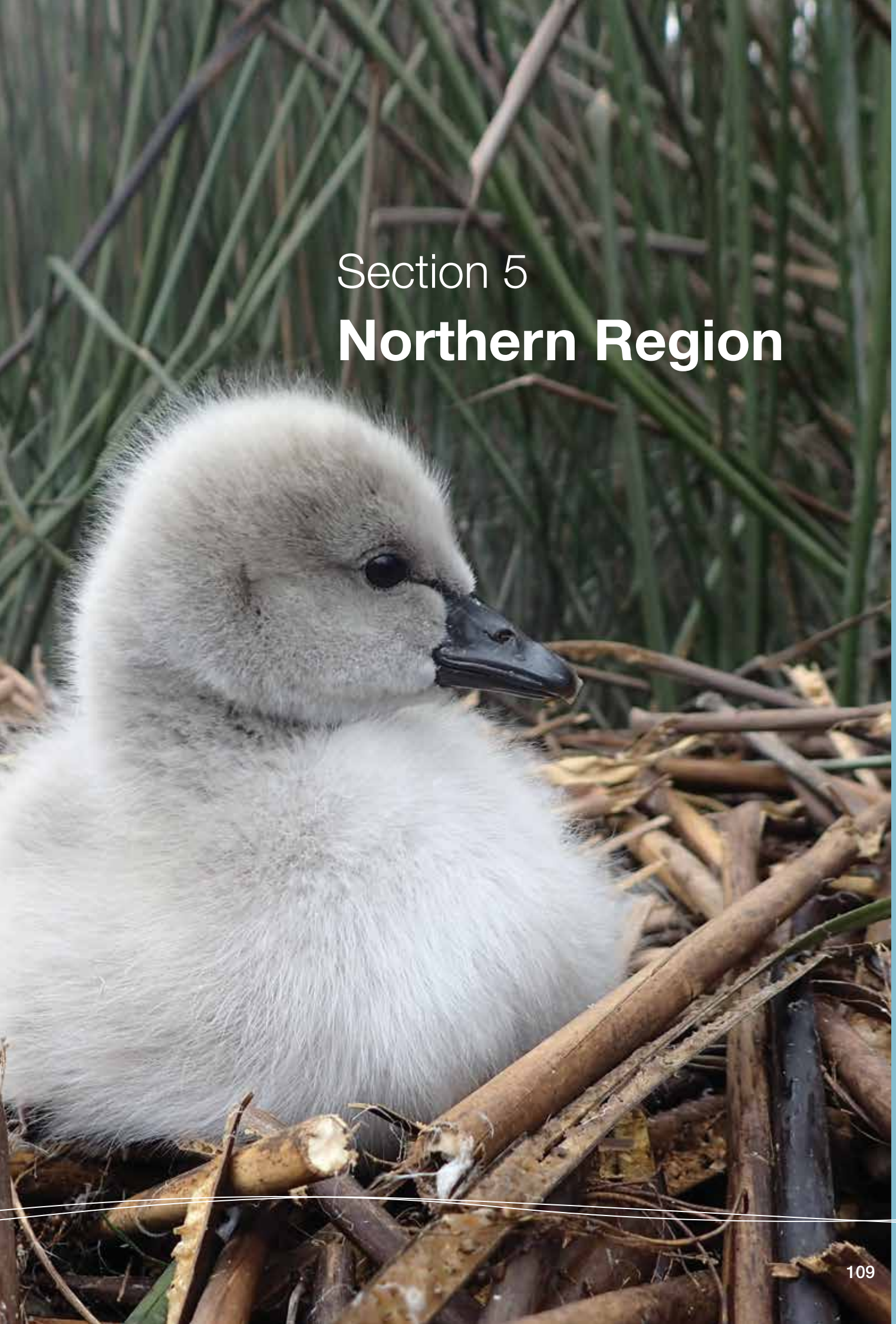


Section 5

Northern Region

5.1 Northern Region overview

The Northern Region has many rivers, wetlands and floodplains with priority sites including the Goulburn, Broken, Loddon, Campaspe and Ovens river systems and some of their associated floodplains and wetlands. On the Victorian Murray system, priority sites include Barmah Forest, Gunbower Forest, Hattah Lakes and Lindsay, Wallpolla and Mulcra islands.

The landscape

The major river systems of northern Victoria include the Ovens, Goulburn, Broken, Loddon and Campaspe rivers, which flow north from headwaters in Victoria's Great Dividing Range into the River Murray. Most environmental water used in northern Victoria is sourced from major storages in these systems including Lake Eildon (Goulburn system) Hume Reservoir (Murray system), Lake Eppalock (Campaspe system) and Cairn Curran Reservoir (Loddon system). These storages hold water for all entitlement holders including for irrigation, urban and environmental use.

Floodplains are an important feature along the River Murray corridor because they provide variable ecosystems as the river flows through areas with different climates, soils and topography. Noteworthy floodplain systems on the River Murray include Barmah Forest, Gunbower Forest, Hattah Lakes and Lindsay Island, which are all included in the VEWH's environmental watering program. There also are thousands of floodplain wetlands and billabongs along the River Murray and its tributaries.

The water systems of the Northern Region are often physically connected through infrastructure (such as Goulburn Weir and the Waranga Western Channel), which allows water to be transferred from the Goulburn River to the Loddon and Campaspe systems. They are also connected through a water market that allows trading of water between systems. Within the limitations of each mechanism, environmental water can be transferred between systems for delivery to environmental sites across northern Victoria, but most environmental water is usually used to provide benefits in the systems where the water is held.

Environmental values

Improving native fish populations is an important objective for environmental watering in northern Victoria. The endangered Murray hardyhead lives in wetlands in the Mallee and North Central CMA areas. Murray cod, silver perch and golden perch benefit from environmental flows in the Goulburn River, lower Broken Creek, Loddon River, Pyramid Creek, Gunbower Creek and Mullaroo Creek.

The vast network of wetlands across northern Victoria support many species of waterbirds that can benefit from environmental water deliveries. For example, magpie geese — endangered in Victoria — are now using Lake Cullen near Kerang to breed after releases of environmental water, and breeding pairs of brolga — considered vulnerable in Victoria — are now regularly found at Moodies Swamp near Shepparton.

The giant bullfrog — critically endangered in Victoria — and the growling grass frog — endangered in Victoria — can be found in floodplain wetlands in the lower River Murray and the Hattah Lakes. Frogs are a good food source for snakes and lizards at these wetlands.

Native vegetation has also benefited from environmental watering across northern Victoria including river swamp wallaby grass — nationally vulnerable — in Barmah Forest, the water nymph — rare in Victoria — in Black Swamp and the jerry-jerry — vulnerable in Victoria — at Lake Yando. River red gums and black box are found beside rivers and on floodplains across all of northern Victoria and these species provide habitat for birds, reptiles, mammals and insects.

Community considerations

Traditional Owners and their Nations in the Northern Region continue to have a deep connection to the region's rivers, wetlands and floodplains. This ancient connection is evidenced by the hundreds if not thousands of scar trees, middens, burial sites, artefacts and ovens along waterways. Aboriginal people maintain an enduring connection to Country including important ceremonial places and resources (such as food and medicine).

The VEWH acknowledges the Traditional Owners of northern Victoria and pays respect to their Elders past, present and future. It recognises that water has significant cultural importance and value for Traditional Owners and Aboriginal people.

The Traditional Owner groups in and around northern Victoria (including areas where there is no environmental water management) include the Barapa Barapa, Dhudhuroa, Dja Dja Wurrung, Latji Latji, Mutti Mutti, Nari Nari, Ngintait, Ngurai-illiam wurrung, Nyeri Nyeri, Tatti Tatti, Taungurung, Wadi Wadi, Wamba Wamba, Waywurru, Wegi Wegi, Yaithmathang, Yita Yita and Yorta Yorta peoples, among others.

Examples of engagement with Traditional Owner groups include:

- North Central CMA working with the Barapa Barapa and Dja Dja Wurrung peoples to understand how environmental water management can better support Aboriginal aspirations
- Mallee CMA engaging with Traditional Owners in the Mallee through its Aboriginal Reference Group.

Rivers and wetlands in northern Victoria are very popular fishing, camping and hunting spots. Hattah Lakes, Gunbower Forest and Barmah Forest are appreciated by locals, tourists and birdwatchers from all over the world. Importantly, these waterways also support business opportunities from tourism, forestry and irrigated agriculture, which contributes significantly to Australia's prosperity through food and fibre farming.

Year by year and case by case, the VEWH and its program partners consider opportunities raised by communities to use environmental water to provide additional social, cultural and recreational benefits (for example, releasing environmental water increases the enjoyment of people camping by a waterway, or publicising an environmental water release in advance provides more opportunities for kayakers). Where possible, the VEWH and its program partners incorporate such opportunities into watering decisions, as long as they do not compromise environmental outcomes or increase demand on the water holdings.

When planning to use water for the environment, the potential social, economic, cultural, and recreational benefits for communities which could arise from the water's use are considered. Some scoped opportunities for shared community benefits in northern Victoria for 2017–18 include:

- starting to fill Hattah Lakes in July to provide enough time to deliver 100 GL of water to inundate black box trees on the floodplain and then allow water drawdown by mid-late spring. It will take over 100 days to deliver 100 GL. Starting in July will provide the optimal timing for black box trees and is also preferred by Parks Victoria so it can prepare the national park for summer visitors
- improving amenity for campers at many reserves, crossings and towns along the Loddon and Campaspe rivers including the popular Aysons Reserve on the Campaspe near Elmore, which draws hundreds of campers during school holidays
- restoration of visitor access to the national park on the lower Ovens floodplain, a popular area for campers and other recreational pursuits
- potentially altering the timing of an environmental flow to ensure rising or stable river levels for the Murray cod opening (a recreational fishing event) on the Goulburn River
- improving the health of native plants (such as water ribbon) and sites in Gunbower Forest and along Gunbower Creek that are culturally significant to the Barapa Barapa people, to help them continue cultural practices
- improving the movement and dispersal of fish (such as golden perch, silver perch and Murray cod) in the Loddon River and Pyramid Creek, which increases fishing opportunities for anglers.

The VEWH's ability to deliver these benefits depends on climate, water available and the way the system is being operated to deliver water for other purposes (such as to homes, farms or businesses).

For more information about scoped opportunities for shared community benefits in 2017–18, contact the VEWH or the relevant waterway manager.

Integrated catchment management

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

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

North Central CMA's implementation of its *Native Fish Recovery Plan* is an example of integrated catchment management in the region. Centred on the Torrumbarry Irrigation Area and encompassing Gunbower Creek, Pyramid Creek, the lower Loddon River and associated wetlands, the recovery plan aims to increase native fish populations by improving waterway connectivity, habitat and flows. So far, with delivery partners such as Goulburn-Murray Water, the Box Creek regulator fish lock, which allows fish to move into Kow Swamp from Pyramid Creek, has been built. A pilot project has begun to install an irrigation channel screen at Cohuna Weir, to stop native fish entering an irrigation channel off Cohuna Weir pool. Snags have been reinstated in Pyramid Creek to improve habitat for Murray cod, golden perch and silver perch and a combination of irrigation water and environmental water has been used to provide flows to support fish movement and spawning.

Other examples of integrated catchment management in the Northern Region include:

- fox baiting in Barmah Forest by the Yorta Yorta Nation Aboriginal Corporation's works crew to protect turtle nests from predation
- removing willows from Birchs Creek
- putting artificial snags in Broken Creek and the Goulburn River in partnership with local fishing clubs.

Six natural resource management (NRM) agencies from Victoria, NSW and SA along the River Murray corridor are integrating programs under the Tri-State Murray NRM Regional Alliance. They formed the alliance in 2015 after recognising that by working together, NRM agencies can achieve better and more cost-effective social, economic and environmental outcomes.

For more information about integrated catchment management programs in the Northern Region refer to the Mallee, North Central, North East and Goulburn Broken regional catchment strategies and waterway strategies.

Seasonal outlook 2017–18

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 2017–18 outlook at 15 May 2017 is that early-season water availability will be higher than in recent years. Opening high-reliability entitlement allocation is expected to be at least 30 percent in the Goulburn and Loddon systems, 50 percent in the Murray system and 100 percent in the Campaspe system, with all expected to reach 100 percent by the end of 2017–18 in all but an extreme dry inflow scenario. Under a wet climate scenario, all systems should reach their 100 percent allocations early in the year. Under an extreme dry scenario (for example, assuming inflows are similar to the lowest one percent of inflows on record), the Goulburn system is expected to reach 45 percent allocation and the Murray system is expected to reach around 70 percent allocation against high-reliability entitlements for the year. Allocation against low-reliability entitlements is also possible in 2017–18.

Environmental water demands in northern Victoria are usually high in winter and spring. As the outlook indicates, there is likely to be good water availability early in the season. High allocations combined with carryover from 2016–17 means that water is likely to be available for early-season demands. Because the storages were relatively full leading into winter, there is an increased chance of storage spills during 2017–18. Storage spills in winter/spring may meet or exceed many of the environmental water flow targets in downstream waterways. This can reduce the amount of environmental water that needs to be delivered, allowing additional watering actions to be undertaken during the year. However, storage spills may also result in some or all unused water carried over from the previous year being deducted from the environmental water account.

The VEWH coordinates its activities with other environmental water holders in northern Victoria, NSW and SA to achieve environmental outcomes at the Murray–Darling Basin scale. One example of coordination is the management of River Murray increased flows (RMIF), these flows being part of VEWH's entitlements in the Murray system. RMIF are co-owned by Victoria and NSW and can be used to achieve environmental outcomes in the Murray system in Victoria, NSW and SA. Recommendations for coordinated use of RMIF are made by the Southern Connected Basin Environmental Watering Committee.

The VEWH liaises with the MDBA and the Commonwealth Environmental Water Office to optimise 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 for relevant systems in the following parts of this section.

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

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 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 MDBA developed the plan under the *Commonwealth Water Act 2007* and it 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

The Victorian Murray system contains many significant floodplains and wetland systems covering the Goulburn Broken, North Central and Mallee CMA areas. The Barmah Forest, Kerang wetlands and Hattah Lakes are internationally significant Ramsar-listed sites due to the abundance and range of waterbird species that use them. Other wetlands in the system are either nationally or regionally significant.

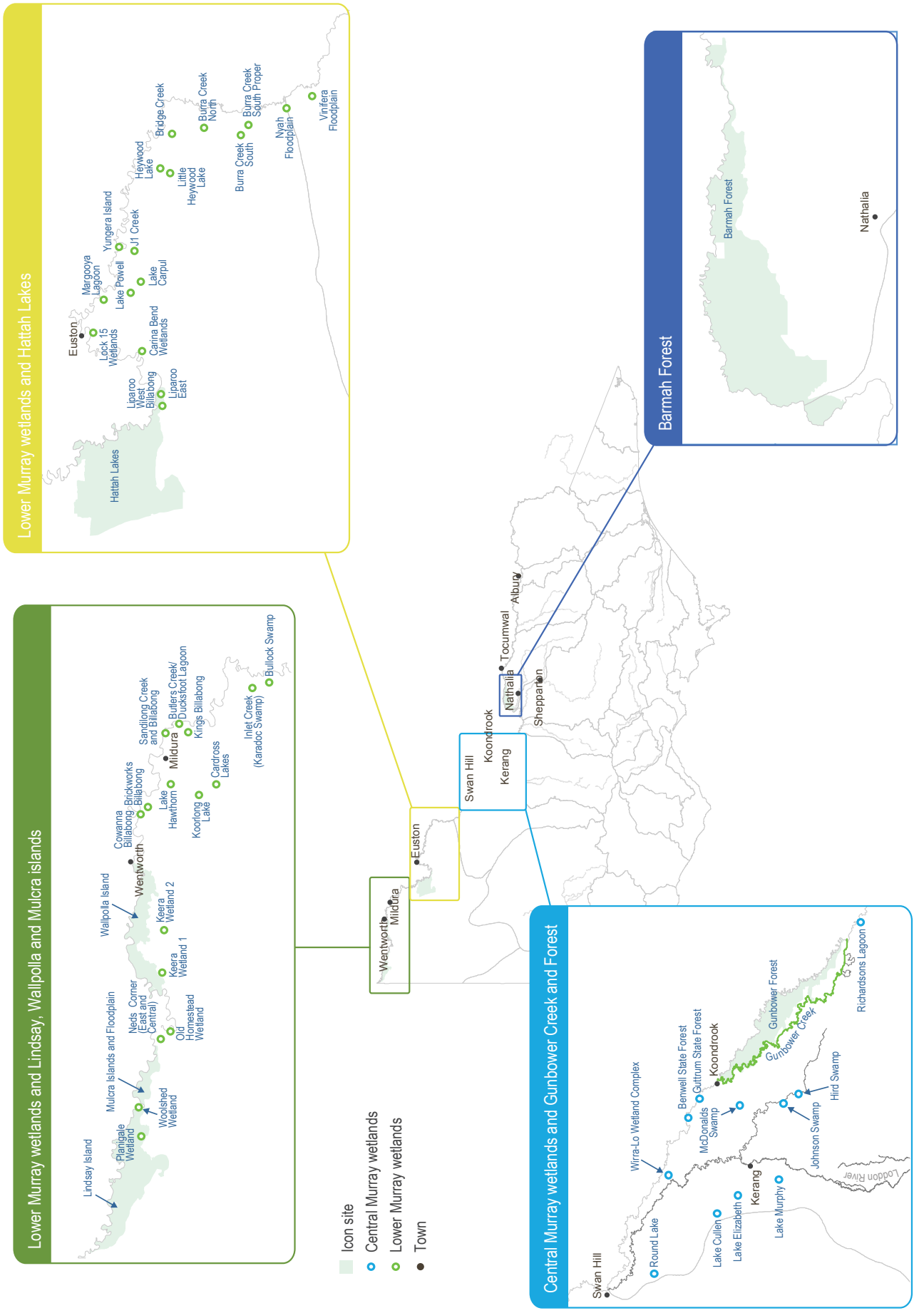
The Victorian Murray system provides a wide range of habitat types that support rare and threatened waterbird species including the painted snipe, brolga, royal spoonbill and white-bellied sea eagle. The system's floodplain wetlands also provide habitat for the nationally endangered Murray hardyhead fish, one of the most threatened vertebrate species in Australia.

The Victorian Murray system supports a variety of recreational activities (such as camping, fishing, water sports, birdwatching 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. These include 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 the ability of the VEWH and its program partners to deliver all watering actions will depend on the availability of water, water commitments by other environmental water holders and operational conditions. As a result, expected environmental water availability is not specified for the Victorian Murray system.

Birdwatching at Lake Powell, by Mallee CMA

Figure 5.2.1 The Victorian Murray system



5.2.1 Barmah Forest

The Barmah–Millewa Forest covers 66,000 ha 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 ha of forest and wetlands.

Environmental values

The Barmah–Millewa Forest is the largest river red gum forest in Australia and the most intact freshwater floodplain system along the River Murray. The forest supports important floodplain vegetation communities including the threatened Moira grass plains and is a significant feeding and breeding site for waterbirds including bitterns, ibis, egrets, spoonbills and night herons. Significant populations of native fish, frogs and turtles also live in the forest's waterways.

Social, cultural and economic values

The Barmah Forest supports a variety of recreational and tourism activities (such as bushwalking, fishing, river cruises and bird watching). Camping is popular along much of the 112 km frontage to the River Murray: with its majestic river red gums, sandy beaches and a large variety of wildlife, the Murray provides the ideal backdrop for camping. Four canoe trails have been developed in the park, and the forest also provides excellent fishing opportunities, particularly for Murray cod, golden perch, freshwater catfish and yabbies.

The forest is valued for its part in Australia's heritage and for its natural and Aboriginal and post-European settlement cultural heritage values. Aboriginal sites of significance include scar trees, middens, burial sites, artefacts and ovens. The Barmah Forest is highly significant for Traditional Owners of the Yorta Yorta Nation who have a continuing connection to Country including important ceremonial places and resources (such as foods and medicines). The Barmah Forest is jointly managed by the Yorta Yorta Nation. Non-Aboriginal artefacts are largely associated with past forestry and grazing practices in the forest.

Ibis colony at Boals Deadwood wetland in Barmah Forest, by Goulburn Broken CMA

Environmental watering objectives in Barmah Forest

	Enhance the health of river red gum communities and aquatic vegetation in the wetlands and watercourses and on the floodplain Increase germination and growth of Moira grass
	Maintain or increase the habitat available for frogs
	Maintain or increase the number of waterbirds feeding in the forest Successfully recruit colonial nesting waterbirds
	Maintain or increase the habitat available for turtles
	Protect and increase populations of native fish by providing flows to encourage them to spawn Maintain or increase the availability of habitat for native fish, including suitable drought refuges
	Enable nutrient cycling (particularly carbon) between the floodplain and the river through connectivity

System overview

Water management in the Barmah–Millewa Forest depends on gravity distribution from the River Murray. When river flows are above 15,000 ML/day downstream of Yarrawonga Weir, both sides of the forest are managed as a whole. When flow is less than 15,000 ML/day, each side of the forest can be managed separately by operating the regulators individually. When flow downstream of Yarrawonga Weir is less than 10,500 ML/day, all regulators are usually closed to prevent unseasonal flooding of the forest in summer and autumn.

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 reduced the diversity, extent and condition of vegetation communities and the habitat and health of dependent animal species.

Environmental water releases aim to protect essential habitat under dry conditions and when possible to build on unregulated flows and consumptive water en route to optimise environmental outcomes. Environmental water delivered to the forest can often be used again at sites further downstream as part of multisite watering events.

Recent conditions

Spring 2016 saw the return of wet conditions and the largest flood event in Barmah–Millewa Forest since 1993. Environmental water deliveries maintained flows in November and December which improved the health of floodplain vegetation and provided water to wetlands through to February to help nesting waterbirds successfully fledge their young.

In most years, downstream demands from other water users result in the river being at capacity through the forest in summer and autumn (10,500 ML/day downstream of Yarrawonga). In 2016–17, flows were lower in these seasons because of reduced irrigation demand from Hume Reservoir. Environmental water was delivered from January to April to maintain a higher flow in the River Murray to support a trial delivery of water through a creek in Millewa Forest, to improve habitat for native fish.

Wetland plants and river red gums responded well to the large, prolonged flood event in Barmah Forest. Environmental water was used to maintain the flooding of Moira grass plains through November and December. Moira grass is a key species of the open plains and excellent growth was recorded across most watered areas. Moira grass flowered profusely at some watered sites, but it was patchy at sites where filamentous brown algae smothered its stems. The nationally endangered river swamp wallaby grass also grew well at sites that received natural flooding and environmental water in 2016.

Waterbirds had a fantastic year across the Barmah–Millewa Forest in 2016–17, with thousands of pairs of birds from a wide range of species nesting and successfully breeding. These included listed species such as egrets and likely breeding of the highly cryptic Australasian little bittern. Environmental water was delivered to particular wetlands to help ibis and spoonbill chicks survive and fledge. Without the delivery of environment water, adult birds would probably have abandoned their nests in response to dropping water levels before the young could look after themselves.

Preliminary results of native fish monitoring showed native species (such as Murray cod and silver and golden perch) spawned in spring. Larval Murray crayfish were found in the River Murray below Barmah Lake, a significant finding as crayfish were extremely uncommon in this area of the river after the 2010–11 hypoxic blackwater event, which caused widespread deaths of fish and crustaceans. Another unusual finding in 2016–17 was of a platypus in a Barmah Forest wetland, adjacent to the river.

Scope of environmental watering

Table 5.2.1 shows potential environmental watering actions and their environmental objectives.

Table 5.2.1 Potential environmental watering actions and objectives for Barmah Forest

Potential environmental watering	Environmental objectives
Spring/summer freshes in the River Murray channel (3 events of up to 1,000 ML/day for 8 days each in October–December)	• Provide flow variability within the main river channel to cue spawning of native fish species, primarily golden and silver perch
Winter/spring low flows to various waterways in Barmah Forest ('translucent regulator' operation providing variable flow rates in July to November)	• Maintain fish and turtle populations in permanent waterways • Maintain connectivity to the river • Remove accumulated organic matter by cycling carbon to the river system and minimising the risk of anoxic (low oxygen) blackwater • Maintain water quality • Provide increased flow variability within the forest
Spring/summer freshes to Gulf and Boals creeks (100 ML/day for 3–5 days as required in November–April)	• Maintain critical drought refuge areas in Barmah Forest • Protect fish and turtle populations in permanent waterways • Maintain water quality
Spring/summer low flows to Gulf and Boals creeks (100 ML/day for 30–60 days as required in November–April)	• Maintain refuge areas in Barmah Forest • Maintain fish and turtle populations in permanent waterways • Maintain connectivity to the river • Remove accumulated organic matter by cycling carbon to the river system and minimising the risk of anoxic (low oxygen) blackwater • Maintain water quality
Spring inundation of floodplain marshes (variable flow rates to extend the duration and inundation extent of natural flooding in September–December)[1]	• Provide flooding of sufficient duration to allow the growth of floodplain marsh vegetation in open plains • Create foraging ground for birds and increase the habitat available for turtles, frogs and small-bodied native fish
Targeted wetland watering to Boals Deadwood, Reedy Lagoon and Top Island wetlands (100–250 ML/day for 4 months in September–February)	• Initiate and/or maintain the breeding of colonial nesting and flow-dependent waterbirds

Table 5.2.1 Potential environmental watering actions and objectives for Barmah Forest *continued*

Potential environmental watering	Environmental objectives
Summer/autumn River Murray high flow (8,000 ML/day downstream of Yarrawonga in January to April)	• Increase large-bodied native fish populations in the River Murray and anabranch creeks
Autumn/winter River Murray low flows (4,000 ML/day downstream of Yarrawonga in May to June)	• Increase large-bodied native fish populations in the River Murray and anabranch creeks

[1] *Environmental water is delivered at flow rates outlined in the MDBA's Objectives and outcomes for river operations in the River Murray System (MDBA, 2016).*

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 dry conditions, objectives focus on maintaining the condition of permanent creeks to sustain fish and turtle populations. Under average or wet conditions, the focus shifts to building resilience in the system by increasing responses to natural flood events. Specific actions may include extending the duration of natural flooding to increase the germination of wetland plants (such as Moira grass) in floodplain marshes or extending watering in river red gum forests to increase the recruitment and survival of young plants.

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 • Low chance of overbank flows in late winter/spring	• Likely chance of small-to-medium unregulated flows in winter/spring • Likely chance of overbank flows in winter/spring	• High probability of moderate-to-large unregulated flows in winter/spring • Expected large overbank flows
Potential environmental watering	• Spring/summer freshes in the River Murray channel • Winter/spring low flows • Spring/summer freshes	• Spring/summer freshes in the River Murray channel • Winter/spring low flows • Spring/summer low flows • Targeted wetland watering • Autumn/winter low flows	• Spring/summer freshes in the River Murray channel • Winter/spring low flows • Spring/summer low flows • Spring inundation of floodplain marshes • Targeted wetland watering • Autumn/winter low flows	• Spring/summer freshes in the River Murray channel • Winter/spring low flows • Spring/summer low flows • Spring inundation of floodplain marshes • Targeted wetland watering • Summer/autumn high flows • Autumn/winter low flows
Possible volume of environmental water required to achieve objectives[1]	• 30,000 ML (no return flows)	• 172,000 ML (with 120,000 ML return flows)	• 596,000 ML (with 480,000 ML return flows)	• 716,000 ML (with 600,000 ML return flows)

[1] *The possible volumes of environmental water required in Barmah Forest are estimates; the actual volumes required are highly dependent on conditions. Unregulated or operational flows may meet some of the demand.*

Risk management

In preparing its seasonal watering proposal, the Goulburn Broken CMA considered and assessed the risks of environmental watering and identified mitigation strategies. Program partners continually reassess risks and mitigation actions throughout the water year (see section 1.3.6).

Engagement

Table 5.2.3 shows the partners and stakeholder organisations with which Goulburn Broken CMA engaged when preparing the Barmah Forest seasonal watering proposal.

Seasonal watering proposals are informed by longer-term regional catchment strategies and regional waterway strategies and by environmental flow studies, water management plans and other studies. The strategies incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the Goulburn Broken Regional Catchment Strategy and Goulburn Broken Waterway Strategy.

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

Partner and stakeholder engagement
• CEWO • DELWP • MDBA (River Murray Operations and Living Murray program) • NSW National Parks and Wildlife Service • NSW Office of Environment and Heritage • Parks Victoria • VEWH • Yorta Yorta Nation Aboriginal Corporation

5.2.2 Gunbower Creek and Forest

Gunbower Forest is a large, flood-dependent forest situated on the River Murray floodplain in northern Victoria between Torrumbarry and Koondrook. Covering 19,450 ha, it is bounded by the River Murray to the north and Gunbower Creek to the south.

Environmental values

Gunbower Forest contains a range of important environmental values including rare and widely diverse 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 range of habitats for birds and supports internationally recognised migratory waterbirds.

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

Social, cultural and economic values

Gunbower Creek and Forest are both valuable sites from a cultural and socioeconomic perspective. The Barapa Barapa and Yorta Yorta communities have a strong connection to the Gunbower Creek and Forest area. The Barapa Water for Country project — a partnership between Barapa Barapa and North Central CMA — has provided an opportunity for Barapa people to spend time on and re-connect with Country in and around Gunbower Forest in recent years.

The forest provides economic values through timber production, apiculture (beekeeping), recreation and tourism. The forest and creek support numerous recreational activities including boating, kayaking, canoeing, camping, fishing and birdwatching. The Gunbower Heritage River Trail is a popular tourist attraction that highlights important Aboriginal and European cultural heritage sites. The River Red Gum Drive is one of Victoria's iconic four-wheel-drive routes and follows the River Murray track through the Gunbower National Park.

Gunbower Creek is the major carrier for the delivery of irrigation supply to the surrounding productive lands.

Environmental watering objectives in Gunbower Creek and Forest

	Maintain and improve the resilience of wetland plants and help river red gums recover from damage they sustained during the Millennium Drought
	Maintain healthy populations of native 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
	Increase the number and type of frog species in the forest

System overview

Gunbower Forest 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 water levels in the creek through spring, summer and autumn is much higher now than under natural conditions due to changing irrigation demand. This significantly affects native fish populations and ecological processes. Environmental water is used to smooth out the sudden and frequent changes in water level by filling the gaps in flows caused by irrigation demand within the creek. This action 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 function (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 ha 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 and the forest to maintain wetland and floodplain condition.

Recent conditions

Gunbower Forest has received six years of consecutive flooding as a result of natural and managed events. Dry conditions were expected for 2016–17 and watering objectives focused on maintaining the health of high-value wetlands — Black Swamp, Reedy Lagoon and Pig Swamp. A small volume of environmental water was pumped to Pig Swamp in upper Gunbower Forest in winter 2016 to support stressed river red gums and wetland vegetation that had not received any water since the 2011 floods.

High rainfall in winter and spring 2016 caused natural floods in Gunbower Forest. Overbank flows from the River Murray into Gunbower Forest commenced in July and continued through to early September. Flows at Torrumbarry Weir peaked at about 52,000 ML/day and inundated at least 10,000 ha of the forest. Environmental water was delivered through one of the lower landscape regulators to enable native fish movement and carbon and nutrient cycling between the creek and forest.

Field observations showed that river red gums responded with a flush of new growth and are in a better condition to withstand future dry conditions. Black box vegetation communities, located on the higher floodplains, were inundated for several weeks, which caused a range of aquatic understorey species including common nardoo to flourish. A high diversity of aquatic plants also germinated in some of the permanent and semipermanent wetlands. Unfortunately, there was little growth of aquatic vegetation in some wetlands (such as Greens Lagoon and Long Lagoon). The lack of response in these wetlands may be due to relatively deep water being held in them for extended periods during late spring and summer, and high turbidity caused by invasive fish species (such as carp). Although Reedy Lagoon had less wetland vegetation diversity after the flooding in spring 2016, surveys in March 2017 recorded some yellow bladderwort, a delicate carnivorous plant rarely found in Gunbower Forest.

Fewer waterbirds used the wetlands in the lower part of Gunbower Forest for feeding and breeding in 2016–17 than in previous years when environmental water was delivered (for example, in 2015–16). The main species to breed in the wetlands in 2016–17 were grey teal and pacific black ducks. Ten pairs of nankeen night herons were also observed in Little Reedy Lagoon, but is it not known whether they successfully bred. The relatively low rates of bird breeding observed in the forest's wetlands in 2016–17 may be linked to the widespread availability of breeding habitat caused by the floods in the River Murray and many of the nearby river systems.

Environmental water was provided through Gunbower Creek to support native fish outside the irrigation season. Traditionally, the creek has been drawn down to a series of disconnected deep pools at the end of the irrigation season: this is now recognised as a major factor threatening the survival of juvenile fish, particularly Murray cod. Providing environmental flows during this period maintains connections 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 intended to trigger spawning of Murray cod in spring and early summer in 2013–14. Surveys in 2016–17 showed the Murray cod population in Gunbower Creek was well-represented by juvenile and subadult size classes, which is similar to populations in the River Murray considered to have sustainable levels of recruitment. These demographic patterns indicate that recently recruited juvenile and adult Murray cod are benefiting from the creek's management. Despite this, the Murray cod population in Gunbower Creek is still below the target size and requires ongoing environmental management to become self-sustaining in the long term.

Scope of environmental watering

Table 5.2.4 shows potential environmental watering actions and their environmental objectives.

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

Potential environmental watering	Environmental objectives
Gunbower Forest	
Reedy Lagoon and Black Swamp (fill in autumn/winter if the wetlands have dried completely)	• Reduce the number of carp in permanent wetlands • 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
Reedy Lagoon and Black Swamp (fill in winter/spring and provide top-ups if significant bird breeding event occurs)	• 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
Reedy Lagoon and Black Swamp (top-ups in autumn/winter)	• Maintain the health and resilience of vegetation communities in permanent wetlands • Maintain suitable feeding and refuge habitat for waterbirds
Winter/spring fresh in Yarran Creek (variable flow rates and duration based on unregulated flows in the River Murray)	• Provide connectivity between Gunbower Creek and River Murray, through Yarran Creek and Shillinglaws regulators, to increase flowing habitat for the lateral movement of native fish, turtles and seed propagules • Provide migration and spawning opportunities for native fish
Extend 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 low flows (up to 400 ML/day between July–August and May–June)	• Increase the survival rate and maintain the growth of native fish (such as Murray cod) by maintaining access to food and habitat 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)	• Increase the recruitment, growth and survival of native fish (such as Murray cod) by maintaining access to breeding habitat and food resources
Summer/autumn low flows (above 300 ML/day, between January to May)	• Maintain the survival rate and growth of native fish by increasing access to food and habitat resources
Increased winter/spring low flows (up to 500 ML/day between July–August and May–June, if unregulated conditions occur in the River Murray)	• Increase native fish recruitment by providing cues for migration and spawning, in line with larger flows in the River Murray • Increase the survival rate and maintain the growth of native fish (such as Murray cod) by maintaining access to breeding habitat and food resources

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 2017–18 is to allow most of the permanent and semipermanent wetlands throughout Gunbower Forest to dry, in the absence of any natural flooding. Drying aims to reduce the number of carp across the forest. A drying phase will also promote the growth of wetland vegetation and allow newly recruited plants to establish and set seed before the next watering of the forest.

In drought conditions, permanent and semipermanent wetlands in Gunbower Forest will be allowed to draw down and dry. Environmental watering is planned to occur at only two very high-priority wetlands, Reedy Lagoon and Black Swamp, in autumn/winter 2018. Drying of these deep wetlands before the delivery of environmental water is crucial to reduce the large number of adult carp in the wetland and hindering the recovery of wetland vegetation.

It is planned that in all other conditions — dry, average and wet — Reedy Lagoon and Black Swamp will receive environmental water in winter/spring 2017. The wetlands will provide drought refuge for waterbirds and other water-dependent animals and maintain wetland vegetation. Environmental water may also be used to maintain water levels in the wetlands to ensure the wetland vegetation remains in good condition, or to increase the success of any significant colonial waterbird breeding event that may be triggered naturally in these wetlands or in others. Bird breeding top-ups will aim to maintain an appropriate inundation depth for the time it takes for juvenile birds to successfully fledge from their nests.

In dry to wet years, higher flows (above 15,000 ML/day for more than two weeks) in the River Murray may result in some natural flooding and could provide opportunities to support a winter/spring fresh in Yarran Creek. Flows through Yarran Creek and Shillinglaws Regulator will increase flowing habitat between Gunbower Creek and the River Murray and support the movement of native fish, turtles and seed propagules.

In winter, higher flows (above 25,000 ML/day) in the River Murray and high rainfall in the upper catchments may cause moderate levels of natural flooding in the forest. Environmental water may be used to extend the duration and extent of the flooding, to enhance the health of the floodplain that is still recovering from the Millennium Drought.

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

The highest environmental water priority for Gunbower Creek is to maintain flowing habitat and access to feeding resources for native fish during winter, when flow rates would otherwise drop due to there being no irrigation demand and Goulburn-Murray Water needing to conduct system maintenance works. The second-highest priority is to smooth out flows during the irrigation season to provide opportunities for native fish (especially Murray cod) to breed and for their larvae to disperse. If there are high unregulated flows in the River Murray during winter/spring, environmental water may be used to increase the low-flow rate in Gunbower Creek to about 500 ML/day to provide cues for Murray cod to migrate and spawn at the same time as populations in the River Murray.

Gunbower Creek, by North Central CMA

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	• Minor natural inflows into Gunbower Forest may occur in winter/spring	• Some natural inflows into Gunbower Forest are likely in winter/spring but unlikely to be significant	• Overbank flows are likely in winter/spring
Potential environmental watering – tier 1 (high priorities)	• Reedy Lagoon and Black Swamp (autumn/winter fill) • Gunbower Creek winter low flows • Gunbower Creek spring/summer high flows • Gunbower Creek summer/autumn low flows	• Reedy Lagoon and Black Swamp (winter/spring) • Gunbower Creek winter low flows • Gunbower Creek spring/summer high flows • Gunbower Creek summer/autumn low flows	• Reedy Lagoon and Black Swamp (winter/spring) • Gunbower Creek winter low flows • Gunbower Creek spring/summer high flows • Gunbower Creek summer/autumn low flows • Yarran Creek winter/spring fresh	• Reedy Lagoon and Black Swamp (winter/spring) • Yarran Creek winter/spring fresh • Gunbower Creek winter low flows • Gunbower Creek spring/summer high flows • Gunbower Creek summer/autumn low flows
Potential environmental watering – tier 2 (lower priorities)[1]	• N/A	• Yarran Creek winter/spring fresh • Reedy Lagoon and Black Swamp (autumn/winter top-ups)	• Gunbower Creek winter/spring increased low flows • Reedy Lagoon and Black Swamp (autumn/winter top-ups)	• Extension of natural inundation of Gunbower Forest floodplain, floodrunners and wetlands • Gunbower Creek winter/spring increased low flows
Possible volume of environmental water required to meet objectives[2,3]	• 28,000 ML (tier 1) • N/A	• 28,400 ML (tier 1) • 3,500 ML (tier 2)	• 31,000 ML (tier 1) • 5,500 ML (tier 2)	• 33,500 ML (tier 1) • 17,000 ML (tier 2)
Priority carryover requirements	• 11,000 ML	• 12,000 ML	• 10,000 ML	• 8,000 ML

1 *Tier 2 actions are lower-priority actions to be considered if water is available.*

2 *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).*

3 *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 the risks of environmental watering and identified mitigation strategies. Program partners continually reassess risks and mitigation actions 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 catchment strategies and regional waterway strategies and by environmental flow studies, water management plans and other studies. The strategies incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the North Central Regional Catchment Strategy and North Central Waterway Strategy.

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

Partner and stakeholder engagement
• CEWO • Gannawarra Shire Council, Campaspe Shire Council, Cohuna Progress Association and Murray Regional Tourism Board • Gunbower Island Community Reference Group (with representatives of the Cohuna Progress Association, bird observers, Field & Game Australia, BirdLife Australia, Gunbower Landcare Group, irrigators and general community members) • Gunbower Operations Advisory Group (with representatives of Goulburn-Murray Water, Parks Victoria, DELWP, Vic Forests, Forestry Corporation NSW, North Central CMA, MDBA, CEWH and the VEWH) • Gunbower Technical Working Group (with DELWP [Threatened Flora and Fauna] representatives and fish, vegetation and bird consultants and ecologists) • North Central CMA Community Consultative Committee, an advisory group to the North Central CMA Board comprising regional community members • VEWH • Yorta Yorta and Barapa Barapa Traditional Owners

5.2.3 Central Murray wetlands

The central Murray wetland system consists of 11 wetlands on the lower Loddon River and River Murray floodplains.

Environmental values

The wetlands in the central Murray system support vulnerable or endangered species including the Australasian bittern, Murray hardyhead, Australian painted snipe and growling grass frog. The wetlands provide habitat for many threatened bird species (including the great egret and white-bellied sea eagle) listed under several Acts and international agreements. Internationally recognised, Ramsar-listed wetlands in the system include Lake Cullen, Hird Swamp and Johnson Swamp, while others are of bioregional significance.

Social, cultural and economic 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. These Nations continue to have a connection to the central Murray wetlands.

The wetlands are used for various recreational activities including birdwatching and bushwalking, and some wetlands are also used for duck hunting. Tourism is an important contributor to the local economy. Groundwater recharge and carbon storage are other indirect benefits of the wetlands.

Environmental watering objectives in the central Murray wetlands

	Maintain and rehabilitate river red gum, black box, lignum woodland and wetland plant communities Provide appropriate wetting and drying conditions to support seed germination, seedling survival and recruitment including of semi-aquatic plant species in damp areas of wetlands Manage the extent and density of invasive plant species including Tall Marsh vegetation Support a mosaic of wetland plant communities to provide feeding and breeding habitat for a diversity of native animals
	Maintain habitat for the critically endangered Murray hardyhead
	Provide habitat for waterbird resting, feeding and breeding including threatened species (such as Australasian bittern, little bittern and brolga)
	Provide habitat for the endangered growling grass frog

System overview

The central Murray wetlands are almost wholly contained within the Torrumbarry Irrigation Area and are all wetlands of regional or international significance. The area has experienced dramatic changes since European settlement with the construction of levees, roads and channels. Most of the wetlands are now cut off from natural flooding and rely on environmental water to maintain their ecological character and health.

Nine of the wetlands can receive environmental water using permanent infrastructure: Lake Cullen, Hird Swamp, Johnson Swamp, Round Lake, McDonalds Swamp, Lake Elizabeth, Lake Murphy, Richardson's Lagoon and the Wirra–Lo wetland complex. To date, neither Guttrum or Benwell forests, which both border the River Murray, have permanent infrastructure to deliver environmental water. Some of the semipermanent wetlands in these forests can receive environmental water via temporary pumping from the River Murray.

Recent conditions

High rainfall during winter/spring caused widespread flooding in the area, including of the Loddon and Avoca River floodplains. The wet conditions in 2016 followed more than three years of below-average rainfall, which shifted management of the wetlands from a planned dry scenario early in the season to a wet scenario by early-to-mid-spring. Environmental watering focused on sites that remained isolated from natural flooding — via channels, roads and levees — as well as the delivery of large wetland watering actions that could not be achieved without assistance from natural floods.

Environmental watering in 2016–17 included top-up flows to Round Lake and Lake Elizabeth to maintain and establish suitable conditions for Murray hardyhead, and to Richardson's Lagoon, McDonalds Swamp, Hird Swamp and Wirra–Lo wetland complex to support the diverse waterbirds, plants and other animals typical of temporary freshwater marshes.

Before 2016–17, Lake Cullen had remained dry since 2012. Under the optimum watering regime, the wetland was due for a fill in the 2016–17 season, but due to the potential for groundwater interaction watering was only proposed if the neighbouring Avoca Marshes and Lake Bael Bael filled first. Heavy rainfall in September and October 2016 saw flooding in the Avoca River and subsequently of Lake Bael Bael. First and Second Marsh filled naturally. Environmental water was used to partially fill Lake Cullen in spring 2016 and supply top-ups in summer and autumn, which provided waterbird feeding and breeding habitats throughout the watering year. The nationally endangered Australasian bittern, Australian little bittern, brolga, magpie geese, whiskered tern and Australian shoveller were also recorded using the tall marsh habitat at the wetland.

Two of the wetlands in the central Murray system — Johnson Swamp and Lake Murphy — did not receive any floodwater or environmental water during 2016–17. Lake Murphy dried in January 2016 and remained dry for the entire year, helping to promote the germination and establishment of vegetation (such as river red gums) in and around the wetland. Johnson Swamp was allowed to draw down and dry following managed deliveries in the previous year, providing habitat for a large number of frogs and waterbirds including breeding brolga and black swan recorded in November 2016. The drawdown phase promoted highly productive mudflat habitat, important for the establishment of amphibious plant species.

Round Lake remained permanently inundated during the season to support the resident Murray hardyhead population. While fish surveys in autumn 2016 detected the presence of the fish, environmental DNA sampling in winter 2016, which detects species by analysing the DNA released by organisms into the environment, did not detect any Murray hardyhead DNA. A negative result from the new technology reflects the difficulties sampling for this species, especially in cooler months when populations are naturally lower. A recommendation was made to repeat surveys in spring and summer when populations are typically higher, if funding allows. Waterbird surveys in spring and summer recorded at least 21 species, with large numbers of Eurasian coot and black swans.

Lake Elizabeth continued to show a high coverage of aquatic plant species favoured by Murray hardyhead since the first environmental watering in 2014. The plants provide ideal habitat for the fish that were translocated into the wetland during spring and autumn in 2015.Waterbird surveys at Lake Elizabeth show that the variety of species and number of waterbirds are at their highest since monitoring began in 2012. The survey in January 2017 recorded up to 7,500 Eurasian coot, large populations of grey teal and threatened species such as freckled duck, blue-billed duck, hard head and Australasian shoveler present at the wetland.

Richardson's Lagoon spring and summer surveys recorded a lower number of waterbirds in comparison to other wet years, although there was still a variety of species and evidence of black swan, pacific black duck, grey teal and dusky moorhen breeding.

The Wirra–Lo wetland complex supported a high diversity of waterbird and woodland bird species in its five wetlands and the creeks adjoining them including the plumed whistling duck, hardhead, Australian wood duck, royal spoonbill, straw-necked ibis and the vulnerable grey-crowned babbler. The previously planted wetland plant species had flourished and spread naturally through the wetland: they include water ribbon, water milfoil, wavy marshwort, swamp buttercup and floating swamp wallaby-grass.

McDonalds Swamp waterbird surveys recorded a large variety and number of waterbirds. This included significant species listed in the Victorian *Flora and Fauna Guarantee Act 1988*: the intermediate egret, Australasian bittern, magpie geese, blue-billed duck, royal spoonbill, grey-crowned babbler, migratory glossy ibis and Latham's snipe. Successful breeding of black swan, pink-eared duck, Australian wood duck, Eurasian coot, black-winged Stilt, red-kneed dotterel, Australian shelduck, pacific black duck, grey teal and purple swamphen was also recorded.

The environmental water delivered to Hird Swamp in late autumn 2017 has provided habitat for a large number of feeding waterbirds. It is expected that the upcoming bird surveys at the wetland will establish that large numbers and species of waterbirds will use the wetland in 2017–18.

Guttrum and Benwell forests received natural inflows during winter and spring 2016 from the high flows in the River Murray. The natural flooding allowed wetland and aquatic plants to germinate and flower in some parts of the forest, although in most parts of the forest the understorey is still in poor condition. Reed Bed Swamp (in Guttrum Forest) had little-to-no wetland vegetation recorded despite the recent flooding. Much of the forest is still recovering from the Millennium Drought and requires a more-natural watering regime and the reduction of grazing pressure to support recovery.

Scope of environmental watering

Table 5.2.7 shows potential environmental watering actions (including wetland drying) and their environmental objectives.

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

Potential environmental watering	Environmental objectives
Wetland watering	
Round Lake (top-ups as required to maintain water-quality targets)	• Maintain habitat for Murray hardyhead • Maintain suitable waterbird habitat
Lake Elizabeth (top-ups as required to maintain water-quality targets)	• Maintain habitat for translocated Murray hardyhead • Support submerged salt-tolerant aquatic plant assemblage and a high diversity of waterbirds
Wirra–Lo wetland complex (top-ups as required to maintain depth)	• Rehabilitate river red gum and a variety of aquatic vegetation communities, providing suitable habitat for the growling grass frog and a high diversity of waterbirds including brolga
Hird Swamp West and East (fill in winter/spring and provide top-ups if required to support bird breeding)	• Optimise the benefits of autumn/winter partial fill and trigger an early waterbird breeding event • Maintain a variety of vegetation communities (including open-water habitat) to support waterbird feeding and breeding habitats
Richardson's Lagoon (fill in winter/spring and provide top-ups if required to support bird breeding)	• Promote germination, growth and recruitment of a variety of floodplain plant species • Maintain a variety of water-dependent species including fish, waterbirds, frogs and turtles
Guttrum and Benwell forests (fill Reed Bed Swamp in winter/spring and provide top-ups if required to support bird breeding)[1]	• Rehabilitate a variety of aquatic vegetation, semi-aquatic vegetation and river red gum communities in semipermanent wetlands that received natural flooding in 2016–17 • Provide refuge habitat for waterbirds and water-dependant animals • Support colonial waterbird breeding, if it occurs
McDonalds Swamp (partial fill in autumn/winter)	• Promote a variety of vegetation communities by supporting juvenile river red gums and reduce the spread of tall marsh • Facilitate early plant germination and provide suitable conditions for winter frog breeding
Lake Murphy (partial fill in autumn/winter)	• Promote the growth of a variety of vegetation communities including recently planted juvenile river red gums to support waterbird and frog feeding and breeding habitats
Wetland drying	
Johnson Swamp (drying) and Lake Cullen (drawdown)	• Not to be actively watered in 2017–18 • The drying phase of Johnson Swamp will help maintain a variety of habitats (such as herbland meadows) to support a range of waterbirds and animals; drying may also assist with the management of large reed encroachment • Lake Cullen will be allowed to draw down to maintain the salt-tolerant wetland plant communities and provide a variety of habitat types to support a diversity of waterbirds

[1] *Guttrum and Benwell forests may receive environmental water in 2017–18 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 mechanism of the Murray–Darling Basin Plan. Until works are approved and completed, environmental watering will only consider semipermanent wetlands that can receive water pumped from the River Murray.*

Scenario planning

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

North Central CMA has done landscape-scale planning for these wetlands to optimise wetland watering regimes over multiple years. An important consideration in this planning is to ensure there is a large variety of habitat types across the area to support waterbirds and other water-dependent animals at all times.

The wetlands of highest priority (tier 1) for environmental water management in the central Murray wetlands in 2017–18 under all planning scenarios are Round Lake, Lake Elizabeth and the Wirra–Lo wetland complex. Round Lake supports what is thought to be the only stable population of the critically endangered Murray hardyhead in the Kerang area. Murray hardyhead were also translocated to Lake Elizabeth in autumn 2016. These wetlands need to be maintained for future stocking and translocation programs to prevent the regional loss of the species. The Wirra–Lo wetland complex is a permanent drought refuge for waterbirds and other threatened species, and an aim is for it to provide habitat to enable the return of the nationally listed growling grass frog.

If water availability increases under all planning scenarios, additional wetlands (under tier 2) may receive environmental water to help meet native plant, animal and waterbird objectives. Under drought and dry conditions, environmental water may be used to fill some wetlands that did not receive environmental water or natural inflows in 2016–17, or to maintain water depth in wetlands that received environmental water in the previous year. This will address the needs of wetland vegetation, native fish and bird species in the area.

Under very wet conditions, natural floods may partially or completely fill some of the central Murray wetlands, but environmental water may be required to maintain water depth to support waterbird breeding and the condition of the vegetation.

Lake Murphy may receive a partial fill in autumn/winter 2017–18 if the recently planted river red gums are large enough to withstand the watering. If the trees are assessed as too small, the fill will be postponed until spring 2018–19.

No environmental water is planned to be delivered to Johnson Swamp and Lake Cullen in 2017–18. Johnson Swamp is in the second year of a drying phase to promote a greater diversity of habitats for waterbirds and to support juvenile river red gums that established after recent environmental watering. Lake Cullen received a fill (from empty) in 2016–17 and will be allowed to draw down naturally in 2017–18. As the wetland draws down, it will allow wetland plants that have germinated to grow and set seed, and it will also provide a range of types of habitat for waterbirds including deep water habitat, tall marsh and mudflats.

Australian little bittern at Johnson Swamp, by Simon Starr

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 are unlikely	• Some catchment run-off and unregulated flows into the wetlands is possible, particularly in winter/spring	• Low-to-moderate catchment run-off and unregulated flows into the wetlands are likely, particularly in winter/spring	• Catchment run-off and unregulated flows into the wetlands may significantly contribute to water levels in the wetlands, particularly in winter/spring
Potential environmental watering – tier 1 (high priorities)	• Round Lake • Lake Elizabeth • Wirra–Lo wetland complex	• Round Lake • Lake Elizabeth • Wirra–Lo wetland complex • Hird Swamp • Richardson's Lagoon • Guttrum and Benwell forests	• Round Lake • Lake Elizabeth • Wirra–Lo wetland complex • Hird Swamp • Richardson's Lagoon • Guttrum and Benwell forests • McDonalds Swamp	• Round Lake • Lake Elizabeth • Wirra–Lo wetland complex • Hird Swamp • Richardsons Lagoon • Guttrum and Benwell forests • McDonalds Swamp
Potential environmental watering – tier 2 (lower priorities)[1]	• Hird Swamp • Richardsons Lagoon • Guttrum and Benwell forests • McDonalds Swamp	• McDonalds Swamp • Lake Murphy	• Lake Murphy	• Lake Murphy
Possible volume of environmental water required to meet objectives[2]	• 4,000 ML (tier 1) • 4,500 ML (tier 2)	• 7,900 ML (tier 1) • 1,300 ML (tier 2)	• 8,500 ML (tier 1) • 700 ML (tier 2)	• 8,500 ML (tier 1) • 700 ML (tier 2)
Priority carryover requirements	• 3,700 ML	• 3,700 ML	• 4,500 ML	• 7,100 ML

1 *Tier 2 actions are lower-priority actions to be considered if water is available.*

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 the risks of environmental watering and identified mitigation strategies. Program partners continually reassess risks and mitigation actions 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 catchment strategies and regional waterway strategies and by environmental flow studies, water management plans and other studies. The strategies incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the North Central Regional Catchment Strategy and North Central Waterway Strategy.

Table 5.2.9 Partners and stakeholders engaged in developing the central Murray wetlands seasonal watering proposal

Partner and stakeholder engagement
• Birdlife Australia
• Central Murray Wetlands Environmental Water Advisory Group (comprising community members, private landholders, a representative of Game Management Authority and North Central CMA project staff and Board and Community Consultative Committee representatives)
• CEWH
• Community members
• DELWP
• Field & Game Australia
• Gannawarra Shire Council
• Goulburn-Murray Water
• Guttrum and Benwell Community Reference Group
• Landholders owning a wetland that receives environmental water
• Loddon Shire Council
• North Central CMA Board
• North Central CMA Community Consultative Committee, an advisory group to the North Central CMA Board comprising regional community members
• Parks Victoria
• Swan Hill Rural City Council
• VEWH

5.2.4 Hattah Lakes

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

Environmental values

Hattah Lakes provides important waterbird breeding habitat, particularly for colonial nesting waterbirds (such as cormorants). Being located in a remote and arid landscape, Hattah Lakes also provides large-scale drought refuge for waterbirds, fish and terrestrial animals. Eleven native and five non-native 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 lignum and black box communities that require inundation two or three times a decade. The reduced frequency and duration of floods in the River Murray has degraded the water-dependent vegetation communities across the Hattah Lakes, which has in turn reduced the diversity and abundance of animals that rely on healthy vegetation for habitat.

Social, cultural and economic values

Hattah-Kulkyne National Park is a popular location for camping, canoeing, birdwatching and photography.

The Hattah Lakes hold significance for Traditional Owners. They contain important ceremonial places and for thousands of years provided resources such as food and materials for the Latji Latji people.

Environmental watering objectives in the Hattah Lakes

	Rehabilitate 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 golden 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

The Hattah Lakes system is naturally filled when there are high flows in the River Murray and some lakes hold water for several years after floods recede. Regulation of the River Murray has significantly reduced the frequency and magnitude of natural floods through the Hattah Lakes system.

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 water to parts of the floodplain and then retain and/or discharge it to provide the water regimes that support the environmental values of the system.

Recent conditions

At the beginning of 2016–17 the delivery of environmental water to Hattah Lakes was not a high priority as environmental water had been provided to Hattah Lakes three times since 2013, a dry year was expected and water allocations were low. Wetland drying was considered appropriate to allow vegetation to establish. As winter and spring progressed, conditions turned wet and it was decided to deliver water to Hattah Lakes to align with the natural conditions that were occurring throughout the region. Almost 35,000 ML of environmental water was pumped into Hattah Lakes in September and October.

In October and November 2016, there was a major flood in the lower River Murray and the Hattah Lakes and floodplain were inundated for 16 weeks above the retention level of the lakes. Floods in major contributing systems, the Edward-Wakool and Murrumbidgee, were the largest in over two decades. Those systems washed huge amounts organic material into the River Murray, causing widespread deoxygenated blackwater and fish deaths. The water that was pumped into the lakes was not impacted by deoxygenated blackwater that arrived later during the flood, and so Hattah Lakes provided a refuge for fish and other animals from the deoxygenated blackwater present in the River Murray.

The combination of pumping water to Hattah Lakes and two flood peaks inundated the floodplain to 44.6 m AHD. This is the second time this water level been reached since 2005, and the condition of black box trees improved in response to the flooding. However, the water did not reach trees at slightly higher elevations, up to 45.0 m AHD, which have not been inundated by floodwater since the 1970s.

Scope of environmental watering

Table 5.2.10 shows potential environmental watering actions and their environmental objectives.

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

Potential environmental watering[1]	Environmental objectives
Winter/spring fill of semipermanent wetlands	• Maintain water in semipermanent wetlands to provide habitat for fish and waterbirds
Winter/spring fill of semipermanent and temporary wetlands	• Improve the condition of red gum forests and woodland
Winter/spring floodplain inundation up to 45.0 m AHD	• Improve the condition of black box woodlands

[1] *The Hattah Lakes pump station may also be operated at any time of year to meet annual maintenance requirements.*

Scenario planning

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

Even with the flooding that occurred in 2016, and the managed environmental watering at Hattah Lakes since 2013, the condition of black box woodland in the highest floodplain terraces remains poor. The trees are unhealthy because the managed flows have not exceeded 45.0 m AHD, where large stands of black box are growing. The last flood of woodland at this height was in 1975. The highest water level in 2016 was 44.6 m AHD, and providing water to 45.0 m AHD in 2017 will help increase survival of black box trees that recruited in 2016, trigger additional recruitment and improve the condition of other established trees.

The lakes have retained water from the 2016 flood and therefore the volume of environmental water needed to meet the target level of 45.0 m AHD is much less than if current water levels were low. About 100,000 ML is needed to fill Hattah Lakes to 45.0 m AHD in 2017. This is a rare opportunity to achieve floodplain inundation not seen since 1975.

It will take at least 100 days to deliver 100,000 ML, therefore it is important to commence filling at the start of the water year so the lakes fill by mid-late spring and then start to draw down into the summer. This is the preferred timing from an environmental perspective. It is also preferred by Parks Victoria, managers of the Hattah-Kulkyne National Park, so that the park can be prepared for visitors in summer.

The rainfall predictions for the Murray–Darling Basin in early winter 2017 are for drier than average conditions, however streamflows will likely be average because major upstream storages remain full and are likely to spill. Based on these streamflow predictions it will be appropriate to commence filling in July, targeting 45.0 m AHD. If conditions are not suitable or environmental water is not available, there is scope to instead focus on environmental objectives for the permanent and semipermanent wetlands at lower elevations with a partial fill later in winter/spring.

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

Planning scenario	Very dry	Dry	Average	Wet	Very wet
Expected conditions	• Low flows year-round in the River Murray and no natural inflows to Hattah Lakes. Substantial wetland drying will occur	• Rare high-flow events in the River Murray and no natural inflows to Hattah Lakes. Substantial wetland drying will occur	• Short periods of high flows, most likely in late winter and spring, providing minor inflows to Hattah Lakes	• Sustained periods of high flows with spills from storages resulting in widespread inundation of Hattah Lakes	• Lengthy periods of high flows with major spills from storages resulting in widespread inundation of Hattah Lakes and floodplain
Potential environmental watering	• Winter/ spring fill of semipermanent wetlands	• Winter/ spring fill of semipermanent and temporary wetlands	• Winter/spring fill of lakes and floodplain inundation to 45.0 m AHD		
Possible volume	• 10,000 ML	• 15,000 ML	• 100,000 ML		

Risk management

In preparing its seasonal watering proposal, Mallee CMA considered and assessed the risks of environmental watering and identified mitigation strategies. Program partners continually reassess risks and mitigation actions 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 catchment strategies and regional waterway strategies and by environmental flow studies, water management plans and other studies. The strategies incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the Mallee Regional Catchment Strategy and Mallee Waterway Strategy.

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

Partner and stakeholder engagement
• Birdlife Australia (Mildura)
• CEWO
• DELWP
• Goulburn-Murray Water
• Landcare Groups (Kulkyne Way Landcare, Red Cliffs and District Landcare, Annuello [Robinvale and District] Landcare, Robinvale Indigenous Landcare, Sea Lake Landcare and Manangatang Landcare)
• Mallee Aboriginal Reference Group
• Mallee CMA Water Technical Advisory Committee (an advisory group to Mallee CMA comprising community members)
• Mid-Murray Field Naturalists
• Mildura 4WD Inc
• MDBA
• Parks Victoria
• Sunraysia bushwalkers
• Sustainable Living Mildura
• VEWH
• Wildside Outdoors

5.2.5 Lower Murray wetlands

The lower Murray wetlands are found across the floodplain of the River Murray between Swan Hill and the SA border. The system includes creeks, wetlands and floodplains that are ecologically important and reflect the natural character and attributes of the River Murray floodplain.

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 wet phase, they provide short-term boom periods when river red gums and wetland plants grow, spread and provide habitat for aquatic animals. During the dry phase, sediments aerate and oxygen is replaced, and terrestrial plants grow and complete life cycles.

Social, cultural and economic values

There are several irrigation districts in the Sunraysia area 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.

The wetlands of the lower Murray wetlands system hold significance for Traditional Owners. For thousands of years they provided resources such as food and materials to the Latji Latji, Wadi Wadi, Dadi Dadi and Wamba Wamba peoples.

Environmental watering objectives in the lower Murray wetlands

	Increase the diversity, extent and abundance of wetland plant life
	Improve the condition of river red gums, black box and lignum to provide habitat for large terrestrial animals (such as lace monitors and bats)
	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

System overview

Regulation and diversion of River Murray flows has substantially reduced the frequency and duration of the high river flows that are needed to provide water to the lower Murray wetlands. This change to the water regime has caused a decline in the environmental values associated with billabongs and other floodplain habitats.

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

Major floods in spring 2016 provided natural inflows to most of the floodplain wetlands that are on lower elevations of the River Murray floodplain. Broad, landscape-scale watering last occurred in summer 2010–11. Before the peak of the flood arrived, several small earthen levees that were built by Mallee CMA to contain environmental water that was pumped into wetlands in previous years were cut to allow floodwater to pass between wetlands. The natural flood met the environmental water objectives for the lower Murray wetlands, and there was no need to deliver environmental water to the system in the first half of 2016–17.

The floods prompted a boom in productivity and growth for most wetlands and provided welcome relief for sites that are heavily affected by salinity. Despite the size of the flood, not all wetlands received flows. Some wetlands at higher elevations and wetlands that are disconnected from the floodplain by levees or road infrastructure remained dry. In March 2017, environmental water was delivered to Lake Heywood to augment natural inflows and enable watering of Little Heywood Lake, which did not received natural inflows in spring.

Scope of environmental watering

Table 5.2.13 shows potential environmental watering actions and their environmental objectives.

Environmental watering will focus on maintaining and improving vegetation condition, habitat quality and availability throughout the wetlands, floodplains and waterways in the lower Murray area. Environmental water may also be used to rehabilitate some 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 (fill in spring or partial fill in autumn, as needed to maintain water-quality targets and minimum water level)	• Maintain and improve the condition of aquatic vegetation and water quality to increase the population of Murray hardyhead
Cardross Lakes (partial fill as needed to maintain water-quality targets and minimum water level)	
Koorlong Lake (partial fill as needed to maintain water-quality targets and minimum water level)	
Lock 15 wetlands (fill or partial fill year-round)	• Improve the productivity of connected riparian zones and wetlands • Rehabilitate floodplain productivity to maintain resident populations of terrestrial animals including carpet python and insectivorous bats • Contribute to the carbon requirements of the River Murray channel ecosystem
Lake Hawthorn (partial fill in spring or as required to maintain water at the minimum level)	• Reintroduce saline marsh habitat, particularly *Ruppia* • Provide habitat for shorebirds
Nyah Floodplain (fill in 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 • Rehabilitate floodplain productivity to maintain resident populations of terrestrial animals including carpet pythons, sugar gliders and grey-crowned babblers
Vinifera Floodplain (fill in spring/summer)	
Burra Creek North (fill in winter/spring)	• Rehabilitate seasonal connectivity along Burra Creek • Improve the health and structure of vegetation • Stimulate the growth of emergent and semi-emergent aquatic vegetation
Burra Creek South (fill in winter/spring)	
Burra Creek South Proper (fill in winter/spring)	
Little Heywood Lake (fill in winter/spring)	• Maintain black box woodland • Provide shallow water habitat for waterbirds
Neds Corner East and Central (fill in spring)	• Provide breeding and roosting habitat for colonial waterbirds
J1 Creek (fill in winter/spring)	• Maintain and improve the health of river red gum, black box and lignum
Yungera Wetland (fill in winter/spring)	
Carina Bend Wetlands (fill in winter/spring)	• Improve the condition of mature river red gum • Provide aquatic habitat to support fish and frogs • Provide habitat for waterfowl
Planigale Wetland (fill in winter/spring)	• Promote the growth of vegetation that aligns with the intermittent swampy woodland, lignum swampy woodland and riverine chenopod ecological vegetation classes • Improve habitat for mammals and reptiles • Support growling grass frogs
Old Homestead Wetland (fill in winter/spring)	• Promote growth of vegetation that aligns with the intermittent swampy woodland, lignum swampy woodland and riverine chenopod ecological vegetation classes
Woolshed Creek (fill in winter/spring)	• Improve the condition of woodland vegetation • Improve habitat for mammals and reptiles • Support growling grass frogs

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

Potential environmental watering	Environmental objectives
Inlet Creek (Karadoc Swamp) (fill in winter)	• Improve the condition of mature black box trees • Provide habitat to support frogs and fish • Provide habitat for waterbirds
Bullock Swamp (fill in winter/spring)	• Provide freshwater inflows and flushing flows to reduce salinity levels and improve the condition and diversity of wetland vegetation • Improve ecological function
Butlers Creek/Ducksfoot Lagoon (fill in spring/summer)	• Provide feeding habitat for waterbirds • Control noogoora burr
Cowanna Billabong (fill in winter/spring)	• Increase wetland productivity • Provide opportunities for fish to move between wetlands and the River Murray
Margooya Lagoon (fill in winter/spring)	• Improve the condition of river red gums • Improve the native fish assemblage of the lagoon • Rehabilitate submerged aquatic vegetation in the open-water areas of the wetland
Liparoo East (fill in winter/spring)	• Improve the condition of the lignum swampy woodland vegetation community and provide habitat for waterbird breeding
Liparoo West (fill in winter)	
Sandilong Creek (fill in spring/summer)	• Support catfish recruitment • Maintain terrestrial vegetation
Keera Wetland 1 (fill in spring)	• Promote the growth of vegetation that aligns with the intermittent swampy woodland, lignum shrubland and lignum swampy woodland ecological vegetation classes
Keera Wetland 2 (fill in spring)	
Wetland drying	
Kings Billabong, Bridge Creek, Heywood Lake, Lakes Powell and Carpul, Sandilong Billabong	• These wetlands will not be actively watered in 2017–18 • Drying will 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 use under a range of planning scenarios.

The highest-priority wetlands for environmental watering in 2017–18 under all climate scenarios and particularly in a drought scenario are Cardross Lakes, Lake Koorlong and Brickworks Billabong, as these sites support the critically endangered Murray hardyhead.

Depending on seasonal conditions and water availability under dry, average and wet scenarios, remaining wetlands are prioritised considering their optimal water regimes and the condition of the environmental values at each site. Additional wetlands will be watered to mimic conditions that would naturally occur. In this way the environmental responses are optimised as plants and animals respond to natural environmental cues.

Some wetlands will not be actively watered in 2017–18 and will be allowed time to dry. This will allow time for vegetation to germinate and establish, and 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 and wetlands rely on environmental water delivery (a very low rainfall year-round and extremely hot and dry conditions in summer/autumn causes substantial wetland drying)	• Short periods of high flows in the River Murray are possible however overbank flows to wetlands do not occur; low rainfall and very warm summer/autumn	• Sustained periods of high flows in the River Murray in late winter and early spring will provide some opportunity for low-lying wetlands to be naturally inundated but most wetlands will still rely on environmental water delivery • Local rainfall may be high and provide catchment flows to some wetlands	• Lengthy periods of high flows and floods with major spills from storages, resulting in widespread inundation of the floodplain and most wetlands • Some reliance on environmental water to achieve target water levels • Local rainfall may be high and will provide catchment flows to most wetlands
Potential environmental watering – tier 1 (high priorities)	• Brickworks Billabong • Cardross Lakes • Koorlong Lake	• Brickworks Billabong • Cardross Lakes • Koorlong Lake • Lock 15 wetlands • Lake Hawthorn • Nyah Floodplain • Vinifera Floodplain • Burra Creek North • Little Heywood Lake • Neds Corner East and Central	• Brickworks Billabong • Cardross Lakes • Koorlong Lake • Lock 15 wetlands • Lake Hawthorn • Nyah Floodplain • Vinifera Floodplain • Burra Creek North • Little Heywood Lake • Neds Corner East and Central • Burra Creek South • Burra Creek South Proper • J1 Creek • Yungera Wetland • Liparoo West Billabong • Carina Bend Wetlands • Planigale Wetland • Old Homestead Wetland • Woolshed Wetland	• Brickworks Billabong • Cardross Lakes • Koorlong Lake • Lock 15 wetlands • Lake Hawthorn • Nyah Floodplain • Vinifera Floodplain • Burra Creek North • Little Heywood Lake • Neds Corner East and Central • Burra Creek South • Burra Creek South Proper • J1 Creek • Yungera Wetland • Liparoo West Billabong • Carina Bend Wetlands • Planigale Wetland • Old Homestead Wetland • Woolshed Wetland • Keera Wetland 2 • Inlet Creek (Karadoc Swamp) • Bullock Swamp • Liparoo East Billabong • Butlers Creek/ Ducksfoot Lagoon • Cowanna Billabong • Margooya Lagoon • Sandilong Creek • Keera Wetland 1

Table 5.2.14 Potential environmental watering for lower Murray wetlands under a range of planning scenarios *continued*

Planning scenario	Drought	Dry	Average	Wet
Potential environmental watering – tier 2 (lower priorities)[1]		• Burra Creek South • Burra Creek South Proper	• Inlet Creek (Karadoc Swamp) • Bullock Swamp • Liparoo East Billabong • Butlers Creek/ Ducksfoot Lagoon • Cowanna Billabong • Margooya Lagoon • Sandilong Creek • Keera Wetland 1	
Possible volume of environmental water required to meet objectives[2]	• 1,150 ML (tier 1) • 0 ML (tier 2)	• 6,000 ML (tier 1) • 1,050 ML (tier 2)	• 11,000 ML (tier 1) • 3,150 ML (tier 2)	• 13,100 ML (tier 1)

[1] *Tier 2 actions are lower-priority actions to be considered if water is available.*

[2] *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 the risks of environmental watering and identified mitigation strategies. Program partners continually reassess risks and mitigation actions 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 catchment strategies and regional waterway strategies and by environmental flow studies, water management plans and other studies. The strategies incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the Mallee Regional Catchment Strategy and Mallee Waterway Strategy.

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

Partner and stakeholder engagement
• 25 Landcare Groups • 4 Friends groups • CEWO • DELWP • Environmental groups (Trust for Nature, Nyah and Districts Action Group, Nyah and Districts Weed Warriors, Sustainable Living in the Mallee, Mallee Fowl Recovery Group, Mid-Murray Field Naturalists) • Goulburn-Murray Water • Lake Lascelles Committee • Lake Tchum Committee • Lower Murray Water • Mallee Aboriginal Reference Group • Mallee CMA Water Technical Advisory Committee (an advisory group to Mallee CMA comprising community members) • Mallee District Aboriginal Services • Meringur Historical Society • Mildura Birdlife, Wildside outdoors – canoeing, Mildura 4WD Inc • Mildura Rural City and Swan Hill Rural City councils • MDBA • Parks Victoria • Recreational Groups (Sunraysia Apiarists Association, Riverside Golf Course, Sunraysia Bushwalkers) • VEWH

5.2.6 Lindsay, Mulcra and Wallpolla islands

Lindsay, Mulcra and Wallpolla islands cover over 26,100 ha of River Murray floodplain, forming part of the Chowilla floodplain and Lindsay–Wallpolla Island Living Murray icon site that straddles the Victoria and SA border.

Environmental values

The Mullaroo and Potterwalkagee creeks are renowned for holding large Murray cod. These creeks provide fast flowing 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 and wetlands throughout the icon site 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 Icon Site is noteworthy because it provides very large expanses of habitat to support wetland-dependent and terrestrial species. 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. These formed important criteria in placing Lindsay Island, Lake Wallawalla and Mulcra Island on the Directory of Important Wetlands in Australia. Terrestrial animals also benefit from the improved productivity and food resources when flooding occurs.

The reduced frequency and duration of floods in the River Murray has degraded the water-dependent vegetation communities, which has in turn caused declines in the diversity and abundance of animals that rely on healthy vegetation for habitat.

Social, cultural and economic values

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

The wetlands and waterways in the Lindsay, Mulcra and Wallpolla islands system hold significance for Traditional Owners. They are important ceremonial places and for thousands of years have provided resources such as food and materials to the Latji Latji, Wadi Wadi, Dadi Dadi and Wamba Wamba peoples.

Environmental watering objectives in the Lindsay, Wallpolla and Mulcra islands

	Increase the diversity, extent and abundance of wetland plant life
	Increase abundance, diversity and distribution of native fish Provide flows for large-bodied fish (including Murray cod and perch) to swim, 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 egret)

System overview

The Lindsay, Mulcra and Wallpolla islands 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

In spring 2016 a major flood in the lower River Murray inundated most of the floodplain across Lindsay, Mulcra and Wallpolla Islands. Floods in the major contributing systems, such as the Edward-Wakool and Murrumbidgee, were the largest in over two decades and washed huge amounts of organic material into the River Murray, causing widespread deoxygenated blackwater and fish deaths. Monitoring has found that although many large fish died, many others found refuge or tolerated the low oxygen and returned to the Lindsay River and Mullaroo Creek when the water quality improved.

The large overbank flows also improved the condition of important floodplain vegetation. The main observations are increased density of river red gum and black box canopies and improved lignum health.

Scope of environmental watering

Table 5.2.16 shows potential environmental watering actions and their environmental objectives.

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

Potential environmental watering	Environmental objectives
Lindsay Island – Mullaroo Creek	
Year-round low flows (up to 600 ML/day)	• Maintain flowing water habitat for native fish species (such as Murray cod, silver perch and golden perch)
Spring/summer high flow (up to 1,300 ML day for up to 4 months between September and January)[1]	• Initiate fish movement and improve spawning and recruitment opportunities for native fish
Lindsay Island – Lindsay River	
Year-round low flows (40 ML/day via the northern regulator)	• Maintain flowing water habitat for native fish species (such as Murray cod, silver perch and golden perch)
Spring/summer high flow (up to 450 ML/day for up to 4 months between September and January via the northern and southern regulator)[1]	• Initiate fish movement and improve spawning and recruitment opportunities for native fish
Lindsay Island wetlands	
Lake Wallawalla (partial or complete fill in winter/spring)	• Improve the diversity and condition of littoral zone herbland plants • Provide opportunities for waterbird breeding and fledging
Websters Lagoon (partial or complete fill in winter/spring)	• Maintain wetland habitat for fish and waterbirds
Mulcra Island – Potterwalkagee Creek	
Year-round low flows in lower Potterwalkagee Creek (40 ML/day via the Stony Crossing regulator)	• Maintain flowing water habitat for native fish species (such as Murray cod, silver perch and golden perch)
Winter/spring/summer low flows in upper Potterwalkagee Creek (up to 100 ML/day between June and February via the upper Potterwalkagee Creek regulator)	• Maintain seasonal flowing water habitat for native fish species (such as Murray cod, silver perch and golden perch)
Spring/summer high flows in lower Potterwalkagee Creek (up to 400 ML/day for 3 months between September and January via the Stony Crossing regulator and upper Potterwalkagee Regulator)[1]	• Initiate fish movement and improve spawning and recruitment opportunities for native fish
Spring/summer high flow in upper Potterwalkagee Creek (up to 150 ML/day for 3 months between September and January)[1]	
Mulcra Island wetlands	
Snake Lagoon (partial or complete fill in winter/spring)	• Improve wetland productivity and habitat for wetland birds and fish
Mulcra Horseshoe (complete fill in winter/spring)	
Wallpolla Island	
Wallpolla Horseshoe (partial or complete fill in winter/spring)	• Maintain variable water levels in the littoral zone to improve wetland productivity
Wallpolla East (partial or complete fill in spring)	• Improve the condition of the riverine grassy woodland and floodway pond herbland ecological vegetation classes
Sandy Creek (partial or complete fill in spring)	• Improve the condition of the grassy riverine forest – floodway pond herbland complex ecological vegetation classes

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 2017–18 will focus on providing minimum low flows and variable high flows in the major waterways and anabranches of the system: the Lindsay River and Mullaroo and Potterwalkagee creeks. Minimum low flows are required under all climatic scenarios to provide permanent habitat for fish. High flows are required to initiate movement of native fish, and the magnitude and duration of high flows will vary depending on seasonal conditions. Most high flows will commence in spring and may extend into early summer. Flows will be coordinated with weir pool operations of lock 7 (Lindsay River and Mullaroo Creek) and Lock 8 (Potterwalkagee Creek).

Sandy Creek and Wallpolla Horseshoe wetlands on Wallpolla Island require water under all climatic scenarios. More water will be delivered to these wetlands if the climatic conditions are average-to-wet, rather than dry.

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

Planning scenario	Very dry	Dry	Average	Wet	Very wet
Expected conditions	• Low flows year-round in the River Murray and no natural floodplain inundation; substantial wetland drying will occur	• Rare high-flow events in the River Murray and no natural floodplain inundation; substantial wetland drying will occur	• Short periods of high flows, most likely in late winter and spring, providing minor inundation of the floodplain	• Sustained periods of high flows with spills from storages resulting in widespread inundation of the floodplain	• Long periods of high flows with major spills from storages resulting in widespread inundation of the floodplain and inundation of most wetlands
Lindsay Island					
Mullaroo Creek and Lindsay River	• Year-round low flow	• Year-round low flow	• Year-round low flow • 1 winter/spring/summer high flow	• Year-round low flow • 1 winter/spring/summer high flow	• Year-round low flow • 1 winter/spring/summer high flow
Wetlands			• Lake Wallawalla (partial fill) • Websters Lagoon • (Complete fill)	• Lake Wallawalla (complete fill) • Websters Lagoon • (Complete fill)	• Lake Wallawalla (complete fill) • Websters Lagoon • (Complete fill)
Water demand[1]	• <2,000 ML	• <2,000 ML	• 8,000–10,600 ML	• 16,000–18,600 ML	• 16,000–18,600 ML
Mulcra island					
Lower Potterwalkagee Creek	• Year-round low flow	• Year-round low flow	• Year-round low flow • Spring/summer high flow	• Year-round low flow • Spring/summer high flow	• Year-round low flow • Spring/summer high flow
Upper Potterwalkagee Creek			• Winter/spring/summer low flows	• Winter/spring/summer low flows • Spring/summer high flow	• Winter/spring/summer low flows • Spring/summer high flow
Wetlands and floodplain				• Snake Lagoon (partial or complete fill)	• Snake Lagoon and Mulcra Horseshoe (complete fill)
Water demand[1]	• <2,000 ML	• <2,000 ML	• 8,000–10,600 ML	• 16,000–18,600 ML	• 16,000–18,600 ML
Mulcra island					
Lower Potterwalkagee Creek	• Year-round low flow	• Year-round low flow	• Year-round low flow • Spring/summer high flow	• Year-round low flow • Spring/summer high flow	• Year-round low flow • Spring/summer high flow

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

Planning scenario	Very dry	Dry	Average	Wet	Very wet
Mulcra island					
Upper Potterwalkagee Creek			• Winter/spring/ summer low flows	• Winter/spring/ summer low flows • Spring/summer high flow	• Winter/spring/ summer low flows • Spring/summer high flow
Wetlands and floodplain				• Snake Lagoon (partial or complete fill)	• Snake Lagoon and Mulcra Horseshoe (complete fill)
Water demand[1]	• <2,000 ML	• <2,000 ML	• <2,000 ML	• 500–2,500 ML	• 5,000–7,000 ML
Wallpolla island					
	• Wallpolla Horseshoe (partial fill) • Sandy Creek (partial fill)	• Wallpolla Horseshoe (partial fill) • Sandy Creek (partial fill)	• Wallpolla Horseshoe (partial fill) • Sandy Creek (partial fill) • Wallpolla East (partial fill)	• Wallpolla Horseshoe (complete fill) • Sandy Creek (partial fill) • Wallpolla East (partial fill)	• Wallpolla Horseshoe (complete fill) • Sandy Creek (complete fill) • Wallpolla East (complete fill)
	• 300 ML	• 700 ML	• 1,600 ML	• 2,200 ML	• 2,800 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 Mullaroo Creek, Lindsay River and Potterwalkagee Creek).*

Risk management

In preparing its seasonal watering proposal, Mallee CMA considered and assessed the risks of environmental watering and identified mitigation strategies. Program partners continually reassess risks and mitigation actions 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, Mulcra and Wallpolla islands seasonal watering proposal.

Seasonal watering proposals are informed by longer-term regional catchment strategies and regional waterway strategies and by environmental flow studies, water management plans and other studies. The strategies incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the Mallee Regional Catchment Strategy and Mallee Waterway Strategy.

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

Partner and stakeholder engagement
• 24 Landcare groups • 4 friends groups • CEWO • DELWP • First People of the Millewa-Mallee Aboriginal Corporation • Goulburn-Murray Water • Lake Lascelles Committee • Mallee Aboriginal Reference Group • Mallee CMA Water Technical Advisory Committee (an advisory group to Mallee CMA comprising community members) • Victorian Malleefowl Recovery Group • Mid-Murray Field Naturalists • Mildura Rural City Council • MDBA • Parks Victoria • Recreational users (Sunraysia bushwalkers, Birdlife Australia (Mildura), Mildura 4WD Inc) • Sustainable Living in the Mallee • VEWH

5.3 Ovens system

Waterway manager – North East Catchment Management Authority

Storage manager – Goulburn-Murray Water

Environmental water holder – Commonwealth Environmental Water Holder

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 downstream of Lake Buffalo, the King River downstream of Lake William Hovell and the Ovens River from its confluence with the Buffalo River to the River Murray.

Environmental values

The Ovens system supports many 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 seen a successful recovery project for trout cod, and efforts to reintroduce Macquarie perch are 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 Ovens wetlands support egrets, herons, cormorants, bitterns and treecreepers while the vegetation along the rivers is mostly river red gums, which are among the healthiest examples in north-east Victoria.

Social, cultural and economic values

Recreational activities include fishing, boating, kayaking, waterskiing, swimming and bushwalking. Irrigation supports the food and wine industries that attract tourists to the system. 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 system including the Yorta Yorta, Bangarang, Taungurung and Dhudhuroa peoples.

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 riverbank 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 maintains a larger proportion of its natural flow regime (particularly in winter/spring) than do other regulated rivers. This is a result of relatively small storages that spill regularly and allow unregulated flows to the rivers.

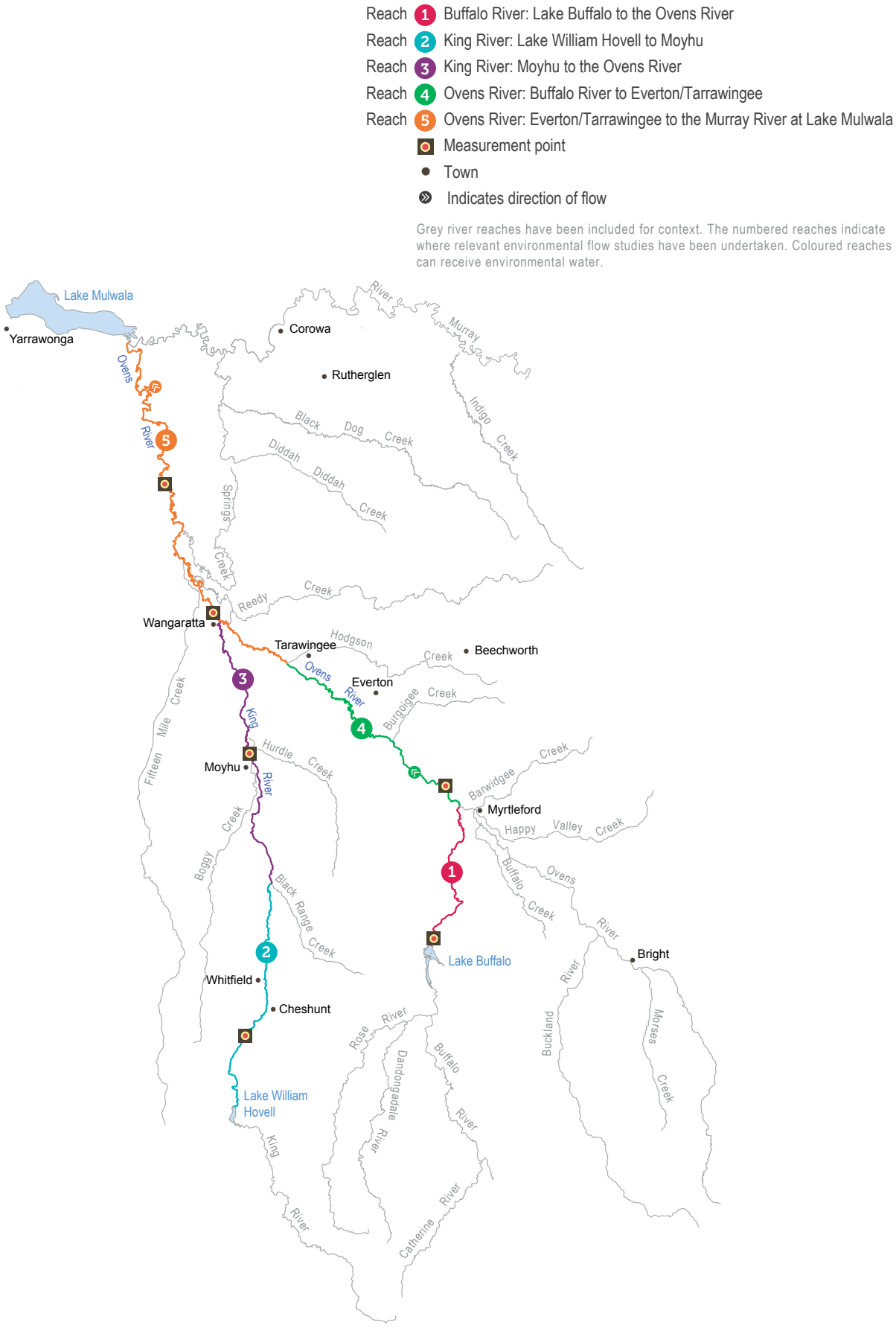
The water that flows out of the Ovens River is regulated by the largest weir pool (Lake Mulwala) on the Murray regulated system. Ovens River flows contribute to the reliability and variability of the flow regime for the River Murray and support many downstream uses including irrigation, urban supply 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. The volume available is well short of the volume required to meet the flow objectives, but it is still delivered in the most beneficial way possible. 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 environmental benefits are likely to be achieved in the lower Ovens River.

Recent conditions

Wet conditions in winter/spring 2016 resulted in significant unregulated flows and the largest spring events in the Ovens catchment since 2010–11. Summer and autumn were mostly dry. A bulk drawdown of Lake Buffalo occurred in February 2017, with environmental water piggybacking to deliver a fresh event down the system. The drawdown occurred earlier than past drawdown events due to infrastructure maintenance works. 50 ML of environmental water was released from Lake William Hovell over two days in mid-March to temporarily vary the flow downstream of the storage in reach 2.

Figure 5.3.1 The Ovens system



Scope of environmental watering

Table 5.3.1 shows potential environmental watering actions and their environmental objectives.

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

Potential environmental watering	Environmental objectives
Summer/autumn fresh in reach 5 (1 fresh of 130–260 ML/day for at least 3 days in December–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 the 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 use 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 more 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. Under wet conditions, the storages are very likely to be spilling due to their small capacity. The desired flows through the Ovens system are likely to be achieved naturally under wet conditions. The environmental water holdings in the Ovens system have a high level of security and are expected to be available under all scenarios.

Buffalo River downstream Lake Buffalo, by North East CMA

Table 5.3.2 Potential environmental watering for the Ovens system under a range of planning scenarios

Planning scenario	Dry	Average	Wet[1]
Expected river conditions	• Possible winter/early spring unregulated flows • Highly likely low summer/ autumn flows • Bulk water release unlikely	• High winter/spring unregulated flows • Possible summer/autumn low flows • Bulk water release likely	• High unregulated flows throughout most of the year • Bulk water release likely • All flow objectives achieved naturally
Expected availability of environmental water	• 50 ML Lake William Hovell • 20 ML Lake Buffalo • 70 ML total		
Potential environmental watering	• Summer/autumn low flows	• Summer/autumn fresh • Summer/autumn low flows	
Possible volume of environmental water required to meet objectives	• 70 ML	• 70 ML	• 0 ML

[1] *Spill conditions likely to mean environmental water cannot be released under wet conditions.*

Risk management

In preparing its seasonal watering proposal, North East CMA considered and assessed the risks of environmental watering and identified mitigation strategies. Program partners continually reassess risks and mitigation actions 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 catchment strategies and regional waterway strategies and by environmental flow studies, water management plans and other studies. The strategies incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the North East Regional Catchment Strategy and North East Waterway Strategy.

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

Partner engagement
• CEWO • Goulburn-Murray Water • VEWH

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 ha or 7.1 percent of the state. The Goulburn River flows for 570 km from the Great Dividing Range upstream of Woods Point to the River Murray east of Echuca. It is an iconic heritage river because of its environmental, 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). Several wetlands in the Goulburn Broken catchment are formally recognised for their conservation significance.

Engagement

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

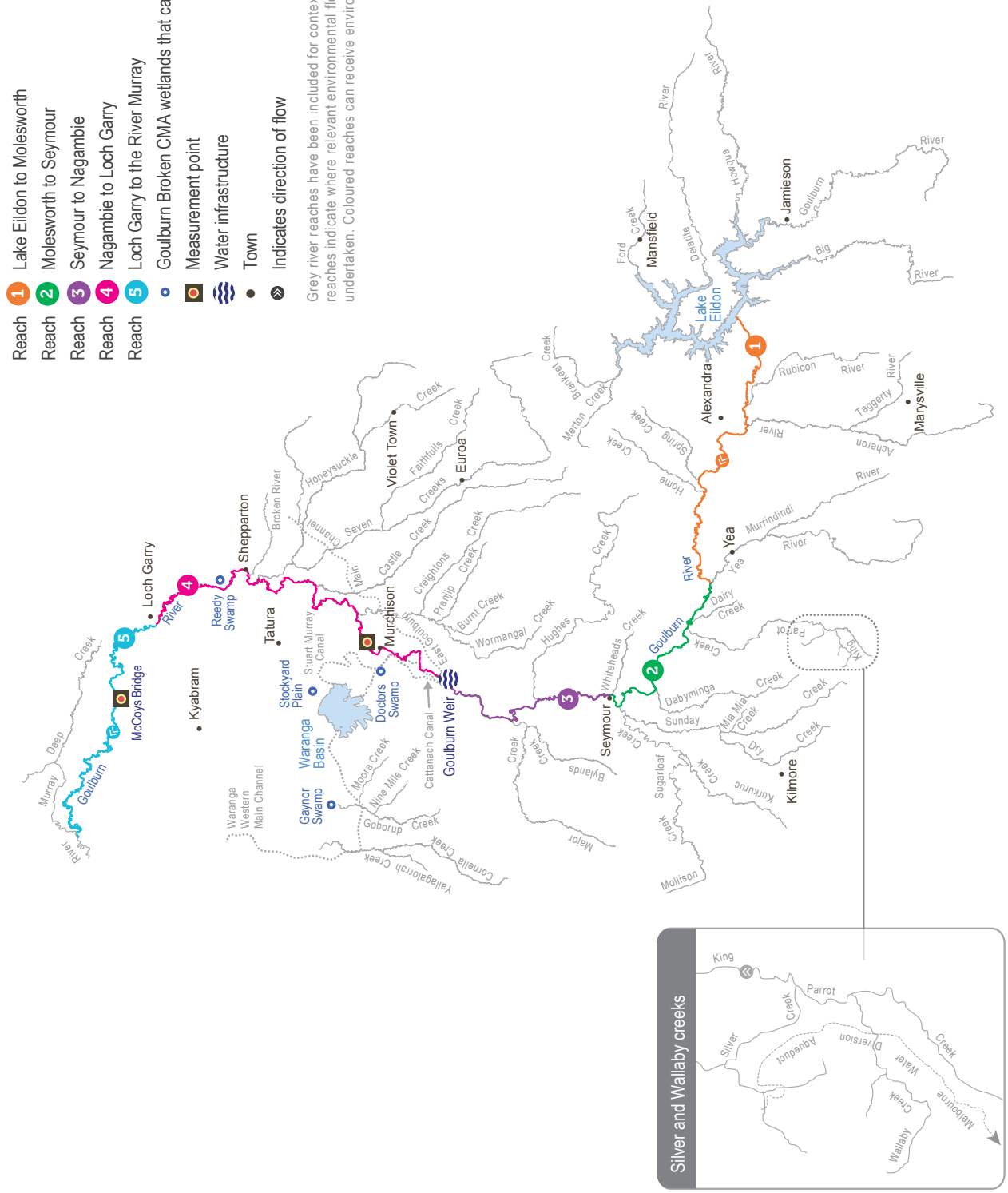
Seasonal watering proposals are informed by longer-term regional catchment strategies and regional waterway strategies and by environmental flow studies, water management plans and other studies. The strategies incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the Goulburn Broken Regional Catchment Strategy and Goulburn Broken Waterway Strategy.

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

Partner and stakeholder engagement
• CEWO • Goulburn Environmental Water Advisory Group, which includes recreational users, local environment groups and landholders • Goulburn-Murray Water • Parks Victoria • VEWH

Having fun at the Goulburn River at Murchison, by Tony Kubeil

Figure 5.4.1 The Goulburn system



5.4.1 Goulburn River

The Goulburn River flows for 570 km from the Great Dividing Range upstream of Woods Point to the River Murray east of Echuca.

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, scour holes and submerged logs provide a high diversity of habitat for 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 vegetation shallowly inundated along and adjacent to the river.

Mid Goulburn River tributaries between Lake Eildon and Goulburn Weir are important Macquarie perch habitat, while freshwater catfish can be found in lagoons connected to the Goulburn River in reach 3. Monitoring in the lower Goulburn River below the Goulburn Weir shows successful spawning in response to environmental flows.

Social, cultural and economic values

The Goulburn Broken catchment covers two percent of the area of the Murray–Darling Basin and contributes 11 percent of the water for use in the basin, with the majority contributed from the Goulburn River. Most of this water is used by irrigated agriculture, with the rest providing water for towns and stock and domestic users. The Goulburn River is popular for recreation, fishing and boating. Fishing in particular provides substantial economic and social benefits to the area. The Goulburn River floodplain 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 in the region, including the Yorta Yorta and Taungurung peoples.

Environmental watering objectives in the Goulburn River

	Increase aquatic and flood-tolerant plants in the river channel and on the lower banks to provide shelter and food for animals and to stabilise the riverbank
	Protect and boost populations of native fish (including golden perch) by increasing the availability of habitat and encouraging fish to migrate and spawn
	Maintain the form of the riverbank and channel — including a high diversity of riverbed surfaces — to support all stream life
	Provide habitat and food for macroinvertebrates, which provide energy, break down organic matter and support the river's food chain

System overview

The construction and operation of Lake Eildon and Goulburn Weir have significantly altered the Goulburn River's natural flow pattern. Water harvesting during naturally wet periods and regulated releases to meet irrigation and other consumptive demand during dry periods mean flow downstream of these structures is typically low in winter and spring and high in summer and autumn. This effectively reverses the natural seasonal flow pattern. Land-use changes and the construction of small dams and drainage schemes have further modified the Goulburn River's flow regime. Levees and other structures prevent water inundating the floodplain.

The regulated flow regime in the Goulburn River is partly ameliorated by inflows from tributaries (such as Seven Creek and the Broken River) that provide some natural flows downstream of Lake Eildon and Goulburn Weir. Large floods that cause these to fill and spill are also important for the flow regime.

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. The availability and use of Commonwealth environmental water is essential to achieve environmental outcomes in the Goulburn River. Environmental water held on behalf of the Living Murray program may also help meet environmental objectives in the Goulburn system en route to icon sites in the Murray system (see Table 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 consumptive 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 help achieve the desired environmental objectives without the need to release environmental water.

The priority environmental flow reaches in the Goulburn River are downstream of Goulburn Weir (reaches 4 and 5) as they are the most flow-stressed sections of the river and support more-abundant and diverse native fish communities. These two reaches are collectively referred to as the lower Goulburn River. Delivering environmental water to the lower Goulburn River also provides benefits to the mid Goulburn River between Lake Eildon and Goulburn Weir (reaches 1 to 3). Environmental water releases from Lake Eildon that target the mid Goulburn River (reach 1 in particular) are most beneficial between late autumn and early spring, when low river flows can occur. For most of the year (early spring to late autumn), transfers of consumptive water from Lake Eildon that are diverted out of the river at Goulburn Weir result in the flow exceeding the environmental flow targets for reaches 1 to 3.

Recent conditions

A series of dry years in the Goulburn catchment from 2013–14 to 2015–16 — with 2015–16 being one of the driest years on record — was broken in 2016–17 with the return of wet conditions. Winter/spring rainfall resulted in significant unregulated flows that provided the second large overbank event in the lower Goulburn River in the past 20 years. Several storm events occurred over summer. A particularly large storm in the last few days of December 2016 washed low-oxygen water from parts of the floodplain into the river channel, which led to an anoxic blackwater event that killed large numbers of fish. Autumn was dry across the catchment. Peak demand in the Goulburn River for environmental water is in spring, but the unregulated flows in spring 2016 met the flow objectives and were well-above what can be delivered with environmental water. The unregulated flows provided ideal conditions for the recovery of vegetation on the mid and upper levels of the bank along the lower Goulburn River. Since the floods, an increase in understory plants, especially native, water tolerant species suited to conditions on a riverbank, have been observed. The vegetation on the lower part of the bank that showed significant recovery in 2015–16 as a result of environmental water deliveries was disturbed by the high river flows, but it is expected to recover.

Environmental water combined with inter-valley transfers (Goulburn water being delivered to the Murray, mostly to meet Murray irrigation demand) to deliver summer low flows and a fresh in late summer/early autumn aimed to provide cues for fish movement into the Goulburn River from the River Murray. Preliminary monitoring results show that some golden and silver perch moved into the Goulburn River during the fresh. A winter fresh commencing in June 2017 is also planned to move sediment, inundate snags and replenish slackwaters, benefiting waterbugs, fish and native vegetation.

The vast majority of environmental water delivered in the Goulburn River is reused at downstream sites along the River Murray. In 2016–17, Goulburn water was reused to meet native fish objectives in Gunbower Creek, along the River Murray and in the Lower Lakes, Coorong and Murray Mouth in SA.

Scope of environmental watering

Table 5.4.2 shows potential environmental watering actions and their environmental objectives.

Checking bank conditions on the Goulburn River near McCoys Bridge, by Goulburn Broken CMA

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

#[1]	Potential environmental watering[2]	Environmental objectives
1	Year-round low flows (500 ML/day in reach 4 and/or 540 ML/day in reach 5)	• Optimise habitat and movement opportunities for large- and small-bodied native fish • Provide conditions that support habitat and food for waterbugs including by maintaining suitable water quality, encouraging the establishment of aquatic vegetation, submerging snags and encouraging plankton production
2	Autumn/winter/spring low flows (400 ML/day in reach 1 in April–September)	• Maintain and improve habitat for small-bodied native fish, waterbugs and aquatic vegetation
3	Winter/spring fresh (1 fresh of up to 10,000 ML/day with flows above 5,600 ML/day for 14 days in reach 4 and reach 5 in June–November)	• Support the 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 the recruitment of golden perch
4a	Winter/spring freshes (up to 2 events of up to 5,000 ML/day for 2 days in reach 4 and reach 5 in July to September)	• Initiate pre-spawning migration of golden perch • Increase available feeding habitat for golden perch
4b	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 the recruitment of golden perch • Maintain macrophyte, waterbug and fish habitat by mobilising fine sediments, submerging snags and replenishing slackwater habitat
5	Increased year-round low flows (830 ML/day in reach 4 and/or 940 ML/day in reach 5)	• Optimise habitat and movement opportunities for large- and small-bodied native fish • Provide conditions that support habitat and food for waterbugs including by maintaining suitable water quality, encouraging the establishment of aquatic vegetation, submerging snags and encouraging plankton production • Submerge additional snags to provide food and habitat for waterbugs • Maintain pool depths and distribute sediment • Provide slackwater habitat in spring/summer to support spring-spawned larvae and juvenile fish
6	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)	• Maintain macrophyte, waterbug and fish habitat by mobilising fine sediments, submerging snags and replenishing slackwater habitat
7	Summer/autumn fresh (1 fresh of up to 5,600 ML/day for up to 10 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 the establishment of flood-tolerant bank vegetation • Stimulate the migration of native fish from the River Murray into the Goulburn River

1 *The numbers in this column refer to the numbered potential environmental watering actions in Table 5.4.3.*

2 *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 riverbanks or benches following higher flows.*

Scenario planning

Table 5.4.3 outlines the potential environmental watering actions 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 priorities for environmental watering in 2017–18 will be providing year-round low flows below Goulburn Weir (reaches 4 and 5) and below Eildon (reach 1). These low flows improve habitat for animals in the river channel and support aquatic vegetation. Under drought conditions, there is less environmental water available and less actions can be delivered. Under dry to wet conditions, almost all actions can be delivered, with good water availability in 2017–18 following on from a wet 2016–17 that increased the volume of water in storage. Delivering more watering actions will have the biggest benefit to the health of the river. Tier 2 actions may be implemented if more water becomes available. Recession flow management is a higher priority under below-average to wet conditions, where the likelihood of large, unregulated flow events in winter and spring increases. Under these conditions, slowing the recession of unregulated peaks can help protect banks from erosion and slumping.

In determining potential watering actions for 2017–18, critical carryover into 2018–19 was considered. Carryover is a priority under the drought scenario, to ensure baseflows can be provided from July to September 2018. Under all other scenarios, there is expected to be sufficient opening allocation on 1 July 2018 to meet this demand in 2018–19.

Goulburn River, by Goulburn Broken CMA

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

Planning scenario	Drought	Dry	Below-Average	Average-Wet
Expected river conditions	• No unregulated flows	• Unregulated flows expected to provide some low flows between winter to mid-spring and likely small winter/spring freshes	• Unregulated flows expected to provide low flows in winter to mid-spring and likely medium winter/spring freshes	• Unregulated flows expected to provide low flows and multiple overbank flow 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	• 189,000 ML carryover • 10,000 ML VEWH • 130,000 ML CEWH • 18,000 ML Living Murray • 347,000 ML total	• 189,000 ML carryover • 10,000 ML VEWH • 276,000 ML CEWH • 39,000 ML Living Murray • 514,000 ML total	• 189,000 ML carryover • 10,000 ML VEWH • 276,000 ML CEWH • 39,000 ML Living Murray • 514,000 ML total	• 189,000 ML carryover • 10,000 ML VEWH • 276,000 ML CEWH • 39,000 ML Living Murray • 514,000 ML total
Potential environmental watering – tier 1 (high priorities)[1]	• Year-round low flows (1) • Autumn/winter/spring low flows (reach 1) (2) • Spring fresh (3) • Spring/summer fresh (4) • Increased year-round low flows (partial) (5)	• Year-round low flows (1) • Autumn/winter/spring low flows (reach 1) (2) • Spring fresh (3) • Spring/summer fresh (4) • Increased year-round low flows (5) • Winter fresh (6)	• Year-round low flows (1) • Autumn/winter/spring low flows (reach 1) (2) • Spring fresh (3) • Spring/summer fresh (4) • Increased year-round low flows (5) • Winter fresh (6) • Recession flow management	• Year-round low flows (1) • Autumn/winter/spring low flows (reach 1) (2) • Spring fresh (3) • Spring/summer fresh (4) • Increased year-round low flows (5) • Winter fresh (6) • Summer/autumn fresh (7) • Recession flow management
Potential environmental watering – tier 2 (lower priorities)[1,2]	• Increased year-round low flows (full) (5) • Winter fresh (6) • Summer/autumn fresh (7) • Recession flow management	• Summer/autumn fresh (7) • Recession flow management	• Summer/autumn fresh (7)	
Possible volume of environmental water required to achieve objectives[3]	• 314,000 ML (tier 1) • 295,000 ML (tier 2)	• 486,000 ML (tier 1) • 103,000 ML (tier 2)	• 504,000 ML (tier 1) • 73,000 ML (tier 2)	• 514,000 ML (tier 1) • 0 ML (tier 2)
Critical carryover into 2018–19	• 23,000 ML	• 0 ML	• 0 ML	• 0 ML

1 *The number in brackets after the potential environmental watering action aligns to the numbering in Table 5.4.2 above.*
2 *Tier 2 actions are lower-priority actions to be considered if water is available.*
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 the risks of environmental watering and identified mitigation strategies. Program partners continually reassess risks and mitigation actions throughout the water year (see section 1.3.6).

5.4.2 Goulburn wetlands

Of some 2,000 natural wetlands in the Goulburn Broken area, only four in the Goulburn catchment (Reedy Swamp, Gaynor Swamp, Stockyard Plain and Doctors Swamp) can currently receive environmental water.

Environmental values

There are a large number of natural wetlands across the Goulburn catchment including Reedy Swamp and Doctors Swamp, which have formally recognised conservation significance. The Goulburn wetlands support a variety of plant 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 and an important stopover feeding site for migratory birds (such as sharp-tailed and marsh sandpipers).

Doctors Swamp is considered one of the most intact red gum swamps in Victoria, supporting over 80 wetland plants.

Gaynor Swamp is a cane grass wetland situated on paleo-saline soils and can sometime receive saline water from nearby saline wetlands during times of flood. When wet, Gaynor Swamp supports thousands of waterbirds including brolga and intermediate egrets. Because Gaynor Swamp has a higher salt concentration than other wetlands in the region, it attracts a different type of feeding waterbird as it draws down. One of the most significant species that feed on exposed mudflats at Gaynor Swamp is the red-necked avocet.

Stockyard Plain is a bioregionally significant wetland that spans private and public land and is valued for its waterbird habitat. The wetland provides breeding habitat for threatened brolga and has the nationally threatened ridged water milfoil.

Social, cultural and economic values

Visitor activities enjoyed at the Goulburn wetlands include birdwatching, picnicking, camping and walking. Doctors Swamp and Gaynor Swamp are state game reserves.

The Goulburn wetlands are identified as culturally sensitive areas under the Victorian *Aboriginal Heritage Act 2006*. The Goulburn wetlands have been and continue to be places of significance for Traditional Owners of the Yorta Yorta Nation. 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

	Maintain and improve the range of native plant life including river red gum and grassy wetland species
	Provide feeding and breeding habitat for waterbirds including migratory and colonial nesting waterbirds
	Provide habitat for frog breeding

System overview

All the Goulburn wetlands can receive environmental water via irrigation supply infrastructure in the Shepparton and Central Goulburn irrigation districts. The volume delivered at any one time depends on the available capacity in the irrigation supply network and may also be negotiated with adjacent landholders.

Reedy Swamp is naturally inundated when flow in the Goulburn River exceeds about 20,000 ML/day. Doctors Swamp can only receive environmental water if the Cattanach Canal is running at 2,500 ML/day and there is available capacity after irrigation demand and operational requirements are met. The opportunity to deliver environmental water to Reedy Swamp is greater in autumn and winter.

Environmental water has not been delivered to Gaynor Swamp or Stockyard Plain. Infrastructure to allow environmental water to be delivered to Gaynor Swamp is due to be completed by autumn 2018, whereas the delivery of environmental water to Stockyard Plain is subject to an agreement with private landholders.

Recent conditions

Natural inflows from regional flooding and high rainfall in the Goulburn catchment filled all Goulburn wetlands in late winter and early spring 2016–17. The inflows triggered plant growth and germination and supported large numbers of waterbirds and frogs. For the first time, Sloane's froglet was recorded at Doctors Swamp along with large numbers of breeding Australasian shelducks and a brown tree creeper that nested in the middle of the swamp. The floods also caused a large field of billy buttons to grow on the fringe of Doctors Swamp.

Summer rainfall topped up the wetlands and some remained wet into autumn 2017. No environmental water was delivered to the Goulburn wetlands in 2016–17.

Reedy Swamp and Doctors Swamp have started to draw down, whereas Gaynor Swamp and Stockyard Plain completely dried over summer 2016–17. All wetlands reached their maximum inundation phase in 2016–17 and require a drying phase to promote vegetation growth and support recently germinated wetland plants.

Scope of environmental watering

Table 5.4.4 shows potential environmental watering actions and their environmental objectives.

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

Potential environmental watering	Environmental objectives
Wetland watering	
Gaynor Swamp (fill in autumn/winter)	• Maintain the diversity of wetland vegetation including cane grass • Provide waterbird breeding and feeding habitat
Stockyard Plain (fill in autumn/winter)	• Maintain the diversity of wetland vegetation including cane grass • Provide waterbird breeding and feeding habitat
Doctors Swamp (partial fill in autumn/winter)	• Maintain the diversity of wetland vegetation including river red gum • Provide waterbird breeding and feeding habitat
Wetland drying	
Reedy Swamp	• Reedy Swamp will not be actively watered in 2017–18 • The drying will help maintain habitats to support a wide range of wetland-dependent birds and animals and to promote the growth and establishment of vegetation in and around the wetland

Scenario planning

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

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

Due to the natural flooding of all the Goulburn wetlands in 2016–17 and the high summer rainfall, all wetlands have exceeded their maximum inundation extents and now require six to nine months of complete drying. Drying the wetlands will allow the vegetation to establish and set seed before the next wet period and build on the objectives of promoting a range of wetland vegetation types to support waterbirds and frogs.

If there are no natural inflows, the Goulburn wetlands will be allowed to dry for the first half of 2017–18. Environmental water may then be used to fill or partially fill Gaynor Swamp, Stockyard Plain and Doctors Swamp in autumn/winter 2018. The wetlands should ideally be allowed to completely dry for at least six months and therefore the specific timing of environmental water deliveries will depend on when each wetland dries. Reedy Swamp will not receive environmental water in 2017–18.

Environmental water deliveries to Gaynor Swamp and Stockyard Plain cannot be guaranteed in 2017–18. Gaynor Swamp can only receive environmental water if new infrastructure is completed and operational by autumn 2018. Deliveries to Stockyard Plain will depend on the agreement of all landholders.

Environmental water is likely to be delivered to Doctors Swamp in autumn/winter 2017–18 if the wetland has been completely dry for at least six months or if vegetation in the wetland is showing signs of significant stress. If neither of these conditions are met, environmental water deliveries may be delayed until 2018–19.

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 are highly unlikely	• Catchment run-off and unregulated flows into the wetlands are unlikely	• Some catchment run-off and unregulated flows into some of the wetlands are 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)	• Gaynor Swamp • Stockyard Plain • Doctors Swamp	• Gaynor Swamp • Stockyard Plain • Doctors Swamp	• Gaynor Swamp • Stockyard Plain • Doctors Swamp	• N/A
Potential environmental watering – tier 2 (lower priorities)[2]	• N/A	• N/A	• N/A	• N/A
Possible volume of environmental water required to achieve objectives[3]	• 2,500 ML (tier 1)	• 2,500 ML (tier 1)	• 1,600 ML (tier 1)	• N/A
Priority carryover requirements	• 2,500 ML	• 2,500 ML	• 1,600 ML	• 0 ML

1 *If any of the wetlands support significant waterbird breeding events in spring/summer, environmental water deliveries may be considered to support bird habitat until fledging.*

2 *Tier 2 actions are lower-priority actions to be considered if water is available.*

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 the risks of environmental watering and identified mitigation strategies. Program partners continually reassess risks and mitigation actions 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. The system also supports a 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.

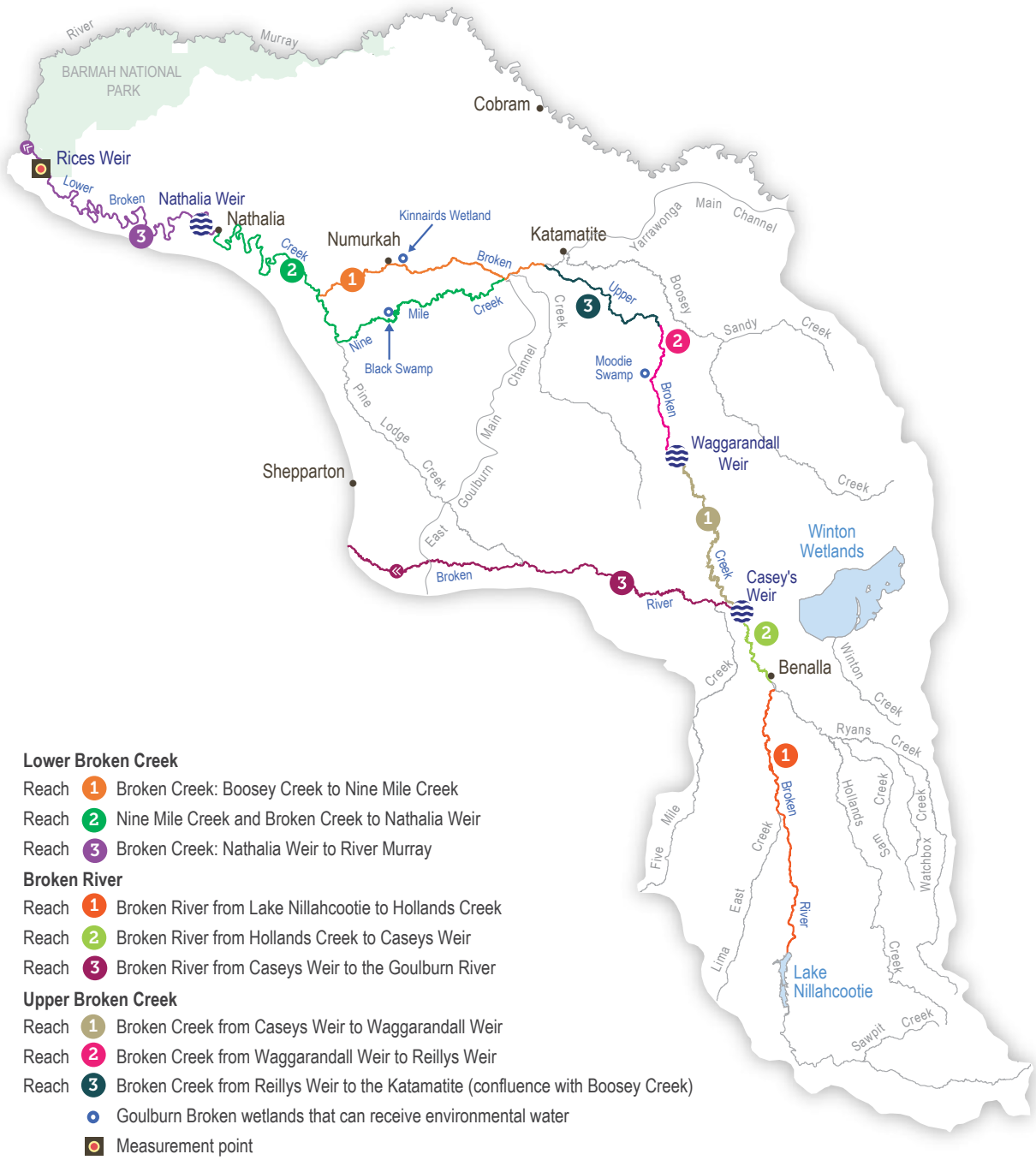
Seasonal watering proposals are informed by longer-term regional catchment strategies and regional waterway strategies and by environmental flow studies, water management plans and other studies. The strategies incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the Goulburn Broken Regional Catchment Strategy and Goulburn Broken Waterway Strategy.

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 • CEWO • Goulburn Broken Catchment Wetland Advisory Group (with representation from Goulburn Valley Landcare, Field & Game Australia, Goulburn-Murray Water, Moira Shire, Council of Greater Shepparton, Turtles Australia, Parks Victoria, Trellys Fishing and Hunting and Kinnairds Wetland Advisory Committee) • MDBA (River Murray Water) • VEWH

Brolga at Moodie Swamp, by Jo Wood

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.

5.5.1 Broken River and upper Broken Creek

The Broken River rises in the Wellington–Tolmie highlands in central Victoria and flows in a westerly direction to Lake Nillahcootie. The river then flows north to Benalla, then west before it discharges to the Goulburn River near Shepparton.

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 receives flood flows from the Broken River although these are much less frequent than occurred naturally, due to earthworks and road construction.

Environmental values

The Broken River supports healthy and diverse aquatic vegetation. A range of native submerged and emergent plant species populate the bed and margins of the river including eelgrass, common reed and water ribbons. The Broken River retains one of the best examples of healthy in-stream vegetation in a lowland river in the region. These plants provide habitat for a range of animals including small- and large-bodied native fish species.

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 a natural features reserve, 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, cultural and economic values

The Broken River and upper Broken Creek floodplain contains a range of Aboriginal cultural heritage values including scar trees and sites of significance for Traditional Owner groups including the Yorta Yorta and Taungurung peoples. The Broken River and Broken Creek systems continue to hold significance for Traditional Owners. The systems also support a range of recreational and tourism values, providing opportunities for bushwalking, fishing and bird watching. The waterways are an important source of water and a delivery mechanism for stock and domestic and irrigation customers.

Environmental watering objectives in Broken River and upper Broken Creek

	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 increase populations of native fish (including threatened Murray cod and golden perch) by improving pool habitat and stimulating fish to migrate and spawn
	Maintain water quality
	Support a wide range and high biomass of waterbugs to provide energy, break down dead organic matter and support the river's food chain

System overview

The Broken River has the characteristics of a foothills stream with relatively steep, confined sections immediately below Lake Nillahcootie. The river then takes on the characteristics of a lowland river with a more-extensive floodplain between Swanpool and its confluence with the Goulburn River at Shepparton. The main tributaries of the Broken River include Hollands Creek, Ryans Creek and Lima East Creek (formerly Moonee's Creek). Much of the area has been cleared for agriculture including dryland agriculture (such as livestock grazing and cereal cropping) and irrigated agriculture (such as dairy, fruit and livestock).

Upper Broken Creek extends for about 65 km from Caseys Weir to Katamatite. The creek has been used to divert consumptive water supplies from the Broken River for more than 100 years, although irrigation entitlements have been significantly reduced 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 the 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 provide infrequent flow. Diverting water from the Broken River to the top reach may achieve some environmental objectives.

Environmental targets can also be met by water delivered from Lake Nillahcootie to meet downstream consumptive demands in the River Murray (known as inter-valley transfers). Broken system inter-valley transfers occur usually during summer and autumn. These flows may help achieve the desired environmental objectives without the need to release environmental water.

Common spadefoot toad at Moodie Swamp, by Jo Wood

Recent conditions

The return of wet conditions in winter/spring 2016 resulted in bankfull and overbank flows along both the Broken River and upper Broken Creek. Flows of such magnitude had not occurred at all in the upper Broken Creek since 2010–11 and were more than double the highest flow rate recorded in the Broken River over the same period.

Tributary inflows over summer/autumn 2016–17 helped maintain a higher average flow in the lower reaches of the Broken River compared to the past few years, but the influence of Lake Nillahcootie reduced flows in reach 1. Over summer/autumn, reaches 2 and 3 experienced low flows typical for this time of year.

Scope of environmental watering

Table 5.5.2 shows potential environmental watering actions and their environmental objectives.

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

Potential environmental watering	Environmental objectives
Summer/autumn fresh in upper Broken Creek (1 fresh of up to 100 ML/day for 2 days in December–May)	• Maintain water quality, particularly in refuge pools
Summer/autumn low flows in the Broken River (up to 15 ML/day in December–May)	• Maintain habitat for native fish, aquatic plants and waterbugs
Summer/autumn fresh in the Broken River (1 fresh of up to 500 ML/day for 2 to 8 days in December–May)	• Move sediment and scour biofilms to increase productivity for waterbugs • Maintain habitat for aquatic plants • Provide passage for native fish and stimulate breeding and movement

Scenario planning

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

The demands for the upper Broken Creek and Broken River are greater than the volume of environmental water expected to be available in the Broken system. Environmental water will be available for use, but it may be used preferentially in Moodie Swamp (see section 5.5.3). Transfers of consumptive water in summer/autumn from Lake Nillahcootie to the Goulburn River are made via the Broken River, which can help meet some or all of the summer/autumn demand. Trade is also a mechanism that environmental water holders can use to increase the amount of environmental water available in the Broken system, subject to trade restrictions.

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

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No unregulated flows • Minimal volume transferred to the Goulburn	• Minimal unregulated flows • Up to 1,500 ML of consumptive water delivered via the Broken River in summer/autumn	• Some contribution of unregulated flows in upper Broken Creek, particularly in winter/spring • Up to 1,500 ML of consumptive water delivered via the Broken River in summer/autumn	
Expected availability of environmental water	• 127 ML	• 253 ML		
Potential environmental watering	• Summer/autumn fresh in upper Broken Creek • Summer/autumn low flows in Broken River	• Summer/autumn fresh in upper Broken Creek • Summer/autumn low flows in Broken River • Summer/autumn fresh in Broken River	• Summer/autumn fresh in upper Broken Creek • Summer/autumn fresh in Broken River	• Summer/autumn fresh in upper Broken Creek
Possible volume of environmental water required to achieve objectives	• Up to 1,900 ML	• Up to 4,200 ML	• Up to 3,300 ML	• Up to 1,000 ML

Risk management

In preparing its seasonal watering proposal, Goulburn Broken CMA considered and assessed the risks of environmental watering and identified mitigation strategies. Program partners continually reassess risks and mitigation actions throughout the water year (see section 1.3.6).

5.5.2 Lower Broken Creek

The lower Broken Creek and Nine Mile Creek (referred to collectively as the lower Broken Creek) begins near Katamatite, downstream of where Boosey Creek enters Broken Creek, and then flows west to join the River Murray.

Environmental values

The lower Broken Creek and Nine Mile Creek support a diverse and abundant native fish community including the threatened Murray cod, golden perch, silver perch, unspecked hardyhead and 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 river swamp wallaby grass and the Australasian bittern.

Social, cultural and economic values

The lower Broken and Nine Mile creeks and associated floodplain and wetland habitats contain many important Aboriginal cultural heritage sites of significance for Traditional Owner groups including the Yorta Yorta Nation, 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

	Control excessive build-up of azolla, which is a native aquatic plant that can lower water quality in the creek when significant blooms occur
	Protect and increase populations of native fish including the threatened Murray cod, golden perch and silver perch by maintaining habitat (water level and quality) and stimulating 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, often contracting to isolated pools or drying out completely. The creeks now have numerous weirs and flow at a relatively constant level from mid-August until mid-May to support adjacent irrigated farming. These modifications have changed the way native animals use the creek. Previously, native fish would have moved into the creek when it was flowing and returned to the River Murray when it dried. Both creeks now provide year-round habitat for native fish, and fish passage structures allow fish to move between weir pools. Environmental water is used to support these permanent fish habitats by providing flows to support fish passage and by providing higher flows to trigger fish movement, control water quality or flush azolla as necessary.

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 to the lower Broken Creek can be sourced from both the Goulburn and Murray systems. Environmental water is sourced from the Goulburn system through the East Goulburn Main Channel and from the Murray system through the Yarrawonga Main Channel. Water is then released into lower Broken Creek from irrigation area regulators along the length of lower Broken Creek. The priority river reach for environmental watering is reach 3 (from Nathalia Weir Pool to the River Murray). Environmental flows that target reach 3 are expected to also deliver the desired flows in reaches 1 and 2. The measurement point for target flows in the lower Broken Creek is at Rices Weir.

Environmental targets can also be met by water delivered from Lake Eildon (known as inter-valley transfers) or Hume Reservoir (known as choke bypass flows) to meet downstream consumptive demands in the River Murray. These consumptive deliveries occur usually during peak irrigation demand: from spring to autumn. These flows may help achieve the desired environmental objectives without the need to release environmental water.

Recent conditions

The wet winter/spring in 2016 resulted in significant unregulated flows in the lower Broken Creek, which met or exceeded the environmental flow targets. The large flood event in the River Murray in September 2016 completely submerged Rices Weir, and high unregulated flows through the whole system successfully flushed all reaches of lower Broken Creek and significantly reduced the risk of azolla build-up in spring and summer.

Environmental water was delivered to the lower Broken Creek from late October to maintain the target 250 ML/day flow rate. The flow release primarily aimed to freshen up the water quality around Rices Weir and reduce the effect of low-dissolved-oxygen water that backed up into the creek from the River Murray in October. The intervention provided a local refuge for native fish that were able to move into the creek via fishways and therefore escape the low oxygen levels in the River Murray.

Flows at Rices Weir were maintained at 250 ML/day for most of summer and autumn to provide habitat for native fish and maintain water quality. The flow rate was reduced to 120 ML/day in April, once cooler conditions arrived and there was less risk of poor water quality. Planning is underway to maintain flows of 40 ML/day from mid-May to mid-August 2017 to allow native fish to move throughout the creek and between the creek and the River Murray during the irrigation shut-down period.

Scope of environmental watering

Table 5.5.4 shows potential environmental watering actions and their environmental objectives.

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 low flows (120 ML/day in August–November)	• Minimise azolla growth
Spring/summer/autumn low flows (150–300 ML/day in October–May)	• Maintain water quality including keeping 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 low flows (250 ML/day in September–December)	• Increase the availability of native fish habitat during the 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 2017–18, environmental flows in the lower Broken Creek will be adjusted as needed to optimise the quantity of habitat and movement opportunities for native fish, maintain water quality and flush azolla through the system. The environmental flow objectives may be partly or wholly met by regulated flows to meet irrigation demand and by natural unregulated flows throughout the year and therefore environmental water will only be used to make up shortfalls. During dry conditions, environmental water will be mainly used to provide higher flows because irrigation demand and the associated consumptive water flows are likely to meet many of the environmental low-flow requirements. During wet conditions, there will be less demand for consumptive water and therefore more environmental water may be needed to meet the low-flow requirements.

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 low flows • Spring/summer/autumn low flows • Winter/spring freshes • Spring/summer low flows		
Possible volume of environmental water required to achieve objectives	• 56,000 ML	• 55,000 ML	• 58,000 ML

Risk management

In preparing its seasonal watering proposal, Goulburn Broken CMA considered and assessed the risks of environmental watering and identified mitigation strategies. Program partners continually reassess risks and mitigation actions throughout the water year (see section 1.3.6).

5.5.3 Broken wetlands

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.

Environmental values

The Broken wetlands (which include Moodie Swamp, Kinnairds Wetland and Black Swamp) support a high diversity of vegetation communities ranging from swamps dominated by river red gums to cane grass wetlands. The wetlands contain state and nationally threatened vegetation communities and species including ridged water milfoil and river swamp wallaby grass. The wetlands also provide food resources and breeding habitat for bird species listed in international agreements and conventions (such as the eastern great egret, Latham's snipe, white-bellied sea eagle and glossy ibis).

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 birdwatching, bike riding, bush walking and camping. Moodie Swamp and Black Swamp are state game reserves.

Environmental watering 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)

Maintain feeding and breeding habitat for waterbirds, particularly for brolga, royal spoonbill and Australasian shoveler

System overview

The water regimes of these wetlands have been greatly influenced by their position in the surrounding Shepparton, Central Goulburn and Murray Valley irrigation districts, which have changed the timing, frequency, volume and duration of inundation. Environmental water, which is delivered via irrigation system infrastructure, aims to restore some of the natural wetting and drying patterns of the wetlands.

Recent conditions

High rainfall and associated inflows filled Black Swamp, Kinnairds Wetland and Moodie Swamp in winter and spring 2016–17. Summer rainfall topped up the wetlands and prolonged their inundation.

Moodie Swamp was still holding water into autumn 2017. The wetland supported a large number of waterbirds including nankeen night herons, brolga, whisked terns and buff-banded rails. Plumed whistling ducks, black swans, Eurasian coots, dusky moorhens and Australian wood ducks bred at the wetland in 2016–17. For the first time, both musk duck and the greater crested grebe were recorded at the wetland. The wetland vegetation responded well to the natural flooding with ridged water milfoil and a new species of water milfoil found at the wetland.

Black Swamp received significant natural inflows in 2016 and remained wet until January 2017. Many young plants at Black Swamp were drowned in 2015–16 after someone deliberately tampered with a regulator, but the natural floods in 2016 have triggered new plant growth and a state-listed rare water nymph was found for the first time at Black Swamp in 2016. Bird surveys in December 2016 recorded the rare freckled duck using the wetland for the first time as well as large numbers of wading birds (such as herons, egrets and spoonbills).

Natural inflows into Kinnairds Wetland attracted a variety of waterbirds. Royal spoonbills and pied cormorants bred at the wetland and the endangered blue-billed duck was observed.

Scope of environmental watering

Table 5.5.6 shows potential environmental watering actions and their environmental objectives.

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

Potential environmental watering	Environmental objectives
Wetland watering	
Moodie Swamp (fill in autumn/winter)	• Maintain the diversity of wetland vegetation • Maintain populations of the nationally threatened ridged water milfoil and slender water milfoil • Provide waterbird feeding and breeding habitat, particularly for brolga
Wetland drying	
Black Swamp and Kinnairds Wetland	• These wetlands will not be actively watered in 2017–18 • Drying of these wetlands will allow newly germinated and planted wetland plants to grow and set seed following extended wet phases

Scenario planning

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

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

Moodie Swamp has been identified as very high priority in all planning scenarios as it supports cane grass habitat for brolga and Australasian bittern. It also supports highly diverse communities of water-dependent plants and animals. Under drought, dry and average scenarios, Moodie Swamp will be allowed to dry for at least six months before a fill in autumn/winter 2018. Watering may be delayed until spring 2018 if natural inflows prevent the wetland from drying for the desired period.

Both Kinnairds Wetland and Black Swamp provide important habitat for waterbirds and wetland vegetation communities including ridged water milfoil, water nymph and river swamp wallaby grass. They have both remained wet for an extended period and require at least a year of drying to allow for the vegetation to recover and set seed. Allowing the wetlands to dry will promote feeding and breeding habitat for waterbirds when they next fill.

In a wet scenario, the ecological objectives at these wetlands are typically met by natural inflows, and only small volumes of environmental water may be required to extend the duration or extent of natural flooding to support a significant waterbird breeding event if it occurs.

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.

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 are highly unlikely	• Catchment run-off and unregulated flows into the wetlands are unlikely	• Some catchment run-off and unregulated flows into some of the wetlands are 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	• Moodie Swamp	• Moodie Swamp	• Moodie Swamp	• Moodie Swamp
Possible volume of environmental water required to achieve objectives	• 500 ML (tier 1)	• 500 ML (tier 1)	• 500 ML (tier 1)	• 500 ML (tier 1)

Risk management

In preparing its seasonal watering proposal, Goulburn Broken CMA considered and assessed the risks of environmental watering and identified mitigation strategies. Program partners continually reassess risks and mitigation actions throughout the water year (see section 1.3.6).

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 km. 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, Forest and Axe creeks downstream of Lake Eppalock.

Malmsbury Reservoir on the Coliban River provides water for towns, irrigation and stock and 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; town water for Bendigo, other local towns and more recently Ballarat (via the Goldfields Superpipe); and 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.

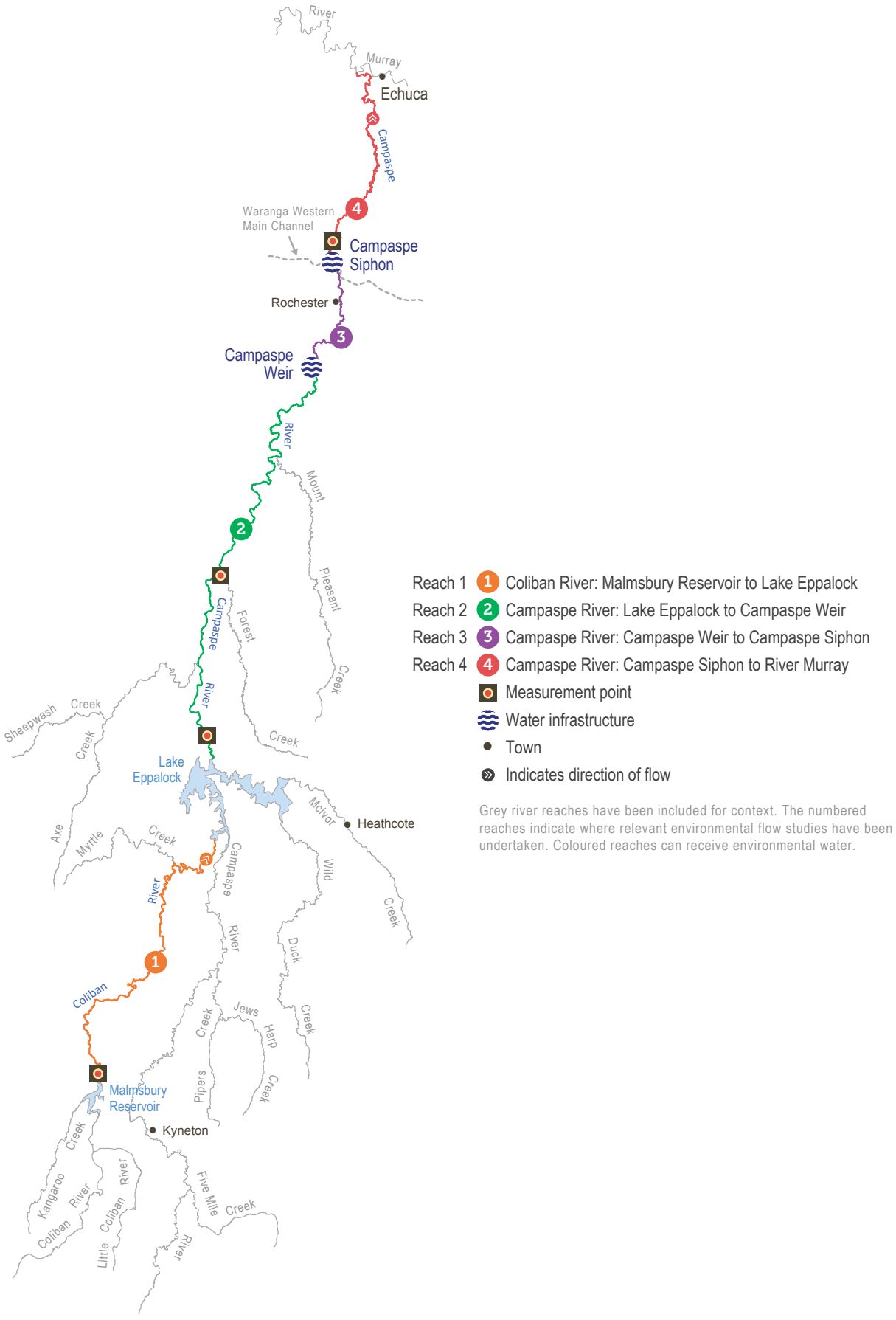
Seasonal watering proposals are informed by longer-term regional catchment strategies and regional waterway strategies and by environmental flow studies, water management plans and other studies. The strategies incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the North Central Regional Catchment Strategy and North Central Waterway Strategy.

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, DELWP, Goulburn-Murray Water, North Central CMA, the VEWH and the CEWH
• Coliban Water
• CEWO
• Community Consultation Committee which provides the North Central CMA with community and local perspectives on projects and functions that have direct public benefits
• Dja Dja Wurrung Clans Aboriginal Corporation
• Dja Dja Wurrung Traditional Owners
• Goulburn-Murray Water
• VEWH

Campers Ron and Andrea Disher at Aysons Reserve, by North Central CMA

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 Murray cod, silver perch, golden perch, Murray–Darling rainbowfish and flat-headed gudgeon. Maintaining flows is important for migration opportunities and dispersal of these native fish species and juvenile platypus. Turtles and frogs are also present and the intact river red gum canopy along the riverbanks supports terrestrial species (such as the squirrel glider).

Social, cultural and economic 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, bushwalking, picnicking and birdwatching. These activities draw locals and tourists alike, providing economic benefits to towns along the river. The Campaspe River is culturally significant with many Aboriginal cultural heritage sites including shell deposits, scar trees, mounds and artefacts recorded along the banks. The Campaspe River continues to be a place of significance for Traditional Owner groups and Nations in the region including the Dja Dja Wurrung, Taungurung and Yorta Yorta people.

Environmental watering objectives in the Campaspe River

	Sustain adult river red gums and increase the growth of new plants Maintain and increase the cover of in-stream and riverside plants
	Provide habitat to help protect and increase populations of native fish Help native fish species (such as the trout cod, river blackfish and Macquarie perch) recolonise the river
	Maintain the resident platypus population by providing places to rest, breed and feed, as well as opportunities for juveniles to disperse to the River Murray
	Provide connection along the length of the Campaspe River and into the River Murray
	Increase the diversity and biomass of waterbugs to provide energy, break down dead organic matter and support the river's food chain
	Prevent high salinity and maintain healthy levels of oxygen in deep pools

System overview

The construction and operation of Lake Eppalock has significantly altered downstream river flows and reversed seasonal flows. Lake Eppalock captures rainfall run-off and reduces natural winter and spring flows downstream. The stored water is then released at a higher-than-natural rate over summer and autumn to meet downstream irrigation demand in the reaches between Lake Eppalock and the Campaspe Siphon. Environmental water is held and released from Lake Eppalock, with some limited ability to regulate flows further downstream at the Campaspe Weir.

Higher-than-natural flows throughout summer may reduce the amount of suitable habitat for juvenile fish, which rely on protected shallow areas of water near the edge of the river channel. 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 together to limit any negative effects these transfers may have on native plants and animals.

Providing the target flows in all reaches below Lake Eppalock is important. Environmental water is usually released from Lake Eppalock to meet specific flow targets in reach 4 (that is, downstream of Rochester). These flows also achieve the desired flow objectives in reaches 2 and 3 between Lake Eppalock and Rochester. Primary flow 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

The Campaspe River has suffered from extreme climatic events over the last 15 years including the Millennium Drought and record floods in January 2011. Most of the recommended environmental flows could not be delivered between 2005 and 2010 because of very low rainfall and inflows to Lake Eppalock, and the ecological condition of the river declined. The 2011 flood scoured most of the established in-stream vegetation and riparian vegetation from the banks of the river. Conditions have been relatively normal since, but 2015–16 was quite dry and there was low water availability at the beginning 2016–17, with allocations starting at zero.

A small volume of water carried over from 2015–16 was used to provide winter low flows at the beginning of 2016–17 before conditions became very wet, causing high inflows to Lake Eppalock, which began to spill on 3 October 2016. Unregulated flows from tributaries downstream of Lake Eppalock and storage spills provided high flows to all reaches during winter and spring, meaning there was no need to release additional environmental water for much of this period. During the spill from Lake Eppalock, an overbank flow event occurred that helped to maintain the river form by scouring sediment from pools and riffles and by improving riparian vegetation. Rainfall throughout the rest of 2016–17 was variable, with a return to drier conditions again toward the end of the year.

Environmental water was delivered in accordance with a wet scenario. This aimed to optimise the benefit of high river flows to maintain and improve environmental values including native fish and bank vegetation and to increase the resilience of the river to cope with stress in future. Monitoring showed an improvement in the native fish community with increasing numbers and range of golden and silver perch throughout the river and high numbers of Murray–Darling rainbowfish. Fewer carp were recorded in reaches that had increased numbers of golden perch. To support native fish, environmental water was used to provide summer low flows targeting the lower reaches of the river to prevent high salinity and low-dissolved-oxygen concentrations and consequent impacts on native fish. Deliveries of water to downstream users in the River Murray in summer and autumn were managed by the storage operator and the CMA to achieve a series of summer and autumn freshes. Low flows in winter were also provided with a combination of environmental water and unregulated flows to allow fish to move between habitats, increase the abundance of waterbug habitat and improve water quality.

Scope of environmental watering

Table 5.6.2 shows potential environmental watering actions and their environmental objectives.

Kids by the Campaspe River, by Victoria Penko

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 the 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 freshes (up to 2 events at 1,000–1,800 ML/day for up to 7 days each in June–November)	• Reduce encroachment by 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 the 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 the permanent longitudinal connectivity of the 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 vegetation • Increase the recruitment of in-channel vegetation • Increase the 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 2017–18 range from maintaining critical habitat under drought conditions to improving the ecological health of the river under wet conditions. The potential watering actions are similar across scenarios but the number, target magnitude and duration of the flows increase under wetter conditions. The volume of environmental water required is therefore greater under wet than under dry conditions.

Water levels in Lake Eppalock will be very high at the beginning of the 2017–18 year. If there are significant inflows, it is highly likely the storage will spill early in the year, leading to a loss of carryover. Under all scenarios, allocations will start at 100 percent, meaning the Campaspe River is in a good position to achieve most of the potential watering actions for the year. If 2017–18 is a wet year, environmental water will be used to increase the number of freshes and increase the magnitude of low flows.

No critical carryover requirements have been identified for the Campaspe system into 2018–19: 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 2018–19. The best environmental outcomes will be achieved by meeting 2017–18 demand rather than by 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	Dry	Average – wet
Expected river conditions	• Few or no unregulated flows • High consumptive water deliveries • No passing flows in winter • No spills from storage	• Some unregulated flows • Some consumptive water deliveries • Increased passing flows • Some unregulated flows from storage spill	• Frequent unregulated flows • Moderate summer consumptive water deliveries in reach 2 and low deliveries in reaches 3 and 4 in summer • Increased passing flows • Significant spills from storage
Expected availability of environmental water	• 20,600 ML VEWH • 6,600 ML CEWH • 100 ML Living Murray • 5,000 ML carryover • 32,300 ML total	• 20,600 ML VEWH • 6,600 ML CEWH • 100 ML Living Murray • 5,000 ML carryover • 32,300 ML total	• 20,600 ML VEWH • 6,600 ML CEWH • 100 ML Living Murray • 5,000 ML carryover • 32,300 ML total
Potential environmental watering – tier 1 (high priorities)	• Summer/autumn low flow • Winter/spring low flow • Winter/spring fresh (1 event) • Summer/autumn freshes (3 events) • Additional freshes may be required to avoid critical loss of species/habitat if a low-dissolved-oxygen event occurs	• Summer/autumn low flow • Winter/spring low flow • Winter/spring freshes (2 events) • Summer/autumn freshes (3 events) • Additional freshes may be required to avoid critical loss of species/habitat if a low-dissolved-oxygen event occurs	• Summer/autumn low flow • Winter/spring low flow • Winter/spring freshes (2 events) • Summer/autumn freshes (3 events) • Additional freshes may be required to avoid critical loss of species/habitat if a low-dissolved-oxygen event occurs
Potential environmental watering – tier 2 (lower priorities)[1]	• Increased magnitude of winter/spring low flow • Winter/spring fresh (1 additional event) • Increased magnitude of summer/autumn freshes	• Increased magnitude of winter/spring low flow • Increased magnitude of winter/spring and summer/autumn freshes	• Increased magnitude of winter/spring low flow
Possible volume of environmental water required to achieve objectives[2]	• 26,900 ML (tier 1) • 16,200 ML (tier 2)	• 30,600 ML (tier 1) • 18,800 ML (tier 2)	• 32,400 ML (tier 1) • 15,300 ML (tier 2)

1 *Tier 2 actions are lower-priority actions to be considered if water is available.*

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 the risks of environmental watering and identified mitigation strategies. Program partners continually reassess risks and mitigation actions throughout the water year (see section 1.3.6).

5.6.2 Coliban River

Environmental values

The Coliban River provides important habitat for platypus, native water rats and small-bodied native fish (such as flat-headed gudgeon and mountain galaxias). The Coliban River also contains a diverse range of waterbugs supported by stands of emergent and submergent aquatic vegetation. It is bordered by remnant patches of streambank shrubland vegetation providing habitat for terrestrial animals. Historical records show that several native freshwater fish species including the Murray cod, river blackfish, Macquarie perch and Australian smelt once inhabited the river.

Social, cultural and economic values

Communities in Malmsbury, Taradale, Metcalfe and the surrounding area value the Coliban River for its aesthetic and recreational features including Ellis Falls and the Cascades. Popular recreational activities in the area include camping, fishing and birdwatching. The upper Coliban storages — Malmsbury and Lauriston Reservoir — supply urban, irrigation, stock and domestic demands in the surrounding area. The river and its adjacent lands are rich in cultural heritage with numerous scar trees, burial sites and artefacts recorded with Aboriginal Victoria. The Coliban River continues to be a place of significance for Traditional Owners who are now represented by the Dja Dja Wurrung Clans Aboriginal Corporation.

Environmental watering objectives in the Coliban system

	Maintain fringing vegetation and in-stream plants
	Protect and increase populations of native fish by providing flows that allow movement and trigger spawning
	Maintain adequate diversity and biomass of waterbugs to provide energy, break down dead organic matter and support the river's food chain
	Improve water quality and maintain healthy levels of dissolved oxygen in pools

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. Therefore, the river below Malmsbury has lower-than-natural flows year-round and environmental water is needed to provide adequate flow during summer and autumn.

The VEWH does not have any environmental entitlements in the Coliban system, but passing flows can be managed to help mitigate some risks associated with critically low summer flow including low levels of dissolved oxygen. A small volume of Commonwealth environmental water is held in the system, but the high cost of delivery means there is no plan to use it in 2017–18.

Recent conditions

The start of the 2016–17 water year was dry and followed several years of mostly below-average streamflow. Therefore, a portion of passing flows was withheld at the beginning of the season to provide critical flows to the river over summer and autumn if dry conditions persisted. Conditions changed early in the year, and there was high rainfall and inflows to storages. The upper Coliban storages quickly filled and spills occurred between September and November providing several important flow events including winter freshes, winter bankfull flows and some small overbank flows. Overbank flows cannot be delivered with planned environmental releases because of infrastructure constraints and only occur when the storages spill.

After the spill event, passing flows were reduced to reserve water for use over summer and autumn. This meant flow in the lower reaches of the Coliban River quickly reduced and eventually ceased, turning lower reaches of the river into a series of disconnected pools. The flows delivered in 2016–17 were well below the environmental flow recommendations of the system except for the unregulated flow period of September to November and an unregulated flow event which reached the objectives of a summer/autumn fresh in April.

Scope of environmental watering

Table 5.6.4 shows potential environmental watering actions and their environmental objectives.

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

Potential environmental watering	Environmental objectives
Summer/autumn freshes (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 flow (2–5 ML/day in December–May)	• Maintain the aquatic vegetation • Maintain fish habitat • Maintain the permanent connectivity of the river for improved water quality • Maintain aquatic habitat for waterbugs • Maintain habitat for platypus
Summer/autumn freshes (of 50–160 ML/day for 3 days each in December–May)	• Maintain/increase riparian and in-channel vegetation • Provide native fish habitat, movement and spawning • Improve water quality • Maintain habitat for waterbugs • Maintain habitat for platypus

[1] *The actual volume and duration freshes 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 poor water quality is more likely and providing constant low flows and/or short freshes can maintain habitat below the reservoir.

The volume of water available will vary depending on inflows, storage spills and the volume of passing flows accumulated, with a lower volume likely to be available under a drought/dry scenario. Water is not likely to be available to provide summer/autumn freshes except under average or wet conditions. The target flows and durations of freshes to manage a potentially catastrophic water-quality incident will vary depending on water availability, the severity of the incident and the amount of flow and water in the river at the time. There is insufficient water available to meet all the environmental water requirements of the Coliban system.

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 freshes • Summer/autumn low flows	• Summer/autumn freshes • Year-round low flows
Potential environmental watering – tier 2 (lower priorities)[1,2]	• Increased magnitude of summer/ autumn low flows	• N/A
Possible volume of environmental water required to achieve objectives[3]	• 900 ML (tier 1) • 250 ML (tier 2)	• 1,200 ML (tier 1)
Priority carryover requirements	• Reserve passing flows for 2018–19	

Risk management

In preparing its seasonal watering proposal, North Central CMA considered and assessed the risks of environmental watering and identified mitigation strategies. Program partners continually reassess risks and mitigation actions 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, silver perch and Murray cod. Pyramid Creek is a tributary of the lower Loddon River that enters the Loddon River near Kerang and provides an important corridor for fish to move from the Loddon system into Kow Swamp, Gunbower Creek and the River Murray. Platypus may also disperse through Pyramid Creek and the lower Loddon River.

The Boort wetlands on the floodplain west 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 herons, egrets and other birds. During temporary dry phases, the floors of these wetlands support a wide range of lakebed plants including some rare and threatened species.

Engagement

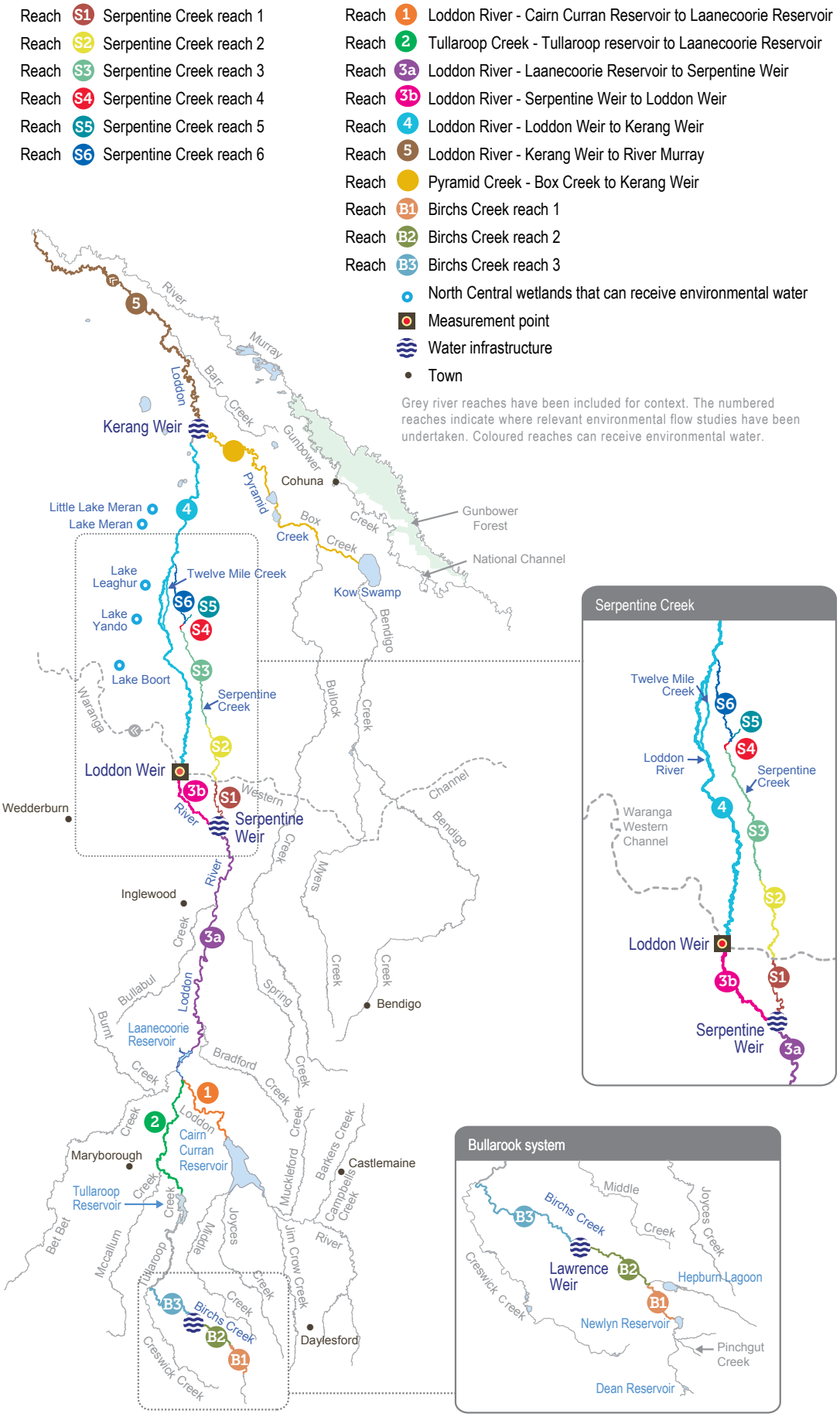
Table 5.7.1 shows the partners and stakeholder organisations with which North Central CMA engaged when preparing the Loddon system seasonal watering proposal.

Seasonal watering proposals are informed by longer-term regional catchment strategies and regional waterway strategies and by environmental flow studies, water management plans and other studies. The strategies incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the North Central Regional Catchment Strategy and North Central Waterway Strategy.

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

Partner and stakeholder engagement
• Birchs Creek Environmental Water Advisory Group and Loddon River Environmental Water Advisory Group (comprising community members and representatives of Goulburn-Murray Water, Central Highlands Water, DELWP and the VEWH)
• Birdlife Australia
• CEWO
• Dja Dja Wurrung Clans Aboriginal Corporation
• Field & Game Australia
• Game Management Authority
• Goulburn-Murray Water
• Loddon Shire Rural Council, Campaspe Shire Rural Council
• North Central CMA Community Consultative Committee, an advisory group to North Central CMA Board comprising community members
• Parks Victoria
• The Wetlands Environmental Water Advisory Group
• VEWH
• VRFish

Figure 5.7.1 The Loddon system



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

The Loddon River flows north from its headwaters near Daylesford towards the River Murray. Tullaroop Creek is the main tributary in the upper Loddon River system. The middle section of the Loddon River includes Serpentine Creek and is characterised by many distributary streams and anabranches flowing north across a broad floodplain. The lower Loddon River is joined by Pyramid Creek at Kerang and at this point the Loddon becomes part of the River Murray floodplain.

Environmental values

The Loddon River system supports platypus, river blackfish and 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 rare Murray–Darling rainbow fish are found in the middle sections of the Loddon River. Pyramid Creek supports large-bodied fish (such as golden perch, Murray cod and silver perch) and is an important corridor for fish migration to and from the Loddon and Murray systems.

A major threat to fish in the Loddon system is the many barriers caused by weirs and reservoirs. In recent years the North Central CMA and Goulburn-Murray Water have upgraded infrastructure to improve fish passage at the chute, Box Creek regulator and Kerang Weir.

The condition of streamside vegetation throughout the Loddon system varies from bad to good depending on the recent water regime and the extent of clearing, grazing and weed invasions. The intact stands of streamside vegetation in good condition support a variety of woodland birds and other native animals.

Social, cultural 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 important recreational fishing species. Bridgewater on Loddon attracts visitors to waterskiing and triathlon competitions.

The Loddon River holds significance for Traditional Owners. The river contains important ceremonial places and for thousands of years provided resources such as food, materials and medicines to Traditional Owners now represented by the Dja Dja Wurrung Clans Aboriginal Corporation.

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 increase 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 major storages in the Loddon River system are Cairn Curran, Tullaroop and Laanecoorie reservoirs. Downstream of Laanecoorie Reservoir the river is further divided into sections due to the Bridgewater, Serpentine, Loddon and Kerang weirs.

Environmental water can be delivered to the Loddon River from Cairn Curran or Tullaroop reservoirs or from the Goulburn system via the Waranga Western Channel (which intersects the Loddon River at Loddon Weir). Water is provided to Pyramid Creek from the Murray system via the National Channel. Water is diverted from the Loddon River to Serpentine Creek and to the Boort Irrigation District to supply agriculture.

The water distribution system in the Loddon is very complicated due to modifications to the natural waterways for irrigation supply. The modifications to waterways and irrigation infrastructure provide challenges and opportunities for effective environmental water management. The highly regulated system makes it possible to manipulate the timing of releases at multiple locations, providing opportunities to accomplish environmental outcomes at discrete locations. However there are also many barriers that limit continuity and constraints that affect the volume and timing of environmental water releases.

The highest-priority reach for environmental watering is from Loddon Weir to Kerang Weir, because there is good potential to rehabilitate environmental values and because the reach doesn't carry irrigation water. Environmental water releases to this reach aim to improve the condition of riparian vegetation and increase the abundance of native fish. Environmental water is also delivered to the upper Loddon River, Tullaroop Creek and Serpentine Creek to maintain or increase populations of river blackfish and platypus.

Recent conditions

In July 2016, water resources in the Loddon system were critically low. There was a high risk that allocations would start at zero, and because Goulburn-Murray Water did not have enough reserve to operate the system for the whole water year, water entitlement holders (including the environment) would not be able to access their full carryover volume from previous years, and passing flows would be reduced. Planning at that time focussed on protecting refuge habitat and optimising the availability of water in the system for all users. High rainfall in July, August and September averted the problem and delivered one of the biggest floods recorded in the Loddon system.

The floods significantly improved the condition of aquatic and floodplain vegetation, and reed beds that had grown in the parts of the channel during the preceding dry years were scoured clear, which increased the quality and quantity of habitat for fish and other aquatic biota. The low dissolved oxygen blackwater events that killed fish in other river systems did not occur in the Loddon River after the floods.

As a result of increased water availability, more environmental water releases were provided in 2016–17 than originally expected. In December 2016, environmental water was released to Serpentine Creek for the first time. Environmental water was also released over summer to reduce the risk of a blackwater event. In April 2017, a coordinated release of water from the Loddon River and Pyramid Creek provided a high flow to stimulate fish migration through fishways at Kerang Weir on the Loddon River and the newly completed fish lock at Kow Swamp.

Scope of environmental watering

Table 5.7.2 shows potential environmental watering actions and their environmental objectives.

Murray River turtle, by North Central CMA

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 year-round)	• Allow fish movement through the reach and maintain depth in pool habitat for native fish • Facilitate the 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 4 freshes of 35–80 ML/day for 1–3 days in December–May)	• Promote the 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 400 to 700 ML/day for 1–5 days in July–October)	• Promote recruitment of riparian vegetation • Stimulate the movement of native fish and increase the breeding success of Murray cod • 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 the 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 4 freshes of 30–40 ML/day for 1–3 days in December–May)	• Promote the 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 200 to 400 ML/day for 1–5 days in July–October)	• Promote the recruitment of riparian vegetation • Stimulate the movement of native fish and increase the breeding success of Murray cod • Flush accumulated leaf litter from banks and low benches into the channel to drive aquatic food webs and increase ecological productivity
Loddon River (reach 4)	
Summer/autumn low flows (25–50 ML/day in December–May)	• 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 the upstream movement of juvenile golden perch to increase the size of local populations • Wet submerged wood and flush silt and biofilms from hard surfaces to promote the growth of new biofilm and increase waterbug populations • Facilitate the downstream dispersal of juvenile platypus in April–May

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

Potential environmental watering	Environmental objectives
Loddon River (reach 4)	
Spring high flow (1 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 increase the 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 bank 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 native 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 • Increase the growth of fringing vegetation (such as sedges and reeds) • Maintain platypus populations by providing foraging and resting habitat
Serpentine Creek (reach 1)[2]	
Summer/autumn low flows (10–20 ML/day in December–May)	• Maintain connectivity between pools to maintain habitat for fish, turtles, platypus and waterbirds • Maintain water quality • Maintain aquatic vegetation
Winter/spring low flows (20–30 ML/day in June–November)	• Maintain spawning habitat and water levels for river blackfish • Provide flow variability to maintain vegetation fringing the bank • Inundate snags to maintain biofilms and foodweb productivity
Summer/autumn freshes (up to 4 freshes of 40 ML/day for 1–3 days in December–May)	• Flush accumulated sediment and scour biofilms to replenish the food chain • Maintain vegetation fringing the bank
Winter/spring fresh (1 fresh of 40–150 ML/day for 2 days in June–November)	• Improve habitat to increase the abundance of native fish and biomass of waterbugs • Maintain habitat for turtles • Scour organic matter that has accumulated in-channel
Serpentine Creek (reach 3)[2]	
Summer/autumn low flows (5–30 ML/day in December–May)	• Maintain connectivity between pools and habitat for fish, turtles, platypus and waterbirds • Maintain water quality • Maintain aquatic vegetation
Winter/spring low flows (30–40 ML/day in June–November)	• Maintain spawning habitat and water levels for river blackfish • Provide flow variability to maintain vegetation fringing the bank • Provide depth to inundate snags and maintain biofilms
Serpentine Creek (reach 3)[2]	
Summer/autumn freshes (up to 4 freshes of 40 ML/day for 3 days in December–May)	• Flush accumulated sediment and scour biofilms to replenish the food chain • Maintain vegetation fringing the bank
Winter/spring fresh (1 fresh of 100–200 ML/day for 2 days in September-November)	• Improve habitat to increase the abundance of native fish and biomass of waterbugs • Maintain habitat for turtles • Scour organic matter that has accumulated in-channel

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

Potential environmental watering	Environmental objectives
Pyramid Creek and Loddon River (reach 5)	
Winter low flow (90–200 ML/day May–August)	• Maintain system connectivity and water quality • Maintain fringing vegetation on the lower banks of the channel
Spring high flow (1 high flow of 700–900 ML/day for 10 days in September to November)	• Trigger and facilitate fish movement and breeding, particularly golden perch and silver perch, to increase local populations • Recruit and maintain riparian vegetation • Flush accumulated leaf litter from banks to provide carbon for aquatic foodwebs
Autumn high flow (1 high flow of 700–900 ML/day for 10 days in March–May)	• Trigger and facilitate the movement of juvenile fish

[1] *Due to potential inundation of private land, environmental flows above 450 ML/day in reach 4 will not be provided without the agreement of potentially affected landholders.*

[2] *Flows in Serpentine Creek will be shepherded through the system and allowed to run down in Pennyroyal Creek and Nine Mile Creek with the agreement of landholders.*

Scenario planning

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

In 2017–18 water availability is expected to be high regardless of climatic conditions. It is therefore a good opportunity to enhance the environmental gains associated with the 2016–17 floods.

In the Loddon River, the magnitude of low flows will be adjusted throughout the year to match seasonal conditions. Under a dry climate scenario, low flows will be released at variable rates close to the low end of the ranges specified for potential watering actions. If it is a wet year, the magnitude of low-flow releases will increase to the upper end of the recommended range. In the Loddon River and Serpentine Creek, three to four summer/autumn freshes are planned for release under all climatic scenarios. During a dry and hot summer, the freshes will be timed to prevent water quality deteriorating.

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, but still a moderate chance of some cease-to-flow periods in some reaches	• Unregulated flows will provide low flows and multiple freshes, most likely in winter and spring • Spills from Loddon system storages will provide extended-duration high flows and overbank flows at any time of the year	
Expected availability of environmental water[1]	• Up to 18,500 ML	• 18,500–24,000 ML		
Loddon River (reach 1) and Tullaroop Creek (reach 2)				
Potential environmental watering	• Year-round low flows • 3 summer/autumn freshes • winter/spring fresh			
Loddon River (reach 4)				
Potential environmental watering	• Year-round low flows • 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	
Serpentine Creek (reaches 1 and 3)				
Potential environmental watering	• Winter/spring low flows • Summer/autumn low flows • Up to 4 summer freshes • 1 winter/spring fresh			
Loddon River, Tullaroop Creek and Serpentine Creek				
Possible volume of environmental water required to achieve objectives	• Up to 18,400 ML	• Up to 20,700 ML	• 9,000–17,300 ML	
Pyramid Creek and Loddon River (reach 5)				
Potential environmental watering	• 1 spring high flow • 1 autumn high flow • Winter low flows			
Possible volume of environmental water required to achieve objectives	• 8,500–17,000 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.*

Risk management

In preparing its seasonal watering proposal, North Central CMA considered and assessed the risks of environmental watering and identified mitigation strategies. Program partners continually reassess risks and mitigation actions throughout the water year (see section 1.3.6).

5.7.2 Boort wetlands

The Boort wetlands are on the floodplain to the west of the Loddon River, downstream of Loddon Weir. They consist of Lake Boort, Lake Leaghur, Lake Yando and the Meran Lakes complex of wetlands. Several other wetlands occur in the district but are currently not managed with environmental water.

Environmental values

The Boort wetlands provide habitat for a range of plant and animal species, many of which are rare and threatened. At Lake Yando, 12 rare plant species have been recorded including the jerry-jerry and water nymph. Bird species recorded at Lake Boort, Lake Leaghur and Lake Meran include the white-bellied sea eagle, Latham's snipe and eastern great egret. Little Lake Meran is a swampy woodland with black box trees on the highest wet margins and river red gums fringing the waterline. Dense mats of water milfoil grow in the shallow margins and on exposed mudflats as the lake recedes. These shallow areas also provide feeding habitat for waterbirds and shorebirds (such as musk duck and common greenshank).

Social, cultural and recreational values

The Boort wetlands provide numerous recreation opportunities. Lake Meran and Lake Boort are state game reserves and hunting is also allowed at Lake Yando and Lake Leaghur. The large expanse of open water at Lake Meran is very popular for boating, fishing and waterskiing, attracting many visitors during holiday seasons. Lakes Yando, Boort and Leaghur contain excellent environmental values and birdwatchers and field naturalists regularly visit the lakes when they are wet or dry.

The Boort wetlands hold significance for Traditional Owners. The wetlands are important ceremonial places and for thousands of years have provided resources (such as food and materials) to the Traditional Owners now represented by the Dja Dja Wurrung Clans Aboriginal Corporation.

Environmental watering objectives in the Boort wetlands

Maintain or increase the growth of river red gums and aquatic and amphibious vegetation

Rehabilitate habitat and provide breeding opportunities to maintain local and regional populations of birds, fish, frogs and turtles

System overview

The natural water regimes of wetlands in the Loddon system have been substantially modified by the construction of levees and channels across the floodplain and by the construction and operation of reservoirs and weirs along the Loddon River. Environmental watering in the Boort wetlands aims to manage wet and dry phases to improve environmental condition and habitat value.

Recent conditions

Major flooding in September and October 2016 filled all of the Boort wetlands apart from Little Lake Meran, which is disconnected from the natural floodplain. The floods met or exceeded all of the environmental watering objectives for the year and therefore no environmental water was delivered to Boort wetlands in 2016–17.

The natural floods at Lake Boort and Lake Meran were well-timed and provided good outcomes for birds and vegetation. Substantial growth and flowering of river red gums was observed at both lakes, and bird breeding occurred. At Lake Yando, the floods drowned some juvenile river red gums that had recruited over the last couple of years, but the trees that survived have benefited from the watering and will likely be resilient to future floods. In January, a bloom of blue-green algae occurred at Lake Leaghur and there were fish deaths at Lake Meran. These events are an unfortunate consequence of the flood, which transported a large load of organic matter and nutrients into the lakes.

Natural floods are essential for the health of the Boort wetlands. They provide a big input of carbon and nutrients that drive ecosystem productivity, but they need to be interspersed with drawdown and dry periods to maintain the full range of wetland ecosystems processes. Lakes Meran, Boort, Leaghur and Yando will all be allowed to draw down naturally over the next couple of years. Because the wetlands vary in size, some will dry before others and so collectively provide a range of habitat types across the landscape of which mobile animals can take advantage.

Scope of environmental watering

Table 5.7.4 shows potential environmental watering actions and their environmental objectives.

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

Potential environmental watering	Environmental objectives
Wetland watering	
Little Lake Meran (partial fill in autumn)	• Provide feeding and breeding opportunities for waterbirds • Provide open-water and mudflat habitats to support aquatic food webs and provide habitat for waterbirds • Increase the growth of river red gums
Wetland drying	
Lake Leaghur, Lake Boort, Lake Meran and Lake Yando (promote natural drawdown and drying)	• These wetlands will be in a drying phase in 2017–18 • The drying will help maintain a high diversity of habitats across the landscape that can support a wide range of wetland-dependent birds and animals • Gradual drawdown at each wetland will help rehabilitate vegetation zones in and around the wetland

Scenario planning

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

Apart from Little Lake Meran which is isolated from the Loddon River floodplain, all Boort district wetlands were filled by floods in 2016–17 and will be allowed to draw down naturally in 2017–18. At Little Lake Meran, up to 500 ML will provide a partial fill of the lake in autumn to increase the growth of river red gums, pending a health assessment of juvenile trees at the lake. If there is a risk that trees are too small to withstand several months' inundation, the watering may be postponed until spring 2018. If it is decided that the trees are mature enough to withstand inundation, environmental watering will go ahead under all climatic scenarios because the seasonal conditions are not expected to interfere with the vegetation outcomes.

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 natural inflows to wetlands	• Periods of high flows combined with localised catchment contributions expected to provide inflows to wetlands	• Multiple spills from Loddon system storages will provide extended durations of high flows and overbank flows which fill all wetlands
Potential environmental watering	• Little Lake Meran	• Little Lake Meran	• Little Lake Meran
Possible volume of environmental water required to achieve objectives	• 500 ML	• 500 ML	• 500 ML

Risk management

In preparing its seasonal watering proposal, North Central CMA considered and assessed the risks of environmental watering and identified mitigation strategies. Program partners continually reassess risks and mitigation actions throughout the water year (see section 1.3.6).

5.7.3 Birchs Creek

Birchs Creek rises in the ranges north-east of Ballarat and flows north-west through Newlyn and Smeaton before joining Tullaroop Creek near Clunes. The target reach for environmental water is reach 3 because it contains the vulnerable river blackfish population, and most irrigation supply is diverted before the reach.

Environmental values

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

Social, cultural and economic values

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

Birchs Creek holds significance for Traditional Owners. The creek is an important ceremonial place and for thousands of years has provided resources (such as food and materials) to the Traditional Owners now represented by the Dja Dja Wurrung Clans Aboriginal Corporation.

Environmental watering objectives in Birchs Creek

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

System overview

Birchs Creek is part of the Bullarook system which has two small storages — Newlyn Reservoir and Hepburn Lagoon — that fill and spill during winter or spring in most years with average or above-average rainfall.

Environmental water is held in and delivered from Newlyn Reservoir. The VEWH is allocated 100 ML of water on 1 December each year unless seasonal determinations of high-reliability water shares in the Bullarook system are less than 20 percent. Any unused environmental allocation from 1 December can be carried over into the first five months of the following water year (that is, from 1 July to 30 November), but if Newlyn Reservoir spills during these months the volume held in carryover is lost. Any water remaining on 30 November is forfeited. When seasonal determinations are less than 20 percent, the VEWH is not allocated water and the system's resources are shared equitably to protect critical human and environmental needs.

Recent conditions

In July 2016, the Birchs Creek catchment was very dry following extremely low rainfall over the preceding two to three years. Consistent rainfall in winter and spring 2016 recharged groundwater aquifers and caused Newlyn Reservoir to fill and spill: Newlyn spilled from July through to mid-December. Heavy rain in September and October caused two large floods in Birchs Creek.

Summer and autumn 2016–17 had below-average rainfall, but groundwater discharge provided consistent baseflows in reach 3. The baseflows maintained adequate water quality for aquatic animals and no environmental water releases were made during 2016–17.

Loddon River near Fernihurst, by Phil Slessar

Scope of environmental watering

Table 5.7.6 shows potential environmental watering actions and their environmental objectives.

Table 5.7.6 Potential environmental watering actions and objectives for Birchs Creek

Potential environmental watering	Environmental objectives
Winter/spring fresh (1 fresh of 30 ML/day for 3 days in September-November)	• Maintain aquatic vegetation along the edges of the river • Scour organic matter that has accumulated in the channel under very low-flow conditions
Summer/autumn freshes (up to 3 freshes of 10 ML/day for 3 days in December–May)	• Maintain water quality to minimise risks to aquatic animals associated with low dissolved oxygen and high water temperature • Maintain connectivity between refuge pools • Maintain aquatic vegetation

Scenario planning

In a drought scenario, 100 ML of environmental water that was carried over from 2016–17 will be available until 30 November 2017 and may be used to deliver a winter/spring fresh to improve vegetation condition before summer. Under a drought scenario, the VEWH will probably not be allocated water in December and water resources in the Bullarook system will be shared equitably, to maintain critical human and environmental needs.

Under a dry scenario, there may be an opportunity to use the water carried over from 2016–17 before 30 November 2017 or before Newlyn Reservoir spills. The VEWH will likely receive its allocation for the 2017–18 water year on 1 December 2017. That water will then be available throughout summer and autumn and may be used to deliver small freshes to improve water quality if flows are low in reach 3. Unused water will be carried over to 30 November 2018.

Under an average or wet scenario, Newlyn Reservoir is expected to spill early in the 2017–18 water year and the carryover from 2016–17 will be unavailable. The VEWH will receive an allocation of 100 ML on 1 December 2017, but it is unlikely that it will be used in summer or autumn because reach 3 of Birchs Creek will receive sufficient baseflows from groundwater discharge.

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

Planning scenario	Drought	Dry	Average-Wet
Potential environmental watering	• 1 winter/spring fresh	• 1 winter/spring fresh • 1–3 summer/autumn freshes	• 1–3 summer/autumn freshes
Possible volume of environmental water required to achieve objectives	• 100 ML	• 100–200 ML	• 100 ML

Risk management

In preparing its seasonal watering proposal, North Central CMA considered and assessed the risks of environmental watering and identified mitigation strategies. Program partners continually reassess risks and mitigation actions throughout the water year (see section 1.3.6).