaspe River and the Coliban River (both upstream of Lake Eppalock) and the lower Campaspe River (downstream of Lake Eppalock). Major tributaries are McIvor and Pipers creeks upstream of Lake Eppalock, and Mount Pleasant and Axe creeks downstream of Lake Eppalock.

Malmsbury Reservoir on the Coliban River provides water for towns and stock and for domestic consumption. Lake Eppalock was constructed in 1965 on the Campaspe River below its confluence with the Coliban River. The storage is an important source of water for downstream irrigated agriculture; of town water for Bendigo, other local towns and more recently Ballarat (via the Goldfields Superpipe); and for the environment.

Engagement

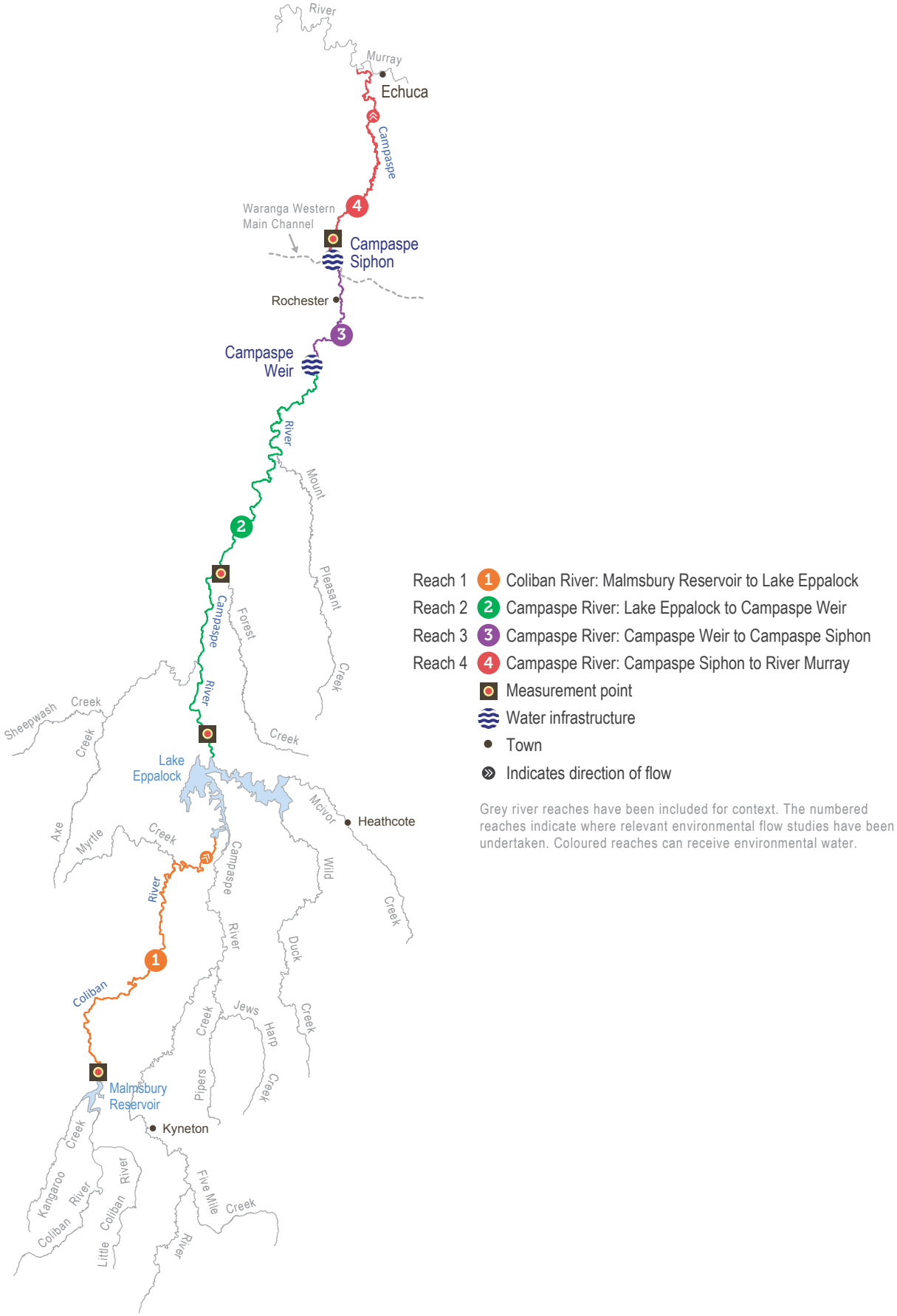
Table 5.6.1 shows the partners and stakeholder organisations with which North Central CMA engaged when preparing the Campaspe system seasonal watering proposal.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies, which incorporate environmental, cultural, social and economic considerations.

Table 5.6.1 Partners and stakeholders engaged in developing the Campaspe system seasonal watering proposal

Partner and stakeholder engagement
• Campaspe Environmental Water Advisory Group (comprising community members, Department of Environment, Land, Water and Planning, Goulburn-Murray Water, North Central CMA, the VEWH and the Commonwealth Environmental Water Office)
• Coliban Water
• Commonwealth Environmental Water Office
• Goulburn-Murray Water
• North Central CMA Community Consultation Committee, a committee of the North Central CMA providing community and local perspectives on North Central CMA projects and functions that have direct public benefits
• North Central CMA Board
• Victorian Environmental Water Holder

Figure 5.6.1 The Campaspe system



5.6.1 Campaspe River

Environmental values

The Campaspe River below Lake Eppalock provides important habitat for several fish species including the Murray cod, silver perch, golden perch, Murray–Darling rainbowfish and flat-headed gudgeon. Maintaining flows is important for migration opportunities and dispersal of juveniles for platypus as well as fish. Turtles and frogs are also present and there is a highly connected, intact river red gum canopy along the river banks that supports terrestrial species (such as the squirrel glider).

Social, cultural and recreational values

The Campaspe River is an important source of water and a delivery mechanism for irrigation and town water. Popular recreational activities along the Campaspe River include camping, boating, kayaking, fishing, swimming, bush walking, picnicking and bird watching. These activities draw locals and tourists alike, providing economic benefit to towns along the river. The Campaspe River is culturally significant with Aboriginal cultural heritage sites such as shell deposits, scar trees, mounds and some artefacts recorded along the banks.

Environmental watering objectives in the Campaspe River system	
	Sustain adult river red gums and encourage the growth of new plants Maintain and increase the cover of in-stream and riverside plants
	Provide habitat to help protect and boost populations of native fish Promote the return of native fish species (such as the trout cod, river blackfish and Macquarie perch)
	Support the resident platypus population by providing places to rest, breed and feed, as well as dispersal opportunities to the River Murray
	Provide connection along the length of the Campaspe River and into the River Murray
	Control salinity and maintain healthy levels of oxygen in deep pools
	Support a wide range of waterbugs to provide energy, break down dead organic matter and support the river's food chain

System overview

The construction and operation of Lake Eppalock has significantly altered downstream river flows and reversed the seasonal flows. The storage captures rainfall run-off and reduces natural winter and spring flows downstream, which is then released as increased flows over summer and autumn. Environmental water is held and released from Lake Eppalock, with some limited ability to regulate flows further downstream at the Campaspe Weir.

Higher flows in summer can mean less suitable habitat for juvenile fish. Delivering water to users downstream in the River Murray when they need it over summer is essential, and storage managers and the CMA have been working cooperatively to do this in an environmentally sensitive manner. This cooperation results in deliveries to downstream users having as little negative effect on native plants and animals as possible.

Providing the target flows in all reaches below Lake Eppalock is important. Environmental watering usually targets reach 4 which will also achieve the desired flow objectives in reaches 2 and 3. Primary measurement points are at Barnadown (reach 2) and downstream of the Campaspe siphon (reach 4). In specific circumstances, water can be delivered to reach 4 from the Goulburn system via the Waranga western main channel.

Recent conditions

Rainfall was below-average in 2015–16 and the traditional storage inflow period of August–November recorded about 40 percent less than the long-term average. Consequently, streamflows into Eppalock for the year to the end of April 2015 were very low, equating to the driest three percent of years.

Environmental water was delivered in accordance with the dry conditions with low flows targeting minimum levels to support the native plants and animals that depend on the river. Where releases from storage for downstream users met the low-flow objective, environmental water was kept in the storage for later in the year.

Monitoring showed continuing improvement in native fish (with increased numbers of golden perch and Murray–Darling rainbowfish) while dwarf flathead gudgeon were recorded for the first time in 2015. To support native fish, environmental water was used to provide minimum flows during the year to maintain their habitat and allow movement of fish up and down the river, including to or from the River Murray. Small freshes in summer and autumn helped maintain water quality, trigger fish movement and support plants. One of the three freshes occurred following a summer storm in January, which resulted in rainfall run-off briefly increasing flows in the river. This natural event meant environmental water was not needed to deliver this fresh.

Vegetation surveys found that in-channel aquatic vegetation recovery following the millennium drought and subsequent flood is continuing. A range of species were identified, particularly in reaches 2 and 3 below the storage. Fringing vegetation has also continued to recover in these reaches. These vegetation improvements are not as great downstream between Rochester and Echuca (reach 4), possibly due to the heavier clay banks making it harder for new plants to establish, impacts such as stock access or a lack of seed from upstream.

Larger freshes delivered in winter helped support successful platypus breeding in the Campaspe. A number of landholders along the river shared their stories of sightings of the (often elusive) platypus.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.6.2.

Table 5.6.2 Potential environmental watering actions and objectives for the Campaspe River

Potential environmental watering	Environmental objectives
Summer/autumn low flows (10–50 ML/day in December–May)	• Maintain aquatic vegetation • Maintain fish habitat and reinstate slack waters (areas with minimal water movement) • Limit the effect of cold water pollution from Lake Eppalock on fish • Maintain access to riffle habitat and water quality for waterbugs • Maintain permanent connectivity for water quality • Maintain permanent connectivity for platypus movement
Winter/spring high flows (up to 2 events at 1,000–1,800 ML/day for up to 7 days each in June–November)	• Reduce encroachment of exotic and terrestrial vegetation • Enhance river red gum recruitment • Stimulate fish movement, allow movement to downstream reaches and provide spawning triggers • Flush and mix river pools for water quality • Flush organics from bank and benches to reduce the risk of blackwater events in summer • Mix and flush river pools for waterbugs • Inundate additional snags and flush sediment off biofilms (groups of microorganisms) for waterbugs • Support platypus habitat and breeding, including triggers for burrow selection
Winter/spring low flows (50–200 ML/day [or natural[1]], in June–November)	• Provide longitudinal connectivity for fish • Maintain access to riffle habitat and water quality for waterbugs • Maintain permanent longitudinal connectivity of river for improved water quality • Facilitate platypus habitat and breeding opportunities
Summer/autumn freshes (up to 3 freshes of 50–200 ML/day for up to 3 days each in December–May)	• Maintain riparian and in-channel recruitment vegetation • Increase extent of / maintain in-stream aquatic vegetation • Provide longitudinal connectivity for fish in periods of low flows • Maintain waterbug habitat and wash organic matter into the river to drive aquatic food webs • Respond to blackwater events as required

1 'Or natural' means that flow rates may be above or below the specified target rates depending on inflows and climatic conditions.

Scenario planning

Table 5.6.3 outlines the potential environmental watering and expected water usage under a range of planning scenarios.

Potential watering actions in 2016–17 range from those considered essential under extreme drought conditions through to those seeking to improve the ecological health of the river under wetter conditions, making it better-placed to withstand future stress events. The potential watering actions are similar across scenarios but the target magnitude and duration of the flows increase under wetter conditions, resulting in more environmental water being required as conditions become wetter.

Under continued dry conditions, it may not be possible for the storage manager to deliver water from Lake Eppalock, including environmental water. Without good inflows into storages from April to June 2016, not enough water will be available to enable the storage manager to operate the system to deliver water carried over into 2016–17. Under this scenario, allocations will start at zero and carryover from 2015–16 may not be able to be accessed until sufficient inflows occur or alternate arrangements are negotiated.

Protecting the environment under such conditions is a very high priority to prevent critical environmental loss. There is some possibility that water could be delivered to the lower part of the river (reach 4) from the Goulburn system via the Western Waranga main channel using environmental water or water from the Goulburn being delivered to meet demands in the Murray.

No critical carryover requirements have been identified for the Campaspe system into 2017–18: allocations available on 1 July 2017 from a very high-reliability component of the environmental entitlement will meet the highest-priority summer low flows in 2017–18. The best environmental outcomes are achieved by meeting 2016–17 demand rather than reserving water for the following year.

Table 5.6.3 Potential environmental watering for the Campaspe River under a range of planning scenarios

Planning scenario	Drought[1]	Drought	Dry	Below-average
Expected river conditions	• No unregulated flows • No consumptive water deliveries except for minimal stock and domestic	• No unregulated flows • Low consumptive water deliveries in reach 2 and low-to-no deliveries in reaches 3 and 4 in summer	• Minimal unregulated flows in winter/spring • Low consumptive water deliveries in reach 2 and low deliveries in reaches 3 and 4 in summer	• Some unregulated river flows particularly in winter/spring • Moderate summer consumptive water deliveries in reach 2 and low deliveries in reaches 3 and 4 in summer
Expected availability of environmental water	• 0 ML VEWH • 0 ML CEWH • 0 ML Living Murray • 0 ML carryover • 0 ML withheld passing flows • 0 ML total	• 1,656 ML VEWH • 0 ML CEWH • 0 ML Living Murray • 9,500 ML carryover • 2,000 ML withheld passing flows • 13,156 ML total	• 3,900 ML VEWH • 980 ML CEWH • 20 ML Living Murray • 9,500 ML carryover • 2,000 withheld passing flows • 16,400 ML total	• 19,500 ML VEWH • 6,000 ML CEWH • 100 ML Living Murray • 9,500 ML carryover • 2,000 ML withheld passing flows • 37,100 ML total
Potential environmental watering – tier 1 (high priorities)	• Summer/autumn low flows (reach 4 only) • Emergency pulse flows to avoid critical loss of species/habitat (by preventing or responding to a low-dissolved-oxygen event and by maintaining pool habitat)	• Summer/autumn low flows • Winter/spring high flow (1 event) • Winter/spring low flows • Summer/autumn fresh (1 event)	• Summer/autumn low flows • Winter/spring high flow (1 event) • Winter/spring low flows • Summer/autumn freshes (3 events)	• Low range summer/autumn low flows • Winter/spring high flows (2 events) • Winter/spring low flows • Summer/autumn freshes (3 events)
Potential environmental watering – tier 2 (additional priorities)	• Winter/spring high flow (1 event) • Top-up winter/spring low flows	• Summer/autumn freshes (2 additional events) • Top-up winter/spring low flows	• Winter/spring high flow (1 additional event) • Top-up low flows year-round	• Increased magnitude and duration of winter/spring high-flow events
Possible volume of environmental water required to achieve objectives[2]	• 1,800 ML (tier 1) • 6,800 ML (tier 2)	• 13,100 ML (tier 1) • 5,600 (tier 2)	• 15,200 ML (tier 1) • 7,500 ML (tier 2)	• 25,800 ML (tier 1) • 7,500 ML (tier 2)

1 Under this drought scenario it is assumed delivery of carryover and allocation is not available. Watering to protect plants and animals from critical loss is expected to be negotiated with relevant stakeholders.
2 Environmental water requirements for tier 2 actions are additional to tier 1 requirements.

Risk management

In preparing its seasonal watering proposal, North Central CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

5.6.2 Coliban River

Environmental values

The Coliban River contains a diverse range of waterbugs supported by stands of emergent and submergent aquatic vegetation. It is bordered by remnant patches of streambank shrubland vegetation providing habitat for a diverse range of terrestrial species. Historical records show that a diverse range of native freshwater fish species (including the Murray cod, river blackfish, Macquarie perch and Australian smelt) inhabited the river, as do populations of platypus and native water rats.

Social and economic values

iLocal communities highly value the Coliban River including those in Malmsbury, Taradale and Metcalfe. Of particular interest are the aesthetic and recreational values of the river (including Ellis Falls and the Cascades). Popular recreational activities in the area include camping, fishing and bird watching. The storages supply urban, stock and domestic demands in the surrounding area.

Environmental watering objectives in the Coliban system

- Maintain water, riverside and in-stream plants
- Protect and boost populations of native fish by providing flows for them to move upstream and downstream, encouraging spawning
- Improve water quality
- Maintain habitat for waterbugs which provide energy, break down dead organic matter and support the river's food chain

System overview

Reach 1 of the Coliban River below Malmsbury Reservoir to Lake Eppalock can benefit from environmental watering. An important distinction between the Coliban River and other regulated Victorian systems is the lack of irrigation demand in the river, as Coliban Water deliver water from the Malmsbury Reservoir via a pipe-and-channel network. Therefore, the river below this point is not subject to the high summer flows that other regulated systems experience: delivering summer flows relies on environmental water releases.

The VEWH does not have any environmental entitlements in the Coliban system but the ability to flexibly manage passing flows in the system provides an opportunity to help mitigate summer low-flow risks. There is a small volume of Commonwealth environmental water held in the system but the high cost of delivery means it is not planned to be used in 2016–17.

Recent conditions

In 2015–16, conditions were dominated by below-average rainfall in most months and corresponding very low volumes of inflows to the storage (around 11 percent of the long-term average).

A portion of passing flows was withheld in spring to reserve water to support the river over summer/autumn. A summer storm provided a flush through the river in January. The withheld flows were then used to deliver a fresh in March to refill and flush remaining pools, with the river having stopped flowing at Lyal.

The flows delivered were generally well below the environmental flow recommendations for the system. However, water availability in 2015–16 was limited and management aimed to protect native species under drought conditions, particularly following cease-to-flow periods in summer.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.6.4.

Table 5.6.4 Potential environmental watering actions and objectives for the Coliban system

Potential environmental watering	Environmental objectives
Summer/autumn pulsed flows (5–15 ML/day for up to 2 weeks in December–May as required)[1]	• Maintain water quality (including dissolved oxygen levels) and habitat for aquatic animals
Summer/autumn low flows (2.5–5 ML/day in December–May)	• Maintain aquatic vegetation • Maintain fish habitat • Maintain permanent connectivity of river for improved water quality • Maintain aquatic habitat for waterbugs • Maintain habitat for platypus
Summer/autumn freshes (of 50–100 ML/day for 3 days each in December–May)	• Maintain riparian and in-channel recruiting vegetation • Provide native fish habitat, movement and spawning • Provide connectivity for water quality • Maintain aquatic habitat for waterbugs • Maintain habitat for platypus

1 The actual volume and duration of pulsed flows will depend on available water resources, climatic conditions and conditions within the river.

Scenario planning

Table 5.6.5 outlines the potential environmental watering and expected water usage under a range of planning scenarios.

Water availability in the Coliban system relies on withheld passing flows in winter/spring for use in the high-risk summer period when issues such as poor water quality are more likely and providing constant low flows and/or short pulses/freshes can maintain habitat below the reservoir.

The volume of water available will vary depending on inflows and the volume of passing flows available, with a lower volume likely to be available under a drought/dry scenario. Water is therefore not likely to be available to provide summer/autumn freshes except under average or wet conditions. The target flows and duration of freshes to manage a potentially catastrophic water quality problem will vary depending on water availability and climate and river conditions. There is insufficient water available to meet all the environmental water requirements of the Coliban system.

Campaspe River, by Victoria Penko, Victorian Environmental Water Holder

Table 5.6.5 Potential environmental watering for the Coliban system under a range of planning scenarios

Planning scenario	Drought/Dry	Average/Wet
Expected river conditions	• Little-to-no unregulated flows	• Some unregulated river flows from tributary inflows
Expected availability of environmental water	• Minimal passing flows and low volume to withhold for use at other times in the season	• Moderate-to-high passing flows with good volumes available 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 1 (high priorities)	• Summer/autumn pulsed flows • Summer/autumn low flows	• Summer/autumn low flows • Summer/autumn freshes
Potential environmental watering – tier 2 (additional priorities)[1]	• Increased magnitude of summer/autumn low flows	• N/A
Possible volume of environmental water required to achieve objectives	• 900 ML (tier 1) • 250 ML (tier 2)	• 1,200 ML (tier 1)
Priority carryover requirements	• Reserve passing flows for 2017–18	

1 Only a priority after 2017–18 critical requirements have been set aside
2 Environmental water requirements for tier 2 actions are additional to tier 1 requirements.

Risk management

In preparing its seasonal watering proposal, North Central CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

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

The Loddon system includes the Loddon River, Serpentine Creek, Tullaroop Creek, Birchs Creek, Pyramid Creek and the Boort wetlands. The system supports a wide range of environmental values as well as tourism and irrigation industries.

River blackfish are found in the upper reaches of the Loddon River and in parts of Serpentine Creek. There is a regionally important population of blackfish in Birchs Creek. The middle and lower reaches of the Loddon River support bony herring, Murray–Darling rainbowfish, golden perch and Murray cod. Pyramid Creek is a tributary of the lower Loddon River that enters the system near Kerang and provides passage through which fish can swim to and from the River Murray system.

The Boort wetlands on the floodplain of the Loddon River are regionally important for waterbird habitat and provide breeding opportunities for birds and turtles when there is water. During wet phases the aquatic plants provide habitat for frogs which in turn provide food for birds like herons and egrets. During temporary dry phases the diversity of plants at most lakes increases and rare and threatened species can grow.

Engagement

Table 5.7.1 shows the partners and stakeholder organisations with which North Central CMA engaged when preparing the Loddon system seasonal watering proposal.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies, which include environmental, cultural, social and economic considerations.

Table 5.7.1 Partners and stakeholders engaged in developing the Loddon system seasonal watering proposal

Stakeholder engagement
• Birchs Creek Environmental Water Advisory Group (comprising community members and representatives of Goulburn-Murray Water and the VEWH)
• Commonwealth Environmental Water Office
• Goulburn-Murray Water
• Loddon Environmental Water Advisory Group (comprising community members and representatives of Field and Game Victoria, Department of Environment, Land, Water and Planning, Goulburn-Murray Water, North Central CMA, the VEWH and Commonwealth Environmental Water Office)
• North Central CMA Natural Resource Management Committee, an advisory group to North Central CMA Board comprising community members
• Victorian Environmental Water Holder

5.7.1 Loddon River system (including Tullaroop, Serpentine and Pyramid creeks)

Environmental values

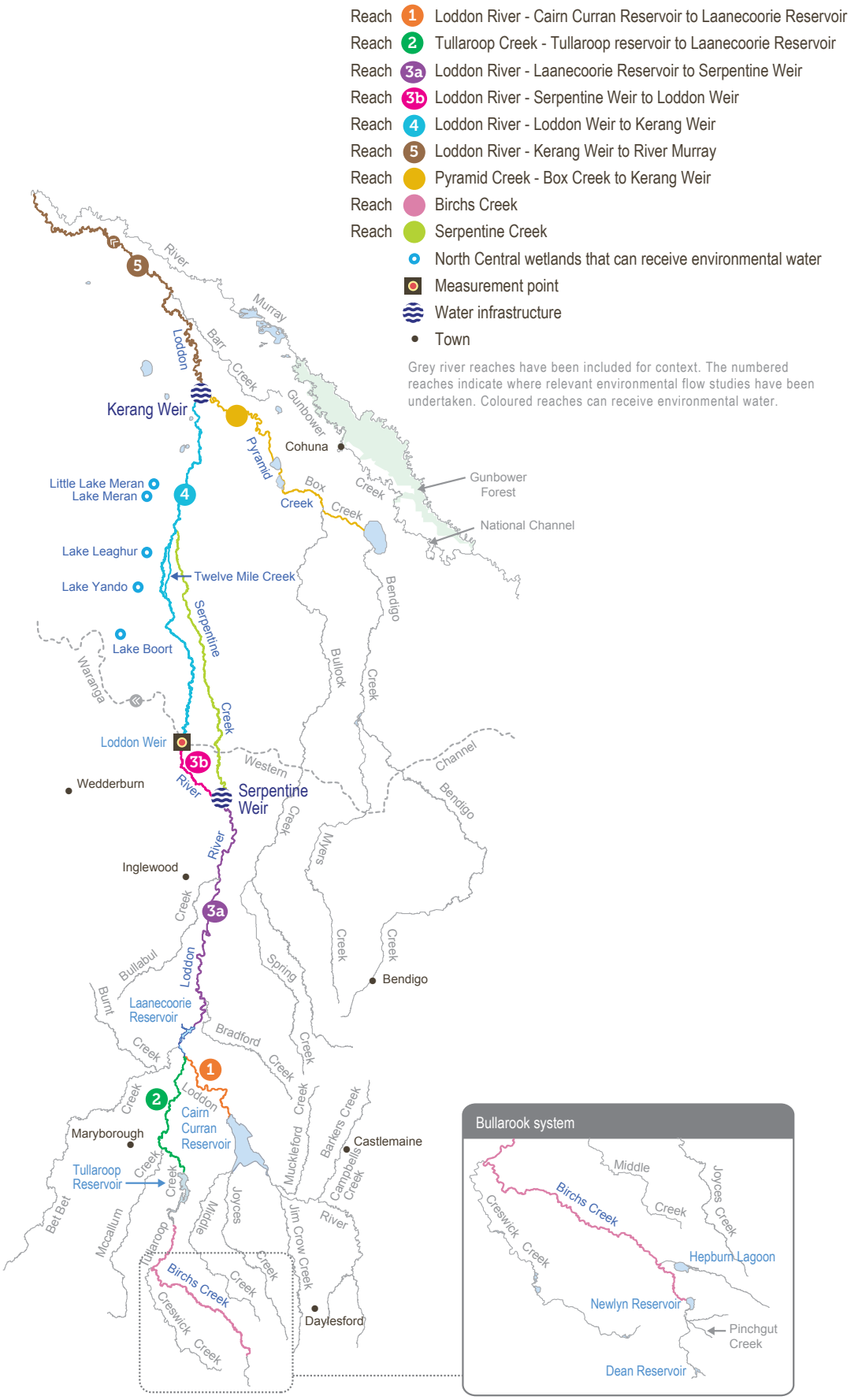
The Loddon River system contains platypus, river blackfish and lots of small native fish (such as flat-headed gudgeon, Australian smelt and mountain galaxias). While fish are most abundant and diverse in the upper reaches of the Loddon River and in Tullaroop Creek, river blackfish are also found in Serpentine Creek and Murray–Darling rainbow fish are in the middle and lower sections of the Loddon River. Pyramid Creek supports large-bodied fish (such as golden perch) and is an important pathway for fish migration to and from the Loddon and Murray systems.

Streamside vegetation condition varies from bad to good depending on several factors such as the recent water regime, the extent of clearing that has occurred, adjacent land use practices and weed invasions. Woodland birds and other native animals are abundant where there is good-quality riparian vegetation providing diverse habitats.

Social and economic values

The Loddon River supplies the Boort irrigation district and is essential for prosperity in the region. Murray cod and golden perch are stocked in the Loddon River and are an important recreational fishing species. Bridgewater on Loddon attracts visitors to waterskiing and triathlon competitions held on the Loddon River. The Loddon River is also rich in Aboriginal heritage, and there are scarred trees and shell middens commonly found throughout the system.

Figure 5.7.1 The Loddon system



Environmental watering objectives in the Loddon River system	
	Maintain river red gum, tea tree and lignum and provide opportunities for new plants to germinate and grow
	Protect and boost populations of native fish by providing flows for them to move upstream and downstream and encourage spawning
	Create opportunities for young platypus to disperse to new, high-quality habitat so they are not competing for space and food and become more resilient to threats (such as predation from foxes)

System overview

The Loddon River flows north from the Great Dividing Range in central Victoria to the River Murray (as Figure 5.7.1 shows). The major storages are Cairn Curran, Tullaroop and Laanecoorie reservoirs.

Environmental water can be delivered to the Loddon River from the Loddon or the Goulburn systems due to the Loddon River's connection with the Goulburn system via the Waranga western channel. Water is provided to Pyramid Creek from the Murray system via the national channel. Water is diverted from the Loddon River to Serpentine Creek, mainly for irrigation.

The highest-priority reach for environmental watering is from Loddon Weir to Kerang Weir where there are good opportunities to improve vegetation condition and fish abundance and because this reach doesn't receive any flows for irrigation deliveries. The upper Loddon River and Tullaroop Creek are also a priority because of the river blackfish and platypus that live there.

Due to the significant modifications to the natural waterways for irrigation supply, the water distribution system in the Loddon is very complicated. This provides both challenges and opportunities for effective environmental water management. It is possible to manipulate the timing and location of releases to accomplish environmental outcomes throughout the system. As experience in managing newly updated environmental flow recommendations is gained in coming years, we expect that water use efficiency and effectiveness will improve.

Recent conditions

The Loddon River system was extremely dry for the entire 2015–16 year and inflows to Loddon system storages were close to the lowest ever recorded.

Due to the effects of dams, weirs and river regulation, the plants and animals in the Loddon system have adapted to a near-permanent flow regime. It is natural for rivers like the Loddon to stop flowing in very low rainfall years, but it is also important to protect the aquatic life in the river during dry times so that it can quickly rebound when conditions improve.

In 2015–16 the combined volume in Cairn Curran and Tullaroop reservoirs fell below the trigger point where Loddon River passing flows are lowered to protect water supplies. Additional environmental water releases were made to maintain minimum low flows through the river and protect the gains made in fish populations and vegetation condition in previous years. Improvements in the condition of aquatic plants have occurred in the last few years. Plants such as water ribbons, eel grass and milfoil have substantially increased, particularly in reaches upstream of Laanecoorie Reservoir.

Higher flows were released to the upper and lower reaches of the Loddon River in spring and summer to improve water quality and provide a chance for fish and platypus to move and feed. These flows also gave the streamside vegetation (including river red gums, shrubs and grasses) a drink, which stabilises the banks and improves habitat for birds, lizards and other animals that live near the river.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.7.2.

Table 5.7.2 Potential environmental watering actions and objectives for the Loddon River system

Potential environmental watering	Environmental objectives
Loddon River (reach 1)	
Year-round low flows (10–80 ML/day)	• Allow fish movement through the reach and maintain depth of pool habitat for native fish • Facilitate long-distance movement of male platypus in the August–October breeding season • Maintain suitable water quality in pools in summer
Summer/autumn freshes (up to 3 freshes of 35–80 ML/day for 1–3 days in December–May)	• Promote movement of fish so they access alternate habitats • Wash organic matter into the stream to drive the aquatic food webs • Mix and re-oxygenate pools and dilute concentrated salt • Inundate lower banks to wet the soil and promote the establishment, growth and survival of sedges and reeds
Winter/spring freshes (1–2 freshes of more than 400 ML/day for 1–5 days in July–October)	• Promote recruitment of riparian vegetation • Stimulate movement of native fish and enhance Murray cod breeding • Flush accumulated leaf litter from banks and low benches into the channel to drive aquatic food webs
Tullaroop Creek (reach 2)	
Year-round low flows (5–40 ML/day year-round)	• Allow fish movement through the reach and maintain the depth of pool habitat for river blackfish • Facilitate long-distance movement of male platypus in the August–October breeding season • Maintain suitable water quality in pools in summer
Summer/autumn freshes (up to 3 freshes of 30–40 ML/day for 1–3 days in December–May)	• Promote movement of fish so they access alternate habitats • Wash organic matter into the stream to drive aquatic food webs • Mix and re-oxygenate pools and dilute concentrated salt • Inundate lower banks to wet the soil and promote the establishment, growth and survival of sedges and reeds
Winter/spring freshes (1–2 freshes of more than 200 ML/day for 1–5 days in July–October)	• Promote recruitment of riparian vegetation • Stimulate movement of native fish and enhance Murray cod breeding • Flush accumulated leaf litter from banks and low benches into the channel to drive aquatic food webs
Loddon River reach 3a and 3b	
Low flows (1–5 ML/day year-round) under a drought scenario	• Maintain adequate water quality and drought refuge habitat for native fish, platypus and waterbugs in reaches 1, 2 and 3 • Protect aquatic vegetation in reaches 1, 2 and 3
Trigger-based freshes (freshes of 30 ML/day for 7 days) under a drought scenario	
Loddon River (reach 4)	
Summer/autumn low flows (25–50 ML/day in December–May)	• Continuous flows through the reach to maintain water quality in pools • Maintain pool habitat for large-bodied fish (such as Murray cod, golden perch and bony herring) • Maintain shallow water habitats for small-bodied fish (such as flat-headed gudgeon) • Maintain connecting flows for aquatic plant propagules to disperse and establish
Summer/autumn freshes (up to 3 freshes 50–100 ML/day for 3–4 days in December–May)	• Facilitate upstream movement of juvenile golden perch • Wet submerged wood and flush silt and biofilms from hard surfaces to promote new biofilm growth and increase waterbug populations • Facilitate downstream dispersal of platypus in April–May
Spring high flow (one high flow of 450–750 ML/day with a 7-day peak in September–October)1	• Inundate banks, floodrunners and low-lying parts of the floodplain to promote growth and recruitment of riparian vegetation • Provide a cue for golden perch and Murray cod to migrate and breed • Flush leaf litter and organic material from the banks to drive aquatic food webs
Autumn high flow (1 high flow of 400 ML/day with a 6-day peak in April–May)	• Provide a cue for fish from the River Murray to swim upstream and colonise the Loddon River • Help juvenile platypus disperse from the upper Loddon River to the lower Loddon River and the River Murray
Winter/spring low flows (50–100 ML/day in June–November)	• Prevent terrestrial plants from encroaching into the channel • Assist the growth of fringing vegetation (such as sedges and reeds) • Provide foraging and resting habitat for platypus

Potential environmental watering	Environmental objectives
Serpentine Creek	
Summer/autumn freshes (2 freshes of 40 ML/day for 1–3 days in December–May)	• Allow fish, platypus and turtle to move through the reach • Inundate benches and fringing vegetation • Inundate wood and promote biofilm development • Maintain water quality and prevent low dissolved oxygen conditions
Winter fresh (1 fresh of 120–150 ML/day for 1 day in July–August)	• Flush organic material from banks to reduce risk of blackwater in summer • Inundate benches and water-fringing vegetation • Inundate wood and scour biofilms from the streambed • Inundate benches to provide breeding habitat for frogs
Pyramid Creek and Loddon River reach 5[2]	
Spring high flow (1 high flow of 900 ML/day for 10 days in September to November)	• Trigger and facilitate fish movement and breeding, particularly golden perch and silver perch • Recruitment and maintenance of riparian vegetation • Flush accumulated leaf litter from banks to provide carbon for aquatic foodwebs
Autumn high flow (1 high flow of 900 ML/day for 10 days in March–May)	• Trigger and facilitate movement of juvenile fish

1 Due to potential inundation of private land, environmental flows above 450 ML per day in reach 4 will not be provided without agreement of potentially affected landholders.
2 Potential watering actions to Pyramid Creek and Loddon River reach 5 are contingent on the operation of the Box Creek fishway that allows fish movement to and from Kow Swamp.

Scenario planning

Table 5.7.3 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Due to low inflows to the Loddon system in 2015–16, the storage manager may not have enough water available to operate the system to deliver water held by entitlement holders in Tullaroop and Cairn Curran reservoirs in early 2016–17. If conditions remain dry, allocations will start at zero, carryover from 2015–16 may not be accessible and passing flows may not be delivered. Under dry conditions, this situation will continue until sufficient inflows enable releases to be made or alternate arrangements are negotiated with all users in the system.

The VEWH can access water held in the Goulburn system for delivery to the Loddon River downstream of the Waranga western channel at Loddon Weir, so limitations on passing flows and carryover in the Loddon system mostly affect the Loddon River upstream of the channel. However, VEWH water in the Goulburn system could be unavailable from time to time due to capacity restrictions in the Waranga western channel and also when the irrigation season is closed (mid-May to mid-August).

Planning for 2016–17 has considered these operational problems and the impacts that consecutive dry years have had on the Loddon system. Under a drought scenario, low flows and a limited number of small freshes through reaches 1, 2 and 3 of the Loddon River will be provided from Loddon system storages (Cairn Curran and Tullaroop reservoirs) subject to sufficient water being available for use. The low flows will target the bottom end of reach 3b and the freshes will be delivered when required to improve water quality and help maintain riparian vegetation. Under a drought scenario there will be total reliance on water from the Goulburn system for flows to reach 4. If access to water from the Goulburn system is restricted (due to capacity restrictions in the Waranga western channel or outside the irrigation season), flows may be reduced which may affect our ability to maintain refuge habitat.

If dry to average conditions eventuate there will be increased access to water from the Loddon River storages, and the aim is to deliver flows commensurate with the seasonal conditions. Passing flow rules will largely meet low-flow requirements, but it may be necessary to supplement passing flows with additional releases to meet low-flow objectives from time to time. High flows and freshes to the Loddon River and Pyramid Creek will be delivered by coordinating water available in the Loddon, Goulburn and Murray systems.

More water will be available under the average to wet scenarios, allowing more regular deliveries that maximise environmental outcomes, focusing on increased platypus and fish movement and improving vegetation. In a very wet year most flows will happen naturally and only a small amount of environmental water will be used, placing the system in a good position for 2017–18.

Table 5.7.3 Potential environmental watering for the Loddon River system under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Negligible contributions from unregulated reaches and tributaries of the Loddon River leading to lengthy cease-to-flow periods in the absence of environmental or consumptive water deliveries	• Small contributions from unregulated reaches and tributaries of the Loddon River contributing to low flows	• Unregulated flows will provide baseflows and multiple freshes, most likely in winter and spring	• Multiple spills from Loddon system storages will provide extended-duration high flows and overbank flows at any time of year
Expected availability of environmental water[1]	• 16,000 ML VEWH • 1,100 ML Commonwealth • 17,100 ML total	• 16,000 to 18,000 ML VEWH • 1,100 to 1,600 ML Commonwealth • 17,100 to 19,600 ML total	• 18,000 to 20,000 ML VEWH • 1,600 to 3,500 ML Commonwealth • 19,600 to 23,500 ML total	• 20,000 ML VEWH • 3,500 ML Commonwealth • 23,500 ML total
Loddon River (reach 1) and Tullaroop Creek (reach 2)				
Potential environmental watering	• Year-round low flows[2] • 1–2 summer/autumn freshes[2]	• Year-round low flows • 1–2 summer/autumn freshes • 1 winter/spring fresh	• Up to 3 summer/autumn freshes • 1–2 winter/spring freshes	• Up to 3 summer/autumn freshes • 2 winter/spring freshes
Loddon River (reaches 3a and 3b)				
Potential environmental watering	• Year-round low flows • Trigger-based freshes at any time of year to improve water quality and maintain riparian vegetation	• Under dry-wet scenarios reach 3 objectives will be met by environmental water delivered from Loddon storages targeting reaches 1 and 2 and en route to reach 4, or by consumptive and system operating water		
Loddon River (reach 4)				
Potential environmental watering	• Year-round low flows • 2–3 summer/autumn freshes • 1 winter/spring high flow	• Year-round low flows • 2–3 summer/autumn freshes • 1 winter/spring high flow	• Year-round low flows • 3 summer/autumn freshes • 1 winter/spring high flow • 1 autumn high flow	• Year-round low flows • 3 summer/autumn freshes • 1 winter/spring high flow • 1 autumn high flow
Serpentine Creek				
Potential environmental watering	• Low flows provided by consumptive water	• 1–2 summer/autumn freshes	• 1–2 summer/autumn freshes • 1 winter/spring fresh	
Loddon River, Tullaroop Creek and Serpentine Creek				
Possible volume of environmental water required to achieve objectives	• Up to 11,600 ML	• 11,600 ML	• 17,000 ML	• 11,000–17,000 ML
Pyramid Creek and Loddon River (reach 5)				
Potential environmental watering	• 1 spring high flow		• 1 spring high flow • 1 autumn high flow	
Possible volume of environmental water required to achieve objectives	• 12,000 ML		• 24,000 ML	

1 Does not include water available in the Goulburn and Murray systems that could be made available to support the achievement of environmental objectives in the Loddon system, subject to trading rules

2 Low flows and freshes in reaches 1 and 2 under the drought scenario will be provided by water en route to Loddon River reach 3

Risk management

In preparing its seasonal watering proposal, North Central CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

5.7.2 Boort wetlands

Environmental values

The Boort wetlands provide habitat for a range of plant and animal species, many of which are rare and considered threatened under state and Commonwealth legislation or international agreements. Bird species that have been recorded at Lake Boort and Lake Meran include the white-bellied sea eagle, Latham's snipe and eastern great egret. At Lake Meran the largest known population of the endangered hoary scurf-pea has become well-established in recent years. There are over 2,000 hoary scurf-pea plants which are also the caterpillar food plant for the chequered swallowtail butterfly.

Social, cultural and recreational values

The Boort wetlands provide recreation opportunities for campers, anglers and bird watchers. Lake Meran and Lake Boort are state game reserves where hunting is allowed. The Boort wetlands also contain resources traditionally used by Aboriginal people and there are numerous sites that have Aboriginal cultural heritage significance.

Environmental watering objectives in the Boort wetlands
Assist growth of river red gum trees and aquatic vegetation
Restore habitat and provide breeding opportunities

System overview

The Boort wetlands are on the floodplain to the west of the Loddon River, downstream of Loddon Weir. The wetlands are comprised of the Lake Meran complex of wetlands and also lakes Boort, Leaghur and Yando.

The natural water regimes of wetlands in the Loddon system have been substantially modified. Environmental watering aims to reinstate a more favourable hydrology to the Boort wetlands by providing wet and dry phases to improve environmental condition and habitat value.

Recent conditions

The Loddon catchment was extremely dry in 2015–16 and the Boort wetlands did not receive natural inflows. Lake Meran was the only lake in the system containing water at the end of 2015–16. A top-up to Lake Meran was supplied in autumn 2016 to maintain a minimum level and protect aquatic habitat, particularly for turtles.

Other lakes (such as Lake Boort and Leaghur) have benefited from drying in recent years which has allowed some vegetation to establish on the drying lake bed. Shrubs and herbs grow profusely in the wet soil of a drying wetland and these plants provide habitat for non-aquatic animals to complete life cycles.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.7.4.

Table 5.7.4 Potential environmental watering actions and objectives for the Boort wetlands

Potential environmental watering	Environmental objectives
Wetland watering	
Lake Boort (partial fill in spring/summer)	• Restore river red gum distribution and the associated plant community including rehabilitation of southern cane grass populations • Restore and rehabilitate vegetation species diversity typical of aquatic and semi-aquatic environments • Promote native vegetation growth to reduce the likelihood of recolonisation by mustard weed
Lake Meran (fill targeting 80.5–81.0 m AHD in spring or autumn)	• Provide breeding opportunities for colonial nesting waterbirds around wetland verges and the southern basin of Lake Meran • Provide feeding and breeding opportunities for wetland birds including black swans, grebes and white-bellied seas eagles • Maintain the condition of adult and juvenile river red gum trees • Rehabilitate understory plant species in the intermittent swampy woodland
Lake Meran (partial fill in autumn to maintain minimum water level 77.3–77.8 m AHD)[1]	• Provide habitat and refuge for turtles and native fish, particularly the Murray River turtle • Rehabilitate the extent of mudflat and flood-tolerant herbland vegetation associated with the lake bed herbland vegetation type (for example, hoary scurf-pea and downy swainson-pea)
Wetland drying	
Lake Leaghur, Little Lake Meran and Lake Yando (promote natural drawdown and drying)	• These wetlands will be in a drying phase throughout 2016–17 • The drying will help maintain a diversity of habitats to support a wide range of wetland-dependent birds and animals and to promote the establishment and growth of vegetation in and around the wetland

1 A partial fill is not required if a fill of 80.5–81.0 m AHD is provided in spring or autumn.

Scenario planning

Table 5.7.5 outlines the potential environmental watering and expected water usage under a range of planning scenarios.

Environmental watering is planned for lakes Boort and Meran in 2016–17.

Lake Boort is approaching its maximum recommended dry interval and therefore a partial fill is planned under all climatic conditions. The fill will provide water for river red gums already established in the lake bed. Watering of Lake Boort will also increase soil moisture and enable germination of river red gum seedlings as the water begins to recede over summer. The partial fill of Lake Boort is planned to start in spring. A top-up in early summer will be considered, depending on conditions at the time and environmental responses that are observed (for example, a top-up may be needed to support bird breeding).

If conditions are dry Lake Meran may be topped up to maintain the minimum target water level of 77.3–77.8 m AHD. Under average to wet conditions (and depending on water availability and an assessment of the condition of wetland values), Lake Meran may be surcharged 80.5–81.0 m AHD in spring or autumn. A complete fill of Lake Meran will optimise conditions for river red gums and aquatic vegetation in the southern basin and set the lake up for a dry phase in the following years.

In all climatic scenarios the delivery of water to Boort wetlands may be limited from time to time due to system operating constraints. If it is a dry year there will be heavy reliance on Goulburn-sourced water via the Waranga western channel, but access to this water may be limited due to irrigation water delivery. In a wet year wetlands might be filled naturally and very little environmental water might be used, depending on the timing and magnitude of floods.

Table 5.7.5 Potential environmental watering for the Boort wetlands under a range of planning scenarios

Planning scenario	Dry	Average	Wet
Expected catchment conditions	• No contribution from unregulated flows	• No substantial unregulated flows with localised catchment contributions expected to provide minor inflows	• Multiple spills from Loddon system storages will provide extended durations of high flows and overbank flows at any time of year • There may be an opportunity to divert flood flows into the Boort wetlands • Top-ups from environmental water are unlikely to be needed
Potential environmental watering	• Lake Boort (partial fill in spring/summer) • Lake Meran (partial fill in autumn to maintain minimum water level 77.3–77.8 m AHD)	• Lake Boort (partial fill in spring/summer) • Lake Meran (fill in spring targeting 80.5–81.0 m AHD)	• Lake Boort (partial fill in spring/summer) • Lake Meran (fill in spring targeting 80.5–81.0 m AHD)
Possible volume of environmental water required to achieve objectives	• 4,000 ML	• 4,800 ML	• 6,300 ML

Risk management

In preparing its seasonal watering proposal, North Central CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

5.7.3 Birchs Creek

Environmental values

Birchs Creek supports native fish including a significant population of the regionally vulnerable river blackfish as well as mountain galaxias, flat-headed gudgeon and Australian smelt. Platypus are present in the creek in low numbers.

Social and economic values

Birchs Creek is popular among the nearby community for its aesthetic appeal and intrinsic value. Water in the Birchs Creek system supports irrigated agriculture of crops, particularly potatoes.

Environmental watering regime objectives in Birchs Creek

Maintain suitable water quality to support river blackfish and other native fish

System overview

Birchs Creek is a tributary of Tullaroop Creek. There are two main storages in the system—Newlyn Reservoir and Hepburn Lagoon—which regulate streamflows for urban and irrigation supply. Environmental water is held in and delivered from Newlyn Reservoir. The target reach for environmental water is reach 3 because it contains the vulnerable river blackfish population, and most irrigation supply is diverted before reaching this most downstream reach.

Recent conditions

In 2015–16 the Birchs Creek catchment was very dry. Rainfall was substantially below-average in winter and spring and as a consequence inflows to storages were extremely low.

The trigger for allocating water to the VEWH's environmental entitlement was not met in the Birchs Creek system in 2015–16, and environmental water releases were therefore not possible. Water to the creek was supplied from localised surface and groundwater inflows through small allocations of consumptive water delivered through the system and through storage management that reserved water for delivery for critical human and environmental needs.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.7.6.

Table 5.7.6 Potential environmental watering actions and objectives for Birchs Creek

Potential environmental watering	Environmental objectives
One summer/autumn fresh (27 ML/day for 3 days in December–May)	• Support native fish (including river blackfish) population structure, composition, age classes and abundance • Minimise risks to fish associated with low dissolved oxygen and high water temperature

Scenario planning

If average or wet conditions eventuate in spring, 100 ML of water in Newlyn Reservoir may be reserved and called on to provide a summer/autumn fresh if required.

If conditions remain dry in winter and spring 2016 it is unlikely that environmental water will be available for use later in the year. If water availability in the system is again very low, the only water able to be delivered in the creek will be for irrigation supply and to meet critical needs (for example, for domestic and stock supply and critical environmental flows).

Table 5.7.7 outlines the potential environmental watering and expected water usage under a range of planning scenarios.

Table 5.7.7 Potential environmental watering for Birchs Creek under a range of planning scenarios

Planning scenario	Drought-Dry	Average-Wet
Priority watering actions	• Nil: some water provided for critical environmental needs	• 1 summer/ autumn fresh
Possible volume of environmental water required to achieve objectives	• 0	• 100 ML

Risk management

In preparing its seasonal watering proposal, North Central CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

Campaspe River, by Victoria Penko, Victorian Environmental Water Holder