Campaspe River, by North Central CMA

Section 5

Northern region

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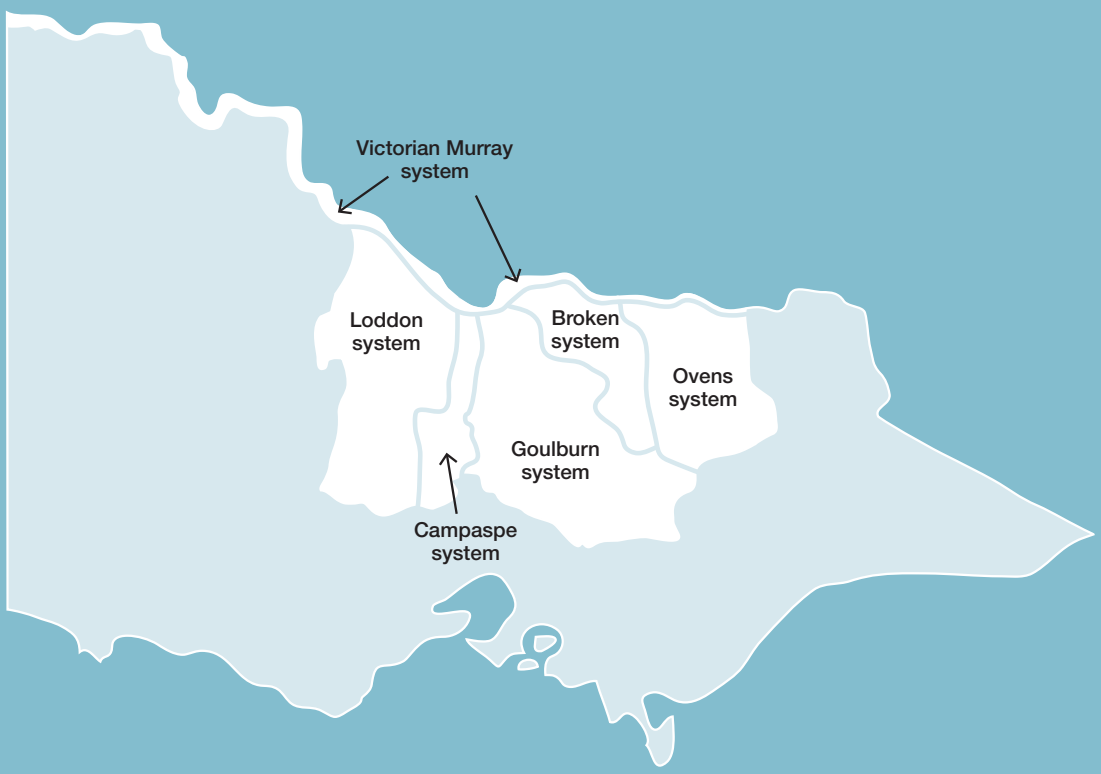


5.1 Northern region overview

The northern region has six river systems, four major floodplain sites and many wetlands that can receive water for the environment. The Broken, Campaspe, Goulburn, Loddon and Ovens river systems are tributaries of the Murray River. The four major floodplain sites along the Murray River corridor are Barmah Forest, Gunbower Forest, Hattah Lakes and Lindsay, Mulcra and Wallpolla islands. The other wetlands are distributed across the Broken, Goulburn, Loddon and Murray floodplains. The rivers and wetlands in the northern region are managed by the Goulburn Broken, Mallee, North Central and North East CMAs.

Many of the water systems in the northern region are connected through infrastructure (such as Goulburn Weir and the Waranga Western Channel), which allows water to be physically delivered from the Goulburn River to the Loddon and Campaspe systems. Water trading also enables transfers of allocation between systems. Within the limitations of each mechanism, water for the environment can be moved between systems for delivery to environmental sites across northern Victoria, although most water for the environment is used to provide benefits in the systems in which the water is held.

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

Traditional Owners in the Northern region

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

The Traditional Owner groups in and around northern Victoria include Barapa Barapa, Dhudhuroa, Latji Latji, Ngintait, Nyeri Nyeri, Taungurung, Tati Tati, Wadi Wadi, Wemba Wamba, Waywurru, Weki Weki, Yorta Yorta and Yaithmathang. The Dja Dja Wurrung Clans Aboriginal Corporation, First People of the Millewa-Mallee Aboriginal Corporation (representing Latji Latji and Ngintait), Taungurung Land and Waters Council and Yorta Yorta Nation Aboriginal Corporation are Registered Aboriginal Parties under the *Aboriginal Heritage Act 2006*.

There are several formal agreements in place with Traditional Owners in the northern region. In 2013, the Dja Dja Wurrung Clans Aboriginal Corporation entered into a recognition and settlement agreement under the *Traditional Owner Settlement Act 2010* in Victoria. Under the agreement, Dja Dja Wurrung has rights to access and use water for traditional purposes, providing the take of water does not affect other parties.

In 2004, the Victorian Government entered into a cooperative management agreement with the Yorta Yorta Nation Aboriginal Corporation to improve collaboration in the management of their Country including Barmah State Forest and reserves along the Goulburn River. In 2010, the Traditional Owner Land Management Agreement under the *Conservation, Forests and Lands Act 1987* over Barmah National Park was signed, enabling the Yorta Yorta Traditional Owner Land Management Board to jointly manage Barmah National Park.

In 2018, the Victorian Government, the Taungurung Clans Aboriginal Corporation and the Taungurung Traditional Owner group signed agreements under the *Traditional Owner Settlement Act 2010* and related legislation.

Engagement

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

The VEWH and its program partners also consider Aboriginal cultural, social and recreational values and uses of waterways when planning for environmental watering activities. Through engagement with community representatives, waterway managers aim to determine how community benefits from environmental flows can be provided while optimising environmental priorities for the year ahead. Aboriginal cultural, social and recreational values and uses are considered for each system in the following systems sections.

The International Association for Public Participation's Public Participation Spectrum (IAP2 Spectrum) has been used to categorise the levels of participation of stakeholders involved in the environmental watering planning process. Table 5.1.1 shows the IAP2 Spectrum categories and participation goals.

Table 5.1.1 International Association for Public Participation's Public Participation Spectrum categories and participation goals[1]

IAP2 level	Engagement goal
Inform	Provide balanced and objective information to assist understanding, alternatives, opportunities and/or solutions
Consult	Obtain feedback on analysis, alternatives and/or decisions
Involve	Work directly throughout a process to ensure that concerns and aspirations are consistently understood and considered
Collaborate	Partner in each aspect of the decision including the development of alternatives and the identification of the preferred solution
Empower	Place final decision-making in the hands of the stakeholder

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

Tables 5.1.2 to 5.1.5 show the partners, stakeholder organisations and individuals with which Goulburn Broken CMA, Mallee CMA, North Central CMA and North East CMA engaged when preparing the Barmah Forest, Goulburn River, Goulburn wetlands and Broken wetlands, Broken River and upper Broken Creek, lower Broken Creek, Hattah Lakes, lower Murray wetlands, Lindsay, Mulcra and Wallpolla islands, Gunbower Creek and Forest, central Murray wetlands and Boort wetlands, Campaspe River, Coliban River, Loddon River, Birchs Creek, Guttrum Forest and Ovens systems' seasonal watering proposals. This includes engagement conducted as part of developing the seasonal watering proposals as well as engagement during the preparation of key foundational documents that directly informed the proposals. VEWH staff were consulted for operational information as part of the development of all annual seasonal watering proposals by CMAs.

Tables 5.1.2 to 5.1.5 also show the level of engagement between Goulburn Broken CMA, Mallee CMA, North Central CMA and North East CMA and stakeholders of the environmental watering program in the northern region, based on the CMAs' interpretation of the IAP2 Spectrum.

The level of engagement differs between organisations and between systems, depending on the availability, capacity or interest of stakeholders to participate, roles and responsibilities of organisations in managing a site or system, and the potential interaction of proposed watering with other activities on the waterway. For example, Moira Shire Council is one of two land managers for Kinnairds Wetland in the Goulburn and Broken wetlands systems, so Goulburn Broken CMA engages with them at a higher level than it does for other local councils in areas that receive environmental flows but do not have direct responsibilities.

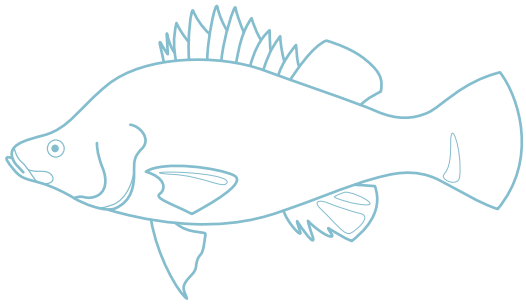


Table 5.1.2 Partners and stakeholders engaged by Goulburn Broken Catchment Management Authority in developing seasonal watering proposals for the Barmah Forest, Goulburn River, Goulburn wetlands and Broken wetlands, Broken River and upper Broken Creek and lower Broken Creek systems and other key foundation documents that have directly informed the proposals (grouped in alphabetical order)

	Barmah Forest	Goulburn system	Goulburn wetlands	Broken wetlands	Broken River and upper Broken Creek	Lower Broken Creek
Community groups and environment groups	**IAP2 level: Consult** • Goulburn Murray Landcare • Goulburn Valley Environment Group • Turtles Australia Inc.	**IAP2 level: Consult** • Goulburn Valley Environment Group	**IAP2 level: Consult** • Goulburn Murray Landcare • Goulburn Valley Environment Group • Turtles Australia Inc.	**IAP2 level: Consult** • Goulburn Murray Landcare • Goulburn Valley Environment Group • Turtles Australia Inc.	**IAP2 level: Inform** • Broken Boosey Conservation Management Network • Broken Creek Field Naturalists Club • Goulburn Murray Landcare	**IAP2 level: Inform** • Broken Boosey Conservation Management Network • Broken Creek Field Naturalists Club • Goulburn Murray Landcare
Government agencies	**IAP2 level: Collaborate** • Commonwealth Environmental Water Office • Goulburn-Murray Water • Greater Shepparton City Council • Moira Shire Council • Murray-Darling Basin Authority • NSW Department of Planning, Industry, and Environment • Parks Victoria • NSW National Parks and Wildlife Service	**IAP2 level: Collaborate** • Commonwealth Environmental Water Office • Goulburn-Murray Water • Murray-Darling Basin Authority • Parks Victoria	**IAP2 level: Collaborate** • Department of Environment, Land, Water and Planning • Goulburn-Murray Water • Greater Shepparton City Council • Moira Shire Council • Parks Victoria	**IAP2 level: Collaborate** • Department of Environment, Land, Water and Planning • Goulburn-Murray Water • Greater Shepparton City Council • Moira Shire Council • Parks Victoria	**IAP2 level: Collaborate** • Commonwealth Environmental Water Office • Goulburn-Murray Water • Parks Victoria	**IAP2 level: Collaborate** • Commonwealth Environmental Water Office • Goulburn-Murray Water • Parks Victoria **IAP2 level: Inform** • Moira Shire Council

Table 5.1.2 Partners and stakeholders engaged by Goulburn Broken Catchment Management Authority in developing seasonal watering proposals for the Barmah Forest, Goulburn River, Goulburn wetlands and Broken wetlands, Broken River and upper Broken Creek and lower Broken Creek systems and other key foundation documents that have directly informed the proposals (grouped in alphabetical order) *(continued)*

	Barmah Forest	Goulburn system	Goulburn wetlands	Broken wetlands	Broken River and upper Broken Creek	Lower Broken Creek
Landholders/ farmers	**IAP2 level: Consult** • Individual landholders who are on the Goulburn Broken Wetland Management Group	**IAP2 level: Consult** • Individual landholders who are on the Goulburn Environmental Water Advisory Group	**IAP2 level: Consult** • Individual landholders who are on the Goulburn Broken Wetland Management Group • Landowners that adjoin wetlands that receive water for the environment and/or use the delivery channel	**IAP2 level: Consult** • Individual landholders who are on the Goulburn Broken Wetland Management Group • Landowners that adjoin wetlands that receive water for the environment and/or use the delivery channel	**IAP2 level: Consult** • Individual landholders who are on the Broken Environmental Water Advisory Group	**IAP2 level: Consult** • Individual landholders who are on the Broken Environmental Water Advisory Group
Local businesses	**IAP2 level: Consult** • Trelly's Outdoor	**IAP2 level: Consult** • Local ecotourism operator • Trelly's Outdoor	**IAP2 level: Consult** • Trelly's Outdoor	**IAP2 level: Consult** • Trelly's Outdoor		
Recreational users	**IAP2 level: Consult** • Field & Game Australia		**IAP2 level: Consult** • Field & Game Australia	**IAP2 level: Consult** • Individual community members on the Broken Environmental Water Advisory Group • Field & Game Australia	**IAP2 level: Consult** • Individual community members on the Broken Environmental Water Advisory Group	**IAP2 level: Consult** • Individual community members on the Broken Environmental Water Advisory Group **IAP2 level: Inform** • Nathalia Angling Club • Numurkah Fishing Club

Table 5.1.2 Partners and stakeholders engaged by Goulburn Broken Catchment Management Authority in developing seasonal watering proposals for the Barmah Forest, Goulburn River, Goulburn wetlands and Broken wetlands, Broken River and upper Broken Creek and lower Broken Creek systems and other key foundation documents that have directly informed the proposals (grouped in alphabetical order) *(continued)*

	Barmah Forest	Goulburn system	Goulburn wetlands	Broken wetlands	Broken River and upper Broken Creek	Lower Broken Creek
Technical experts		**IAP2 level: Consult** • Staff from the Monitoring, Evaluation and Research Program, Goulburn River (Commonwealth Environmental Water Office program)	**IAP2 level: Consult** • Scientists and consultants on the Goulburn Broken Wetland Technical Reference Group	**IAP2 level: Consult** • Scientists and consultants on the Goulburn Broken Wetland Technical Reference Group		
Traditional Owners	**IAP2 level: Consult** • Yorta Yorta Nation Aboriginal Corporation	**IAP2 level: Consult** • Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation	**IAP2 level: Consult** • Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation	**IAP2 level: Consult** • Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation	**IAP2 level: Consult** • Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation	**IAP2 level: Consult** • Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation

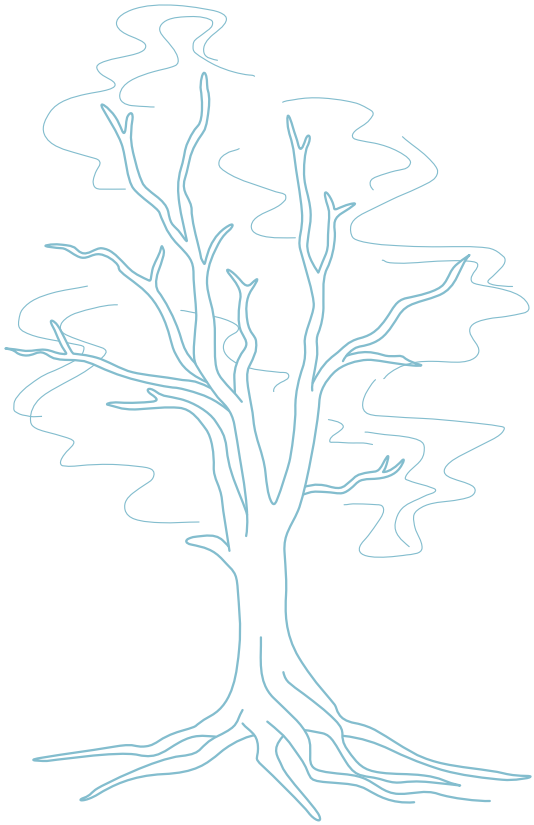


Table 5.1.3 Partners and stakeholders engaged by Mallee Catchment Management Authority in developing seasonal watering proposals for the Hattah Lakes, lower Murray wetlands and Lindsay, Mulcra and Wallpolla islands systems and other key foundation documents that have directly informed the proposals (grouped in alphabetical order)

	Hattah Lakes	Lower Murray wetlands	Lindsay, Mulcra and Wallpolla islands
Community groups and environment groups Government agencies	**IAP2 level: Inform** • Community members on the Mallee CMA Land and Water Advisory Committee	**IAP2 level: Inform** • Community members on the Mallee CMA Land and Water Advisory Committee • Mallee Conservation and Landcare Group • Mallee Landcare Group • OzFish Unlimited	**IAP2 level: Inform** • Community members on the Mallee CMA Land and Water Advisory Committee • Lindsey Point Landcare Group • Millewa-Carwarp Landcare Group • Wider community • OzFish Unlimited
	IAP2 level: Inform • Mallee Conservation and Landcare Group • Mid-Murray Field Naturalists • OzFish Unlimited		
	IAP2 level: Collaborate • Commonwealth Environmental Water Office • Murray-Darling Basin Authority • Parks Victoria	**IAP2 level: Collaborate** • NSW Department of Planning, Industry, and Environment • Parks Victoria	**IAP2 level: Collaborate** • NSW Department of Planning, Industry, and Environment • Parks Victoria
	IAP2 level: Involve • Department of Environment, Land, Water and Planning	**IAP2 level: Involve** • Lower Murray Water • Swan Hill Rural City Council	**IAP2 level: Involve** • Lower Murray Water
	IAP2 level: Consult • Goulburn-Murray Water		**IAP2 level: Consult** • Commonwealth Environmental Water Office • Department of Environment, Land, Water and Planning (Water and Catchments) • Murray-Darling Basin Authority) • SA Water
	IAP2 level: Inform • Mildura Rural City Council	**IAP2 level: Inform** • Mildura Rural City Council	**IAP2 level: Inform** • Mildura Rural City Council • Victorian Fisheries Authority
Landholders/farmers	**IAP2 level: Inform** • Landholders and farmers who live around the Hattah Lakes	**IAP2 level: Collaborate** • Bullock Swamp landholder	**IAP2 level: Inform** • Lindsay Point irrigators • Neighbouring Landholder

Table 5.1.3 Partners and stakeholders engaged by Mallee Catchment Management Authority in developing seasonal watering proposals for the Hattah Lakes, lower Murray wetlands and Lindsay, Mulcra and Wallpolla islands systems and other key foundation documents that have directly informed the proposals (grouped in alphabetical order) *(continued)*

	Hattah Lakes	Lower Murray wetlands	Lindsay, Mulcra and Wallpolla islands
Local businesses	**IAP2 level: Inform** • Hattah Store owners • Mallee Tours • Mildura Regional Development • Mildura Visitor Information and Booking Centre • Murray Offroad Adventures • Victorian Apiarists' Association (Sunraysia branch) • Wild Side Outdoors	**IAP2 level: Inform** • Mallee Tours • Mildura Regional Development • Mildura Visitor Information and Booking Centre • Murray Offroad Adventures • Victorian Apiarists' Association (Sunraysia branch) • Wild Side Outdoors	**IAP2 level: Inform** • Lake Cullulleraine Store • Mallee Tours • Mildura Regional Development • Mildura Visitor Information and Booking Centre • Murray Offroad Adventures • Victorian Apiarists' Association (Sunraysia branch) • Wild Side Outdoors
Recreational users	**IAP2 level: Inform** • BirdLife Mildura • Mildura 4WD Club • Sunraysia Bushwalkers Inc.	**IAP2 level: Inform** • BirdLife Mildura • Cabarita Community Inc. • Mid-Murray Field Naturalists • Mildura 4WD club • Sunraysia Bushwalkers Inc.	**IAP2 level: Inform** • BirdLife Mildura • Mildura 4WD Club • Sunraysia Bushwalkers Inc.
Traditional Owners	**IAP2 level: Collaborate** • Traditional Owners of Hattah Lake	**IAP2 level: Collaborate** • First People of the Millewa-Mallee Aboriginal Corporation • Local Aboriginal community • Robinvale Community Elders/Knowledge Holders	**IAP2 level: Involve** • First People of the Millewa-Mallee Aboriginal Corporation • Local Aboriginal community

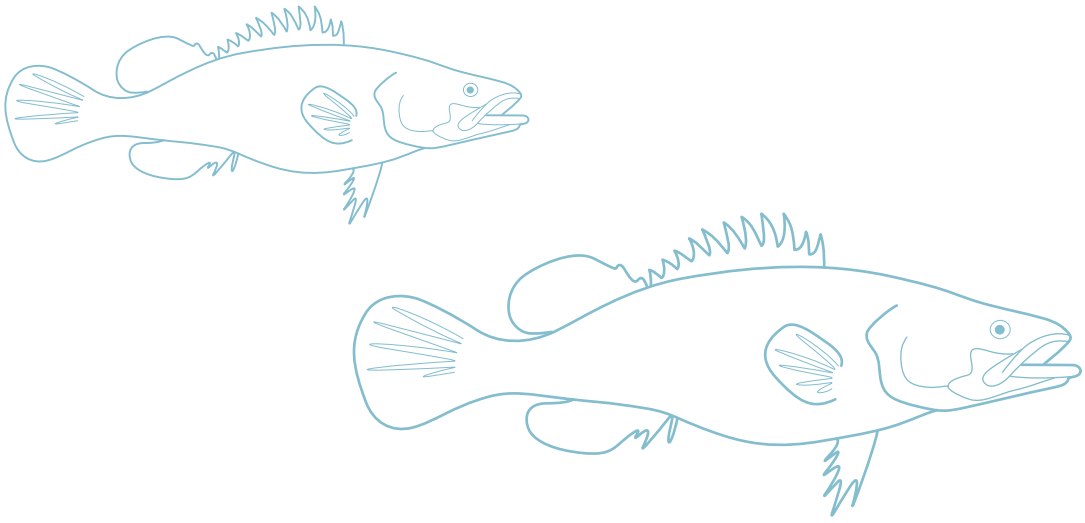


Table 5.1.4 Partners and stakeholders engaged by North Central Catchment Management Authority in developing seasonal watering proposals for the Gunbower Creek and Forest, central Murray wetlands and Boort wetlands, Campaspe River, Coliban River, Loddon River, Birchs Creek and Guttrum Forest systems and other key foundation documents that have directly informed the proposals (grouped in alphabetical order)

	Gunbower Creek and Forest	Central Murray wetlands and Boort wetlands	Campaspe system	Coliban River	Loddon system	Birchs Creek	Guttrum Forest
Community groups and environment groups	**IAP2 level: Consult:** • BirdLife Australia • Community members on the Gunbower Island Community Reference Group' • Gunbower Landcare Group	**IAP2 level: Inform** • Birdlife Australia	**IAP2 level: Consult** • Echuca Moama Landcare Group • Strathallan Family Landcare	**IAP2 level: Consult** • Malmsbury and District Landcare Group			
Government agencies	**IAP2 level: Collaborate** • Commonwealth Environmental Water Office • Department of Environment, Land, Water and Planning • Forestry Corporation of NSW • Goulburn-Murray Water • Murray-Darling Basin Authority • Parks Victoria • VicForests	**IAP2 level: Collaborate** • Commonwealth Environmental Water Office • Goulburn-Murray Water	**IAP2 level: Collaborate** • Commonwealth Environmental Water Office • Goulburn-Murray Water	**IAP2 level: Collaborate** • Coliban Water • Commonwealth Environmental Water Office • Department of Environment, Land, Water and Planning	**IAP2 level: Collaborate** • Commonwealth Environmental Water Office • Goulburn-Murray Water	**IAP2 level: Collaborate** • Goulburn-Murray Water	**IAP2 level: Collaborate** • Commonwealth Environmental Water Office • Department of Environment, Land, Water and Planning • Forestry Corporation of NSW • Goulburn-Murray Water • Murray-Darling Basin Authority • Parks Victoria • VicForests
	IAP2 level: Inform • Gannawarra Shire Council • Campaspe Shire Council	**IAP2 level: Inform** • Department of Environment, Land, Water and Planning	**IAP2 level: Inform** • Department of Environment, Land, Water and Planning • Game Management Authority	**IAP2 level: Inform** • Game Management Authority	**IAP2 level: Consult** • Department of Environment, Land, Water and Planning	**IAP2 level: Inform** • Department of Environment, Land, Water and Planning • Parks Victoria	

Table 5.1.4 Partners and stakeholders engaged by North Central Catchment Management Authority in developing seasonal watering proposals for the Gunbower Creek and Forest, central Murray wetlands and Boort wetlands, Campaspe River, Coliban River, Loddon River, Birchs Creek and Guttrum Forest systems and other key foundation documents that have directly informed the proposals (grouped in alphabetical order) *(continued)*

	Gunbower Creek and Forest	Central Murray wetlands and Boort wetlands	Campaspe system	Coliban River	Loddon system	Birchs Creek	Guttrum Forest
Landholders/ farmers	**IAP2 level: Consult** • Community members (including irrigators) on the Gunbower Island Community Reference Group	**IAP2 level: Inform** • Individual landholders and community members	**IAP2 level: Consult** • Individual Landhold-ers and community members	**IAP2 level: Inform** • Individual Landhold-ers and community members	**IAP2 level: Inform** • Individual landholders and community members	**IAP2 level: Inform** • Individual landholders and community members	**IAP2 level: Inform** • Adjacent landholders
Recreational users		**IAP2 level: Inform** • Field and Game Australia	**IAP2 level: Inform** • Local canoe club • Paddle Victoria • VRFish	**IAP2 level: Inform** • VRFish		**IAP2 level: Inform** • VRFish	
Technical experts	**IAP2 level: Collaborate** • Vegetation, fish and bird ecologists		**IAP2 level: Collaborate** • Arthur Rylah Institute (Department of Environ-ment, Land, Water and Planning)				**IAP2 level: Collaborate** • Vegetation, fish and bird ecologists
Traditional Owners	**IAP2 level: Collaborate** • Barapa Barapa Traditional Owners **IAP2 level: Inform** • Yorta Yorta Nation Aboriginal Corporation	**IAP2 level: Consult** • Barapa Barapa Traditional Owners • Dja Dja Wurrung Clans Aboriginal Corporation • Wemba Wamba Traditional Owners • Yorta Yorta Nation Aboriginal Corporation	**IAP2 level: Consult** • Dja Dja Wurrung Clans Aboriginal Corporation • Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation	**IAP2 level: Consult** • Dja Dja Wurrung Clans Aboriginal Corporation	**IAP2 level: Collaborate** • Barapa Barapa Traditional Owners • Dja Dja Wurrung Clans Aboriginal Corporation • Wemba Wamba Traditional Owners	**IAP2 level: Consult** • Dja Dja Wurrung Clans Aboriginal Corporation	**IAP2 level: Collaborate** • Barapa Barapa Traditional Owners • Wemba Wamba Traditional Owners

Table 5.1.5 Partners and stakeholders engaged by North East Catchment Management Authority in developing the seasonal watering proposal for the Ovens system and other key foundation documents that have directly informed the proposal (grouped in alphabetical order)

	Ovens system
Community groups and environment groups	**IAP2 level: Collaborate** • Wangaratta Landcare and Sustainability Incorporated
Government agencies	**IAP2 level: Collaborate** • Commonwealth Environmental Water Office • Goulburn-Murray Water
	IAP2 level: Involve • Rural City of Wangaratta • Victorian Fisheries Authority
Landholders/farmers	**IAP2 level: Collaborate** • Catholic Education Sandhurst Limited
Technical experts	**IAP2 level: Involve** • Arthur Rylah Institute (Department of Environment, Land, Water and Planning)
Traditional Owners	**IAP2 level: Collaborate** • Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation

Integrated catchment management

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

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

Examples of catchment management authority (CMA) on-ground works programs that are likely to support environmental watering outcomes in the northern region include:

- the implementation of a strategic action plan for the protection of floodplain marshes in Barmah Forest, which identifies management actions addressing key threats to the delicate floodplain vegetation including removal of feral horses and other invasive animals and control of invasive plants. Parks Victoria and the Yorta Yorta Nations jointly manage Barmah National Park
- construction of fishways enabling fish passage through the Koondrook and Cohuna weirs in Gunbower Creek is planned for winter 2021. The fishways will provide migration opportunities for fish species such as the iconic Murray cod. These works are in addition to fish screens that were installed in Gunbower Creek to reduce the number of native fish lost to irrigation channels, and other fish passage works that will create a fish migratory pathway between the Loddon River, Pyramid Creek, Ghow Swamp and Gunbower Creek
- restoration of Australasian bittern habitat through revegetation of tall marsh vegetation communities in Guttrum Forest. Planting will coincide with a planned delivery of water for the environment to help tall marsh become established
- planting native aquatic plants in lower Broken Creek to accelerate the recovery of in-stream vegetation that will provide shelter and foraging habitat for native fish, platypus and other aquatic animals.

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

Risk management

During the development of the seasonal watering proposals for the northern region systems, environmental watering program partners assessed risks associated with potential environmental watering actions for 2021-22 and identified appropriate mitigating strategies. Risks and mitigating actions are continually assessed by program partners throughout the year (see subsection 1.3.6).

What is the Basin Plan 2012?

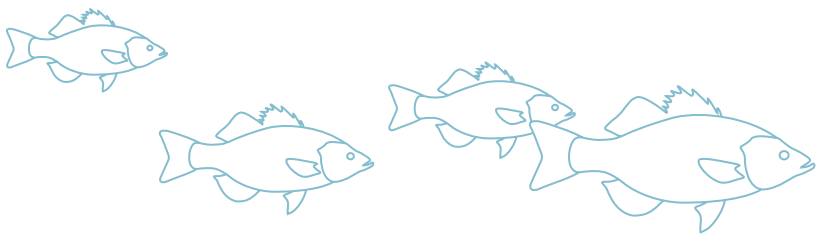
Northern Victoria is a part of the Murray-Darling Basin and deliveries of water for the environment in the northern region are subject to the requirements of the Basin Plan 2012, also known as the Murray-Darling Basin Plan or just the Basin Plan. The Murray-Darling Basin Authority developed the Basin Plan under the *Commonwealth Water Act 2007* and it became law in November 2012. The Basin Plan sets legal limits on the amount of water that can be taken from the Murray-Darling Basin's surface and groundwater resources. Chapter 8 of the Basin Plan 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 are consistent with the requirements of the Basin Plan. The potential environmental watering outlined in sections 4 and 5 of this seasonal watering plan fulfil Victoria's obligations to identify annual environmental watering priorities for Victoria's water resource areas under section 8.26 of the Basin Plan 2012.

What is River Murray Increased Flows (RMIF)?

River Murray Increased Flows (RMIF) is water for the environment that has been recovered as part of the Snowy Water Initiative, established in 2002 to address environmental impacts associated with the operation of the Snowy Mountains Scheme. RMIF is stored in Snowy Hydro Limited's storages and released to maintain and improve environmental values in the Murray River. RMIF becomes available when:

- Snowy Hydro Limited release more than their nominated annual release volume, as part of their power generation operations and/or
- managers of water for the environment request additional RMIF be made available when volumes in Murray River storages exceed specified limits.

The call for and use of RMIF are coordinated by the Southern Connected Basin Environmental Watering Committee, and they must be authorised by the VEWH and NSW Department of Primary Industry and Environment.



Northern Victoria and the southern Murray-Darling Basin

Rivers, creeks and floodplains in northern Victoria form part of the southern connected Murray-Darling Basin. Water flows directly from the Victorian rivers and floodplains into the Murray River, which means that environmental flows delivered in northern Victorian systems can achieve ecological objectives at multiple sites throughout the Murray-Darling Basin. For example, water for the environment delivered in the Goulburn River flows into the Murray River and can be managed to ensure it flows all the way to the Lower Lakes and Coorong in South Australia, providing environmental outcomes at Gunbower Forest, Hattah Lakes, Lindsay Island and the Chowilla floodplain along the way.

The Basin Plan 2012 and the Basin-wide environmental watering strategy (second edition, 2019) guide the long-term planning of water for the environment in the Murray-Darling Basin. Under the Basin Plan, environmental objectives are met by achieving outcomes for connectivity, native vegetation, waterbirds and native fish.

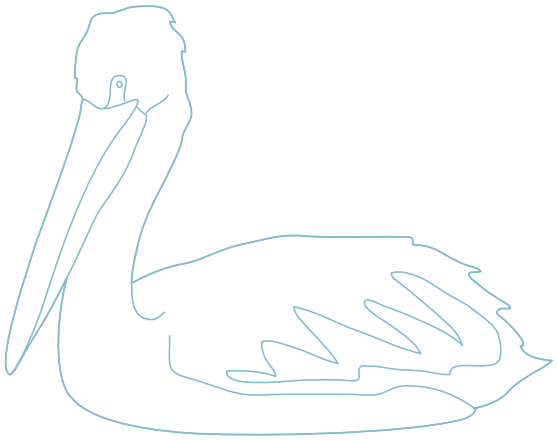
Objectives and outcomes under the Basin Plan reflect local site- and state-based objectives, though site-based objectives are often broader in scope and cover additional values (such as frogs, turtle, waterbugs and physical processes like sediment movement). Watering actions that support Basin Plan outcomes have significant benefits for many other species that rely on the surrounding landscape (such as squirrel gliders living along the lower Campaspe River or flocks of regent parrots moving into the Hattah Lakes floodplain after watering).

The VEWH coordinates its activities with other environmental water holders in northern Victoria, NSW and South Australia to achieve environmental outcomes at the southern connected Murray-Darling Basin scale. Collaborative planning focuses on how upstream and downstream objectives align and how the broader operation of the Murray River system can help support environmental outcomes, as well as complementary outcomes for Traditional Owners (as set out in the *Statement on environmental water use in 2021-22* on pages 202-3) and local communities.

Annual planning is documented in basin annual environmental watering priorities (by the Murray-Darling Basin Authority under the Basin Plan), in annual portfolio management plans (by the Commonwealth Environmental Water Office) and the VEWH's annual seasonal watering plan (this document). In Victoria, all water for the environment must be delivered in line with the VEWH's seasonal watering plan, meaning coordination during annual planning is fundamental to successful basin-scale outcomes.

Environmental water holders in the Murray-Darling Basin are increasingly emphasising the coordination of water deliveries to achieve landscape-scale environmental outcomes. Examples include:

- delivering a winter fresh in the Goulburn River, which subsequently passed through to the Lower Lakes in South Australia and through the barrages to the Coorong to trigger upstream migration of fish (such as lamprey)
- delivering a spring flow from Hume Reservoir to support floodplain sites (such as Barmah-Millewa Forest) and the river channel from the mid-Murray to the lower Murray all the way to the Lower Lakes and Coorong in South Australia. This event carries carbon and nutrients from the floodplain to the river and transports them through the system, increasing food availability, helping native fish to move and breed and supporting native aquatic plants in the river channel.



The VEWH holds Victorian environmental entitlements for water recovered under interstate projects and agreements — Living Murray and RMIF entitlements — and these require coordinated decision-making about where they are used. The primary objective of Living Murray entitlements is to support Murray icon sites, which include the Barmah Forest, Gunbower Forest, Hattah Lakes and the Lindsay Mulcra Wallpolla islands in Victoria. RMIF also support environmental objectives along the Murray system in Victoria, NSW and South Australia. Recommendations for the coordinated use of Living Murray allocation and RMIF are made by the Southern Connected Basin Environmental Watering Committee.

The VEWH partners with the Commonwealth Environmental Water Office to optimise the benefits of water for the environment held by the Commonwealth Environmental Water Holder (CEWH) and delivered in Victoria. Delivery of the Living Murray's and Commonwealth's environmental Water Holdings, to meet Victorian environmental watering objectives, is included in relevant system sections in the following pages of this document.

Water for the environment delivered through northern Victorian waterways can often be reused to achieve further environmental benefits downstream. If return flows are not reused at Victorian environmental sites, VEWH, Living Murray and CEWH return flows continue to flow across the border to South Australia where they will be used to provide environmental benefits along the Murray River and in the Coorong, Lower Lakes and Murray Mouth area.

The VEWH may order, or authorise waterway managers to order, Living Murray and Commonwealth water for the environment for environmental outcomes at downstream (non-Victorian) sites. The VEWH may also order water for delivery in the Murray system to non-Victorian sites under river operating rules that help improve environmental outcomes while maintaining the reliability of entitlements for all water users. In previous years, this has included deliveries to the Murray from the lower Darling, orders for delivery from Lake Victoria and orders for delivery to the Murray River.

Murray system-scale planning and Traditional Owners in the southern Murray-Darling Basin

Environmental water holders consider the objectives and cultural values of First Nations in the Murray-Darling Basin, and they seek to support these where possible. The health of the Murray-Darling Basin benefits from meaningful partnerships with Traditional Owners, and their involvement in water planning, coordination and delivery from the local to the basin scale is a priority for environmental water holders.

In April 2021, a forum on Latji Latji Country in Mildura brought together Traditional Owner representatives from many parts of the southern Murray-Darling Basin to share information about the health of Country and discuss preferred outcomes from the management of environmental water. The forum was funded by the Commonwealth Environmental Water Office and organised with the Murray-Darling Basin Authority's Living Murray Program and the Murray Lower Darling Rivers Indigenous Nations.

The *Statement on environmental water use in 2021-22* made by participants at the Southern Basin First Nations' Environmental Watering Forum 2021 is reproduced on the following pages. This statement will be used to guide environmental water planning for the 2021-22 water year, particularly through the Southern Connected Basin Environmental Watering Committee. It will work hand-in-hand with existing, site-based First Nations planning and environmental water delivery along the Murray (see Traditional Owner cultural values and uses in the system sections following).

Southern Basin First Nations' Environmental Watering Forum 2021

Statement on environmental water use in 2021-22

In April 2021,Traditional Owners from many parts of the Southern Murray Darling Basin came together on Latji Latji Country, in Mildura to share information about the health of Country and discuss preferred outcomes from the management of environmental water.

We want water holders, managers and decision makers to hear these key messages:

Respect water, Country and lore

First Nations are willing to share and collaborate with Government agencies to improve river health. But the inherent risks of the settler – colonial water management systems, that have been imposed on our Country, must be addressed. The current water regime in the Murray – Darling Basin ignores the principles and knowledges that underpin our practices of caring for Country.

Water can never be 'owned'. Water and rivers have life and spirit which cannot be bought and sold. All 'ownership' of water in this Country is based on the dispossession of First Nations and imposition of colonial legal frameworks. We have never ceded our inherent rights as guardians and caretakers of rivers and waters. First Nations lore provides a holistic, interconnected management system, where all elements contribute to the good of the whole.

We want to collaborate, but we do not accept or endorse the legal and management frameworks that have been imposed on our rivers. We ask our partners to respect our water spirits, knowledge and lore.

Address our concerns

We have major concerns about the legal, policy and governance setting that dictate how our rivers flow and how we get a voice. These include:

- Overallocation of water and water allocation decisions which do not leave enough in our rivers to sustain their survival or meet our cultural needs
- Over Reliance on damaging infrastructure to regulate and replicate complex natural systems, with little real benefit to our Country
- Short term decision making that doesn't properly account for a changing climate
- Limited commitment to and resourcing for First Nations participation and empowerment
- Decision making that marginalises First Nations' rights and interests
- Commodification and trading of water that disregards the limitations of natural systems
- Water theft and illegal extraction
- Inequitable access to water and poor distribution of the social and economic benefits it can bring

The settler-colonial water framework has generated perverse outcomes which we contend with on a daily basis. The mindset of water management needs to change.

Recognise that our rivers are at risk

We see powerful examples where environmental water is helping to heal Country, but the overall policy and legal settings mean our waterways and cultural values are at risk.

Our biodiversity is suffering. We are struggling to save remnants of our ecologically and culturally significant landscapes. We are being asked to prioritise some places, while we watch others decline or die. We are grappling with this reality.

Infrastructure, including dams, weirs, regulators and pumps, is segmenting our waterways and damaging our Country with little real benefit. There is too much regulation of the floodplain and huge investment in infrastructure without proper engagement with our people.

Fluctuating river levels and unseasonably high flows, driven by consumptive demand, are degrading our waterways and cultural values. Land Use is driving unsustainable water demands and limited channel capacity means we can't get water to where we need it.

Water holes are silting up. Bank erosion and slumping is causing huge impacts on cultural heritage.

Poor water quality, algal blooms and salinity are being compounded by the disruption of natural systems that flush and clean our rivers and wetlands. Waterways, creeks and wetlands are being left to dry out, exposing cultural sites and degrading cultural values.

The health of significant trees and medicinal plants is declining because of lack of water, impacting on our cultural sustainability, health and wellbeing. Culturally significant birds and animal species are not seen where they used to be. There are not enough native fish in the system.

Delivering water to our wetlands and billabongs through artificial systems can mean delivering the wrong water for Country. Legal and infrastructure constraints restrict us from being able to direct water to where we need it

Help us protect and grow the things that are important to us

We are passionate about working together to protect and sustain our waterways.

We need the agency and life force of the river to be respected. We want to see more water going out onto Country and filling all our creeks and billabongs. We want water holders and managers to work with us, looking at the whole system and how to restore it to what it was, with adequate flows and proper timing. We want overbank flows to support total system health.

We want increased recovery of water for the environment, not decreased.

We want to see the Murray Mouth open and salt being flushed from the system.

We want the lakes, billabongs, creeks, wetlands and rivers that are important to us to get the water they need to thrive. We want to see dry and degraded wetlands restored to life with culturally informed watering to protect our cultural heritage values.

We want regular re-connecting flows from floodplains and billabongs, allowing the life in our natural nurseries to restock and replenish the river. We need adequate, sustained flows through our rivers to keep them connected and mitigate variation from irrigation demand.

We want healthy water to flow out of our Country to all mobs downstream. We want the nutrition and healthy water from upstream to replenish Country. We want to build back biodiversity and Traditional Owner management to improve water quality. We want to collaborate with all mobs to ensure a healthy system, renewing cultural connections between Nations.

We need to exercise self-determination over the development and operation of infrastructure on Country. We want to be empowered to use our natural and cultural infrastructure, billabongs, fish traps and breeding structures, to slow down flows and recharge the landscape.

We need adequate healthy water for improved tree health and thriving floodplain forests with red gum, black box and yellow box.

We need flows to replenish the floodplain and support our important cultural plants like old man weed, grasses and sedges, nardoo, cumbungie and milfoil.

We want to see water birds, ducks, swans and brolgas, returning and thriving in our wetlands.

We need connectivity and good water quality to support native fish including black bream, congoli, crayfish, mussels, small bodies fish, shrimp, shield shrimp, yabbies', yellowbelly, Murray cod, catfish, black fish, Murray hardyhead and trout cod. We want turtles, platypus, frogs and all the other animals that rely on water to be able to return to Country.

We want co-management of all environmental water. We want to be empowered to make the decisions about how environmental water is used. Prioritisation and water planning should be driven from the ground up, by First Nations. Give us control and we will show you how to heal Country and, in doing so, we will maintain intergenerational transfer of knowledge.

We want water managers to listen deeply to what Traditional Owners and Elders have to say and to help us access your science to back our objectives (not the other way round).

We need policy changes, transparency and reviews of the existing entitlement system. We need to review and amend the Basin Plan to reflect our knowledge, science and human rights. We need Traditional Owners involved in the highest level of all Government agencies and we need our own agencies and statutory bodies.

Seasonal outlook 2021-22

Rainfall across northern Victoria in 2020-21 was close to the long-term average in most areas, although slightly below the long-term average in the north-west and parts of the eastern ranges. Mean maximum temperatures were close to or slightly above average across the region. Winter rainfall resulted in some relatively small, unregulated flow events in the Goulburn, Ovens and Kiewa rivers. Further rain in spring gradually increased storage levels and provided occasional unregulated pulses that remained within the channel in the regulated rivers. Environmental flows were delivered to rivers and wetlands across the region in 2020-21 to provide what would have occurred naturally without river regulation and to support native plants and animals.

Inter-valley transfers (IVTs) from the Goulburn system to the Murray system over summer and autumn were reduced from 50,000 ML per month in 2019-20 to 40,000 ML per month in 2020-21, to help protect native vegetation and reduce bank erosion in the lower Goulburn River. Anecdotal evidence suggests the rate of bank erosion has slowed and there has been some recovery of native vegetation, but the river is far from fully recovered. Monitoring will continue to assess the condition of the banks and bank vegetation over the next few years.

The climate outlook from June to August 2021 indicates average to above-average rainfall and average to above-average temperatures are likely. However, it appears autumn 2021 will be relatively dry, so moderate to high rainfall will be needed to wet the catchments before there will be significant natural inflows to waterways and storages. Above-average rainfall throughout winter and spring 2021 should increase water in storage and deliver some natural flow pulses in the rivers. Environmental flows may piggyback onto or extend the duration of natural events, where doing so helps achieve particular environmental flow objectives. If 2021-22 is considerably drier than average, environmental flows will mainly be used to maintain rather than improve the health of native plants and animals in the region's rivers and wetlands.

Many of the Murray River floodplains have not been inundated since 2016-17, and they are prioritised for environmental watering in 2021-22 under all climate scenarios to prevent native plant communities from exceeding their tolerable dry period. Watering floodplain wetlands at Hattah Lakes, and across Lindsay, Mulcra and Wallpolla Islands will be especially important in 2021-22 because proposed construction activities for the Victorian Murray Floodplain Restoration Project will prevent planned environmental flows to these sites in 2022-23 and 2023-24. A watering event that commenced at Hattah Lakes in autumn 2021 is likely to continue into winter and spring 2021, while planned watering actions at Gunbower Forest are likely to commence in winter or spring 2021 even under a dry climate scenario. Without these environmental flow events, the health of the plant and animal communities that live on the floodplain will significantly decline.

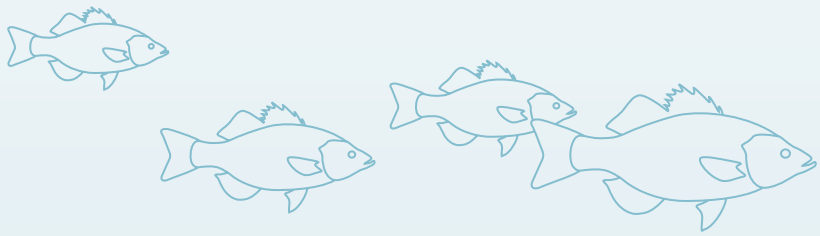
Operational inter-valley transfers of water (IVTs) from the Goulburn system via lower Broken Creek and the Goulburn and Campaspe rivers to the Murray River are again expected to feature prominently in summer and autumn 2021-22. Specific IVT limits will be determined through the review of the Goulburn to Murray trade rule, which is due to conclude in June 2021. Proposed rates of IVT delivery remain above recommended environmental flow rates, but importantly they remain significantly lower than in past years. It will be essential to enable environmental flows to be adaptively managed year-round, to support the health of the lower Goulburn River and other waterways, including downstream sites.

The allocation outlook for 2021-22 provided by the Northern Victoria Resource Manager on 17 May 2021 indicated low opening allocations across all systems, particularly for the smaller Broken and Bullarook systems that are likely to have zero opening allocation. The larger Murray, Goulburn, Campaspe and Loddon systems are expected to open below 25 percent allocation to high-reliability water shares. Carried-over water can be delivered in all systems, and it will likely be important for meeting early-season demands from July 2021.

Under an extreme dry[1] scenario, very little increase in water allocation is expected during 2021-22. Under a dry climate scenario, the Broken and Campaspe systems may reach 30 percent allocation, while the Murray, Goulburn and Loddon systems may reach 60 percent allocation. All systems should get close to or reach 100 percent allocation under average or wet scenarios in 2021-22. The Northern Victoria Resource Manager has not provided an outlook for low-reliability entitlements, but for planning purposes the VEWH has assumed no allocation against low-reliability entitlements during 2021-22 unless there are significantly above-average inflows to storages.

Under drought and dry climate scenarios, environmental flows are expected to focus on protecting and maintaining habitat for native plants and animals, to avoid decline or loss. Examples include watering selected wetlands in the Kerang Lakes to maintain vegetation and provide refuge for waterbirds and maintaining low flow in rivers to protect native fish and platypus. In some systems (such as the Goulburn River), relatively high volumes of carryover will enable the delivery of some larger watering actions — actions that can usually be delivered only under average climate scenarios — to be delivered in a dry climate scenario, to improve or enhance environmental outcomes.

If conditions and allocations improve, water for the environment may be used to deliver larger events to improve the health of the environment. Under average and wet climate scenarios, larger floodplain watering events are planned at icon sites along the Murray River, and additional wetlands will likely be watered across the region. These larger-scale watering events will increase the quality and quantity of wetland habitat for waterbirds, frogs and turtles, support waterbird breeding events and transfer carbon from floodplains to rivers to increase the productivity of food webs and provide food for native fish and other aquatic animals. Increased flows in creeks and rivers will aim to increase the abundance of waterbugs, enhance the breeding and recruitment of native fish and improve fringing bank vegetation.



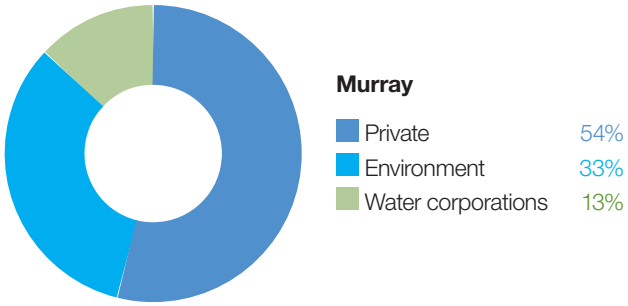
1 Northern Victoria Resource Manager resource outlooks refer to the driest outlook as ‘extreme dry’. In the seasonal watering plan, the driest climate scenario is usually called ‘drought’.

5.2 Victorian Murray system

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

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

Environmental water holders – Victorian Environmental Water Holder (including the Living Murray program), Commonwealth Environmental Water Holder



Proportion of water entitlements in the Murray basin held by private users, water corporations and environmental water holders on 30 June 2020.

Did you know...?

Long-term data for the Murray, Goulburn, Broken, Ovens and King rivers was used to examine the effects of flow and environmental flow management on the recruitment of Murray cod. While specific links between flows and recruitment varied across rivers, the data is evidence that managing flows in line with a more natural flow regime will significantly improve outcomes for Murray cod. The same is also likely to apply to species with similar breeding strategies (such as trout cod and river blackfish).

Top: Barmah Lake vegetation response, by Keith Ward, Goulburn Broken CMA
Right: River redgum at Hattah Lakes, by the VEWH

Traditional Owners have a unique connection to their lands and water, including what is referred to as the Murray River system. Traditional Owners within their traditional borders refer to the Murray in their own languages. For example, the Yorta Yorta People know the Murray as *Dhungulla*. They possess distinct cultural boundaries, language and cultural practices. The Victorian Murray system referred to in this plan includes waterways, storages, weirs, locks and regulators managed under state and federal legislation. This system overlays many Traditional Owner boundaries.

Within the Victorian Murray system, there are many significant floodplains and wetland systems covering the Goulburn Broken, North Central and Mallee CMA areas. They are sites of significance for Traditional Owners, with tangible and intangible cultural connections dating back many thousands of years and continuing to the present day. The Barmah Forest, Kerang wetlands and Hattah Lakes are internationally recognised Ramsar-listed sites due to the significance of their wetland types and the abundance and range of waterbird species that use them. Many other wetlands in the system are either nationally or regionally significant.

Water for the environment can be supplied to the Victorian Murray system from a range of sources. These include entitlements held by the VEWH, which includes those held on behalf of the Living Murray program and the Commonwealth Environmental Water Holder (CEWH); reuse of return flows; and in some instances, use of operational water en route. The source of the water used for individual watering actions and the ability to deliver all watering actions will depend on water availability, water commitments by other environmental water holders and operational requirements. As a result, the following Victorian Murray system sections do not specify the expected availability of water for the environment.

5.2.1 Barmah Forest

System overview

The Barmah Forest is located within Yorta Yorta's traditional boundaries. The Barmah-Millewa Forest covers 66,000 ha and spans the New South Wales – Victoria border between Tocumwal, Deniliquin and Echuca (Figure 5.2.1). The Barmah-Millewa Forest is listed under the Convention on Wetlands of International Importance (the Ramsar Convention) and is on the Australian Directory of Important Wetlands and is one of six Living Murray icon sites. The forest's Victorian components are the Barmah National Park and part of the River Murray Reserve, covering 28,500 ha of forest and wetlands that support a vast range of significant plant and animal species and culturally significant sites to the Yorta Yorta.

The wetlands throughout the forest continue to provide a constant source of nutritional foods and significant fibres for the Yorta Yorta People. It is also evident that the resources in the landscape were utilised to manufacture canoes, shields and carrying devices.

Flooding in the Barmah-Millewa Forest depends on flows in the Murray River. A natural narrowing of the river (commonly referred to as 'the Barmah Choke') restricts flow and causes overbank flooding when flows below Yarrawonga Weir exceed the channel's capacity. This restriction influences both the operation of Yarrawonga Weir and the upper limit of environmental flows that can be delivered to the forests. The Yorta Yorta People see this narrow part of their *Dhungulla* as a culturally significant creation story, and it provides ecosystem services both from a culturally and environmentally signifcant viewpoint. The name 'the Barmah Choke' is not a culturally appropriate name for the Yorta Yorta and is seen as a negative way to view their traditional lands and waters. Yorta Yorta People may refer to this as the 'Pama Narrows'.

Before the river was regulated, Barmah-Millewa Forest would have regularly flooded with high flows from rainfall in winter and spring. These regular floods shaped a rich, productive forest environment. The construction and operation of Hume Reservoir and Dartmouth Dam have greatly reduced the size and frequency of natural winter/spring floods in Barmah-Millewa Forest. Also, operational deliveries to supply water to users downstream of the Barmah Choke can cause unseasonal low-level floods, which can damage the forest and banks of the river depending on the timing and volume of the flows. Country for the Yorta Yorta People continues to change, but the changes have been rapid post-settlement due to infrastructure installation and river regulation. This has changed Country culturally and environmentally for the Yorta Yorta People. Their language word for water is *Wala* and this includes if an area is wet but may imply to others a 'flood' which is viewed as negative water.

The delivery of irrigation water during summer/autumn is managed to minimise unseasonal flooding of the forest. Regulators along the banks of the Murray River that control flow between the river and the forest remain closed during summer and autumn to restrict flow through low-lying flood runners. The delivery of water to Barmah-Millewa Forest is also limited by a flow constraint below Yarrawonga Weir to minimise impacts to adjacent farming operations in NSW. The current constraint limits regulated flows to a maximum river level of 3.3 m at the Tocumwal gauge (about 18,000 ML per day downstream of Yarrawonga Weir), subject to various conditions. Regulated flow up to a river level of 3.0 m on the Tocumwal gauge (about 15,000 ML per day downstream of Yarrawonga Weir) can be delivered at any time during the year and is not subject to conditions. To overcome this constraint, most environmental flows are shared between Barmah and Millewa forests to deliver water to low-lying wetlands in each forest at least every second year. It is currently not possible to achieve the desired flood depth and duration for floodplain marsh vegetation in both forests at the same time without larger natural flooding.

Water management at Barmah-Millewa Forest seeks to build on natural flow and the delivery of consumptive and operational water en route to optimise environmental outcomes when possible. As Barmah-Millewa Forest is located towards the upper reaches of the regulated portion of the Murray River, water for the environment that passes through the forest and returns to the river can often be used at sites further downstream as part of multi-site watering events.

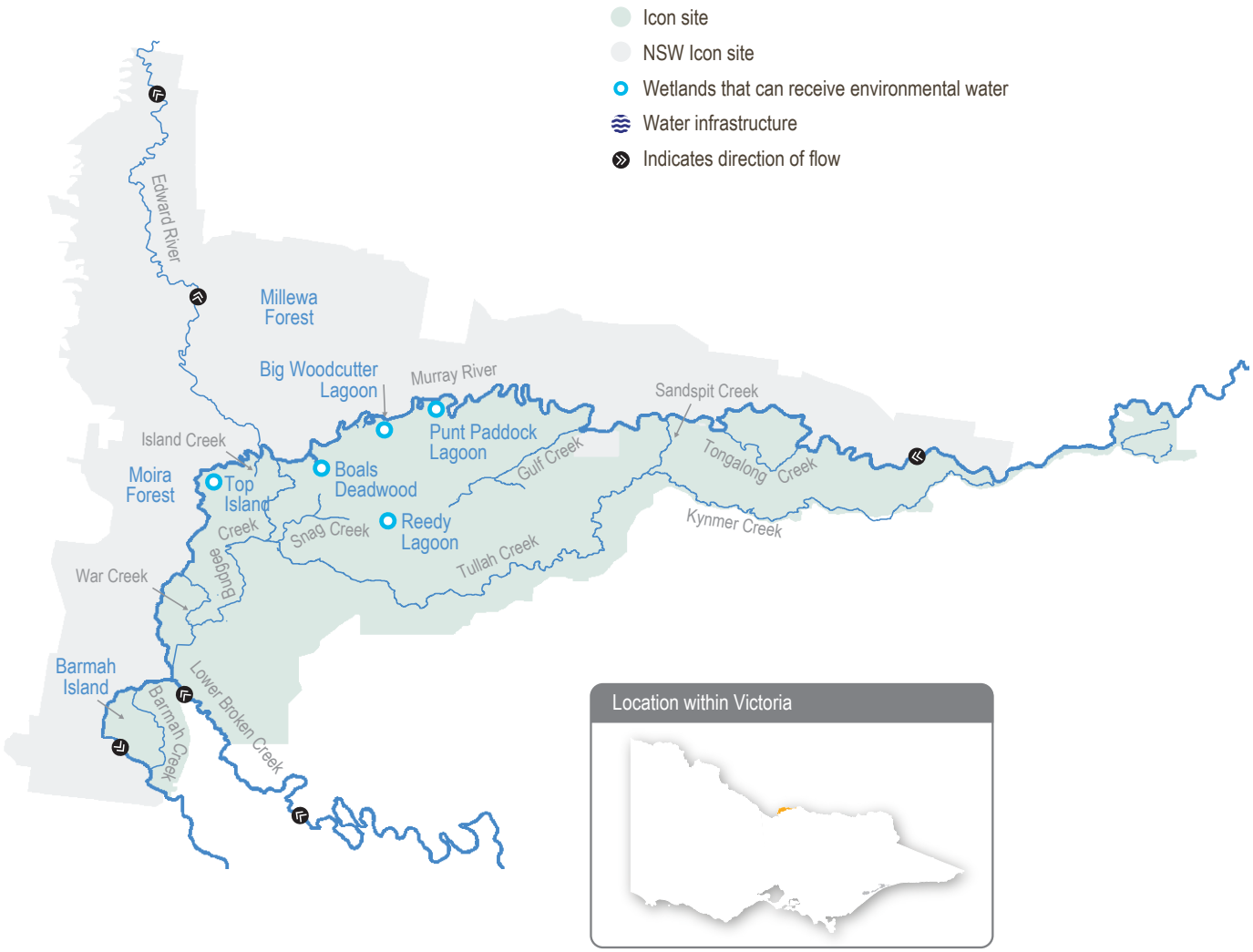
Environmental values

The Barmah-Millewa Forest is the largest river red gum forest in Australia and the most intact freshwater floodplain system along the Murray River. The forest supports important floodplain vegetation communities including the threatened Moira grass plains and is a significant feeding and breeding site for waterbirds including bitterns, ibis, egrets, spoonbills and night herons. Significant populations of native fish, frogs and turtles also live in the forest's waterways. Barmah Forest is known to support 74 plant and animal species protected under state and national legislation.

Environmental watering objectives in the Barmah Forest

	Enable carbon and nutrient cycling between the floodplain and river through connectivity
	Maintain or increase habitat for native fish and increase their population
	Maintain or increase frog populations
	Protect forest waterways from increased erosion
	Maintain turtle populations including the broad-shelled turtle
	Enhance the health of river red gum communities and aquatic vegetation in the wetlands and watercourses and on the floodplain Promote the growth of floodplain marsh vegetation communities, with a particular focus on increasing the extent of Moira grass
	Provide feeding and nesting habitat for the successful recruitment of colonial nesting waterbirds
	Reduce the risk of low-oxygen events in summer

Figure 5.2.1 Barmah Forest



Traditional Owner cultural values and uses

'We are the First People of this place. We were here even before the Murray River flowed through Barmah.'—
Uncle Des Morgan, Yorta Yorta Elder
Joint Management Plan for Barmah National Park

Yorta Yorta are joint managers of Barmah National Park under a Traditional Owner Land Management Agreement with the State of Victoria. Goulburn Broken CMA worked with the Yorta Yorta Nation Aboriginal Corporation during the water for the environment planning process to get their feedback about planned watering actions. Yorta Yorta Traditional Owners have been involved in the development of longer-term management plans that have informed these watering actions.

Examples of Yorta Yorta cultural values and uses in Barmah Forest that are supported through environmental flow delivery include:

- maintaining refuges, which protects turtles that are an important totemic species for the Yorta Yorta People
- watering to support floodplain marsh vegetation, which includes important food, fibre and medicinal plants (such as sneezeweed and weaving sedge)
- healthier river red gums, which has benefits for important Yorta Yorta sites and significant markings such as a scarred tree and furthers connections to Country
- broader restoration to achieving health of Country.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.2.1, Goulburn Broken CMA considered how environmental flows could support values and uses including:

- water-based recreation (such as boating and fishing)
- riverside recreation and amenity (such as birdwatching, camping, benefits physical, mental and social wellbeing of residents and visitors)
- community events and tourism (such as boat tours)
- socio-economic benefits (such as apiarists and irrigation diverters).

Recent conditions

Despite a La Niña event in south-eastern Australia, Barmah Forest experienced drier-than-average conditions throughout most of 2020-21. Maximum temperatures were generally close to the monthly long-term average, and there were no prolonged hot spells in summer. Local rainfall was below the long-term mean (measured at Echuca) in winter, spring and summer. Carryover of water combined with Murray allocations in Victoria (100 percent of high-reliability water shares) and New South Wales (50 percent of general security) provided sufficient water for the environment to meet the planned watering actions in Barmah Forest.

Forest regulators were opened from August 2020 to December 2020 to allow a natural connection between the Murray River and the waterways within Barmah Forest. Two small natural floods occurred in Barmah Forest in July and August 2020. Water for the environment was delivered to the forest from October to mid-December, to mimic some of the low-level flooding that would have naturally occurred without river regulation. The environmental watering event was part of a coordinated 'southern spring flow' that aimed to achieve environmental objectives along the Murray River from Hume Reservoir to the sea. Managed environmental flows slowly reduced through December to enable fish and turtles to return to the main channel, but a short pulse was delivered during the flow recession to trigger golden and silver perch spawning. One regulator remained open in Barmah Forest from mid-December to February to maintain water levels in a wetland until breeding white ibis, straw-necked ibis and royal spoonbills successfully fledged their chicks.

All watering actions for Barmah Forest aligned with an average scenario were delivered as planned in 2020-21, noting the delivery of autumn/winter low flows in May and June 2021 had not occurred at the time of writing. Maintaining a winter/spring connection between the river and the forest enabled carbon and nutrient exchange and improved food resources and habitat for fish, frogs, turtles and waterbirds. Low-level flooding in spring supported wetland plant growth and flowering for species (such as Moira grass) that were unable to flower in 2019-20 due to floodplain watering ending mid-October 2019. The targeted wetland watering through summer helped some 450 pairs of ibis and spoonbills successfully fledge young birds. This was the first successful nesting for these species in Barmah Forest since 2016-17. Bitterns were also recorded calling throughout the forest wetlands in 2020-21, and they are likely to have bred. The drying phase implemented throughout the forest in summer/autumn 2020-21 is important to maintain plant diversity and wetland productivity.

The spring environmental flow to the forest was diverted a little more into Barmah Forest than Millewa Forest in 2020, to achieve the best possible outcomes for the floodplain marshes in Barmah Forest while somewhat compromising the equivalent outcomes in Millewa Forest. This reflected a delivery targeting 3.0 m in the Murray River at Tocumwal (about 15,000 ML per day downstream of Yarrawonga). Delivering to the current maximum constraint of 3.3 m at Tocumwal in 2021-22 would improve floodplain marsh vegetation outcomes in both Barmah and Millewa forests, as well as increase lateral connection and provide more habitat for native fish, turtles, frogs and waterbirds.

Scope of environmental watering

Table 5.2.1 describes the potential environmental watering actions in 2021-22, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objective(s) they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

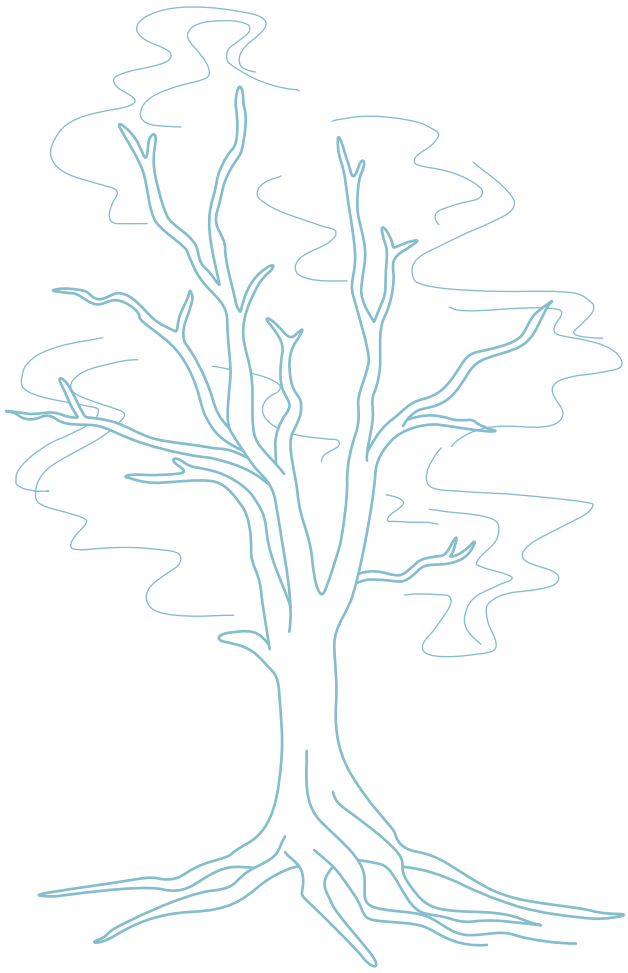


Table 5.2.1 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Barmah Forest

Potential environmental watering action	Expected watering effects	Environmental objectives
Winter/spring forest low flow to various waterways in Barmah Forest (variable flow rates and duration during July to November)	• Provide a gradual connection of waterways with the Murray River to minimise erosion within those waterways • Provide flow in forest waterways to ensure adequate refuge pools persist for native fish and turtles • Provide adequate depth and connection between floodplain waterways and the river to facilitate the movement of native fish • Remove accumulated organic matter from waterways to cycle carbon to the river system and minimise the risk of hypoxic blackwater by ensuring through-flow commence in the cooler months	
Winter/spring/summer low flow (8,500-18,000[1] ML/day below Yarrawonga Weir during August to December)	• Maintain a sufficient water level in the Murray River main channel to avoid Murray cod nest abandonment, increase juvenile survival and improve dispersal opportunities	
Spring/summer fresh(es) in the Murray River channel (one to three freshes that increase flow by at least 500 ML/day and maintain it for two to eight days during October to December)	• Provide variable water levels once water temperatures exceed 22° C, to trigger spawning of native fish species, primarily silver perch	
Spring/summer/autumn freshes to Gulf and Boals creeks (100 ML/day for three to five days as required during November to April)	• Maintain critical refuge pools to provide habitat for native fish and turtles • Flush refuge pools to maintain water quality	
Spring/summer/autumn low flow to floodplain waterways including Sandspit, Gulf, Big Woodcutter, Boals and Island creeks and Punt Paddock Lagoon (200 ML/day for 30 to 60 days during November to April)	• Replenish refuge pools in permanent waterways to maintain water quality, fish and turtle populations • Maintain connectivity between the forest and the river • Remove accumulated organic matter, cycle carbon to the river system and minimise the risk of hypoxic blackwater	
Fill or top-up Boals Deadwood, Harbours Lake, Reedy Lagoon and Top Island wetlands (200-400 ML/day for four and a half months during September to February)	• Provide a cue to initiate waterbird breeding and maintain a depth of at least 0.5 m beneath reed bed nesting breeding colonies • Maintain wetting duration and depth for growth of wetland vegetation	

Table 5.2.1 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Barmah Forest *(continued)*

Potential environmental watering action	Expected watering effects	Environmental objectives
Spring wetting of floodplain marshes (variable flow rates of > 9,500-18,000[1] ML/day below Yarrawonga Weir for three months during September to December)	• Wet open plains for sufficient depth and duration to allow the growth of floodplain marsh vegetation • Inundate forest wetlands and low-lying floodplain areas to create foraging opportunities for waterbirds and increase available habitat for turtles, frogs and small-bodied native fish	
Autumn/winter low flow in the Murray River (1,800-4,000 ML/day downstream of Yarrawonga during May to June)	• Increase water depth in the Murray River channel to provide habitat for large-bodied native fish in the Murray River and unregulated anabranches in Barmah-Millewa Forest	

1 The maximum flow constraint is a level of 3.3 m at the Tocumwal gauge in the Murray River, estimated at 18,000 ML/day downstream of Yarrawonga Weir. The maximum flow rate actually delivered may vary for these actions.

Scenario planning

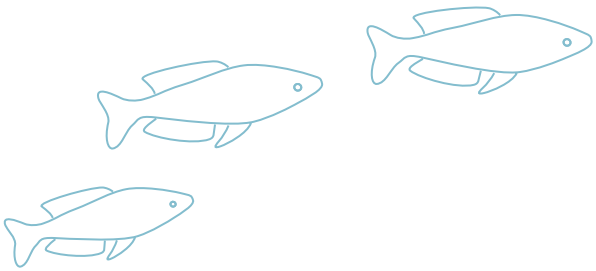
Table 5.2.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The ecological objectives at Barmah-Millewa Forest require sustained flows in the Murray River that peak in spring. Flow control structures are used to direct water from the Murray River channel into the forest and facilitate the later return of most of that water back to the river to transport carbon and nutrients and for use further downstream.

Demands for water for the environment in Barmah Forest vary significantly in response to natural conditions. Variable winter/spring low flow and spring/summer freshes are required under all scenarios. The variable winter/spring low flow is required to maintain habitat and movement opportunities for aquatic animals (such as native fish) and is achieved by keeping the regulating structures open and allowing water to move in and out of the forest in response to normal flow changes in the Murray River. The spring/summer freshes are achieved by providing changes in the flow rate in the Murray River below Yarrawonga Weir that trigger the spawning of silver perch.

Under extreme dry and dry conditions, potential environmental watering actions will primarily aim to maintain water levels and water quality in refuge habitats to sustain fish and turtle populations. Actions to achieve these objectives require relatively small volumes of water to be directed into the forest. These actions are unlikely to return much water to the Murray River for downstream use.

A new action for 2021-22 is the winter/spring/summer low flow in the Murray River channel to maintain sufficient water levels for successful Murray cod nesting and recruitment under dry to wet climate scenarios. This watering action aims to increase the Murray cod population and improve the recovery of this species. The volume needed to achieve this depends on the contribution of natural flows and the delivery of operational water downstream through the Barmah Choke. This action will provide environmental return flows downstream for use at other sites along the Murray River.



Under the average or wet scenarios, the focus shifts to building resilience in the system by increasing the ecological response to natural flood events. Specific actions under the average or wet scenarios may include extending the duration of natural flooding to increase the germination of wetland plants (such as Moira grass) in floodplain marshes or extending watering in river red gum forests to maintain the health of the trees. These actions may require large volumes of water to be directed into the forest, with water for the environment provided as a directed release from Hume Reservoir targeting specific flow rates downstream of Yarrawonga Weir and managed via forest regulators. Most of the water used for these actions is eventually returned to the Murray River through the natural shedding action of the floodplain.

A prolonged, low-level, spring watering event in 2021-22 is desirable, to help floodplain vegetation flower, set seed and recruit. Some floodplain inundation will occur when flow downstream of Yarrawonga exceeds 9,500 ML per day, but a higher flow will inundate more of the floodplain to a greater depth and therefore deliver a better environmental outcome for floodplain vegetation and benefit native fish, turtles and waterbirds. Ideally, the flow will be delivered up to 3.3 m on the Tocumwal gauge (about 18,000 ML per day downstream of Yarrawonga Weir) to inundate larger areas to an appropriate depth in Barmah and Millewa forests, compared to 2019-20 and 2020-21.

Targeted wetland watering may occur under various scenarios to support the breeding of colonial nesting waterbirds and other flood-dependent birds via the diversion of water through specific regulators.

Spring wetting of floodplain marshes is not considered a high priority in 2021-22 under the dry and extreme dry scenarios, but it would provide environmental benefit and may be delivered under certain circumstances. For example, if the above-channel-capacity operational transfers from Hume Reservoir are delivered through Barmah Forest, then the watering action could be achieved by delivering a relatively small volume of environmental flow on top of or following the operational delivery, even under an extreme dry or dry climate scenario. A multi-site environmental watering objective supporting whole-of-River-Murray and/or downstream environmental objectives during winter and spring may also deliver flow through Barmah Forest, and it could be supplemented to optimise environmental outcomes. The volume of water for the environment required to achieve the floodplain marsh flow objectives under the dry or extreme dry climate scenarios depends on demands for operational water or environmental multi-site events, and it is therefore not estimated in Table 5.2.2 below.

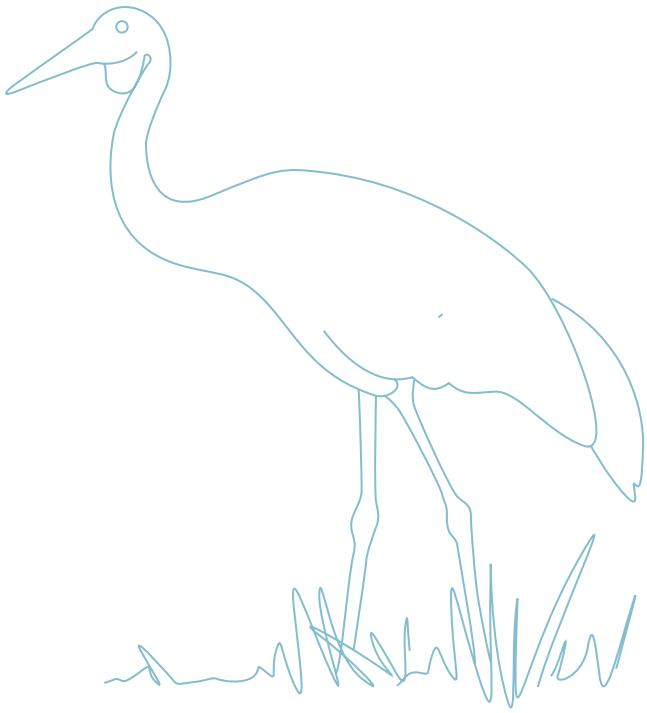


Table 5.2.2 Potential environmental watering for the Barmah Forest under a range of planning scenarios

Planning scenario	Extreme dry	Dry	Average	Wet
Expected river conditions	• Unregulated flow periods unlikely • Flow in the Murray River will remain within the channel all year	• Some small unregulated flows in late winter/spring • Low chance of overbank flow in late winter/spring	• Likely chance of small-to-medium unregulated flows in winter/spring • Likely chance of overbank flow in winter/spring	• High probability of moderate to large unregulated flows in winter/spring • Expected large overbank flow
Potential environmental watering – tier 1 (high priorities)[1]	• Winter/spring forest low flow • Spring/summer freshes (one to three freshes) • Spring/summer/ autumn freshes (to Gulf and Boals creeks)	• Winter/spring forest low flow • Winter/spring/ summer low flow • Spring/summer freshes (one to three freshes) • Spring/summer/ autumn low flow • Fill or top-up Boals Deadwood, Harbours Lake, Reedy Lagoon and Top Island wetlands	• Winter/spring forest low flow • Winter/spring/ summer low flow • Spring/summer freshes (one to three freshes) • Spring/summer/ autumn low flow • Fill or top-up Boals Deadwood, Harbours Lake, Reedy Lagoon and Top Island wetlands • Spring wetting of floodplain marshes • Autumn/winter low flow (in Murray River)	• Winter/spring forest low flow • Winter/spring/ summer low flow • Spring/summer freshes (one to three freshes) • Spring/summer/ autumn low flow • Fill or top-up Boals Deadwood, Harbours Lake, Reedy Lagoon and Top Island wetlands • Spring wetting of floodplain marshes • Autumn/winter low flow (in Murray River)
Potential environmental watering – tier 2 (additional priorities)	• Spring wetting of floodplain marshes	• Spring wetting of floodplain marshes		
Possible volume of water for the environment required to achieve objectives[2]	• 8,500 ML (tier 1)	• 61,500 ML (tier 1)	• 576,000 ML (tier 1)	• 570,000 ML (tier 1)

1 Tier 1 potential environmental watering at Barmah Forest is not classified as tier 1a or 1b, because the water available for use is shared across various systems and it is not possible to reliably determine the supply specifically available for Barmah Forest.

2 The possible volumes of water for the environment required in Barmah Forest are estimates and highly variable, depending on factors such as seasonal conditions and the contributions of operational and/or unregulated flows. Much of the water for the environment delivered to Barmah Forest is returned to the Murray River — around 80 percent under the dry to wet climate scenarios — and can be reused at downstream environmental watering sites.

5.2.2 Gunbower Creek and Forest

System overview

Gunbower Forest is a large, flood-dependent forest situated on the Murray River floodplain in northern Victoria between Torrumbarry and Koondrook (Figure 5.2.2).

Covering 19,450 ha, it is bounded by the Murray River to the north and Gunbower Creek to the south. It is an internationally significant site under the Ramsar Convention and forms part of the Living Murray Gunbower- Koondrook-Perricoota forests icon site. River regulation and water extraction from the Murray River and Gunbower Creek has reduced the frequency, duration and magnitude of flood events in Gunbower Forest. This has affected the extent and condition of floodplain habitats and the health of plant and animal communities (such as river red gum and black box communities, native fish, birds, platypus, frogs and turtles) that depend on those habitats.

Gunbower Creek is a natural creek that has been modified to supply irrigation water from the Murray River to the Torrumbarry Irrigation Area. There are twelve lagoons, largely located in the upper reaches of the creek system, that are permanently or seasonally connected to Gunbower Creek. Water for the environment is used in Gunbower Creek to improve habitat for native fish, especially Murray cod.

The Living Murray environmental works program in the middle and lower forest was completed in 2013. The works allow up to 4,500 ha of the wetlands and floodplain to be watered with considerably less water than would be required if the watering infrastructure was not in place. The works enable efficient watering through Gunbower Creek and the forest to maintain wetland and floodplain condition and provide connectivity between the creek, forest floodplain and the Murray River. Frequent connections between the river and floodplain habitats allow biota to move between habitats and support critical ecosystem functions (such as carbon exchange).

Environmental values

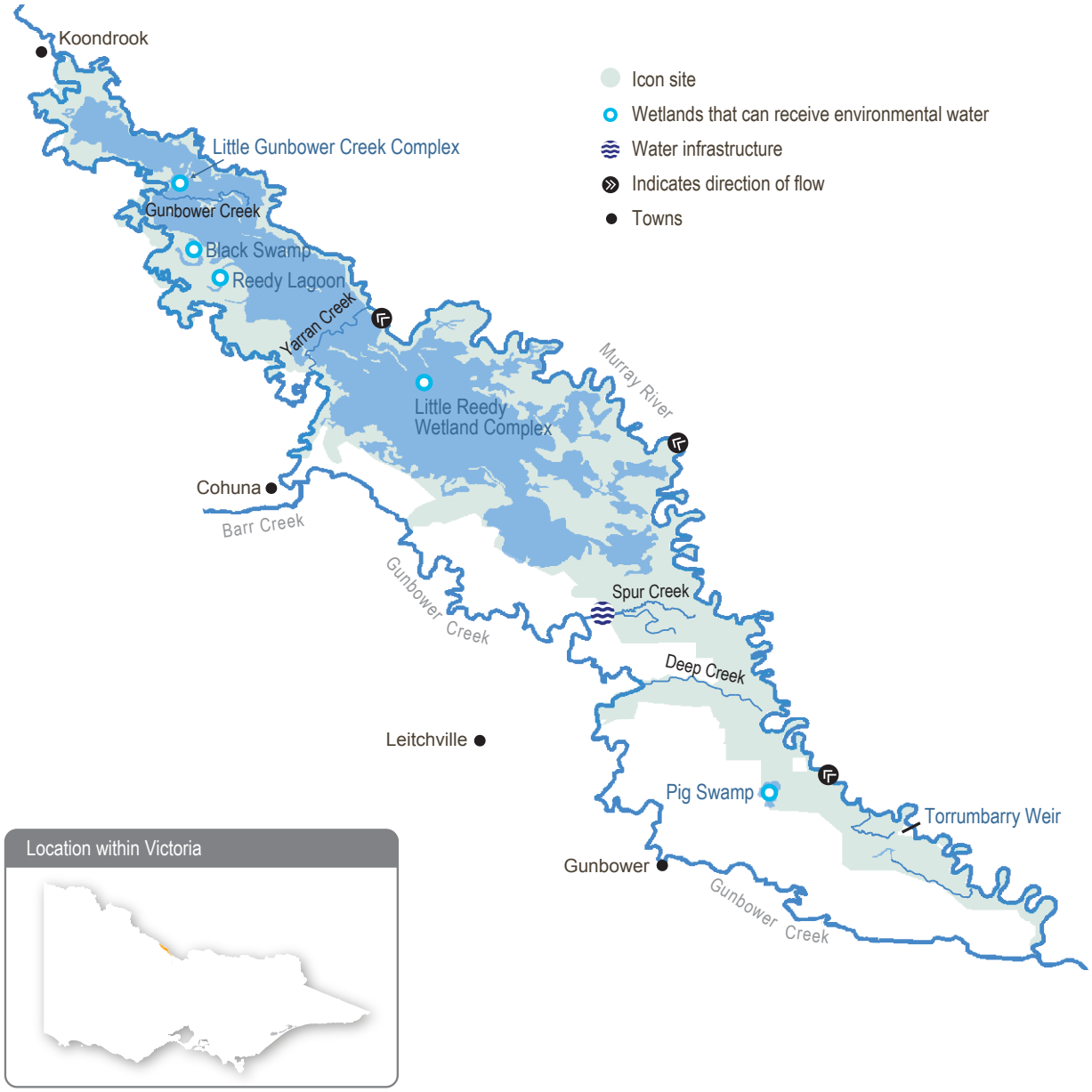
Gunbower Forest contains many important environmental values. It includes rare and diverse wetland habitats and large areas of remnant vegetation communities (such as river red gum forest and woodlands). It is also home to vulnerable and endangered plants and animals including river swamp wallaby grass, wavy marshwort, Murray-Darling rainbowfish, eastern great and intermediate egrets. It also supports internationally recognised migratory waterbird species.

Gunbower Creek provides important habitat for native fish (such as Murray cod, golden perch and freshwater catfish). It is a valuable refuge for native fish and provides a source of fish to recolonise surrounding waterways.

Environmental watering objectives in Gunbower Creek and Forest

	Provide feeding, breeding and refuge habitat for small-bodied native fish (such as Murray-Darling rainbow fish) in forest wetlands Maintain and improve populations of large-bodied native fish (such as Murray cod) in Gunbower Creek
	Provide suitable feeding, breeding and refuge habitat for frogs
	Provide suitable feeding, breeding and refuge habitat for turtles
	Support carbon and nutrient cycles in the forest and wetlands and periodically deliver carbon and nutrients from the forest to adjacent waterways to support food webs
	Maintain and improve the health and increase the abundance of native vegetation in permanent and semi-permanent wetlands Improve the health of river red gums and black box communities
	Provide feeding, breeding and refuge habitat for waterbirds including colonial nesting species (such as egrets, cormorants and herons)
	Maintain and improve water quality in Gunbower Creek

Figure 5.2.2 Gunbower Creek and Forest



Traditional Owner cultural values and uses

The middle and lower area of Gunbower Forest is recognised as the traditional Country of the Barapa Barapa people, and the upper Gunbower Forest is recognised as the traditional Country of the Yorta Yorta people. North Central CMA seeks engagement and input from both Traditional Owner groups when undertaking annual water for the environment planning and throughout the year as part of the Living Murray Indigenous Partnerships Program.

Increasing the involvement of Traditional Owners in environmental water planning and management, and ultimately providing opportunities to progress towards self-determination within and beyond the environmental watering program, is a core commitment of the VEWH and its agency partners. This is reinforced by a range of legislation and policy commitments (for example the *Water Act 1989*, the Victorian Aboriginal Affairs Framework, *Water for Victoria* (2016)) and, in some cases, agreements under the *Traditional Owner Settlement Act 2010*. Where Traditional Owners are more deeply involved in the planning and/or delivery of environmental flows for a particular site, their contribution is acknowledged in Table 5.2.3 with an icon. The use of this icon is not intended to indicate that these activities are meeting all the needs of Traditional Owners but is incorporated in the spirit of valuing that contribution, and indicating progress towards this objective.

Watering planned and/or delivered in partnership with Traditional Owners to support cultural values and uses

Barapa Barapa custodians have clearly expressed their aspirations for an active role in the management of land and water, to fulfil custodianship obligations and contribute to improvements in the health of Country.

Barapa Barapa Traditional Owners have been working in partnership with the North Central CMA to deliver the Water for Country project in Gunbower Forest since 2015. The Water for Country project builds on the work of the previous Barapa Barapa Cultural Heritage Mapping of Lower Gunbower Forest project, delivered in 2013-14 to map a catalogue of cultural heritage assets in the forest. The Water for Country project aims to investigate how Traditional Owners' cultural and spiritual values may be better represented in water management. In 2018, the Water for Country group has evolved to also include Wemba Wamba Traditional Owners and continues to have a focus on Gunbower Forest.

Barapa Barapa Wemba Wamba Water For Country project members identified a range of opportunities for 2021-22 watering to support cultural values (Table 5.2.3).

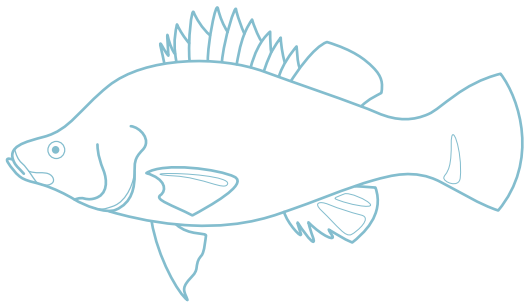


Table 5.2.3 Cultural values and uses at Gunbower Forest as identified by the Barapa Barapa Wemba Wamba Water For Country project

Value/use	How the value/use will be considered by environmental watering in 2021-22
Cultural plants, cultural practices	• Water in wetlands and on the floodplain from environmental watering and natural flooding supports culturally important plants throughout Gunbower Forest and allows the continuation of cultural practices including harvesting of food, medicine, and weaving plants. • The watering actions via the lower landscape regulators in 2021 and the Hipwell Road event in autumn 2022 will support cultural plants that Barapa Barapa Traditional Owners value and provide opportunities for cultural practices to continue. • The amount of resources available is linked to the scale of watering able to be achieved. Floodplain watering via the Hipwell Road Regulator provides a greater amount of resources and enables abundant harvests with less travel and effort to harvest the desired amount of resources. • Barapa Barapa Traditional Owners recognise the value of resources that occur on the drawdown after the inundation of the forest floodplain, providing food for animals and cultural plants (such as old man weed). This can be supported by allowing wetlands to draw down naturally after receiving water, to expose mudflats. • Having a diversity of habitat and vegetation responses is a priority for Barapa Barapa Traditional Owners. They consider it important to have a range of water depths, which creates a more diverse vegetation response and results in a variety of resources becoming available over a longer period. • Delivering water to the floodplain supports this by inundating wetlands of varying depth and condition, which supports a variety of cultural and ecological values.
Healthy Country	• Providing drought refugia and maintaining areas with healthy habitat is a high priority for Barapa Barapa Traditional Owners. In the absence of natural flooding, they feel it is important to ensure that water is delivered to healthy areas, such as Reedy Lagoon, which elicit a good vegetation response and can support wetland and forest fauna. • Environmental watering actions will ensure water is present on the floodplain and in high-priority wetlands regardless of whether flooding is received. This will provide refuge habitat for forest fauna and the provision of water in Reedy Lagoon ensures high-quality habitat is available. • Barapa Barapa Traditional Owners have also expressed the importance of looking after areas that are in good condition by conducting follow-up watering. This will be by delivering the Hipwell Road environmental watering event to build upon outcomes achieved by the lower landscape watering in 2021.
Cultural heritage	• Barapa Barapa Traditional Owners value having water in natural creeks and billabongs off main wetlands which can contain cultural heritage sites including earth mounds and a large canoe tree on the edge of a large flood runner. • Delivering water to the floodplain supports this with water flowing through natural creeks and floodrunners on the floodplain. Environmental watering results in lower levels than natural flooding, which can ensure that earth mounds or other cultural heritage are not overtopped and harmed. • Barapa Barapa Traditional Owners have noted that areas of black box and river red gum have cultural heritage values, however the changed watering regime since regulation and climate change climate is causing the encroachment of black box into areas previously dominated by river red gum. Barapa Barapa Traditional Owners expressed the desire to preserve the tree community that was historically present, which is supported by delivery of water to the floodplain. The lower landscape regulators can target small areas of river red gum, however the Hipwell Road watering event planned in autumn 2022 will inundate large areas of river red gum and potentially suppress black box encroachment within the flood footprint.
Cultural practices	• Barapa Barapa Traditional Owners have aspirations to reintroduce traditional fish traps into natural creeks within Gunbower Forest. The flood-runners around the Little Gunbower Creek Complex have been identified as potential trial sites and opportunities will be provided to pursue this in spring 2021. • Traditional Owners have indicated that a smoking ceremony should be a regular activity each year when water is delivered, as it is something that their ancestors would have done when the floodwaters arrived and would represent a restoration of an important cultural practice. The timing of environmental water deliveries will be communicated to Traditional Owners so that opportunities to practice their culture can be realised.
Cultural resources	• Barapa Barapa Traditional Owners have expressed that the ongoing survival of fish populations are important as a standing food resource. Wetland fish populations persisting in Reedy Lagoon following the 2020 watering event will be supported by top-ups in spring 2021 and autumn 2022 ensuring a permanent fish population remains across multiple years.

The Barapa Barapa Wemba Wamba Water for Country project has led to the creation of the *Barapa Barapa Cultural Watering Objectives Framework*, which is a guiding document to ensure cultural priorities and outcomes are considered and incorporated in the planning for and management of water for the environment. The framework considers cultural objectives matched with hydrological considerations, indicators and measures for monitoring success (Table 5.2.4). These objectives are considered in conjunction with the environmental and functional watering objectives for the potential watering actions in Table 5.2.5.

Planning for environmental watering in 2021-22 included discussion of vegetation monitoring results, forest condition and potential watering requirements with a field ecologist and a field visit to review the previous year's cultural objectives and outcomes and discuss potential new objectives.

Applying the framework during seasonal watering proposal engagement with the Barapa Barapa Wemba Wamba Water for Country project members will ensure that environmental watering activities incorporate Barapa Barapa Traditional Owners' cultural aspirations and that water managers are culturally informed when delivering environmental water.

All potential watering actions in Table 5.2.5 provide the opportunity to support Barapa Barapa cultural values and objectives, but achievement will be guided by climatic conditions.

Table 5.2.4 Barapa Barapa cultural objectives for environmental watering in Gunbower Forest 2021-22 (from the Barapa Barapa Cultural Watering Objectives Framework)

Cultural objective	Hydrological aim	Indicator	Measure
Promote and maintain healthy and abundant native fish communities in Gunbower Creek and Gunbower Forest	• Presence of water in wetlands before spring to support fish spawning events	• Presence of native fish spawning • Native fish populations show a range of ages	• Fish surveys, larval sampling
	• Presence of water in deep wetlands, so that fish can survive for longer	• Presence of native fish following watering event	• Fish surveys
Promote the natural flow of water	• Water flows via natural flow paths to culturally important sites	• Presence of water at culturally significant sites (e.g. fish ponds)	• Photo points, site surveys
	• Presence of healthy looking and smelling forest	• Presence of healthy canopies and good ground cover on the forest floodplain	• Plant surveys
Promote and maintain healthy cultural plants and resources	• Presence of water in small wetlands and depressions to provide resources across the forest, particularly in dry years	• Presence of food and fibre resources distributed across the forest	• Cultural harvests, plant surveys, seed collection
	• Presence of water in wetlands which are healthy	• A diverse range of plants, animals and insects living in harmony	• Results of monitoring activities (e.g. macroinvertebrate surveys, flora and fauna surveys)
Promote healthy waterbird populations	• Presence of water in wetlands that support waterbird breeding	• Presence of waterbird breeding	• Waterbird surveys, spring/ summer surveys for eggs

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.2.5, North Central CMA considered how environmental flows could support values and uses including:

- water-based recreation (such as boating, canoeing, duck hunting, fishing, and stand-up paddle boarding and water skiing)
- riverside recreation and amenity (such as birdwatching, camping, photography and walking)
- community events and tourism (such as park visitation, tour and activity operators)
- socio-economic benefits (such as consumptive water users including irrigation and domestic use, timber harvesting and education).

Recent conditions

Rainfall and temperatures in the Gunbower Forest and surrounding areas were close to the long-term average during 2020-21. Carryover of water in the Murray system was important to meet demands for water for the environment early in the water year. Allocations against high-reliability water shares in Victorian Murray entitlements to water for the environment, which are used to supply Gunbower Forest and Gunbower Creek, reached 55 percent in October 2020 and 100 percent in February 2021. Water for the environment was delivered to Gunbower Forest and Gunbower Creek in line with an average climate scenario in 2020-21, and most planned actions were achieved.

Small peaks in the Murray River delivered minor inflows to Gunbower Forest via low-lying flood runners in July 2020. Another short peak in September 2020 was excluded from the forest by closing the regulators on the Murray River to prevent nuisance flooding of Yarran Creek. In late winter/spring 2020, water for the environment was used to fill Reedy Lagoon and Black Swamp within Gunbower Forest. Some of the water from Black Swamp spilled into wetlands within the Little Gunbower wetland complex. Other wetlands within Gunbower Forest were allowed to draw down during the first half of 2020-21, to reduce carp. Additional deliveries of water for the environment in autumn 2021 topped up Reedy Lagoon and filled the Little Reedy wetland complex. The planned autumn top-up watering action at Black Swamp did not proceed, to allow the wetland to dry and hence reduce carp abundance ahead of a planned fill in winter/spring of 2021-22.

Fishway construction activities in Gunbower Creek limited deliveries of water for the environment to Gunbower Forest via the Hipwell Road Regulator in autumn and early winter 2021. Vegetation monitoring in autumn 2020 detected a slight decline in the condition of river red gums in some parts of the forest. Delivering water to selected wetlands and river red gum stands is proposed after the construction works conclude in winter/spring 2021, and more extensive floodplain watering in autumn/winter/spring 2022 is a high priority to improve tree and understorey condition and provide habitat for native fish and waterbirds.

In Gunbower Creek, water for the environment was used to maintain access to habitat and food resources for native fish during winter 2020 (when irrigation flows cease) and to promote spawning and improve the quality of nursery habitats for native fish (especially Murray cod) during spring and summer. Construction of new fishways at Cohuna Weir and Koondrook Weir commenced in May 2021 and should be completed by August 2021. During the construction period, there will be little flow in Gunbower Creek, and pool habitats will be maintained downstream of the weirs to support native fish.

Annual fish surveys in Gunbower Creek have detected successful breeding and survival of Murray cod each year that water for the environment has been delivered, and the surveys are showing improvements in abundance and age structure within the resident Murray cod population over time. Freshwater catfish are also breeding in Gunbower Creek. Environmental flows will be necessary to help restore native fish habitat and support fish dispersal from the managed refuge pools once the fishway construction activities are complete. The fishways are expected to significantly improve the abundance and diversity of fish populations over time by allowing fish to move between Gunbower Creek and the Murray River. This will enable fish that successfully breed in Gunbower Creek to migrate into the Murray system and for species (such as golden perch and trout cod) that breed elsewhere to move into Gunbower Creek to feed and develop. Greater fish movement into and out of Gunbower Creek will help to grow populations of native fish within Gunbower Creek and across the broader region.

Scope of environmental watering

Table 5.2.5 describes the potential environmental watering actions in 2021-22, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objective(s) they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.2.5 Potential environmental watering actions, expected watering effects and associated environmental objectives for Gunbower Creek and Forest

Potential environmental watering action	Expected watering effects	Environmental objectives
Gunbower Forest		
Little Reedy wetland complex and Reedy Lagoon top-up (winter/spring 2021)	• Maintain water depth and extent to support the growth and successful recruitment of wetland vegetation • Maintain water depth and quality to provide habitat for small-bodied native fish • Provide a diversity of water depths throughout the season to provide feeding and breeding habitat for water-dependent biota including waterbirds, turtles and frogs	
Black Swamp and Little Gunbower wetland complex fill (winter/spring 2021)		
Black Swamp, Little Gunbower wetland complex, Little Reedy wetland complex and Reedy Lagoon overtop (winter/spring/summer 2021)	• Increase water depth and extent to support the growth and successful recruitment of wetland and surrounding river red gum understorey flood-dependent vegetation • Increase water depth and quality to provide habitat for small-bodied native fish • Maintain a diversity of water depths throughout the season to provide feeding and breeding habitat for water-dependent biota including waterbirds, turtles and frogs	
Winter/spring fresh in Yarran Creek (variable flow rates and duration based on water levels in Gunbower Forest and flows in the Murray River and Gunbower Creek)	• Provide connectivity between Gunbower Creek and Murray River through the Yarran Creek and Shillinglaws regulators, to increase flowing habitat for the lateral movement of native fish, turtles, carbon and nutrients • Provide migration and spawning opportunities for native fish	
Extend natural flooding in Gunbower Forest floodplain, floodrunners and wetlands (with variable flow rates to maintain an appropriate wetted extent during winter/spring 2021)	• Extend the duration of floodplain and wetland inundation over the optimal growth season • Maintain water depth and quality to provide habitat for small-bodied native fish including Murray-Darling rainbowfish • Maintain a diversity of water depths throughout the season to provide feeding and breeding habitat for water-dependent biota including waterbirds, turtles and frogs	

Table 5.2.5 Potential environmental watering actions, expected watering effects and associated environmental objectives for Gunbower Creek and Forest *(continued)*

Potential environmental watering action	Expected watering effects	Environmental objectives
Trigger-based top-up of permanent and semi-permanent wetlands (variable flow rates during spring/summer as required in response to bird breeding event)	• Maintain a waterbird breeding event • Maintain the wetland vegetation to provide habitat for colonial nesting and flow-dependent waterbirds	
Reedy Lagoon autumn/ winter top-up (2022)	• Maintain water depth and extent to support the growth and successful recruitment of wetland vegetation • Maintain water depth and quality to provide habitat for small-bodied native fish including Murray-Darling rainbowfish • Maintain a diversity of water depths throughout the season to provide feeding and refuge habitat for water-dependent biota including waterbirds, turtles and frogs	
Gunbower Forest floodplain, floodrunners and wetlands inundation (with variable flow rates during autumn/winter 2022)	• Inundate river red gums and the flood-dependent and flood-tolerant understorey species • Provide access to breeding habitat and food resources for native fish (such as Murray cod) • Provide habitat for frogs, turtles, small-bodied native fish and waterbirds including colonial nesting species	
Gunbower Creek		
Irrigation season low flow (300-500 ML/day during August to March)	• Maintain habitat and food resources for native fish (such as Murray cod) by minimising large variations in the water level during the irrigation season • Provide cues for the migration and spawning of native fish • Maintain connectivity between Gunbower Creek, lagoons and fishways, to maintain habitat for the movement of native fish • Dilute low-oxygen water exiting Gunbower Forest below Koondrook Weir if required	
Autumn/winter low flow (above 200 ML/day during March to June 2022)[1]	• Maintain habitat and food resources for native fish (such as Murray cod) during the off-irrigation period and/or when Hipwell Road regulator is operational • Maintain connectivity between Gunbower Creek, lagoons and fishways, to maintain habitat and support the movement of native fish	
Autumn/winter freshes (500 ML/ day for one to four weeks during July to August 2021 and May to June 2022)	• Make delivery in response to high flow in the Murray River and low-oxygen water draining off Gunbower Forest during the non-irrigation season to protect water quality and allow fish to move between the Murray River and Gunbower Creek	

1 This flow is prioritised only when deliveries are occurring to Gunbower Forest through Hipwell Road regulator.

Scenario planning

Table 5.2.6 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Gunbower Forest

The highest-priority potential watering actions under all climate scenarios for Gunbower Forest are to provide water to Reedy Lagoon, Black Swamp and the Little Gunbower and Little Reedy wetland complexes in winter/spring 2021. These are permanent and semi-permanent wetlands, and water is needed to improve their health, support the growth and recruitment of wetland plants and provide feeding and breeding habitat for small-bodied native fish, frogs, turtles and waterbirds following a drying phase over much of the forest during summer and early autumn 2021. These wetlands will be topped up or filled where possible under a drought climate scenario, to maintain their environmental conditions. Larger deliveries will be provided under dry, average and wet climate scenarios, to overtop the wetlands and so improve the condition of floodplain vegetation communities and environmental values in connected flood runners. Additional top-ups may be delivered to Reedy Lagoon in autumn/winter 2022 if dry conditions are forecast for 2022-23, to maintain water quality and increase habitat for small-bodied native fish. If a waterbird breeding event commences in any wetland, top-ups may be needed under any scenario to maintain water depth and habitats through spring and summer 2021-22 until juvenile waterbirds have fledged.

Inundating the Gunbower Forest floodplain, floodrunners and wetlands will be a high priority in autumn/winter 2022 under all climate scenarios. Floodplain watering is proposed for autumn/winter 2022 even if a natural flood occurs between winter and early summer 2021, because successive floodplain inundation will consolidate plant and animal outcomes. Water for the environment may also be used to increase the level or duration of a natural flood in winter/spring 2021, to target vegetation communities at higher elevations and allow wetland plants to flower, set seed and germinate. The floodplain area that can be targeted by environmental flows last received water in winter/spring 2018, and the river red gum vegetation communities are being stretched beyond their tolerances for dry conditions. The need for watering is supported by annual vegetation surveys that indicate the condition of the river red gum canopies is beginning to decline following several years of dry climatic conditions, and understorey plants have not had an opportunity to complete their life cycles. As these trees and plants provide important food and nesting resources as well as physical habitat, it is important to maintain the condition of these areas for floodplain fauna.

If conditions are suitable in winter/spring, a fresh may be delivered in Yarran Creek to allow carbon, fish, turtles and seed propagules to move between Gunbower Creek, Gunbower Forest and the Murray River.

Gunbower Creek

No water will be delivered in Gunbower Creek between mid-May and mid-August 2021 (off-irrigation period) due to the construction of fishways at Koondrook Weir and Cohuna Weir. These fishways will provide extensive opportunities for fish movement once constructed. Water will be held in selected pools during the construction period to provide habitat for native fish, and conditions will be monitored in those pools to protect resident fish. Once the construction work is complete, the highest priority for Gunbower Creek will be to maintain continuous low flow for the rest of the year to restore fish habitat and food and allow fish to disperse throughout the system. The low-flow magnitude may be increased to 500 ML per day at any time if required to dilute low-oxygen water exiting the Gunbower Forest outfall located downstream of Koondrook Weir.

The Gunbower Creek low-flow magnitude may also be deliberately increased to 500 ML per day under average or wet climate scenarios, to align with higher flow in the Murray River and support native fish breeding or movement. A minimum carryover volume of 56,000 ML is required to support high-priority watering action in the Gunbower Creek and Forest system in 2022-23. The volume will provide certainty of supply for low flow in Gunbower Creek during the non-irrigation season, to maintain flowing habitat and continue the autumn/winter/spring delivery to Gunbower Forest's floodplain, floodrunners and wetlands that is expected to commence in autumn 2022.

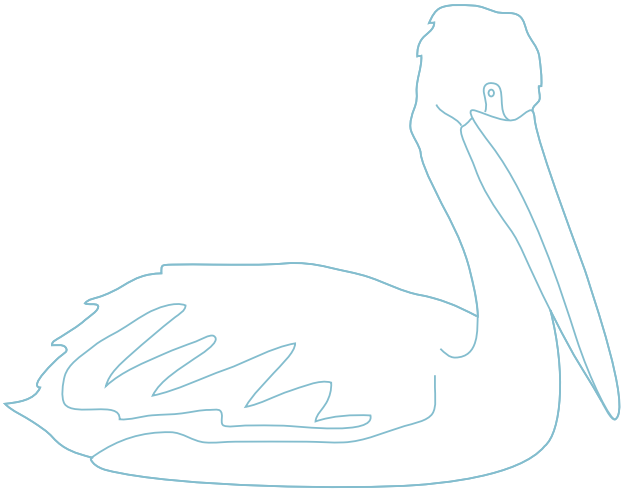


Table 5.2.6 Potential environmental watering for Gunbower Creek and Forest under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No natural inflow into Gunbower Forest	• No natural inflow into Gunbower Forest	• Minor natural inflow into Gunbower Forest may occur in winter/spring	• Overbank flow is likely in winter/spring
Gunbower Forest				
Tier 1 (highest priorities)[1]	• Little Reedy wetland complex and Reedy Lagoon winter/spring top-up • Black Swamp and Little Gunbower wetland complex winter/spring fill • Trigger-based top-up permanent and semi-permanent wetlands • Reedy Lagoon autumn/winter top-up • Gunbower Forest, floodplain, floodrunners and wetlands inundation	• Black Swamp, Little Gunbower wetland complex, Little Reedy wetland complex and Reedy Lagoon overtop in winter/spring • Trigger-based top-up permanent and semi-permanent wetlands • Reedy Lagoon autumn/winter top-up • Gunbower Forest, floodplain, floodrunners and wetlands inundation	• Black Swamp, Little Gunbower wetland complex, Little Reedy wetland complex and Reedy Lagoon overtop in winter/spring • Yarran Creek fresh • Trigger-based top-up permanent and semi-permanent wetlands • Reedy Lagoon autumn/winter top-up • Gunbower Forest, floodplain, floodrunners and wetlands inundation	• Black Swamp, Little Gunbower wetland complex, Little Reedy wetland complex and Reedy Lagoon overtop in winter/spring • Yarran Creek fresh • Extend natural flooding in Gunbower Forest floodplain, floodrunners and wetlands • Trigger-based top-up permanent and semi-permanent wetlands • Reedy Lagoon autumn/winter top-up • Gunbower Forest, floodplain, floodrunners and wetlands inundation
Gunbower Creek				
Tier 1 (highest priorities)[1]	• Irrigation season low flow • Autumn/winter low flow	• Irrigation season low flow • Autumn/winter low flow	• Irrigation season low flow • Autumn/winter low flow	• Irrigation season low flow • Autumn/winter low flow • Autumn/winter freshes
Possible volume of water for the environment required to achieve objectives	• 44,300 ML	• 59,000 ML	• 62,500 ML	• 87,000 ML
Priority carryover requirements	• 56,000-60,000 ML			

1 Tier 1 potential environmental watering at Gunbower Creek and Forest is not classified into tier 1a and 1b, because the water available for use is shared across various systems and it is not possible to reliably estimate supply.

5.2.3 Central Murray wetlands

System overview

The central Murray wetlands are located on the lower Loddon River and Murray River floodplains (Figure 5.2.3). The wetland system includes Guttrum and Benwell state forests, Hird Swamp, Johnson Swamp, Lake Cullen, Lake Elizabeth, Lake Murphy, McDonalds Swamp, Muringa wetlands, Richardson's Lagoon, Round Lake, Third Reedy Lake and the Wirra-Lo wetland complex.

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

Eleven of the central Murray wetlands can receive water for the environment from permanent infrastructure: Hird Swamp, Johnson Swamp, Lake Cullen, Lake Elizabeth, Lake Murphy, McDonalds Swamp, Muringa wetlands, Richardson's Lagoon, Round Lake, Third Reedy Lake, and the Wirra-Lo wetland complex. Temporary pumps may be used to deliver water for the environment from the Murray River to some semi-permanent wetlands in the Guttrum and Benwell forests.

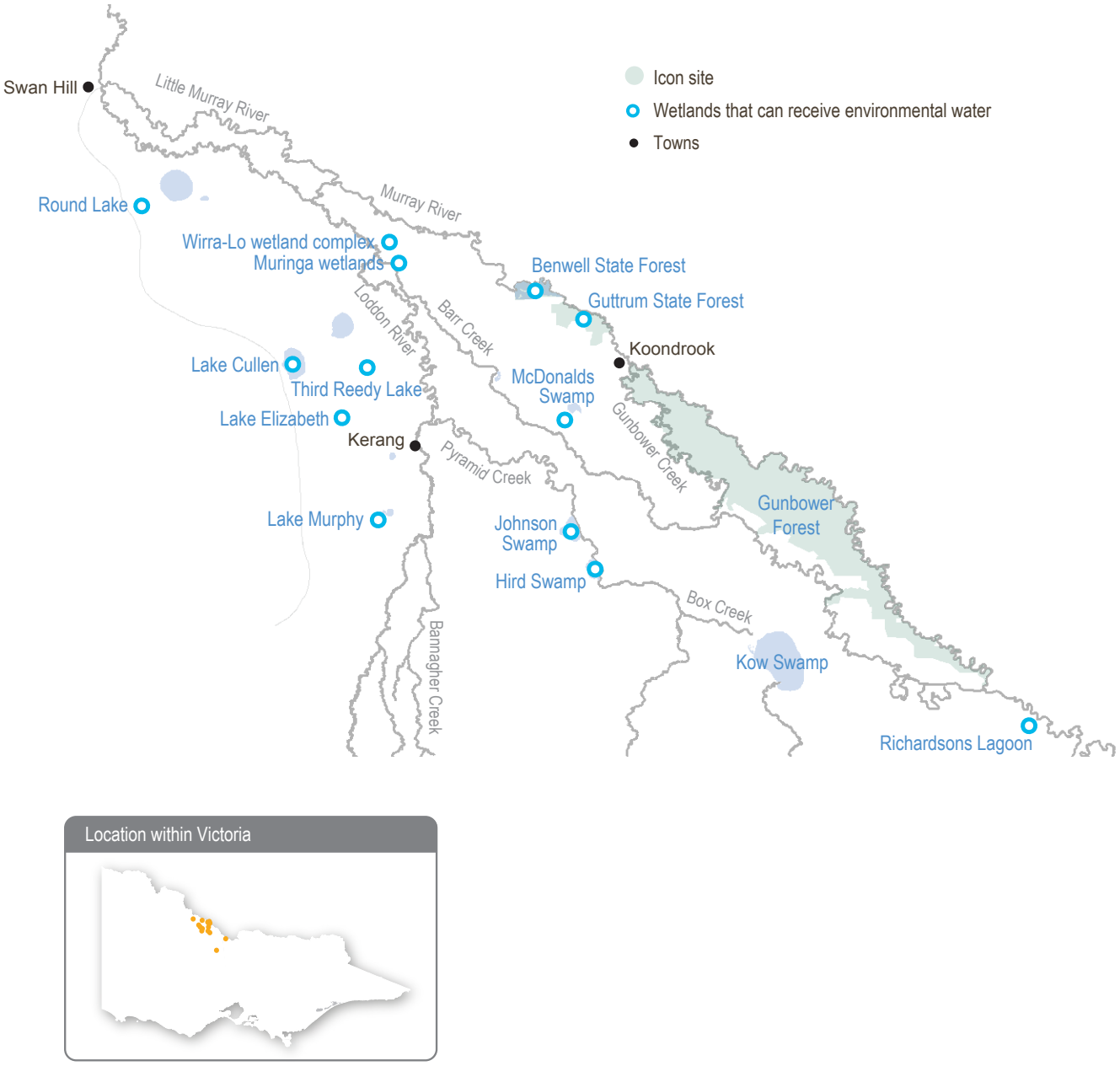
Environmental values

The central Murray wetlands support numerous listed threatened species ranging from vulnerable to critically endangered including the Australasian bittern, Murray hardyhead, Australian painted snipe, growling grass frog and the southern purple spotted gudgeon, which was presumed extinct in Victoria until it was found at Third Reedy Lake in spring 2019. When the wetlands receive environmental water, they can attract prolific birdlife and provide feeding and breeding habitat for many threatened and endangered bird species (including the eastern great egret and white-bellied sea eagle) listed under legislation and international agreements. Lake Cullen, Hird Swamp, Third Reedy Lake and Johnson Swamp are internationally recognised under the Ramsar Convention, while the other wetlands in the central Murray system have bioregional significance.

Environmental watering objectives in the central Murray wetlands

	Maintain and improve populations of listed threatened species including critically endangered Murray hardyhead and southern purple spotted gudgeon Maintain or increase populations of common small-bodied native fish (such as carp gudgeon and flat-headed gudgeon)
	Maintain and improve populations of the endangered growling grass frog Maintain populations of common native frogs (such as barking marsh frog, Peron's tree frog and spotted grass frog)
	Maintain populations of native turtle species (such as Murray River turtle and the common long-necked turtle)
	Restore and maintain the health of streamside trees (such as river red gum and black box) Restore and maintain mudflat vegetation communities (such as tall marsh, herblands, rushes and sedges) Restore and maintain native aquatic vegetation species (such as tassel, milfoil and pondweed) Reduce the extent and density of invasive plant species Support a mosaic of wetland plant communities across the region
	Provide resting, feeding and breeding habitat for a variety of waterbird feeding guilds including threatened species (such as Australasian bittern, little bittern and brolga)

Figure 5.2.3 The Central Murray wetlands



Traditional Owner cultural values and uses

The wetlands and surrounding land in the central Murray area have rich cultural values belonging to the Traditional Owners, including the Barapa Barapa, Wemba Wamba and Yorta Yorta People. Their traditional knowledge is a living cultural evident throughout the landscape in tree markings, significant cultural sites, and cultural tools for cultural practices. The rivers and floodplains are a food and fibre source and contain many sites of significance (such as camp sites and meeting places). Environmental watering supports values such as native fish, waterbirds and turtles, and it promotes the growth of culturally important plants that provide food, medicine and weaving materials for Traditional Owner groups. The presence of water itself can be a cultural value, as well as the quality of the water: healthy water promotes a healthy Country.

Barapa Barapa, Wemba Wamba and Yorta Yorta Traditional Owners have contributed to planning for water for the environment for wetlands important to them in the central Murray region in 2021-22. Focus areas include the following.

- Barapa Barapa and Wemba Wamba Traditional Owners have highlighted maintaining or improving the health of wetland vegetation as a key priority across the wetlands. Watering activities in Guttrum Forest will again be a particular focus for Barapa Barapa and Wemba Wamba Traditional Owners in 2020-21, as described below.
- North Central CMA and Barapa Barapa Traditional Owners have collaborated to deliver the DELWP-funded Decision Support Tool (DST) project, which is guiding vegetation works at McDonalds Swamp, as well as Lake Leaghur and Lake Yando – which are sites within the Boort wetlands (see subsection 5.7.2). This has allowed them to align watering actions in these wetlands with the watering requirements of the revegetation and enabled monitoring to be completed by the Barapa Barapa Traditional Owners.
- Yorta Yorta Traditional Owners have considered watering priorities for 2021-22, with a particular focus on Richardsons Lagoon. The Yorta Yorta Traditional Owners support the proposed fill and top-ups at the lagoon. The watering can support the growth of cultural plants which enables a continuation of cultural practices (such as harvesting, medicine and weaving). Deliveries of water for the environment can be managed so the revegetated areas are provided with an appropriate water regime — plants are watered but are not drowned — to ensure their ongoing survival and to provide opportunities for natural recruitment.

Increasing the involvement of Traditional Owners in environmental water planning and management, and ultimately providing opportunities to progress towards self-determination within and beyond the environmental watering program, is a core commitment of the VEWH and its agency partners. This is reinforced by a range of legislation and policy commitments (for example the *Water Act 1989*, the Victorian Aboriginal Affairs Framework, *Water for Victoria* (2016)) and, in some cases, agreements under the *Traditional Owner Settlement Act 2010*. Where Traditional Owners are more deeply involved in the planning and/or delivery of environmental flows for a particular site, their contribution is acknowledged in Table 5.2.7 with an icon. The use of this icon is not intended to indicate that these activities are meeting all the needs of Traditional Owners but is incorporated in the spirit of valuing that contribution, and indicating progress towards this objective.

Watering planned and/or delivered in partnership with Traditional Owners to support cultural values and uses

Barapa Barapa and Wemba Wamba input to watering actions for Guttrum Forest in 2021-22

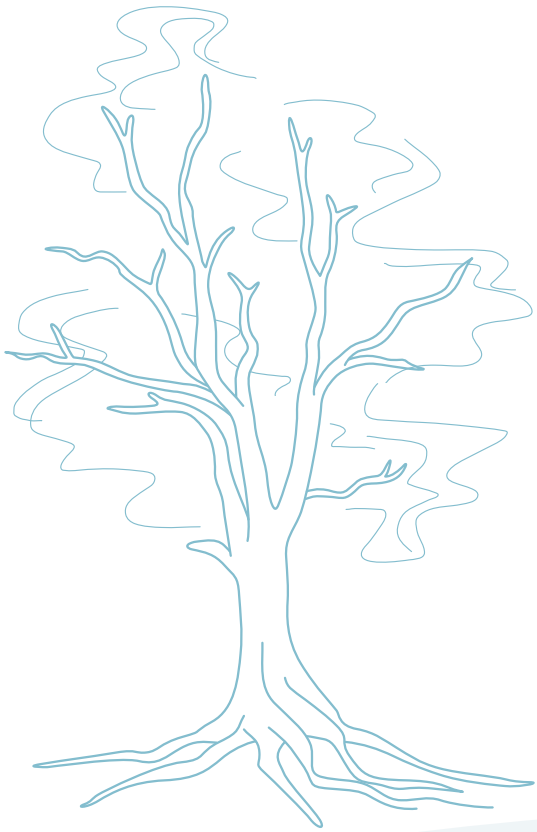
The proposed delivery of water for the environment to Guttrum Forest during 2021-22 has been planned in conjunction with the Barapa Barapa and Wemba Wamba peoples, for whom the wetlands and surrounding forest are places of high cultural significance. The Traditional Owners have been an important part of Guttrum Forest planning and management from the outset and were directly involved in the delivery of environmental flows to Reed Bed Swamp in 2019-20.

Barapa Barapa and Wemba Wamba collaborate with waterway managers to ensure that during watering events their cultural heritage is protected and that the hydrological needs of important cultural values (such as food and medicinal plant species, scar trees and ring trees) are supported through the timing and duration of planned watering actions to the forest.

Table 5.2.7 outlines the values and uses considered in the planning for and management of water for the environment at Guttrum Forest in 2021-22.

Table 5.2.7 Barapa Barapa and Wemba Wamba cultural values and uses at Guttrum Forest

Value/use	Considerations
Food, fibre and medicinal plants	• A winter fill followed by a spring top-up will ensure that the duration of wetting will be long enough to support aquatic vegetation during its optimal growth period. Allowing the wetland to dry before summer will also promote cultural plants on the mudflats in these areas. • An autumn fill followed by a spring top-up will ensure that the duration of inundation will be long enough to support aquatic vegetation during its optimal growth period. Allowing the wetland to draw down before summer will also promote cultural plants on the mudflats in these areas.
Cultural heritage	• Watering of Reed Bed Swamp supports fringing large old trees including a couple of ring trees and scar trees. The condition of these trees was seen to improve following the 2019 watering: for example, there was new growth.
Spiritual wellbeing	• The improvement in condition of the wetland and the presence of water and moisture contributed to a sense of spiritual wellbeing.
Sharing cultural knowledge	• The Traditional Owners provide support and advice about what ecological values to target: that is, they provide information about what the wetland used to look like and what values it previously supported. • Traditional Owners were also present during the set-up of infrastructure and were able to provide advice about avoiding impacts to their cultural heritage.
Employment opportunities	• Traditional Owners want to become more involved in the management of their Country through increased employment opportunities (such as ecological and cultural monitoring). This occurred as part of the 2019 watering of Reed Bed Swamp.
Cultural landscape	• Maintaining the open-water habitat and mudflats underneath that will disappear if the river red gum saplings that germinated in the 2016 floods are not removed. This is important for maintaining the cultural landscape and access to food and medicinal resources.
Cultural practice	• In 2019-20 when environmental water was first delivered in Guttrum Forest, a smoking ceremony and celebration was held to welcome the water back to the wetland. The Traditional Owners have indicated that this should be a regular activity each year when water is delivered, as it is something that their ancestors would have done when the floodwaters arrived and would represent a restoration of an important cultural practice.



Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.2.8, North Central CMA considered how environmental flows could support values and uses including:

- water-based recreation (such as canoeing, fishing, kayaking, swimming and water sports)
- riverside recreation and amenity (such as birdwatching, duck hunting, camping, cycling, running and walking)
- community events and tourism (such as visitation during the hunting and fishing seasons, Breakfast with the Birds events (North Central CMA), supporting Aboriginal cultural heritage and history-based tours)
- socio-economic benefits (such as ecosystem services like groundwater recharge, flood mitigation, nutrient treatment and carbon storage, stock and domestic users).

Recent conditions

Rainfall across the central Murray wetlands (based on records at Kerang) was slightly below the long-term average in 2020-21, but monthly temperatures were close to the long-term averages. Water for the environment used in the central Murray wetlands is supplied from entitlements held in the Murray system. Allocations against high-reliability water shares in the Murray system reached 100 percent in November 2020.

Seven central Murray wetlands received water for the environment in 2020-21 in line with planning under an average scenario.

Hird Swamp was filled in spring, to provide feeding and breeding habitat for waterbirds, especially Australasian bittern. Additional water was delivered through Hird Swamp in summer and discharged into Pyramid Creek to transport carbon and nutrients to the creek system to support native fish. Hird Swamp has similar habitat and environmental values to nearby Johnson Swamp, which can also receive environmental water, but Johnson Swamp was allowed to draw down in 2020-21 to support dry-phase ecosystem processes.

Round Lake and Lake Elizabeth were filled in spring and topped up over summer and autumn to maintain water levels and salinity within the target range for endangered Murray hardyhead. Brolga Swamp, Bunyip Swamp East and Bunyip Swamp West within the Wirra-Lo wetland complex were watered in spring, summer and autumn to support growling grass frogs, waterbirds and wetland vegetation communities. Red Gum Swamp, which is also within the Wirra-Lo wetland complex, could not be watered as planned due to access issues associated with a change in land ownership.

After completing its drying cycle, McDonalds Swamp received a partial fill in autumn 2020 to prime the wetland for a 2020 spring fill. Water for the environment was delivered to promote the growth of native aquatic plants and to support waterbird breeding and feeding. The fill inundated more of the wetland area than previous deliveries of water for the environment and provided more habitat for waterbirds to feed and breed. Monitoring undertaken at the wetland detected Australasian bitterns. Richardson's Lagoon was filled in spring 2020, to provide feeding and breeding habitat for waterbirds, frogs and turtles.

Third Reedy Lake was watered over summer and autumn 2020-21, to maintain habitat for southern purple spotted gudgeon, while longer-term management plans to protect the species were being developed. Several larger populations of southern purple spotted gudgeon were recorded at other wetlands near Kerang during 2020-21, which means it is no longer essential to maintain a constant water level at Third Reedy Lake. A more variable water regime will be implemented at Third Reedy Lake from 2021-22, to support a wider range of environmental outcomes.

Water for the environment was delivered to Reed Bed Swamp and Little Reed Bed Swamp in Guttrum Forest during late autumn and winter 2021, to support the recovery and health of wetland vegetation and river red gums around the wetland complex. The inundation aimed to drown river red gum saplings that were encroaching into the wetlands and to provide feeding habitat for waterbirds, turtles and woodland birds in winter.

Scope of environmental watering

Table 5.2.8 describes the potential environmental watering actions in 2021-22, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objective(s) they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.2.8 Potential environmental watering actions, expected watering effects and associated environmental objectives for the central Murray wetlands

Potential environmental watering action	Expected watering effects	Environmental objectives
Guttrum Forest (top-ups in winter/spring and further top-ups as required)	• Wet the fringing adult river red gums to support their growth and drown river red gum saplings within the wetland bed to maintain open-water habitat • Promote the growth and re-establishment of aquatic vegetation and tall marsh vegetation at the fringe of the wetland • Maintain the depth of the wetland to support frogs and waterbird feeding and breeding	
Guttrum Forest (partial fill in autumn/winter 2022)	• Increase the water depth and extent to trigger wetland plants to germinate in late winter and early spring • Provide feeding and refuge habitat for waterbirds and frogs	
Johnson Swamp (partial fill in autumn)	• Drown terrestrial weeds to limit their growth and reduce their extent • Promote the germination and establishment of aquatic vegetation • Inundate the wetland fringe to provide habitat for waterbirds, frogs and turtles and provide conditions suitable for macroinvertebrates and small-bodied native fish that are food for waterbirds	
Lake Elizabeth (fill in spring, top-ups as required)	• Maintain salinity within 15,000-80,000 EC to support suitable habitat and breeding conditions for Murray hardyhead and growing conditions of salt-tolerant aquatic plants that provide habitat for Murray hardyhead • Provide permanent water habitat for waterbirds	
Lake Murphy (fill in winter/spring, top-ups as required)	• Create wet area habitat for native waterbirds, frogs and turtles • Stimulate the germination of aquatic vegetation • Inundate and increase soil moisture to support the growth of recently planted river red gums	
McDonalds Swamp (partial fill in autumn)	• Drown terrestrial weeds to limit their growth and reduce their extent • Promote the germination and establishment of aquatic vegetation • Provide habitat for waterbirds, frogs and turtles • Support the growth of planted river red gums and other aquatic and herbland vegetation as part of the DST project	
Muringa wetlands: north and south (fill in winter/spring, top-ups as required)	• Support the establishment and growth of reed beds to create feeding and nesting habitats for Australasian bitterns and growling grass frogs • Provide wetland habitat to support the occurrence of waterbirds and frogs	
Richardson's Lagoon (fill in winter/spring, top-ups as required)	• Inundate a mosaic of habitats for native waterbirds, frogs and turtles to use • Maintain the water level to support the condition of aquatic macrophytes and aquatic reeds and rushes around the deep lagoon channels • Support the growth of traditional plant species at a significant cultural site enabling continuation of cultural practices (e.g. harvesting, medicine, weaving).	
Round Lake (fill in spring, top-ups as required)	• Maintain salinity within 15,000-70,000 EC — it may go up to 80,000 EC — to support suitable habitat and breeding conditions for Murray hardyhead and growing conditions for submerged aquatic plants • Provide permanent water habitat for waterbirds	

Table 5.2.8 Potential environmental watering actions, expected watering effects and associated environmental objectives for the central Murray wetlands *(continued)*

Potential environmental watering action	Expected watering effects	Environmental objectives
Wirra-Lo wetland complex: Bunyip Swamp East and Bunyip Swamp West (fill in spring, top-ups as required)	• Inundate recently established reed beds to stimulate their growth to create feeding and nesting habitat for Australasian bittern	
Wirra-Lo wetland complex: Cattleyard Creek (fill in spring, top-ups as required)	• Inundate river red gum woodland trees to promote their growth and improve their condition • Promote the germination and establishment of aquatic vegetation	
Wirra-Lo wetland complex: Duck Creek North (fill in spring, top-ups as required)	• Improve soil moisture in the wetland fringe to promote the recruitment and increase the extent of river red gum trees • Inundate the aquatic and herbland vegetation to promote its growth and increase its extent • Maintain open-water and associated mudflat habitats for waterbirds to feed and breed	
Wirra-Lo Wetland complex: Emu Creek (fill in spring, top-ups as required)	• Inundate black box trees and the lignum vegetation community along the creekline to improve their condition • Promote the germination and growth of aquatic vegetation in the deeper sections of the wetland to support frogs and freshwater turtles • Provide soil moisture along the perimeter to maintain the condition of trees for terrestrial fauna including resident grey crowned babblers	
Wirra-Lo wetland complex: Lignum Swamp North (fill in spring, top-ups as required)	• Promote the establishment and growth of submerged and emergent aquatic vegetation to provide feeding and breeding habitat for growling grass frogs • Inundate habitat to provide feeding and breeding opportunities for frogs, waterbirds and turtles	
Wirra-Lo wetland complex: Red Gum Swamp (fill in spring, top-ups as required)	• Inundate established river red gum trees to promote their growth and maintain their condition • Inundate habitat to provide feeding and breeding opportunities for frogs, waterbirds and turtles	

Scenario planning

Table 5.2.9 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The North Central CMA has developed a wetland strategy that aims to manage combinations of wetlands at a landscape scale to address particular environmental objectives. In applying the criteria described in the strategy, the North Central CMA has identified potential watering actions for 11 wetlands under a drought climate scenario, 14 wetlands under a dry scenario and 15 wetlands under average and wet scenarios.

Watering actions at Guttrum Forest (in winter/spring and autumn/winter), Johnson Swamp, Lake Elizabeth, Lake Murphy and Richardsons Lagoon and at five wetlands within the Wirra-Lo wetland complex — Lignum Swamp North, Duck Creek North, Red Gum Swamp, Bunyip Swamp East and Bunyip Swamp West — are a high priority under all climate scenarios in 2021-22.

The proposed watering actions at Lake Elizabeth and Round Lake are needed to maintain permanent habitat for Murray hardyhead (which is critically endangered), while Lignum Swamp North and Red Gum Swamp provides habitat for the growling grass frog (which is endangered). Guttrum Forest also supports an endangered species — the Australasian bittern — and planned watering actions in spring aim to suppress the growth of river red gum saplings that have been slashed in the bed of the wetland and improve the condition of vegetation that provides important breeding habitat for Australasian bittern. Guttrum Forest's Reed Bed Wetland Complex will be allowed to draw down over summer 2021-22 before another partial fill in autumn/winter 2022, to boost productivity leading into the next spring.

Johnson Swamp, Lake Murphy and Richardson's Lagoon are all ephemeral wetlands, and proposed watering actions at these sites aim to initiate their wet phase that will contribute to a mosaic of wetlands in different stages of wetting and drying across the central Murray area. In accordance with the management plan, Johnson Swamp completely dried in December 2020 and the proposed partial fill in autumn 2022 is recommended to prime the wetland ahead of a planned fill in spring 2022. Lake Murphy last filled in 2018-19 and has been dry since spring 2019. Revegetation works have recently been completed at Lake Murphy, and a partial fill in late winter and early spring will increase the survival of planted river red gums and other vegetation communities. Watering at Richardson's Lagoon will allow wetland plants that germinated during spring 2020 to flower and set seed, including plant species of cultural importance to the Yorta Yorta People.

Within the Wirra-Lo wetland complex, five of the nine sites — Duck Creek North, Lignum Swamp North, Red Gum Swamp, Bunyip Swamp East and Bunyip Swamp West — are proposed to receive water for the environment under all climate scenarios. Lignum Swamp North and Red Gum Swamp require water to support growling grass frogs (as described above), and the river red gum community at Red Gum Swamp needs to be inundated because it has been dry for five years and is showing signs of stress. Watering at Bunyip Swamp East and Bunyip Swamp West will help recently planted vegetation communities to properly establish and expand. Duck Creek North contains red gum, aquatic and herbland vegetation in moderate condition that would benefit from watering, and the site will provide mudflat habitat for waterbirds, which will contribute to habitat diversity across the wetland complex.

Proposed watering actions at McDonalds Swamp and Cattleyard Creek and Emu Creek within the Wirra-Lo wetland complex are a high priority under dry to wet climate scenarios. McDonalds Swamp filled in spring 2020 and completely dried in January 2021, which helped to limit the growth of tall marsh vegetation. The wetland can tolerate dry conditions for several years, and it is not considered a priority for watering under a drought climate scenario. However, a partial fill is recommended in autumn 2022 under dry to wet climate scenarios, to prime the wetland for a larger fill in spring 2022. Extending the dry phase at McDonalds Swamp through the rest of 2021 and then watering it in 2022 will contribute to the mosaic of wetlands in different phases across the area. Cattleyard Creek at Wirra-Lo has not received water for the environment before, and the river red gums are showing signs of stress. It is not feasible to water this site under a drought scenario, but watering it under dry to wet climate scenarios is expected to significantly improve the vegetation condition. Emu Creek is dominated by lignum and black box vegetation that require less frequent inundation, and the proposed watering will mainly target deep sections of the wetland to trigger the germination and growth of aquatic vegetation to support native frogs and turtles. Water delivered to the deep parts of Emu Creek will increase soil moisture for fringing black box trees without inundating them.

It is planned to deliver water for the environment for the first time to the Muringa wetlands in 2021-22, to promote the growth and establishment of tall marsh, aquatic herblands and spike-sedge species as part of a remediation project. The proposed watering actions are a high priority under average and wet climate scenarios but are a lower priority under a dry climate scenario if the planned remediation works are deferred.

Third Reedy Lake and Hird Swamp will be allowed to draw down during 2021-22, to support dry-phase ecosystem processes in accordance with recommendations in their management plans.

Priority carryover for 2022-23 of 3,700 ML is essential to maintain water at sites for endangered fish and frogs and to provide a mosaic of refuge wetlands across the region in the event of dry or drought conditions.

Table 5.2.9 Potential environmental watering for the central Murray wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Catchment run-off and natural flow into the wetlands are unlikely	• Some catchment run-off and natural flow into the wetlands is possible, particularly in winter/spring	• Low-to-moderate catchment run-off and natural flow into the wetlands is likely, particularly in winter/spring	• Catchment run-off and natural flow into the wetlands is likely with potential widespread flooding in some wetlands, particularly in winter/spring
Potential environmental watering – tier 1 (high priorities)[1]	• Guttrum Forest (winter/spring 2021) • Guttrum Forest (autumn/winter 2022) • Johnson Swamp • Lake Elizabeth • Lake Murphy • Richardsons Lagoon • Round Lake • Wirra-Lo wetland complex (Lignum Swamp North, Duck Creek North, Red Gum Swamp, Bunyip Swamp East, Bunyip Swamp West)	• Guttrum Forest (winter/spring 2021) • Guttrum Forest (autumn/winter 2022) • Johnson Swamp • Lake Elizabeth • Lake Murphy • McDonalds Swamp • Richardsons Lagoon • Round Lake • Wirra-Lo wetland complex (Lignum Swamp North, Duck Creek North, Red Gum Swamp, Cattleyard Creek, Emu Creek, Bunyip Swamp East, Bunyip Swamp West)	• Guttrum Forest (winter/spring 2021) • Guttrum Forest (autumn/winter 2022) • Johnson Swamp • Lake Elizabeth • Lake Murphy • McDonalds Swamp • Muringa wetlands • Richardsons Lagoon • Round Lake • Wirra-Lo wetland complex (Lignum Swamp North, Duck Creek North, Red Gum Swamp, Cattleyard Creek, Emu Creek, Bunyip Swamp East, Bunyip Swamp West)	• Guttrum Forest (winter/spring 2021) • Guttrum Forest (autumn/winter 2022) • Johnson Swamp • Lake Elizabeth • Lake Murphy • McDonalds Swamp • Muringa wetlands • Richardsons Lagoon • Round Lake • Wirra-Lo wetland complex (Lignum Swamp North, Duck Creek North, Red Gum Swamp, Cattleyard Creek, Emu Creek, Bunyip Swamp East, Bunyip Swamp West)
Potential environmental watering – tier 2 (additional priorities)	• N/A	• Muringa wetlands	• N/A	
Possible volume of water for the environment required to achieve objectives	• 11,400 ML (tier 1)	• 11,300 ML (tier 1) • 100 ML (tier 2)	• 11,000 ML (tier 1)	• 8,730 ML (tier 1)
Priority carryover requirements	• 3,700 ML			

1 Tier 1 potential environmental watering at the central Murray wetlands is not classified into tier 1a and 1b, because the water available for use is shared across various systems and it is not possible to reliably estimate supply.

5.2.4 Hattah Lakes

System overview

The Hattah-Kulkyne National Park is situated in north-west Victoria adjacent to the Murray River (Figure 5.2.4). The national park contains a complex of more than 20 semi-permanent freshwater lakes known collectively as the Hattah Lakes.

The ecology of the Hattah Lakes and surrounding floodplain is strongly influenced by flooding regimes of the Murray River. The system fills when there is high flow in the Murray River, and some lakes hold water for several years after floods recede. Regulation of the Murray River has significantly reduced the frequency and duration of small- to medium-sized natural floods in the Hattah Lakes system. Over time, this has degraded vegetation communities and reduced the diversity and abundance of animals that use the vegetation and wetlands for habitat and food.

The Hattah Lakes complex can be broadly divided into the southern Hattah Lakes, which contains permanent to semi-permanent wetlands, and the higher-elevation northern Hattah Lakes, which are mostly ephemeral wetlands.

The Messenger, Oateys and Cantala regulators allow water to flow between the Murray River and Hattah Lakes. When flows in the Murray River are about 26,000 ML per day, water begins to flow through Messengers regulator into Chalka Creek and through to the Hattah Lakes complex. A permanent pump station can deliver up to 1,000 ML per day to the southern Hattah Lakes through Chalka Creek. The regulators and pump station are used in combination with several small constructed levees to restore a beneficial pattern of flooding to the lakes system. Lake Kramen is in the south-east area of Hattah-Kulkyne National Park and disconnected from the main Hattah Lakes complex, but the Hattah Lakes pump station can deliver up to 145 ML per day to Lake Kramen to restore flooding regimes.

Current infrastructure enables environmental flows to the southern Hattah Lakes and Lake Kramen. Future infrastructure being built under the Victorian Murray Floodplain Restoration Project will allow water to reach additional wetlands and the floodplain in the northern Hattah Lakes.

Environmental values

Hattah Lakes is home to a diverse range of flood-dependent vegetation that changes with the topography of the landscape. Vegetation types range from wetland communities in lower-lying areas that require almost annual flooding to lignum and black box communities situated higher on the floodplain that only need flooding once every four to five years (on average).

A combination of natural flooding and the delivery of environmental flows since 2010 has improved tree canopy health and recruitment of black box and river red gum communities throughout the Hattah Lakes. Woodland birds, including the endangered regent parrot, have benefitted from the improved tree health.

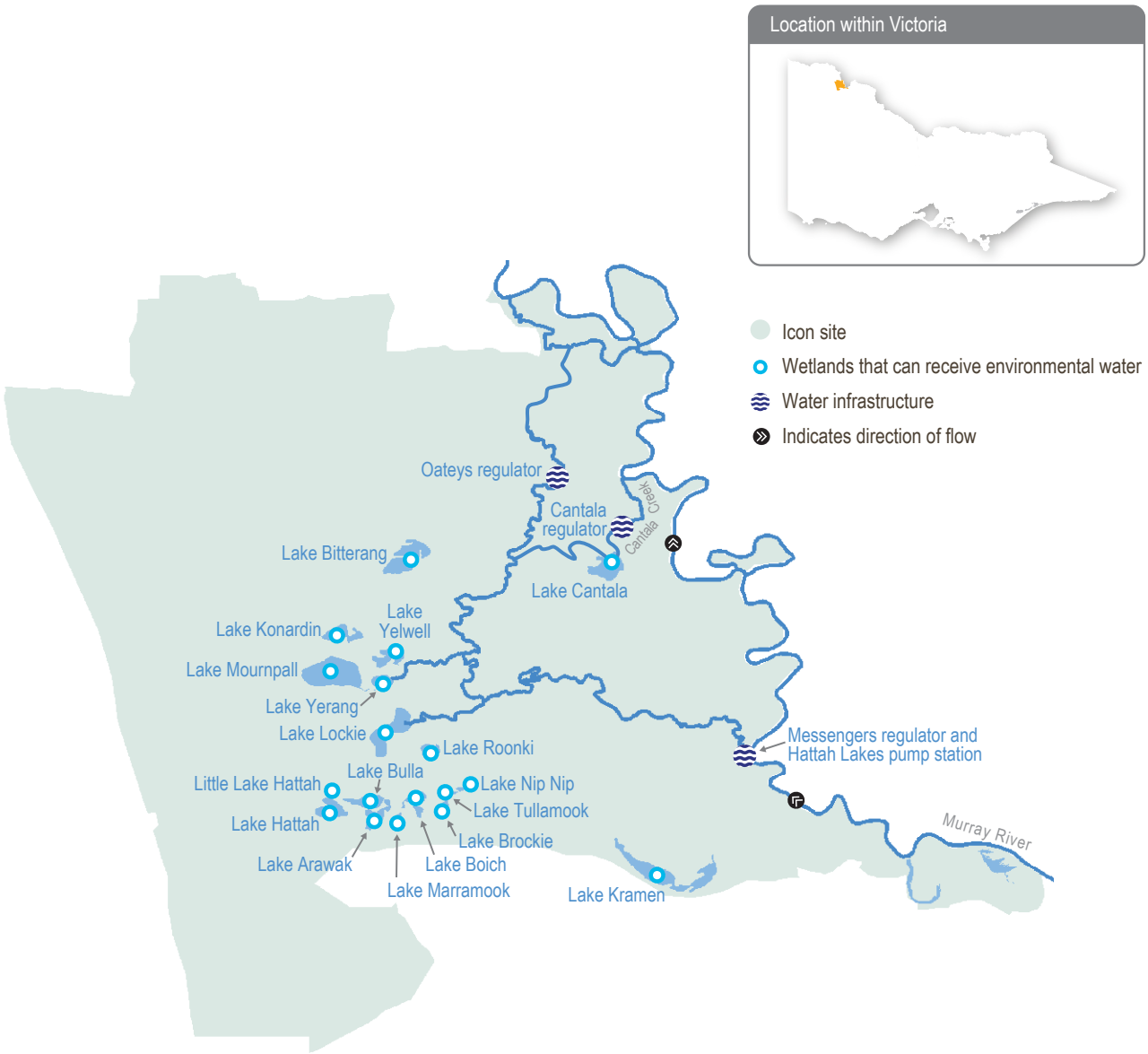
Hattah Lakes provides important waterbird breeding sites in an arid landscape. A total of 34 species of waterbirds are known to breed at the lakes when conditions are suitable. Another six species of waterbirds breed in the surrounding floodplain. Wetland drought refuge sites are limited in the region, making Hattah Lakes critically important for water-dependant flora, waterbirds and terrestrial animals.

The Hattah Lakes support large-bodied native fish species (such as golden perch) and small-bodied wetland species (such as carp gudgeon). Fish move between the lakes and the Murray River when flows are suitable and also persist in wetlands that retain water in the Hattah Lakes during dry years before dispersing again during flooding.

Environmental watering objectives in the Hattah Lakes

	Increase the native fish populations
	Restore carbon and nutrient cycling within and between wetlands, waterways and the floodplain, to increase ecosystem productivity
	Restore and maintain a mosaic of healthy wetland and floodplain plant communities
	Provide feeding and nesting habitat for the successful recruitment of waterbirds and woodland birds

Figure 5.2.4 The Hattah Lakes



Traditional Owner cultural values and uses

The Hattah Lakes system is part of a highly sensitive region for Aboriginal cultural values and lies on the border of two documented language groups, the Latji Latji and the Jari Jari. More than 1,000 Indigenous archaeological sites at the Hattah Lakes are registered with Aboriginal Victoria, with the freshwater lakes and wetlands providing focal points for trade and cultural exchanges amongst the region's Traditional Owners. The local Aboriginal community maintains strong connections to the land and its resources such as native species used for food and medicine.

Mallee CMA has sought the input of Aboriginal Elders and members of the Aboriginal community who have expressed their connection with the Hattah Lakes area to environmental water planning. Mallee CMA held on-Country meetings and discussions with Elders and community members to explore their interests and aspirations for the Hattah Lakes region. Themes raised included:

- areas where environmental flows are planned to take place in 2021-22 and the quantity of water that will be delivered
- areas that Aboriginal Elders and other participants believe require water (such as black box in the northern part of Hattah-Kulkyne National Park)
- dying gum trees and black box, and future work that may assist with the delivery of water to these affected trees
- the protection of known burial sites by Parks Victoria Cultural Heritage rangers near Lake Mournpall in the Hattah Lakes system.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.2.10, Mallee CMA considered how environmental flows could support values and uses including:

- water-based recreation (such as fishing, kayaking and swimming)
- riverside recreation and amenity (such as birdwatching, camping, photography and walking)
- community events and tourism (such as 'Junior Ranger' school holiday programs including bushwalking, birdwatching and bug hunting, school education programs and tours involving kayaking, bike riding and camping)
- socio-economic benefits (such as bee keeping, connecting with nature, ecotourism and social gatherings).

Recent conditions

Rainfall and temperatures in the Hattah Lakes region during 2021-22 were close to the long-term average. Victorian Murray allocations reached 55 percent of high-reliability water shares by mid-October and 100 percent by February 2021. Allocations and return flows from other environmental deliveries in upstream Goulburn and Murray river systems provided sufficient supply to achieve environmental watering requirements at Hattah Lakes during 2020-21.

High rainfall in the upper Murray River catchment and a large release of water for the environment to the Murray River resulted in flows of more than 15,000 ML per day in the Murray River at Robinvale on several occasions between July and November 2020, but these were well below the 26,000 ML per day flow that is needed for natural inflows to the Hattah Lakes. The river's flow gradually receded during summer and autumn to operational levels of between 5,000 to 11,000 ML per day.

The Hattah Lakes filled when water for the environment was delivered to them in 2017 and held water until February 2020. Lake Kramen was filled with water for the environment in spring 2019 and still retains some water.

Deliveries of water for the environment to the Hattah Lakes commenced again in May 2021. About 30,000 ML of water for the environment was pumped into the Hattah Lakes between May and June 2021 to fill low-lying wetlands to improve the condition of trees, stimulate the growth of aquatic plants, support carbon and nutrient cycles and provide food and habitat for waterbirds. Depending on climatic conditions and water availability, this watering event will be extended into winter and spring 2021, to inundate more wetlands to a greater depth to increase outcomes for various vegetation communities, waterbirds and native fish.

Scope of environmental watering

Table 5.2.10 describes the potential environmental watering actions in 2021-22, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objectives they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.2.10 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Hattah Lakes

Potential environmental watering action[1]	Expected watering effects	Environmental objectives
Southern Hattah Lakes (top-up and fill of selected wetlands and lower floodplain during spring 2021)	• Stimulate the growth and improve the condition of river red gums fringing wetlands and on the lower floodplain • Provide breeding habitat for waterbirds • Stimulate new growth of aquatic vegetation • Inundate dry wetlands to release carbon and nutrients to increase food web productivity • Provide spawning and recruitment habitat for small-bodied native fish	
Hattah Lakes (floodplain inundation up to 45 m Australian Height Datum (AHD) at any time if there is a natural flood)	• Wet river red gums and black box on the floodplain to stimulate growth and improve the condition of mature trees • Provide suitable soil conditions for the germination of black box trees on the floodplain and support the survival and growth of trees that germinated in 2017 • Provide suitable conditions to support waterbird breeding and feeding • Provide connections to allow native fish to move between Hattah Lakes and the Murray River • Provide spawning and recruitment habitat for small-bodied native fish and nursery habitat for large-bodied native fish (such as golden perch) • Inundate dry wetlands to release carbon and nutrients to increase food web productivity	

1 The Hattah Lakes pump station may also be operated at any time of the year for maintenance requirements.

Scenario planning

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

In 2021-22, environmental watering is planned for Hattah Lakes under all climate scenarios except for drought.

In a wet climate scenario, substantial natural flow into Hattah Lakes is expected to occur, most likely in spring. Little or no water for the environment may be needed to supplement a large flood, but if there is only moderate natural flooding, the Hattah pumps or regulators may be used to increase the duration and spatial extent of inundation, to ensure parts of the floodplain that rely on natural floods are watered.

In the absence of a natural flood, the highest priority is to use the Hattah pumps in spring to top up the lakes that were partially filled in autumn 2021 and fill dry wetlands located at the margin of the system (such as Lake Bitterang and Lake Cantala). The proposed spring watering is important for two reasons. First, it will ensure that more wetland and floodplain vegetation communities do not exceed their optimal dry period. Second, it will capitalise on the autumn watering event that triggered a range of ecological and chemical processes, and so will achieve greater environmental outcomes than could be achieved if the water was delivered into dry wetlands.

The level of watering will likely vary between a dry and average climate scenario, based on likely water availability and to mimic natural variations in water levels that would be expected under different climatic conditions. In the dry climate scenario, water for the environment will aim to fill 16 targeted wetlands within the southern Hattah Lakes system. Under an average climate scenario, the intention is to fill the same 16 wetlands and also inundate some of the adjacent low-lying floodplain.

The water delivered to the Hattah Lakes in autumn 2021 will likely persist in some wetlands throughout 2021-22 without additional water. If drought conditions develop, this water will provide a refuge habitat for waterbirds, frogs and potentially some small-bodied fish. There is little value in trying to deliver extra water to trigger plant and animal growth and reproduction during drought conditions, because there may not be sufficient resources within the landscape to sustain new life. Up to 30,000 ML of available water will instead be prioritised for carryover, to help maintain refuge habitats within the Hattah Lakes in 2022-23 if drought conditions persist.

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

Planning scenario	Drought	Dry	Average	Wet
Expected conditions	• Low flow year-round in the Murray River and no natural inflow to Hattah Lakes; substantial wetland drying will occur	• Rare high-flow events in the Murray River and no natural inflow to Hattah Lakes	• Short periods of high flow in the Murray River, most likely in late winter/ spring, providing minor natural inflow to Hattah Lakes	• Lengthy periods of high flow in the Murray River with major spills from storages resulting in widespread wetting of Hattah Lakes and floodplain
Potential environmental watering – tier 1 (high priorities)[1]	• N/A	• Southern Hattah Lakes spring top-up and fill targeting wetlands	• Southern Hattah Lakes spring top-up and fill targeting wetlands and low-level floodplain inundation	• Hattah Lakes (floodplain inundation up to 45.0 m AHD)
Possible volume of water for the environment required to achieve objectives	• N/A	• 30,000-47,000 ML	• 47,000 ML	• Up to 150,000 ML[2]
Priority carryover requirements	• up to 30,000 ML	• Not required under dry-wet scenarios		

1 Tier 1 potential environmental watering at Hattah Lakes is not classified into tier 1a and 1b, because the water available for use is shared across various systems and it is not possible to reliably estimate supply.

2 In a wet scenario, it is expected that natural floods will meet most of the required watering actions, with water for the environment making up the deficit if needed.

5.2.5 Lower Murray wetlands

System overview

The lower Murray wetlands are dispersed across the Murray River floodplain between Swan Hill and the South Australian border. The system includes a myriad of interconnected creeks, wetlands and floodplains that are ecologically important and reflect the natural character and attributes of the floodplain. While the number of wetlands across the lower Murray region is in the hundreds, about 54 of these have received water for the environment to date.

Regulation and diversion of Murray River flows have substantially reduced the frequency and duration of the high river flows that would naturally water the lower Murray wetlands. This change to the water regime has been exacerbated by climate change and has reduced the variety and condition of environmental values associated with billabongs and other floodplain habitats.

Water for the environment can be delivered to some wetlands in the region through direct pumping from the Murray River and/or use of irrigation supply infrastructure. Most wetlands that receive environmental flows can be managed independently of each other.

Environmental values

The lower Murray wetlands are comprised of multiple wetlands, creeks and billabongs. Depending on their location in the landscape, interactions with groundwater and their management history, the wetlands may be permanent or temporary, freshwater or saline. Differences in water regime and water quality between the wetlands provide a range of habitats for plants and animals. For example, permanent, saline wetlands (such as Koorlong Lake) provide vital habitat for the endangered Murray hardyhead fish. Ephemeral wetlands support different ecological processes in their wet and dry phases. During the wet phase, they provide short-term boom periods when river red gum trees and wetland plants grow, spread and provide habitat for aquatic animals (such as waterbugs, birds, frogs and in some cases fish). During the dry phase, sediments are exposed to the air (which is important for carbon and nutrient cycles), and terrestrial plants grow and complete life cycles.

Environmental watering objectives in the lower Murray wetlands

	Promote carbon and nutrient cycling to enable wetland processes for food webs
	Maintain and/or increase populations of native fish in permanent wetlands
	Maintain and/or grow populations of native frogs including the endangered growling grass frog
	Increase the diversity, extent and abundance of wetland plants Improve the condition of river red gums, black box and lignum
	Provide feeding and breeding habitat for a range of waterbird species including threatened and migratory species and colonial nesting species (such as egrets)

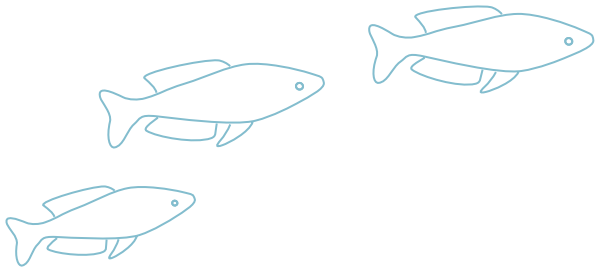
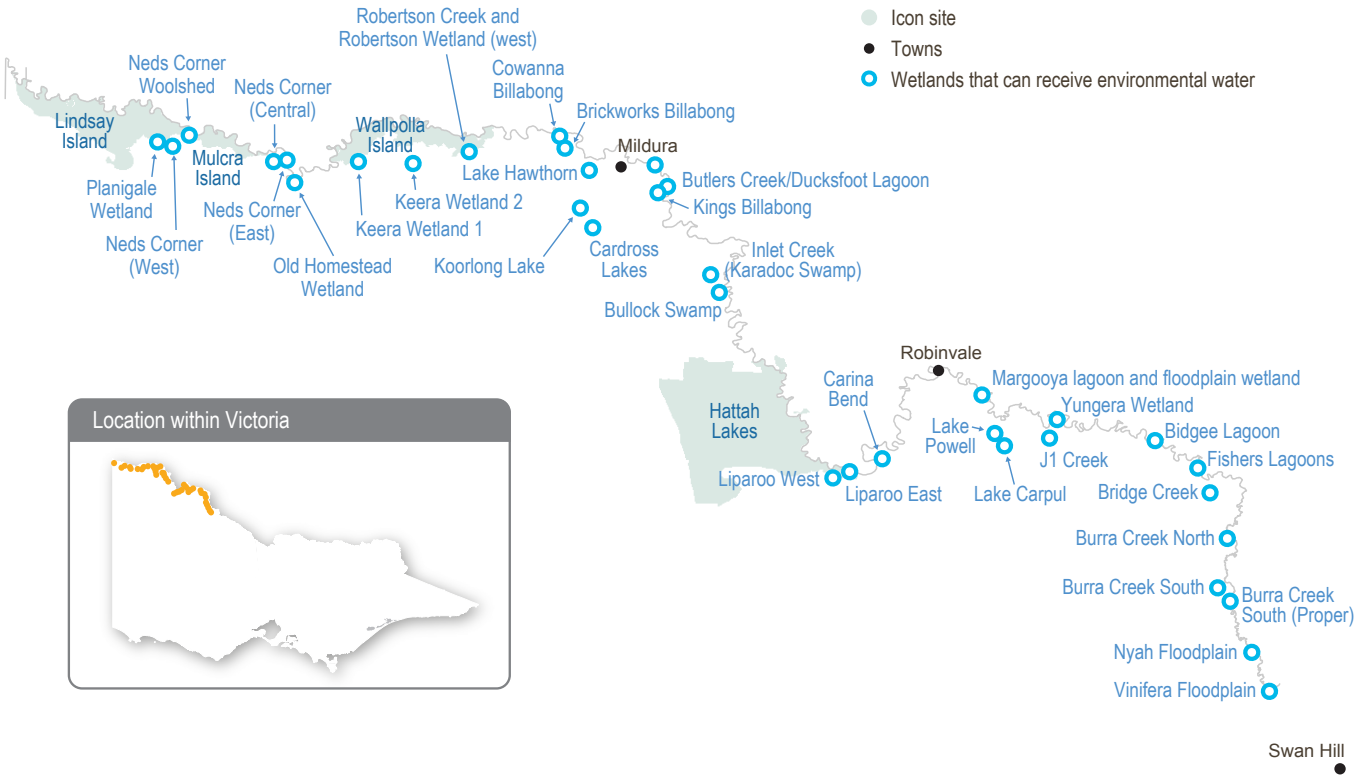


Figure 5.2.5 The lower Murray wetlands



Traditional Owner cultural values and uses

Watering of the lower Murray wetlands supports values such as traditional food sources and medicines and important species, and provides opportunities for teaching, learning and storytelling.

Mallee CMA has actively sought engagement, involvement and contributions on the proposed watering program for 2020-21 from the following Traditional Owners and Aboriginal Victorians:

- First People of the Millewa-Mallee Aboriginal Corporation, comprised of Latji Latji and Ngintait (Traditional Owners from Hattah to the South Australia border)
- other Aboriginal groups who have expressed an interest in the landscapes of the lower Murray wetlands including but not limited to Wemba Wamba, Wadi Wadi, Tati Tati, Weki Weki, Munatunga Elders and the Pearce family.

Discussions covered a range of options for how environmental flows can be delivered in 2021-2022 and what the traditional ecological needs were in the current climate. Elders participated in planning and prioritisation processes on Country important to them and relationships with the Mallee CMA were strengthened. The values, knowledge and concerns raised through these discussions have supported Mallee CMA's planning for wetland watering across the lower Murray region.

Increasing the involvement of Traditional Owners in environmental water planning and management, and ultimately providing opportunities to progress towards self-determination within and beyond the environmental watering program, is a core commitment of the VEWH and its agency partners. This is reinforced by a range of legislation and policy commitments (for example the *Water Act 1989*, the Victorian Aboriginal Affairs Framework, *Water for Victoria* (2016)) and, in some cases, agreements under the *Traditional Owner Settlement Act 2010*. Where Traditional Owners are more deeply involved in the planning and/or delivery of environmental flows for a particular site, their contribution is acknowledged in Table 5.2.12 with an icon. The use of this icon is not intended to indicate that these activities are meeting all the needs of Traditional Owners but is incorporated in the spirit of valuing that contribution, and indicating progress towards this objective.

Watering planned and/or delivered in partnership with Traditional Owners to support cultural values and uses

Robertson Creek is an area of high cultural significance that is being degraded as vegetation dies from lack of water and wind erodes the landscape. The First People of the Millewa-Mallee Aboriginal Corporation are undertaking a program of restoration and protection work at the site.

An environmental flow was delivered to the creek in spring 2020-21 to complement the protection and restoration objectives, which was the first time the creek had received water since flooding in 2016. This has resulted in an improvement in the condition of trees and nearby shrubs and helped return and protect cultural values which can be used by community for learning, teaching and increasing overall wellbeing.

An environmental flow is planned for 2021-22 in all scenarios except drought. This will build on the outcomes from the previous watering event by further improving the condition of established vegetation and increasing protection against wind erosion by supporting the revegetation of native trees, shrubs and grasses. The event will be delivered in partnership with First People of the Millewa-Mallee Aboriginal Corporation as part of the continued work to protect this significant area.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.2.12, Mallee CMA considered how environmental flows could support values and uses including:

- water-based recreation (such as canoeing, fishing and kayaking)
- riverside recreation and amenity (such as bike riding, birdwatching, bushwalking, camping, geocaching, photography and running)
- community events and tourism (such as day trips and sight-seeing; education programs for school, TAFE and university students; citizen science projects about birds, frogs and bats; and sporting events)
- socio-economic benefits (such as economic benefits for businesses in the accommodation, beekeeping, food and beverage, ecotourism, hospitality and retail sectors; creating a focal point for socialising; and providing natural, green spaces for the local community).

Recent conditions

After several years of very dry conditions, rainfall and temperatures in the lower Murray region were closer to the long-term average during 2020-21. Large rain events in late winter, spring and summer helped to water some floodplain vegetation but did not lead to much surface run-off or contribute significant inflows to floodplain wetlands. Flows in the Murray River were also not sufficient to naturally connect any wetlands on the lower Murray floodplain, so all the wetland watering described below was provided with water for the environment. Water availability was met through a combination of carryover and Murray allocations (100 percent of high-reliability water shares), which provided sufficient water for the environment to meet the planned watering actions.

In 2020-21, water for the environment was delivered to seven lower Murray wetlands that were identified as a high priority under an average climate scenario. Most deliveries occurred in late spring, to maintain native vegetation and provide habitat for fish and waterbirds. Environmental flows were delivered for the first time to Margooya floodplain wetland and Bidgee Lagoons. Inundation at Bidgee Lagoons was less than planned, so outcomes for that site were only partially achieved.

Robertson Creek was filled in spring 2020 to water black box, lignum and nitre goosefoot. It was the first time the site had received significant water since 2016, and further watering will be required to improve the condition of native vegetation communities, which are still recovering from prolonged drying through the Millennium Drought.

A slow through-flow was provided at Woolshed Creek in spring 2020, to consolidate the benefits of a similar watering event in 2019-20. The consecutive watering events have improved the condition of streamside vegetation along the creekline, and many species flowered in 2020-21. Growling grass frogs and waterbirds were also observed along the creekline during the watering event.

Top-ups were provided to three permanent wetland systems — Brickworks Billabong, Koorlong Lake and Lake Hawthorn — during summer and autumn, to protect habitat for endangered Murray hardyhead. The wetted margins of these wetlands also provide important foraging habitat for shorebirds.

Nyah Floodplain, Vinifera Floodplain, Burra Creek North and Burra Creek South have all been dry since 2019, and the river red gum communities at these sites are reaching the end of their optimal dry period. Burra Creek South Proper has been dry for the last seven years, and its vegetation community is in relatively poor condition.

Scope of environmental watering

Table 5.2.12 describes the potential environmental watering actions in 2021-22, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objectives they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

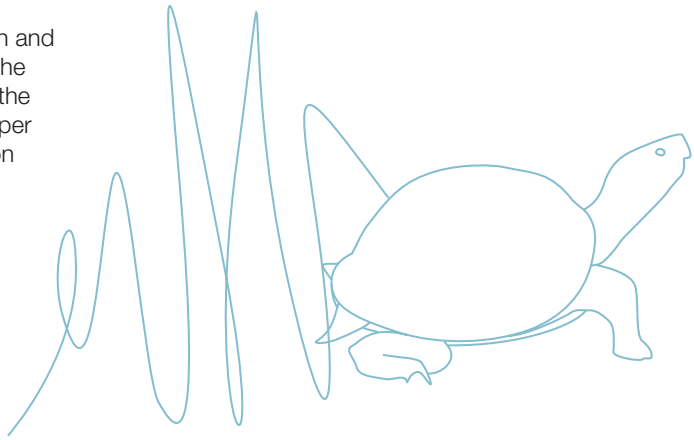


Table 5.2.12 Potential environmental watering actions, expected watering effects and associated environmental objectives for the lower Murray wetlands

Potential environmental watering action	Expected watering effects	Environmental objectives
Bidgee Lagoons (fill in spring)	• Inundate adjacent river red gum and black box communities to stimulate growth and flowering to improve their condition and extent • Provide conditions and water levels to support the growth of annual aquatic and emergent vegetation and promote the diversity of emergent vegetation communities • Provide feeding and breeding opportunities for frogs • Mobilise leaf litter to promote carbon and nutrient cycling	
Brickworks Billabong (top-up in spring, top-ups as required over summer/ autumn) (target water level between 33 m Australian Height Datum [AHD] and 34 m AHD)	• Maintain water levels to inundate benthic herblands including ruppia beds to provide nursery habitat for Murray hardyhead and provide high levels of aquatic productivity • Maintain water quality suitable for Murray hardyhead • Provide shallow-water habitat and exposed mudflats to support foraging and resting of waterbirds including migratory waterbirds	
Bullock Swamp (partial fill in spring)	• Inundate adjacent black box and lignum to improve their condition • Provide feeding opportunities for waterbirds • Provide lateral spread of freshwater to refresh local groundwater which will support the condition of black box trees not directly inundated	
Burra Creek North (fill in autumn)	• Inundate the main creekline and adjacent red gum, lignum and black box vegetation communities to improve their condition • Provide habitat through improved vegetation communities and water resources for waterbirds and frogs • Mobilise leaf litter to promote carbon and nutrient cycling	
Burra Creek South (fill in autumn)	• Inundate the main creekline and adjacent red gum, lignum and black box vegetation communities to improve their condition • Provide habitat through improved vegetation communities and water resources for waterbirds and frogs • Mobilise leaf litter to promote carbon and nutrient cycling	
Burra Creek South Proper (fill in autumn)	• Inundate the main creekline and adjacent red gum, lignum and black box vegetation communities • Provide habitat through improved vegetation communities and water resources for birds and frogs • Mobilise leaf litter to promote carbon and nutrient cycling	
Fishers Lagoon (fill in spring) (target 54.2 m AHD)	• Promote the growth of aquatic vegetation and provide soil moisture for terrestrial vegetation communities • Provide temporary habitats for frogs and waterbirds • Inundate water-dependent Floodplain Grassy Wetland Ecological Vegetation Class (classified as endangered in the Murray Fans bioregion)	
Koorlong Lake (fill in spring, top-ups as required) (target between 36.7 m AHD and 38.0 m AHD)	• Increase and maintain the water level to support the growth of saline aquatic vegetation including ruppia to provide nursery habitat for Murray hardyhead and provide high levels of aquatic productivity • Maintain water levels within a 30 cm range to provide feeding resources for shorebirds and to maintain the Murray hardyhead population	
Lake Carpul (fill in spring)	• Provide a range of open-water, shallow-water and emergent-vegetation habitats for water-dependent birds to support breeding and feeding opportunities • Inundate and wet outer fringing river red gum, black box, lignum and vegetation communities to improve their condition • Mobilise carbon and nutrients within the wetland to support wetland processes	

Table 5.2.12 Potential environmental watering actions, expected watering effects and associated environmental objectives for the lower Murray wetlands *(continued)*

Potential environmental watering action	Expected watering effects	Environmental objectives
Lake Hawthorn (fill in spring, top-ups as required) (target between 33 m AHD and 33.3 m AHD)	• Increase and maintain water levels to encourage the germination and growth of ruppia to provide nursery habitat for Murray hardyhead and visitation by shorebirds • Maintain water levels within a 30 cm range to provide feeding resources for shorebirds and to maintain the Murray hardyhead population	
Lake Powell (fill in spring)	• Provide a range of open-water, shallow-water and emergent-vegetation habitats for water-dependent birds, to support breeding and feeding opportunities • Inundate and wet fringing river red gum, black box, lignum and vegetation communities to improve their condition • Mobilise carbon and nutrients within the wetland to support wetland processes	
Nyah Floodplain (fill in autumn)	• Inundate the base and littoral zone of Parnee Malloo Creek to support plant communities • Improve the condition of vegetation communities to provide a range of habitats and feeding and breeding resources for birds and frogs • Inundate the floodplain adjacent to Parnee Malloo Creek to promote the growth of herb and shrub layers • Inundate river red gum to improve their condition • Mobilise carbon and nutrients to promote chemical and biological processes	
Robertson Creek (fill in spring)	• Wet fringing river red gum, black box, lignum and vegetation communities to improve their condition • Provide lateral spread of freshwater to refresh local groundwater to support the condition of trees not directly inundated • Provide a range of open-water, shallow-water and inundated lignum habitats, to provide waterbird feeding opportunities and help protect the highly culturally significant site in the adjacent landscape	
Robertson Wetland (partial fill in spring) (target 28 m AHD)	• Wet fringing river red gum, black box, lignum and vegetation communities to improve their condition • Inundate cane grass beds to improve their condition and resilience • Provide a range of open-water, shallow-water and inundated lignum habitat to provide waterbird feeding opportunities	
Vinifera Floodplain (fill in autumn)	• Inundate the base and littoral zone of Parnee Malloo Creek to support plant communities • Improve the condition of vegetation communities to provide a range of habitats and feeding and breeding resources for birds and frogs • Inundate the floodplain adjacent to Parnee Malloo Creek to promote the growth of herb and shrub layers • Inundate river red gums to improve their condition • Mobilise carbon and nutrients to promote chemical and biological processes	

Scenario planning

Table 5.2.13 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Brickworks Billabong, Burra Creek North, Burra Creek South, Burra Creek South Proper, Koorlong Lake, Lake Hawthorn, Nyah Floodplain and Vinifera Floodplain are high priorities for watering in 2021-22 under all climate scenarios. Brickworks Billabong, Koorlong Lake and Lake Hawthorn are permanent wetlands that support populations of endangered Murray hardyhead. These sites require top-ups every year, to maintain salinity levels within a tolerable range and maintain submerged vegetation that provides habitat for fish. Burra Creek North, Burra Creek South, Burra Creek South Proper and the Nyah and Vinifera floodplains are ephemeral systems that support important vegetation communities and rely on periodic inundation to maintain the condition of that vegetation.

Burra Creek North, Burra Creek South, Nyah Floodplain and Vinifera Floodplain were last inundated in 2018-19, and their vegetation is in moderate condition. Burra Creek South Proper has been dry for almost seven years. Watering these five sites is a high priority in 2021-22, because planned construction work for the Victorian Murray Floodplain Restoration Project (VMFRP) will limit watering opportunities in 2022-23 and 2023-24, and the condition of vegetation communities will decline if they are not watered for another four years.

Bidgee Lagoons and Robertson Creek are priority watering sites under dry to wet climate scenarios, to consolidate and build on the environmental outcomes of watering in 2020-21. These two sites would not be expected to receive water naturally under a drought climate scenario, and potential watering opportunities in subsequent years will not be restricted by the proposed VMFRP construction works.

Some of the priority wetlands listed above are likely to receive natural inflows under a wet climate scenario, which may mean water for the environment is not needed. That possibility has been factored into the total volume of water for the environment that may be needed under that scenario.

Bullock Swamp, Fishers Lagoon, Lake Carpul, Lake Powell and Robertson Wetland have been identified as tier 2 watering actions for 2021-22. These sites do not require water every year, and it is not essential to water them in 2021-22. However, the environmental values at these sites will potentially benefit from water in 2021-22, and it would reduce the need to water them in 2022-23 or 2023-24. They may therefore be watered if the opportunity allows.

Carryover of about 2,000 ML is required in 2022-23 to protect Murray hardyhead in Brickworks Billabong, Koorlong Lake and Lake Hawthorn.

Table 5.2.13 Potential environmental watering for the lower Murray wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Natural flow in the Murray River is too low to connect to wetlands • Wetlands rely on the delivery of water for the environment; very low rainfall year-round and extremely hot and dry conditions in summer/autumn causes substantial wetland drying	• Short periods of high flow in the Murray River are possible but overbank flow to wetlands is unlikely; low rainfall and very warm summer/autumn	• Sustained periods of high flow in the Murray River in late winter and early spring may wet some low-lying wetlands but most wetlands will rely on water for the environment • Local rainfall may be high and provide run-off to some wetlands	• Lengthy periods of high flow and floods with major spills from storages, resulting in widespread wetting of the floodplain and most wetlands • Some reliance on water for the environment to achieve target water levels • Local rainfall may be high and will provide run-off to most wetlands
Potential environmental watering – tier 1 (high priorities)[1]	• Brickworks Billabong • Burra Creek North • Burra Creek South • Burra Creek South Proper • Koorlong Lake • Lake Hawthorn • Nyah Floodplain • Vinifera Floodplain	• Bidgee Lagoons • Brickworks Billabong • Burra Creek North • Burra Creek South • Burra Creek South Proper • Koorlong Lake • Lake Hawthorn • Nyah Floodplain • Robertson Creek • Vinifera Floodplain	• Bidgee Lagoons • Brickworks Billabong • Burra Creek North • Burra Creek South • Burra Creek South Proper • Koorlong Lake • Lake Hawthorn • Nyah Floodplain • Robertson Creek • Vinifera Floodplain	• Bidgee Lagoons • Brickworks Billabong • Burra Creek North • Burra Creek South • Burra Creek South Proper • Koorlong Lake • Lake Hawthorn • Nyah Floodplain • Robertson Creek • Vinifera Floodplain
Potential environmental watering – tier 2 (additional priorities)	• N/A		• Bullock Swamp • Fishers Lagoon • Lake Carpul • Lake Powell • Robertson Wetland	• Lake Carpul • Lake Powell
Possible volume of water for the environment required to achieve objectives[1]	• 6,495 ML (tier 1)	• 7,945 ML (tier 1)	• 8,245 ML (tier 1) • 8,210 ML (tier 2)	• 3,275 ML (tier 1) • 6,300 ML (tier 2)
Priority carryover requirements	• 2,000 ML			

1 Tier 1 potential environmental watering at the lower Murray wetlands is not classified as tier 1a or 1b, because the water available for use is shared across various systems, and it is not possible to reliably determine the supply specifically available for the lower Murray wetlands.

5.2.6 Lindsay, Mulcra and Wallpolla islands

System overview

Lindsay, Mulcra and Wallpolla islands cover over 26,100 ha of Victorian floodplain in the Murray-Sunset National Park (see Figure 5.2.6). They form part of the Chowilla Floodplain and Lindsay-Wallpolla islands icon site that straddles the Victoria–South Australia-New South Wales border in the mid-Murray River system.

The Lindsay, Mulcra and Wallpolla islands floodplain is characterised by a network of permanent waterways, small creeks and wetlands. The Lindsay River, Potterwalkagee Creek and Wallpolla Creek form the southern boundaries of the site and create large floodplain islands with the Murray River to the north.

In their natural state, these waterways and wetlands would regularly flow and fill in response to high water levels in the Murray River. Large floods still occur, but major storages in the upper reaches of the Murray River system and extraction for consumptive use have reduced the frequency of small- to moderate-sized floods.

Flows in the mid-Murray River system are regulated through a series of weir pools. The weir pools are colloquially called locks, in reference to structures at the weirs that allow vessels to navigate from one weir pool to the next. The weir pools are primarily managed as small water storages to ensure adequate water levels for off-stream diversion via pumps.

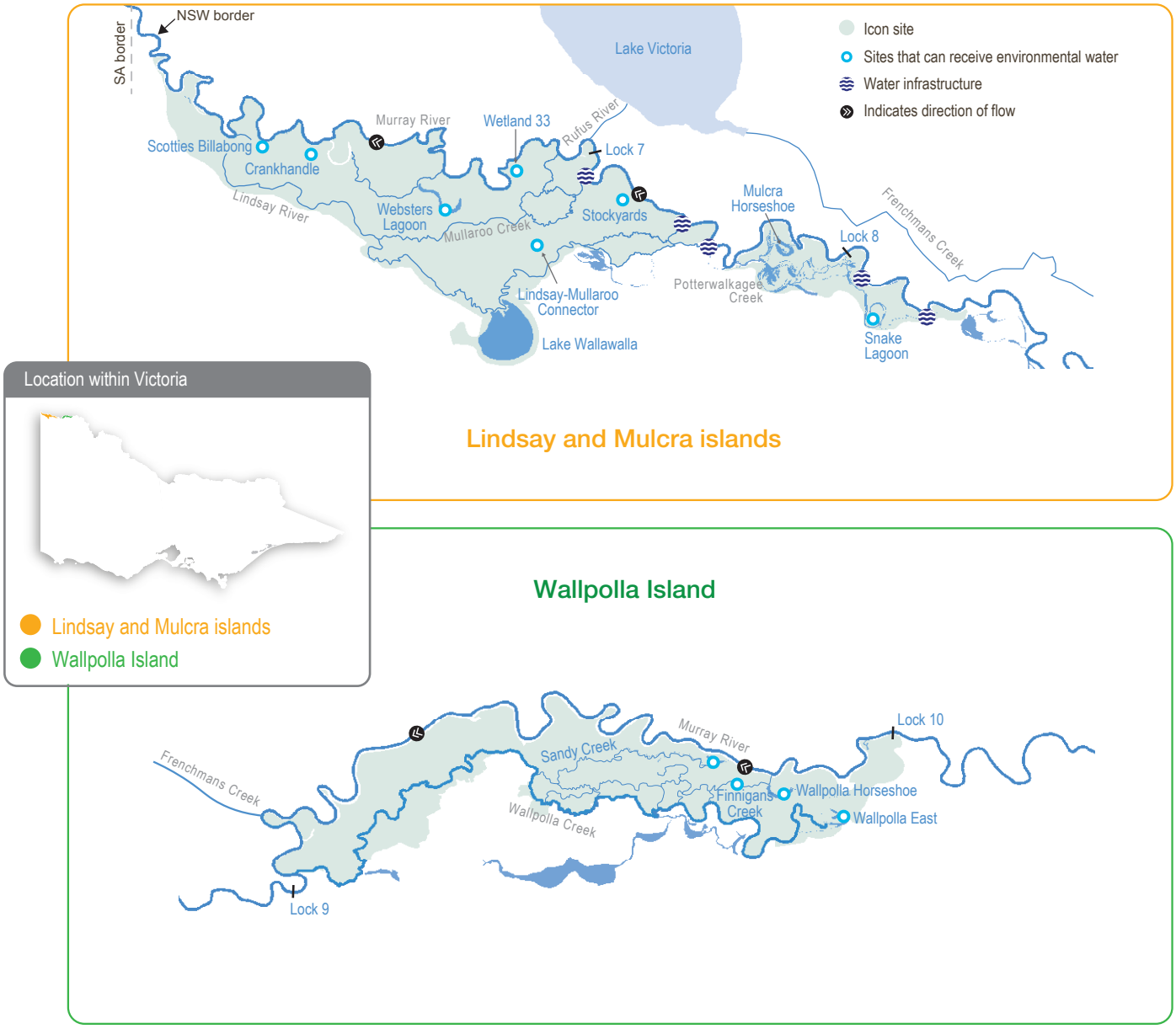
Water is diverted from weir pool 9 in the Murray River to Lake Victoria, where it is stored for later use to meet South Australian water demands. The diversion causes water to bypass Murray River weir pools 7 and 8, and at times it has a significant impact on flow in those reaches.

In recent years, the water levels in weir pools 7 and 8 have been managed to achieve ecological benefits in the Murray River channel. For example, weir pool levels have been raised during winter and spring then lowered during summer and autumn, to mimic seasonal river flows. The raising and lowering provide greater environmental benefits than a stable weir pool, because it wets and dries off-channel habitats and creates more variable flow patterns in the Murray River and connected floodplain streams. Changes in water levels during appropriate seasons helps establish fringing vegetation in shallow margins of the river channel and promotes cycling of nutrients and carbon as conditions fluctuate between wet and dry.

Static weir pool levels and reduced flow in the Murray River have a big effect on flow in the Lindsay River and Potterwalkagee Creek. When natural flow increases and/or when water levels in weir pools 7 and 8 are raised above the full supply level, flow to Potterwalkagee Creek increase and the upper Lindsay River starts flowing. When weir pools are lowered, flow to both the Lindsay River and Potterwalkagee Creek cease. Mullaroo Creek is less affected by weir pool levels and flow is controlled independently through the Mullaroo Creek regulator, which connects the creek and the Murray River. Moderate lowering of the lock 7 weir pool level has little effect on Mullaroo Creek, but lowering beyond 0.5 m below full supply level makes it difficult to deliver the recommended minimum flow of 600 ML per day that is required to maintain fast-flowing habitat for native fish, especially Murray cod.

Fluctuation of weir pool levels is a major consideration for jurisdictions managing flow in the Murray River and the anabranch waterways of Lindsay, Mulcra and Wallpolla islands. Environmental objectives and associated water regimes for the Murray River sometimes conflict with those for the Lindsay, Mulcra and Wallpolla anabranch systems. Responsible agencies in Victoria and NSW and the Murray-Darling Basin Authority collaboratively plan how to effectively manage weir pools and flows to floodplain habitats.

Figure 5.2.6 The Lindsay, Mulcra and Wallpolla islands



Environmental values

The Lindsay, Mulcra and Wallpolla islands represent three separate anabranch systems including streams, billabongs, large wetlands and swamps. When flooded, waterways and wetlands within these systems provide habitat for native fish, frogs, turtles, waterbirds and water-dependant plants. Terrestrial animals (such as woodland birds) also benefit from improved productivity and food resources when anabranch systems are inundated. Large floodplain wetlands (such as Lake Wallawalla) can retain water for several years after receiving inflows; they provide important refuges for wetland-dependent species and support terrestrial animals (such as small mammals and reptiles).

Mullaroo Creek supports one of the most significant populations of Murray cod in the mid-Murray River system. Mullaroo Creek provides fast-flowing habitat that Murray cod favour, which contrasts with the artificially slow-flowing and still habitats in the nearby Murray River weir pools. Fish in Mullaroo Creek breed and produce juveniles that contribute to populations in adjacent parts of the Murray system (such as in the Darling River in NSW and the lower Murray River in South Australia). Waterways and wetlands throughout the icon site support several other fish species including freshwater catfish, golden perch, silver perch, Murray-Darling rainbowfish and unspecked hardyhead.

The reduced frequency and duration of floods in the Murray River have degraded the water-dependent vegetation communities throughout the Lindsay, Mulcra and Wallpolla island system, which has in turn reduced the diversity and abundance of animals that rely on healthy vegetation for habitat.

Environmental watering objectives for Lindsay, Mulcra and Wallpolla islands

	By 2030, increase the abundance of small-bodied native fish and the spread of age classes for long-lived native fish, compared to 2006-12 baseline levels
	By 2030, improve or maintain populations of flow-dependent fauna
	By 2030, improve the function of water-dependent ecosystems by maintaining or improving productivity linkages between the river and floodplain habitats
	By 2030, improve or maintain populations of threatened flora that are flow-dependent By 2030, improve the condition and maintain the distribution of river red gum, black box and lignum, compared to 2006 baseline levels By 2030, improve the species richness and abundance of native wetland and floodplain aquatic vegetation functional groups
	By 2030, maintain communities and species diversity of colonial nesting waterbirds, waterfowl, waders and piscivores By 2030, increase populations of colonial nesting waterbirds at Lake Wallawalla and non-colonial waterbirds at Mulcra Horseshoe and Wallpolla Horseshoe

Traditional Owner cultural values and uses

Mallee CMA has met on Country with the First People of the Millewa-Mallee Aboriginal Corporation (representing Latji Latji and Ngintait Traditional Owners) to discuss watering requirements for their Country.

The Traditional Owners have identified ways in which environmental water can support cultural values and uses, which are outlined in Table 5.2.14.

Table 5.2.14 Traditional Owner values and uses of watering sites in the Lindsay Mulcra Wallpolla icon site

Waterway	Traditional Owner group	Values / Uses / Objectives / Opportunities
Lindsay Island	Ngintait	• Black swan (Totem) nests in bull rush. Traditional Owners have observed a lack of bull rush around certain areas, so they would like to see it restored along the river banks, making for more nesting opportunities and a greater black swan population.
Lindsay Island	Ngintait	• Three-pronged grass are used for weaving. Traditional Owners are looking at places to plant seeds to grow this species, so elders can sit with community and teach weaving using the grass.
Lindsay-Mulcra-Wallpolla	Ngintait/Latji Latji	• Old Man Weed (*Centipeda cunninghamii*) is used for bush medicine. This grows in mud as water recedes. Both Traditional Owner groups from the Lindsay, Mulcra and Wallpolla region would like to see more of this.
Lindsay-Mulcra-Wallpolla	Latji Latji	• Latji Latji would like more opportunities to get back onto Country and begin discussions about managing Country.
Lake Wallawalla	Ngintait	• Protection of Cultural Heritage sites bordering Lake Wallawalla.

Their recommendations for watering actions have shaped planning for water for the environment for 2021-22 and beyond.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.2.15, Mallee CMA has also considered how environmental flows could support other values and uses such as:

- water-based recreation (such as canoeing, kayaking, fishing and yabbying)
- riverside recreation and amenity (such as bushwalking, camping, bird and wildlife watching, four-wheel driving and photography)
- community events and tourism (such as increased visitation and ecotourism and education programs for school, TAFE and university students)
- socio-economic benefits (such as for apiarists, local businesses providing accommodation and hospitality to tourists and local water delivery contractors).

Watering planned to support angling activities

Wallpolla Horseshoe is currently being managed as a nursery habitat for native golden and silver perch, which were released as fingerlings into the wetland in March 2019. This was undertaken in partnership with First People of the Millewa-Mallee Aboriginal Corporation, Victorian Fisheries and Mallee CMA.

Delivery of water for the environment to Finnigans Creek will be targeted to provide a connection between Wallpolla Horseshoe and Finnigans Creek, with the intent of allowing dispersal of stocked native fish from Wallpolla East to Finnigans Creek and eventually to the Murray River via Wallpolla Creek. Additional water will be proposed for Wallpolla Horseshoe, to support fish remaining in the wetland after the exit strategy is trialled.

Recent conditions

Rainfall and daily maximum temperatures at Lindsay, Mulcra and Wallpolla islands were close to the long-term average throughout 2020-21. Carryover of water in the Murray system was important, to meet demands for water for the environment early in the water year. Victorian Murray allocations reached 55 percent of high-reliability water shares by mid-October 2020 and 100 percent of high-reliability allocation by mid-February 2021. Allocations combined with carryover provided a sufficient supply of water for the environment to meet the planned watering actions identified for the Lindsay, Mulcra and Wallpolla islands system.

Flows in the Murray River throughout late autumn, winter and early spring 2020 allowed the Murray-Darling Basin Authority to achieve Lake Victoria's storage level targets. As a result, less water was diverted from the Murray River weir pool 9 to Lake Victoria in middle to late spring 2020 than would be the case in a drier year, but diversions occasionally occurred to meet Lake Victoria's requirements. Weir pools 7 and 8 were both held near to or above full supply levels from early winter 2020 to early summer, which meant additional water associated with natural inflows from the upper Murray catchment and a coordinated spring pulse of water for the environment delivered from Lake Hume was pushed into the upper Lindsay River (via Lindsay River north) and Potterwalkagee Creek for short periods. These flows were affected by occasional diversions to Lake Victoria, and they were not large enough to provide sustained flows in Lindsay River and Potterwalkagee Creek, let alone fill wetlands or inundate floodplain habitats on the islands. A spring high flow was also provided to Mullaroo Creek through the Mullaroo Creek regulator and fishway.

Flow in the Murray River returned to normal operating levels in summer and autumn 2021, and weir pools 7 and 8 were lowered to increase the amount of flowing-water habitat for native fish in the Murray River and to expose banks to support the establishment of vegetation. These actions ceased the flow to the Lindsay River and Potterwalkagee Creek, and flow in Mullaroo Creek was returned to low flow (600 ML per day) for the rest of 2020-21.

In spring 2020, water for the environment was delivered (via temporary pumps) to four wetlands on Lindsay Island for the first time since natural floods in 2016 and four wetlands/creeklines on Wallpolla Island watered the previous spring. In autumn/winter 2021, Lake Wallawalla was partially filled with water pumped from the Lindsay River.

Management of the system during 2020-21 was principally in line with a dry climate scenario, and the planned watering actions identified for those conditions in the *Seasonal Watering Plan 2020-21* were mostly achieved. The only required watering actions that were not fully achieved were the planned fills at Crankhandle and Scotties Billabong. Seepage rates at these sites were higher than expected, which meant the delivered water did not inundate as much of the fringing river red gum, black box and lignum vegetation communities as planned. Topping up these wetlands in spring 2021 will be a priority.

Recent condition monitoring shows that the health of river red gum, black box and lignum is generally in decline across the Lindsay, Mulcra and Wallpolla islands. In many areas, understory vegetation coverage is gradually transitioning to non-flood-dependant species. The poorest-quality vegetation is at Lindsay and Wallpolla islands, but without significant watering, the vegetation community on Mulcra Island is expected to deteriorate significantly. Environmental watering targeting selected wetlands on Lindsay and Wallpolla islands will be needed in 2021-22 to address the decline at specific sites, while larger-scale floodplain watering is recommended at Mulcra Island.

Scope of environmental watering

Table 5.2.15 describes the potential environmental watering actions in 2021-22, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objective(s) they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.2.15 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Lindsay, Mulcra and Wallpolla islands

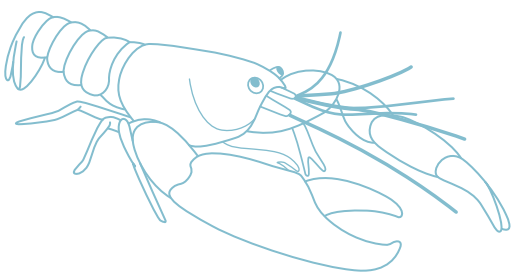
Potential environmental watering action	Expected watering effects	Environmental objectives
Lindsay Island – Mullaroo Creek		
Year-round low flow (minimum of 600 ML/day)	• Maintain fast-flowing habitat for native fish (such as Murray cod, silver perch and golden perch) • Maintain habitat for aquatic vegetation and soil moisture to maintain the condition of streamside vegetation	
Spring high-low flow (1,200 ML/day for three months during September to November)	• Increase the extent and velocity of fast-flowing water habitat to cue movement and spawning and improve recruitment opportunities for native fish • Provide improved fish passage between Mullaroo Creek and the Murray River via the Mullaroo Creek regulator fishway	
Lindsay Island – Lindsay River		
Winter/spring/summer low flow via the southern regulator (50 ML/ day for six months during July to December) Winter/spring/summer low flow via the northern regulator (95 ML/ day for six months during July to December)	• Provide temporary flowing water to connect pools and support dispersal, spawning and recruitment opportunities for native fish • Wet the substrate and debris (snags) close to the bank to promote the growth of biofilms, which provide a food source for animals higher in the food chain • Maintain bank soil moisture to support the growth of streamside vegetation	
Lindsay Island wetlands		
Crankhandle (top-up in spring)	• Inundate the margins of the wetland to provide foraging and breeding opportunities for frogs, reptiles and waterbirds • Provide conditions for lake bed herbaceous plants to grow in the drying phase after watering • Increase soil moisture to maintain and improve the condition of streamside vegetation, particularly lignum • Stimulate the growth of aquatic vegetation	
Lake Wallawalla (partial to complete fill in winter/ spring)	• Provide shallow-water habitat, open-water habitat and shoreline habitat to create foraging opportunities for waterbirds • Stimulate the release of carbon and nutrients to increase the productivity of the floodplain food web, to increase the growth rate of yabbies • Provide conditions for lake bed herbaceous plants to grow in the drying phase after watering • Increase soil moisture to maintain and improve the condition of streamside vegetation, particularly river red gum • Provide roosting habitat over open water to support breeding colonial nesting birds	
Lindsay-Mullaroo connector (fill in spring) Scotties Billabong (fill in spring) Stockyards (fill in autumn)	• Provide shallow-water habitat to provide refuge (if conditions are dry in the next 2-3 years) and feeding habitat for frogs and waterbirds • Provide conditions for lake bed herbaceous plants and semi-aquatic plants to grow in the littoral zone in the drying phase after watering • Maintain habitat for aquatic vegetation and provide soil moisture to maintain and improve the condition of river red gums and black box	

Table 5.2.15 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Lindsay, Mulcra and Wallpolla islands *(continued)*

Potential environmental watering action	Expected watering effects	Environmental objectives
Websters Lagoon (fill in spring)	• Provide a connection between Websters Lagoon and the Murray River to allow the exchange of carbon, nutrients and fish between the wetland and the river • Provide conditions for lake bed herbaceous plants and semi-aquatic plants in the littoral zone to grow during the drying phase after watering • Provide variable water levels in the littoral zone to provide feeding habitat for shorebirds • Provide open-water habitat as a refuge (if conditions are dry in the next 2-3 years) and feeding and breeding habitat for waterbirds	
Wetland 33 (top-up in spring)	• Provide shallow-water habitat to provide feeding habitat for frogs, reptiles and waterbirds • Maintain water of sufficient depth to encourage nesting waterbirds to complete the fledgling process	
Mulcra Island – Potterwalkagee Creek		
Spring low flow via the Stony Crossing regulator (115-280 ML/day for three months during September to November) Spring low flow via the upper Potterwalkagee Creek regulator (15-145 ML/day for three months during September to November)	• Provide temporary flowing water to connect pools and support dispersal, spawning and recruitment opportunities for native fish • Wet the substrate and debris (snags) close to the bank to promote the growth of biofilms, which provide a food source for animals higher in the food chain • Maintain soil moisture to maintain the condition of streamside vegetation	
Winter/spring overbank flow via the Stony Crossing regulator (470 ML/day for 4 months during August to November) Winter/spring overbank flow via the upper Potterwalkagee Creek regulator (420 ML/day for 4 months during August to November)	• Provide a connection between Potterwalkagee Creek and the floodplain to allow the exchange of nutrients and carbon between the floodplain and the Murray River system • Provide off-channel habitat for small-bodied fish to feed and breed	
Mulcra Island wetlands		
Mulcra Horseshoe (fill in spring)	• Provide shallow and open-water habitat to create foraging and breeding opportunities for waterbirds • Provide shallow-water habitat to provide refuge (if conditions are dry in the next 2-3 years) and feeding habitat for frogs and turtles • Stimulate the growth of emergent, aquatic and streamside vegetation • Provide moisture for lake bed herbaceous plants to grow during the drying phase of the wetland • Stimulate the release of carbon and nutrients to increase the productivity of the floodplain food web	

Table 5.2.15 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Lindsay, Mulcra and Wallpolla islands *(continued)*

Potential environmental watering action	Expected watering effects	Environmental objectives
Mulcra Island floodplain (floodplain inundation in spring)	• Provide shallow- and open-water habitat to create foraging and breeding opportunities for waterbirds • Provide shallow-water habitat to provide feeding habitat for frogs and turtles • Increase soil moisture to maintain and improve the condition of streamside and floodplain vegetation, specifically river red gum, black box and lignum • Stimulate the release of carbon and nutrients from the sediment to increase the productivity of the floodplain food web • Provide a connection to the Murray River to allow the exchange of carbon and nutrients between the floodplain and the river	
Wallpolla island		
Finnigans Creek (low flow in spring) 	• Provide connections between Wallpolla Horseshoe and Finnigans Creek to allow the dispersal of stocked native fish from Wallpolla East to Finnigans Creek and eventually to the Murray River via Wallpolla Creek • Provide variable water levels in the littoral zone to promote the growth of aquatic vegetation and increase soil moisture for streamside vegetation, particularly river red gums • Provide shallow-water habitat to provide refuge (if conditions are dry in the next 2-3 years) and feeding habitat for wetland-dependant species including frogs and waterbirds	
Wallpolla Horseshoe Lagoon (partial or complete fill in spring/ autumn) 	• Provide connections between Wallpolla Horseshoe and Finnigans Creek to allow the dispersal of stocked native fish from Wallpolla East to Finnigans Creek and eventually to the Murray River via Wallpolla Creek • Wet/drown river red gum saplings in the inlet channel to Wallpolla Horseshoe to limit their coverage • Increase soil moisture to maintain and improve the condition of streamside and vegetation, specifically river red gum • Provide suitable breeding conditions for waterbirds • Provide permanent habitat for fish in the wetland • Provide shallow- and open-water habitat to create foraging and breeding opportunities for frogs and turtles • Provide the conditions for lake bed herbaceous plants and semi-aquatic plants to grow in the littoral zone during the drying phase after watering	



Scenario planning

Table 5.2.16 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The two categories of environmental watering opportunities at Lindsay, Mulcra and Wallpolla islands in 2021-22 are:

- environmental watering of anabranch waterways (Mullaroo Creek, Lindsay River and Potterwalkagee Creek) and floodplain wetlands in coordination with weir pool operation
- a program of environmental deliveries via temporary pumps to individual wetlands at Lindsay, Mulcra and Wallpolla islands.

Among the waterways and floodplain wetlands connected to the weir pools, two sites are proposed to receive water for the environment under all planning scenarios: Mullaroo Creek and Websters Lagoon. Permanent flowing water and a modest increase in flow in spring are essential for Mullaroo Creek in all scenarios, because there is strong evidence this watering regime promotes fish movement and breeding, particularly for Murray cod and golden perch. Websters Lagoon is a low-lying wetland close to the Murray River that benefits from having a wet-dry cycle and hydraulic connection to the Murray River every year.

Environmental flows are not proposed for Lindsay River and Potterwalkagee Creek under a drought climate scenario, but under dry, average or wet scenarios it would be necessary to deliver flows in winter/spring when weir pools 7 and 8 are raised. In a wet climate scenario, unregulated flow in the Murray River is likely to meet these anabranch flow requirements naturally. These flows are needed under dry to wet climate scenarios to connect pools and provide soil moisture to increase the growth and condition of streamside vegetation, which is in poor health after successive dry years.

Floodplain inundation at Mulcra Island is required under an average or wet climate scenario, because the Mulcra Island floodplain is reaching its dry-period limit and the vegetation condition has declined. Extensive inundation of the Mulcra Island floodplain is not feasible under a drought or dry climate scenario, because weir pool 8 would be too low to operate the floodplain infrastructure, but the Mulcra Horseshoe section of the floodplain can be watered via temporary pumping and will be a high priority under all scenarios.

Temporary pumps will be needed to deliver water for the environment to five wetlands on Lindsay Island in 2021-22. Crankhandle, the Lindsay-Mullaroo connector and Scotties Billabong were watered in 2020,-21 and they are all planned to receive follow-up watering in 2021-22. Consecutive years of watering will consolidate and build on the environmental benefits achieved last year and are expected to improve the growth and condition of river red gum and black box surrounding the wetlands and creeklines.

Stockyards is a priority watering site under all climate scenarios in 2021-22, because it has not been inundated since 2016 and the health of river red gums and black box at the site is very poor. The largest proposed watering action at Lindsay Island is a fill of Lake Wallawalla. Between 6,000 ML (dry climate scenario) and 10,000 ML (average climate scenario) is proposed to be pumped to the wetland to extend the environmental watering event that began in May 2021. Under a wet climate scenario, water for the environment may be delivered on top of natural inflows to Lake Wallawalla, to ensure fringing black box communities are inundated.

It will be particularly important to water the nominated wetlands on Lindsay Island in 2021-22, because the impending construction activities associated with the Victorian Murray Floodplain Restoration Project (VMFRP) will limit watering opportunities in 2022-23 and 2023-24. When complete, the VMFRP will significantly improve the deliverability of water for the environment at Lindsay Island. It is necessary to water selected sites across Lindsay Island in 2021-22, to build environmental resilience until the VMFRP infrastructure becomes operational.

Wetland 33 on Lindsay Island is a tier 2 watering priority in 2021-22, because the water retained from the delivery in spring 2020 is expected to support the environmental objectives in 2021-22, which include providing habitat for waterbird breeding. It is unlikely that follow-up watering will be needed at Wetland 33 in 2021-22, but Mallee CMA will monitor water levels during winter-spring 2021 and may deliver a spring top-up if circumstances change.

The main focus of water for the environment at Wallpolla Island in 2021-22 will be to provide connectivity between the Murray River, Wallpolla Creek, Wallpolla Horseshoe and Finnigans Creek, to allow native fish that were stocked into Wallpolla Horseshoe to disperse and supplement regional populations. The Wallpolla Horseshoe fish exit strategy — where deliveries to Wallpolla Horseshoe and Finnigans Creek will be coordinated to attract fish into Wallpolla Creek and eventually to the Murray River — will be attempted under all climate scenarios except drought.

Table 5.2.16 Potential environmental watering for Lindsay, Mulcra and Wallpolla islands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Year-round low flow in the Murray River and no natural floodplain wetting • Weir pools will be maintained at full supply level in winter and drawn down below full supply level during spring, summer and autumn • Substantial wetland drying will occur	• Rare high-flow events in the Murray River and no natural floodplain wetting • Weir pools will be raised in winter and spring and drawn down below full supply level in summer and autumn • Substantial wetland drying will occur	• Short periods of high flow, most likely in late winter/spring, providing minor wetting of the floodplain • Weir pool levels will be raised in winter/spring and drawn down in summer/autumn	• Long periods of high flow, with major spills from storages resulting in widespread wetting of the floodplain and wetting of most wetlands • Weirs would be removed to allow the passage of natural flow
Lindsay Island				
Potential environmental watering – tier 1 (high priorities)[1]	• Year-round low flow (Mullaroo Creek) • Spring low flow (Mullaroo Creek) • Stockyards (fill in autumn) • Websters Lagoon (fill in spring)	• Year-round low flow (Mullaroo Creek) • Spring low flow (Mullaroo Creek) • Winter/spring/summer low flow (Lindsay River via the north and south regulator) • Crankhandle (top-up in spring) • Lake Wallawalla (partial to complete fill in winter/spring) • Lindsay-Mullaroo connector (fill in spring) • Scotties Billabong (fill in spring) • Stockyards (fill in autumn) • Websters Lagoon (fill in spring)	• Year-round low flow (Mullaroo Creek) • Spring low flow (Mullaroo Creek) • Winter/spring/summer low flow (Lindsay River via the north and south regulator) • Crankhandle (top-up in spring) • Lake Wallawalla (partial to complete fill in winter/spring) • Lindsay-Mullaroo connector (fill in spring) • Scotties Billabong (fill in spring) • Stockyards (fill in autumn) • Websters Lagoon (fill in spring)	• Year-round low flow (Mullaroo Creek) • Spring low flow (Mullaroo Creek) • Winter/spring/summer low flow (Lindsay River via the north and south regulator) • Crankhandle (top-up in spring) • Lake Wallawalla (partial to complete fill in winter/spring) • Lindsay-Mullaroo connector (fill in spring) • Scotties Billabong (fill in spring) • Stockyards (fill in autumn) • Websters Lagoon (fill in spring)
Potential environmental watering – tier 2 (additional priorities)	• N/A	• Wetland 33 (top-up in spring)	• Wetland 33 (top-up in spring)	• Wetland 33 (top-up in spring)
Possible volume of water for the environment required to achieve objectives[2]	• 800 ML (tier 1)	• 9,000 ML (tier 1) • 50 ML (tier 2)	• 13,000 ML (tier 1) • 50 ML (tier 2)	• 0-6,000 ML (tier 1)

Table 5.2.16 Potential environmental watering for Lindsay, Mulcra and Wallpolla islands under a range of planning scenarios *(continued)*

Planning scenario	Drought	Dry	Average	Wet
Mulcra Island				
Potential environmental watering – tier 1 (high priorities)[1]	• Mulcra Horseshoe (fill in spring)	• Spring low flow (Potterwalkagee Creek via Stony Crossing and upper Potterwalkagee Creek) • Mulcra Horseshoe (fill in spring)	• Overbank flow (Potterwalkagee Creek via Stony Crossing and upper Potterwalkagee Creek) • Mulcra Horseshoe (fill in spring) • Mulcra floodplain inundation (floodplain inundation in spring)	• Spring low flow (Potterwalkagee Creek via Stony Crossing and upper Potterwalkagee Creek) • Overbank flow (Potterwalkagee Creek via Stony Crossing and upper Potterwalkagee Creek) • Mulcra Horseshoe (fill in spring) • Mulcra floodplain inundation (floodplain inundation in spring)
Possible volume of water for the environment required to achieve objectives[3]	• 1,500 ML (tier 1)	• 1,900 ML (tier 1)	• 3,300 ML (tier 1)	• 0-3,300 ML (tier)
Wallpolla Island				
Potential environmental watering – tier 1 (high priorities)[1]	• Wallpolla Horseshoe (partial or complete fill in spring and autumn)	• Wallpolla Horseshoe (partial or complete fill in spring and autumn) • Finnigans Creek (low flow in spring)	• Wallpolla Horseshoe (partial or complete fill in spring and autumn) • Finnigans Creek (low flow in spring)	• Wallpolla Horseshoe (partial or complete fill in spring and autumn) • Finnigans Creek (low flow in spring)
Possible volume of water for the environment required to achieve objectives	• 400 (tier 1)	• 1,200 (tier 1)	• 1,200 (tier 1)	• 0-1,200 (tier 1)

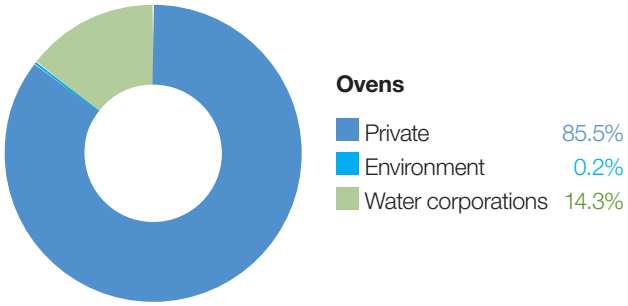
1 Tier 1 environmental watering at Lindsay, Mulcra and Wallpolla islands is not classified as tier 1a or tier 1b, because the water available to use is shared across various systems, and it is not possible to reliably determine supply specifically available for the islands.

2 These estimates include the use of water for the environment for Mullaroo Creek, Lindsay River and the Lock 7 weir pool. Water for the environment used at these sites may be accounted for in Victoria or New South Wales.

3 The estimates include the use of water for the environment for Potterwalkagee Creek, Mulcra Island and the Lock 8 weir pool. Water for the environment used at these sites may be accounted for in Victoria or New South Wales.

5.3 Ovens system

Waterway manager – North East Catchment Management Authority
Storage manager – Goulburn-Murray Water
Environmental water holder – Commonwealth Environmental Water Holder



Proportion of water entitlements in the Ovens basin held by private users, water corporations and environmental water holders on 30 June 2020.

Did you know...?

In 2021, 36 ML of water owned by the Taungurung Land and Waters Council was delivered as an environmental flow down the King River. The flow has contributed to healing Country by providing a boost to the health and productivity of the waterway.

Top: Buffalo River, by Natalie Ord, courtesy of North East CMA
Above: Water vegetation and frog spawning at Mullinmur Wetland, by Manifeasto Photography

System overview

The Ovens River rises in the steep, forested mountains of the Great Dividing Range near Mount Hotham and flows about 150 km to join the Murray River in the backwaters of Lake Mulwala (Figure 5.3.1). The system has two small water storages: Lake Buffalo on the Buffalo River and Lake William Hovell on the King River. The regulated reaches of the Ovens system include the Buffalo and King rivers below these storages and the Ovens River from its confluence with the Buffalo River to the Murray River.

As its storages are quite small and spill regularly, the Ovens system maintains a large proportion of its natural flow regime, particularly in winter/spring. However, the storages and licensed water extractions throughout the system can restrict flow during low flow periods, and parts of the system can become quite flow-stressed during summer and autumn.

The Ovens River flows into Lake Mulwala on the Murray River, the largest weir pool on the Murray regulated system. Ovens River flows contribute to the reliability and variability of flows in the Murray River and support many downstream uses including irrigation, urban supply and watering of iconic floodplain sites (such as Barmah Forest).

Water for the environment is held in Lake Buffalo and Lake William Hovell and can be released when the storages are not spilling. Five reaches in the Ovens system can benefit from releases of water for the environment. While all are important, there is a relatively small volume (123 ML) of water available, and it is insufficient to meet most of the environmental flow objectives. The available water is used selectively to deliver the greatest possible environmental benefit. Water for the environment is most commonly used in the Ovens system to deliver critical flow events in reaches immediately below the two main storages, or it is used in conjunction with operational water releases to influence flow in the lower Ovens River. It is also used to fill and top up Mullinmur Wetland in Wangaratta.

Environmental values

The diverse aquatic habitat and abundant food resources associated with the Ovens system support a wide range of native fish species including Murray cod, trout cod, golden perch and unspecked hardyhead. The Buffalo River provides valuable habitat for large-bodied fish species during part of their breeding cycle, while trout cod have a large range within the system and are found as far up the King River as Whitfield. A project to recover trout cod populations in the Ovens system has been successful, and efforts to reintroduce Macquarie perch are continuing.

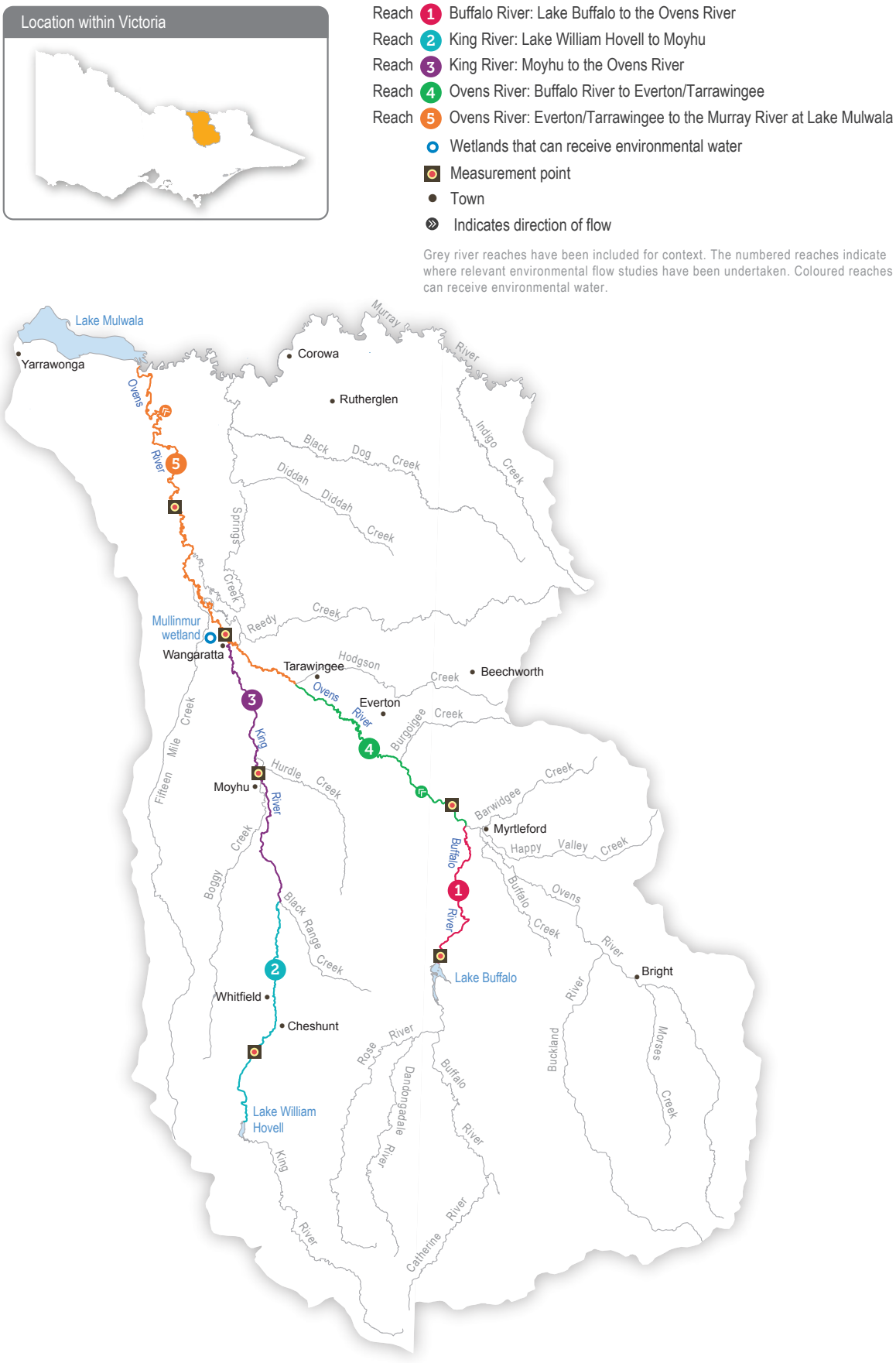
Frogs (such as the giant banjo frog and growling grass frog) are abundant in the lower reaches and associated wetlands of the Ovens River and the King River above Cheshunt. The lower Ovens wetland complex contains over 1,800 wetlands, is listed as nationally significant and is home to a variety of waterbirds including egrets, herons, cormorants and bitterns. The streamside zones of river channels throughout the Ovens system support some of Victoria's healthiest river red gum forests and woodlands, while the wetlands support a variety of aquatic and semi-aquatic vegetation communities.

Water for the environment was delivered to Mullinmur Wetland at Wangaratta for the first time in 2019-20. This site has been the focus of several environmental improvement projects in recent years. Specific management actions include carp removal, a revegetation program and a project that started in December 2019 to determine whether the wetland can support a sustainable brood stock population of native freshwater catfish. The Arthur Rylah Institute translocated 60 freshwater catfish into Mullinmur Wetland in December 2019, and ongoing monitoring throughout 2021-22 will assess the viability of the population.

Environmental watering objectives in the Ovens River

- Maintain the size and distribution of native fish populations
- Maintain the form of the riverbank and channel and ensure river bed surfaces are in suitable condition to support all stream life
- Maintain the condition and extent of wetland vegetation communities
- Maintain an adequate abundance and diversity of waterbugs, to support river food webs and associated ecosystem processes
- Maintain water quality for all river life

Figure 5.3.1 The Ovens



Traditional Owner cultural values and uses

North East CMA has consulted with the Taungurung Land and Waters Council and the Yorta Yorta Nation Aboriginal Corporation in planning for water for the environment for the Ovens system. The environmental and ecological objectives of the seasonal watering proposals were supported and align with the broad values of these Traditional Owner groups.

Taungurung Land and Waters Council are interested in identifying off-stream wetlands that require watering to improve the ecological and cultural values of their Country.

Yorta Yorta Nation Aboriginal Corporation has developed a new *Whole of Country Plan*, which will support more culturally informed planning for water in the lower Ovens River in future.

Increasing the involvement of Traditional Owners in environmental water planning and management, and ultimately providing opportunities to progress towards self-determination within and beyond the environmental watering program, is a core commitment of the VEWH and its agency partners. This is reinforced by a range of legislation and policy commitments (for example the *Water Act 1989*, the Victorian Aboriginal Affairs Framework, *Water for Victoria* (2016)) and, in some cases, agreements under the *Traditional Owner Settlement Act 2010*. Where Traditional Owners are more deeply involved in the planning and/or delivery of environmental flows for a particular site, their contribution is acknowledged in Table 5.3.1 with an icon. The use of this icon is not intended to indicate that these activities are meeting all the needs of Traditional Owners but is incorporated in the spirit of valuing that contribution, and indicating progress towards this objective.

Watering planned and/or delivered in partnership with Traditional Owners to support cultural values and uses

The Taungurung Land and Waters Council may consider using their water entitlement in the King River system to support environmental objectives as part of their goal of healing Country. The Taungurung Land and Waters Council's allocation has been released from Lake William Hovell three times as an environmental flow in partnership with North East CMA, Goulburn-Murray Water and the VEWH, to provide additional water to the King River and assist in healing Country. The flow provided a small variation in the water level to inundate new habitat for in-stream biota (fish and macroinvertebrates), allowing them to move more freely and find new sources of food.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.3.1, North East CMA considered how environmental flows could support values and uses including:

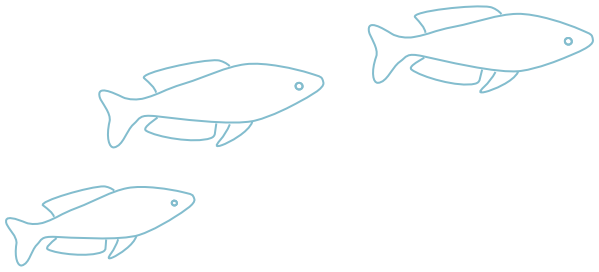
- water-based recreation (such as boating and fishing)
- riverside recreation and amenity (such as camping, visitation for mental health and wellbeing)
- community events and tourism (such as providing a setting for community gatherings, school outdoor learning, sporting events, and citizen science projects)
- socio-economic benefits (such as businesses used by anglers, stock and domestic use).

Environmental flows will be delivered to Mullinmur Wetland over summer, to support aquatic vegetation and support native catfish which were translocated to the wetland in 2019 from a drying lake in Barham, New South Wales. This site will continue to be used as a catfish broodstock location for future reintroductions into the region.

The water will also support other benefits for the local community, as the site is managed by the Catholic Education Department with support from Wangaratta Landcare and Sustainability Incorporated. It is used as a community environmental education site for Galen Catholic College students, young people attending the Borinya Wangaratta Community Partnership and other members of the local community, demonstrating the important ecological functions that wetlands provide and how water for the environment is used to support ecological values.

An education hub has recently been built at the site, providing a great space for school groups and community groups to develop and share knowledge in nature. Six photo points have also been placed around the wetland, to enable citizen-science opportunities. Anyone can take a photo from the specially made phone holders and upload them to Instagram, documenting the changes at the site.

A team of Waterwatch citizen scientist volunteers have provided water-quality recordings before and after environmental watering, helping waterway managers to understand the optimal conditions for native fish and plant species.



Recent conditions

The Ovens catchment experienced slightly below-average rainfall across the 2020-21 season. Lake William Hovel received 80 percent of its long-term average inflows, and Lake Buffalo received 85 percent of its average inflows. Lake William Hovell began the season at full capacity, and rainfall through winter quickly filled Lake Buffalo, which reached full capacity by spring. Allocations against Ovens system environmental water shares remained at 100 percent during the season, and the Ovens River and reaches of the King and Buffalo rivers directly below their storages retained much of their natural flow variability throughout the year.

Local rainfall delivered natural, high-flow events in the Ovens system in July, August, October and February. The October event was the largest, with flow peaking at 11,300 ML per day in Wangaratta. Water for the environment was released in conjunction with operational bulk water transfers from Lake Buffalo, to deliver a small autumn fresh in late March to improve water quality and connect habitat for native fish and waterbugs in the Buffalo River (reach 1) and Ovens River (reaches 4 and 5). Taungurung Land and Waters Council donated some of their annual water allocation to the VEWH to support environmental outcomes in the King River. This water and some water for the environment were released from Lake William Hovell in late March, to improve habitat quality and food resources for fish and waterbugs in reaches 2 and 3 of the King River.

Mullinmur Wetland was topped up with natural flows from the Ovens River in October 2020 and again in February 2021. These natural events negated the need for planned deliveries of water for the environment to the wetland in 2020-21. A native fish population assessment will determine if catfish stocked in Mullinmur Wetland moved into the Ovens River during the October or February high flow events. Surveys are also being conducted at Mullinmur Wetland to determine whether deliveries of water for the environment over the last two years have had the intended effect on native vegetation.

Scope of environmental watering

Table 5.3.1 describes the potential environmental watering actions in 2021-22, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objectives they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.3.1 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Ovens system

Potential environmental watering action	Expected watering effects	Environmental objectives
Mullinmur Wetland (top-up during November to February)	• Maintain the water level within the wetland to support the growth and recruitment of aquatic vegetation • Maintain habitat for freshwater catfish	
Autumn fresh (one fresh of greater than 430 ML/day for three days in reaches 1 and 4, and greater than 130-260 ML/ day for three days in reach 5 during March to April)	• Provide flow cues to stimulate the movement of native fish • Increase connectivity between pools for fish movement • Mix pools to improve the water quality • Provide small variations in river levels and velocity, to flush sediment from hard substrates and maintain waterbug habitat • Scour biofilm from the river bed	
Summer/autumn low-flow variability (greater than 80 ML/ day for one to two days during February to March in reaches 1, 2 and 3) 	• Increase connectivity between pools for fish movement • Provide small variations in river levels to move sediment and maintain waterbug habitat • Maintain sufficient oxygen levels	

Scenario planning

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

The weather and inflows into storages have a large effect on how water for the environment is likely to be used in the Ovens River. Under dry and average conditions, the main objective for water for the environment in the Ovens River will be to deliver summer/autumn low flow variability to limit the duration of extremely low flow or cease-to-flow events that can stress native fish and waterbugs. Under average conditions, the objective will be to provide a higher flow, to support fish movement and breeding and to increase the abundance and diversity of waterbugs. There is not enough water for the environment to deliver the recommended autumn fresh in full, so releases of water for the environment will need to be timed to coincide with operational water releases to achieve the intended outcome. All the recommended environmental flows for the Ovens River system are expected to be met naturally under a wet climate scenario.

The main priority for Mullinmur Wetland in 2021-22 will be to provide top-ups throughout the warmer months, to offset seepage and evaporation and maintain wetland vegetation and suitable habitat for the freshwater catfish broodstock. This will likely require some active deliveries of water for the environment under drought and dry climate scenarios, but it may be met by natural connections to the Ovens River under average and wet climate scenarios.

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

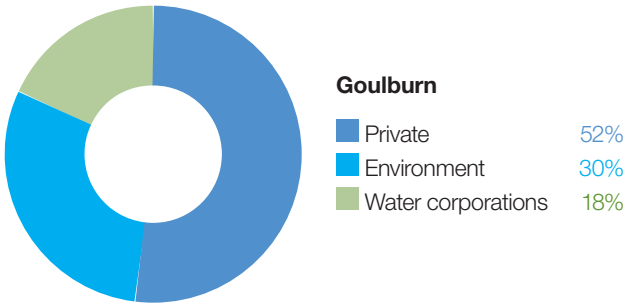
Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Possible winter/early spring natural flow • Very low flow through summer and autumn • No bulk water release	• Possible winter/early spring natural flow • Very low flow through summer and autumn • Bulk water release unlikely	• High winter/spring natural flow • Moderate flow in summer and autumn with occasional natural freshes • Bulk water release likely	• High natural flow throughout most of the year • Bulk water release likely • All flow objectives achieved naturally
Predicted supply of water for the environment	• 123 ML			
Potential environmental watering – tier 1 (high priorities)	**Tier 1a (can be achieved with predicted supply)**			
	• Summer/autumn low flow variability • Mullinmur Wetland top-up	• Summer/autumn low flow variability • Mullinmur Wetland top-up	• Autumn fresh • Summer/autumn low flow variability • Mullinmur Wetland top-up	• Autumn fresh • Summer/autumn low flow variability • Mullinmur Wetland top-up
Possible volume of water for the environment required to achieve objectives	• 123 ML	• 123 ML	• 123 ML	• 0 ML

5.4 Goulburn system

Waterway manager – Goulburn Broken Catchment Management Authority

Storage manager – Goulburn-Murray Water

Environmental water holders – Victorian Environmental Water Holder (including the Living Murray program), Commonwealth Environmental Water Holder



Proportion of water entitlements in the Goulburn basin held by private users, water corporations and environmental water holders on 30 June 2020.

Did you know...?

Yorta Yorta people know the lower Goulburn River as *Kaiela*, meaning 'father water'. Taungurung people know the mid-Goulburn River as *Waring*, and they have a special connection to the river and its tributaries.

The waters of *Waring* have a special connection with Taungurung including its tributaries (such as the Broken River, Hughes Creek, Seven Creeks, Yea River, Acheron River, King Parrot Creek, Rubicon River, Jamieson River and the Howqua and Delatite rivers. Taungurung's involvement is crucial, to incorporate their traditional ecological knowledge into water management in the region.

Top: Goulburn River, by Goulburn Broken CMA
Right: Wetland vegetation at Reedy Swamp (Goulburn wetlands), by the VEWH

The Goulburn system includes the Goulburn River and Goulburn wetlands

5.4.1 Goulburn River

System overview

The Goulburn is Victoria's largest river basin, covering over 1.6 million ha or 7.1 percent of the state (Figure 5.4.1). The Goulburn River flows for 570 km from the Great Dividing Range upstream of Woods Point to the Murray River east of Echuca. It is an ancient, iconic river rich with environmental, cultural and recreational values.

There are several environmental water holders in the Goulburn system. The Commonwealth Environmental Water Holder (CEWH) holds the largest volume and use of Commonwealth Water Holdings is critical to achieving outcomes in the Goulburn River, as well as priority environmental sites further downstream. Water for the environment held on behalf of the Living Murray program may assist in meeting objectives in the Goulburn system en route to icon sites in the Murray system (see subsection 1.4.2). Water held by the VEWH in the Goulburn system is primarily used to meet environmental objectives in the Goulburn River and the Goulburn wetlands, but can also be used to support ecological objectives at downstream sites along the Murray River and in South Australia.

The construction and operation of Lake Eildon and Goulburn Weir have significantly altered the natural flow regime of the Goulburn River. Water-harvesting during wet periods, and releases to meet irrigation and other consumptive demands during dry periods, means that flow below these structures is typically low in winter/spring and high in summer/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 from inundating the floodplain and filling many of the natural wetlands and billabongs. Several tributaries including the Acheron and Yea rivers and the Broken River below Lake Eildon add some flow variation on top of the Goulburn River's regulated flow regime. Large floods that cause the Goulburn River's storages to fill and spill are also important for the overall flow regime and its associated environmental values.

The priority environmental flow reaches in the Goulburn River are downstream of Goulburn Weir (reaches 4 and 5), which are collectively referred to as the lower Goulburn River. The mid-Goulburn River extends from Lake Eildon to Goulburn Weir (reaches 1 to 3). From early spring to late autumn, large volumes of water are delivered from Lake Eildon to Goulburn Weir to supply the irrigation system. During that period, flow in the mid-Goulburn River is usually well above the recommended environmental flow targets. Deliveries of water for the environment have the most benefit in the mid-Goulburn River (especially in reach 1 immediately downstream of Lake Eildon) outside the irrigation season when the flow is much lower than natural.

Environmental flow targets can sometimes be met by the coordinated delivery of operational water being transferred from Lake Eildon to the Murray River. These transfers are known as inter-valley transfers (IVTs). These transfers occur during the irrigation season between spring and autumn, and they may meet environmental flow objectives without the need to release water for the environment. In recent years, operational transfers in the Goulburn River have significantly exceeded the environmental flow recommendations for summer and early autumn and have damaged bank vegetation and eroded the riverbanks. Interim operating rules have been put in place to help minimise this damage, and a revised Goulburn to Murray trade rule and operating rule is expected to be introduced for 2021-22.

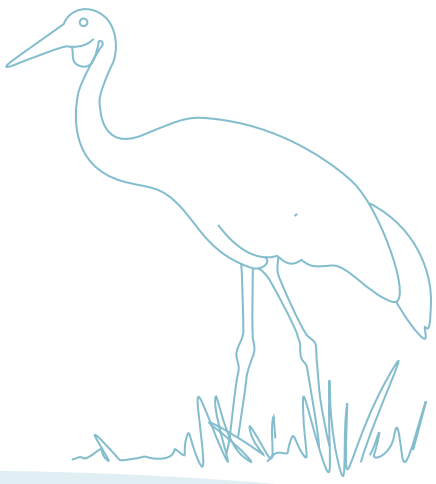
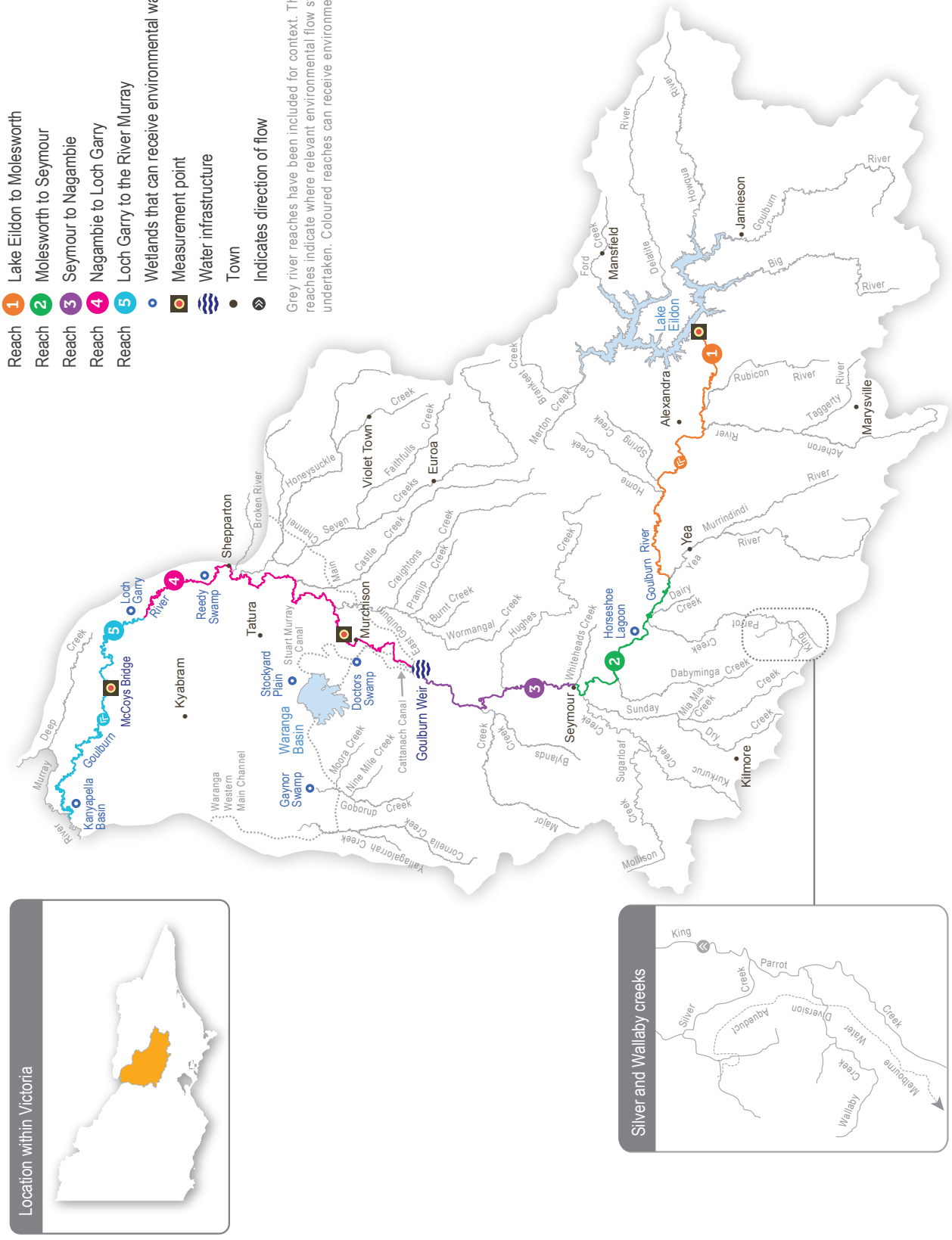


Figure 5.4.1 The Goulburn system



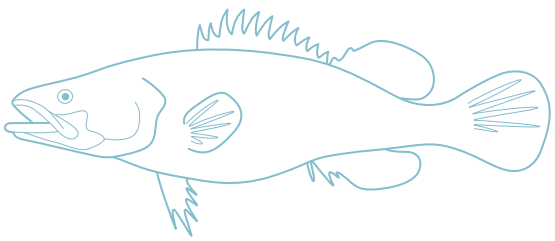
Environmental values

The Goulburn River and its tributaries support a range of native fish (including golden perch, silver perch, Murray cod, trout cod, Macquarie perch, freshwater catfish), turtles, platypus and rakali (water rats). Aquatic vegetation, scour holes and woody debris within the channel provide high-quality habitat for adult and juvenile fish. River red gums are a dominant feature of the streamside zone along the length of the Goulburn River. These trees shade the river and provide habitat for many species including the squirrel glider. Leaves that fall from the river red gums provide carbon that supports riverine food webs, and dead trees that fall into the river provide a surface for biofilms and waterbugs and habitat for fish. Birds (such as egrets, herons and cormorants) use trees along the river to roost and feed, while frogs benefit from shallowly- wetted vegetation at the edge of the river channel and in adjacent wetlands.

The Goulburn River system is an important conservation area for threatened species. Several wetlands in the Goulburn catchment are formally recognised for their conservation significance. Tributaries of the mid-Goulburn River between Lake Eildon and Goulburn Weir host some of the last remaining Macquarie perch populations in the Murray-Darling Basin, while freshwater catfish occur in lagoons connected to reach 3 of the Goulburn River. Citizen science monitoring programs indicate the mid-Goulburn River supports a strong population of platypus, which are now classified as vulnerable under Victoria's *Fauna and Flora Guarantee Act 1988*. Monitoring in recent years shows that environmental flows in the lower Goulburn River trigger golden perch and silver perch to spawn. However, the extent to which these spawning events contribute to populations locally and in the wider southern basin is unknown. Self-sustaining populations of Murray cod have been confirmed, and trout cod are extending their range in the lower Goulburn River.

Environmental watering objectives in the Goulburn River

- Protect and increase populations of native fish
- Maintain the form of the riverbank and channel, and a high diversity of river bed surfaces to support all stream life
- Increase populations of platypus
- Maintain populations of turtles
- Provide sufficient rates of carbon and nutrient production and processing to support native fish and waterbug communities
- Increase the abundance of aquatic and flood-tolerant plants in the river channel and on the lower banks, to provide shelter and food for animals and to stabilise the riverbank
- Maintain abundant and diverse waterbug communities, to support riverine food webs
- Minimise the risk of hypoxic blackwater



Traditional Owner cultural values and uses

Goulburn Broken CMA consulted with the Taungurung Land and Waters Council and the Yorta Yorta Nation Aboriginal Corporation during the planning of environmental flows in the Goulburn River. The environmental and ecological objectives of the proposals were supported and align with the broad values of these Traditional Owner groups.

The Taungurung Land and Waters Council indicated there is alignment between planned environmental flows in the mid-Goulburn River, *Waring* and healing Country. Reach 1 baseflows and the winter and spring freshes will help protect the landscape and health of the land. These flows will help support the health of cultural values and landscapes, protecting intangible cultural heritage, valued species, traditional food and medicine plants. The flows will also help fulfil Caring for Country responsibilities and support investigations into rehabilitating degraded significant sites.

Taungurung has a special interest in the rehabilitation of floodplain wetlands associated with *Waring*, which are now largely disconnected from the main river channel due to the impacts of river flow regulation. Taungurung is currently assessing habitat condition at six of the disconnected wetlands, and their findings will inform future seasonal watering proposals and planning for water for the environment. Currently, Taungurung is working to enhance habitat conditions for native species in the area, and healthy Country assessments will provide important information about cultural objectives and indicators.

Yorta Yorta Nation Aboriginal Corporation indicated there is alignment between planned watering actions in the lower Goulburn River (*Kaiela*) (reaches 4 and 5) and the cultural and ecological values of the Yorta Yorta Peoples. A Yorta Yorta representative contributed to the recent *Kaiela (Lower Goulburn River) Environmental Flows Study 2020*, which shaped planning for environmental flows in the lower Goulburn River during 2021-22 and beyond. Through this consultation, Yorta Yorta and Goulburn Broken CMA have identified that environmental flows are critical for culturally important species of both plants and animals. Flows encouraging spawning activity, recession flows to alleviate slumping of culturally important sites (such as middens and scar trees) and flows with a focus on reviving streamside vegetation are important to sustain food, fibre, and medicine.

Increasing the involvement of Traditional Owners in environmental water planning and management, and ultimately providing opportunities to progress towards self-determination within and beyond the environmental watering program, is a core commitment of the VEWH and its agency partners. This is reinforced by a range of legislation and policy commitments (for example the *Water Act 1989*, the Victorian Aboriginal Affairs Framework, *Water for Victoria* (2016)) and, in some cases, agreements under the *Traditional Owner Settlement Act 2010*. Where Traditional Owners are more deeply involved in the planning and/or delivery of environmental flows for a particular site, their contribution is acknowledged in Table 5.4.1 with an icon. The use of this icon is not intended to indicate that these activities are meeting all the needs of Traditional Owners but is incorporated in the spirit of valuing that contribution, and indicating progress towards this objective.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.4.1, Goulburn Broken CMA considered how environmental flows could support values and uses such as:

- water-based recreation (such as boating, canoeing, fishing, gaming hunting and kayaking)
- riverside recreation and amenity (such as landholders and visitors)
- community events and tourism (such as paddling and boating businesses)
- socio-economic benefits (such as stock and domestic uses, irrigation diverters and water supply for settlements on the Goulburn River).

If the timing or management of planned environmental flows may be modified to align with a community benefit, this is acknowledged in Table 5.4.1 with the following icon.

Watering planned to support angling activities

The Goulburn River provides numerous recreational and economic benefits. Environmental flows support native fish populations by providing fish passage and habitat and by encouraging fish migration and spawning, which in turn provides benefits for recreational anglers. Following community feedback, the timing of a targeted environmental flow in November/December is planned to reduce impacts on river access around peak fishing periods, benefitting anglers and local businesses.

Recent conditions

Rainfall in the Goulburn catchment was above the long-term average in winter and early spring 2020, but slightly below average in late spring and through summer. The high rainfall at the start of the year resulted in significant inflows to catchment storages, and allocations against high-reliability water shares in the Goulburn system reached 100 percent by mid-November. Sufficient water was available for the environment through carryover and new allocation to meet high-priority environmental flow requirements throughout the year.

Waranga Basin filled in early winter, and natural flows caused Goulburn Weir to spill throughout winter and early spring. There were few operational or consumptive water releases from Lake Eildon during this period, and water for the environment was used to maintain habitat for native fish and waterbugs in the reach immediately downstream of the reservoir. Water for the environment was used to slow the recession of spills at Goulburn Weir on three occasions in April, May and August 2020, to minimise erosion and reduce the risk of mass bank slumping. The largest natural flow event in August transported sediment and seed from mid-Goulburn tributaries and helped prime the system for an early spring fresh. Water for the environment was used in combination with unregulated flows to deliver an early spring fresh between September and October 2020, providing increased habitat for fish and macroinvertebrates. A late spring fresh was delivered in November 2020 to stimulate the spawning of golden perch. IVTs met or exceeded the recommended environmental flow rates in the lower Goulburn River from late November 2020 to April 2021. Water for the environment was used to deliver a fresh in April 2021, to help maintain the bank vegetation.

Deliveries of water for the environment were managed between an average and wet climate scenario during 2020-21, and all planned watering actions were achieved through natural events, IVTs or managed releases of water for the environment. Water for the environment delivered in the Goulburn River is reused at downstream sites along the Murray River, after a deduction for losses. In 2020-21, environmental flows that passed through the Goulburn River were used to support native fish objectives in Gunbower Creek, inundate wetlands in Gunbower Forest and the Hattah Lakes system and support ecological objectives in South Australia.

Recent monitoring suggests that rules restricting IVT flows to a maximum of 40 GL per month in summer are reducing the impacts to lower-bank vegetation and the erosion seen in previous years. Field monitoring following winter and spring freshes has reinforced the ecological benefits of these watering actions, especially when they are delivered in conjunction with natural inflows from upstream tributaries. Tributary inflows carry sediment, seeds and plant propagules that help banks in the lower Goulburn River recover. Fish monitoring confirmed that the late-spring fresh triggered the highest rate of golden perch spawning recorded in the lower Goulburn River in several years. It will be important to deliver targeted spring freshes and high flows in 2021-22, to support the continued recovery of bank vegetation and provide opportunities for more fish spawning and migration.

Scope of environmental watering

Table 5.4.1 describes the potential environmental watering actions in 2021-22, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objective(s) they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.4.1 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Goulburn River

Potential environmental watering action	Expected watering effects	Environmental objectives
Goulburn River reach 1		
Year-round low flow (400-1,000 ML/day in reach 1)	• Maintain habitat for small-bodied native fish • Scour fine sediment from the gravel bed and riffle substrate • Maintain adequate foraging habitat for platypus and reduce the risk of predation • Provide habitat and food for turtles • Maintain existing beds of in-channel vegetation • Wet and maintain riffles to provide habitat for biofilms and waterbugs	
Winter/spring fresh (one fresh of more than 5,000 ML/day for two days in reach 1 during July to September)	• Encourage female platypus to select a nesting burrow higher up the bank, to reduce the risk of higher flow later in the year flooding the burrow when juveniles are present	
Goulburn River reaches 4 and 5		
Year-round low flow (600-800 ML/day in reach 4 and 600-1,000 ML/day in reach five)	• Provide slow, shallow habitat required for the recruitment of larvae/juvenile fish and habitat for adult small-bodied fish • Provide deep-water habitat for large-bodied fish • Submerge snags and littoral vegetation to provide habitat for fish and waterbugs and a substrate for biofilms to grow • Provide habitat and food for turtles • Maintain habitat for aquatic vegetation and water the root zone of low-bank vegetation • Vary flow within a specified range to encourage plankton production for food, disrupt biofilms and maintain water quality • Low, variable flow enables vegetation to establish to protect against notching and bank erosion	
Winter/autumn fresh (one fresh of more than 7,300 ML/day for two days in reaches 4 and 5 during July to August 2021 and May to June 2022)	• Provide organic matter and carbon (e.g. leaf litter) to the channel • Provide connectivity to off-channel habitats and through the river for fish dispersal and greater food resources • Scour bed sediments to maintain pools and change in-channel complexity to improve habitat • Provide cues for platypus to nest higher in the bank • Provide sediment and plant propagules from tributary inflows after large rain events, to encourage the establishment of new plants • Inundate and reduce terrestrial vegetation on low banks and trigger the recruitment of native, flood-tolerant streamside vegetation • Improve waterbug habitat and food availability by scouring fine sediments	
Pass a portion of natural tributary flows in the mid-Goulburn to reaches 4 and 5 when flows in reach 3 are above 4,000 ML/day (1,000- 5,000 ML/day in reaches 4 and 5 during May and October)	• Provide organic matter and carbon (e.g. leaf litter) to the channel • Transport and deposit seed, sediment and plant propagules on the riverbank	

Table 5.4.1 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Goulburn River *(continued)*

Potential environmental watering action	Expected watering effects	Environmental objectives
Early spring fresh (one fresh of up to 10,500 ML/day with more than seven days above 7,300 ML/day during September and October in reaches 4 and 5)	• Provide organic matter and carbon (e.g. leaf litter) to the channel • Provide connectivity to off-channel habitats and through the river for fish dispersal and greater food resources • Scour bed sediments to maintain pools and change in-channel complexity for improved habitat • Increase soil moisture in banks to improve the condition of existing native vegetation • Provide sediment and plant propagules from tributary inflows after large rain events to encourage the establishment of new plants • Inundate and reduce terrestrial vegetation on low banks and trigger the recruitment of native flood-tolerant streamside vegetation • Improve waterbug habitat and food availability by scouring fine sediments and biofilms from hard substrates	
Late spring fresh (one fresh of more than 6,000 ML/day for two days during November and December in reaches 4 and 5) 	• Stimulate spawning of golden and silver perch • Scour bed sediments to maintain pools and change in-channel complexity for improved habitat • Improve waterbug habitat and food availability by scouring fine sediments and biofilms from hard substrates	
Autumn fresh (one fresh of more than 5,700 ML/day for two days during March and May in reaches 4 and 5)	• Cue fish to move into and through the system to increase their abundance and dispersal • Scour bed sediments to maintain pools, and change in-channel complexity for improved habitat • Increase soil moisture in banks for existing vegetation maintenance	
Slow recession of unregulated flows or releases from Goulburn Weir (3,000 ML/day and below in summer/autumn and from 6,000 ML/day in winter/spring in reaches 4 and 5)	• Minimise the risk of bank erosion associated with a rapid reduction in the water level • Transport and deposit seed, plant propagules and sediment on the riverbank • Minimise the risk of hypoxic blackwater after natural events	
Flows should not exceed 1,000 ML/day for six to eight weeks after an early spring fresh in reaches 4 and 5	• Protect littoral vegetation as habitat for small-bodied fish and macroinvertebrates • Allow recently germinated littoral, lower bank and semi-aquatic vegetation to become established	

Scenario planning

Table 5.4.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Providing year-round low flow in reach 1 of the mid-Goulburn River is a high priority under all climate scenarios, to maintain habitat for fish, platypus, turtles and waterbugs. This low flow also ensures in-stream vegetation remains inundated and persists through the non-irrigation season, when operational flows cease. The focus of water for the environment in the lower Goulburn River will be on vegetation recovery, to improve the condition of the lower banks that have been damaged by high IVTs over summer and autumn in recent years. Providing year-round low flow in the lower Goulburn River is the highest priority under all scenarios, to provide habitat for fish and macroinvertebrates and help the lower bank vegetation to recover. Goulburn-Murray Water generally diverts a proportion of natural high flow from Goulburn Weir into the Waranga Basin. These operational transfers cause flow rates in the lower Goulburn River to drop rapidly after a natural high-flow event. Water for the environment is used when required to slow the recession of natural spills at Goulburn Weir, reduce the risk of bank slumping and provide a more natural flow pattern for native fish.

Delivering a winter/autumn fresh in reaches 4 and 5 is a high priority under dry, below average and average climate scenarios, to provide channel-forming processes that are required as often as possible to scour bed sediments and improve habitat. Water availability under a drought climate scenario would prevent delivery of a winter/autumn fresh, but it is expected to occur naturally under a wet climate scenario. In reach 1, a winter/autumn fresh is a high priority under all scenarios, to cue platypus to nest higher in the bank. Water for the environment will be used to deliver a winter/spring fresh in reach 1 under drought and wet climate scenarios, and water released from Lake Eildon for the winter fresh in reaches 4 and 5 will meet the reach 1 winter/spring fresh-flow target under dry and average climate scenarios.

Timing deliveries of water for the environment alongside large, natural-flow events will again be a focus for 2021-22. Passing these flows from the mid-Goulburn River to the lower Goulburn River to provide variability through winter and spring is a high priority under dry to wet climate scenarios. Tributary flows following high-rainfall events carry more plant seed, nutrients and sediments that are beneficial to the lower Goulburn River than water released from Lake Eildon does.

An early-spring fresh to prime the system and stimulate plant germination is a high priority under all climate scenarios. A late-spring fresh to trigger perch spawning is also a high priority under all scenarios, but this watering action will not be delivered if it is likely to impact the recovery of bank vegetation, and it will only be delivered under drought to below-average climate scenarios if sufficient water is available. If summer low-flow targets are met (that is, if IVTs are not too high), an autumn fresh will be delivered between March and May 2022, to maintain the bank vegetation and allow new seeds to germinate.

Carrying over water to meet minimum low-flow objectives from July 2022 to September 2023 is an important consideration under drought, dry and below-average climate scenarios.

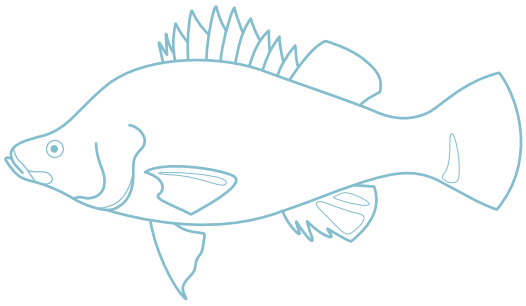


Table 5.4.2 outlines the potential environmental watering and expected water use for the Goulburn River under a range of planning scenarios

Planning scenario	Drought	Dry	Below average	Average	Wet
Expected river conditions	• Very few or no large natural-flow events • Blackwater could be an issue if there is a large rain event in the warmer months	• One to two short-duration, large, natural-flow events are likely to provide small winter/spring freshes • Blackwater could be an issue if there is a large rain event in the warmer months	• Large natural-flow events are expected to provide some low flow for a few months from winter/mid-spring and are likely to provide small winter/spring freshes • Blackwater could be an issue if there is a large rain event in the warmer months	• Large natural-flow events will provide low flow for most of the year and will likely provide winter/spring freshes • Blackwater could be an issue if there is a large rain event in the warmer months	• Large natural-flow events will provide low flow and multiple overbank flow events in winter/spring
Predicted supply of water for the environment[1]	• 330 GL	• 431 GL	• 512 GL	• 590 GL	• 590 GL
Goulburn River reach 1					
Potential environmental watering – tier 1 (high priorities)[2]	**Tier 1a (can be achieved with predicted supply)**				
	• Year-round low flow • Winter/spring fresh	• Year-round low flow • Winter/spring fresh	• Year-round low flow • Winter/spring fresh	• Year-round low flow • Winter/spring fresh	• Year-round low flow • Winter/spring fresh

Table 5.4.2 outlines the potential environmental watering and expected water use for the Goulburn River under a range of planning scenarios *(continued)*

Planning scenario	Drought	Dry	Below average	Average	Wet
Goulburn River reaches 4 & 5					
Potential environmental watering – tier 1 (high priorities)[2]	**Tier 1a (can be achieved with predicted supply)**				
	• Year-round low flow • Early spring fresh • Autumn fresh (partial) • Recession flow management	• Year-round low flow • Winter/autumn fresh • Pass mid-Goulburn tributary flows • Early spring fresh • Autumn fresh • Recession flow management	• Year-round low flow • Winter/autumn fresh • Pass mid-Goulburn tributary flows • Early spring fresh • Autumn fresh • Recession flow management	• Year-round low flow • Winter/autumn fresh • Pass mid-Goulburn tributary flows • Early spring fresh • Late spring fresh • Autumn fresh • Recession flow management	• Year-round low flow • Winter/autumn fresh • Pass mid-Goulburn tributary flows • Early spring fresh • Late spring fresh • Autumn fresh • Recession flow management
	Tier 1b (supply deficit)				
	• Pass mid-Goulburn tributary flows • Late spring fresh	• Late spring fresh	• Late spring fresh	• N/A	
Possible volume of water for the environment required to achieve objectives	• 330,000 ML (tier 1) • 60,000 ML (tier 1b)	• 396,000 ML (tier 1) • 45,000 ML (tier 1b)	• 504,000 ML (tier 1) • 45,000 ML (tier 1b)	• 520,000 ML (tier 1)	• 458,000 ML (tier 1)
Priority carryover requirements	• 23,000 ML			• 0 ML	

1 When trading opportunities are available, additional allocations of water for the environment from the Murray River can be transferred to meet Goulburn demand.

2 Low-flow periods following a spring fresh or between summer/autumn pulses are considered tier 1a priorities under all planning scenarios.

5.4.2 Goulburn wetlands

System overview

Within the Goulburn Broken catchment, there are about 2,000 natural wetlands identified, but only six — Doctors Swamp, Gaynor Swamp, Horseshoe Lagoon, Kanyapella Basin, Loch Garry and Reedy Swamp — have received water for the environment through VEWH or CEWH entitlements. Several other small wetlands in the Goulburn catchment have been watered under a separate arrangement through the Murray-Darling Wetlands Working Group.

Doctors Swamp, Gaynor Swamp, Kanyapella Basin, Loch Garry and Reedy Swamp can receive water for the environment through irrigation supply infrastructure. The volume of water that can be delivered to each wetland depends on the physical capacity of the infrastructure and the seasonal allocation. Water for the environment can be delivered from the Goulburn River to Horseshoe Lagoon via a temporary pump.

Environmental values

Many natural wetlands across the Goulburn catchment including Doctors Swamp, Gaynor Swamp, Kanyapella Basin, Loch Garry and Reedy Swamp are formally recognised for their conservation significance. The Goulburn wetlands support a variety of plant communities ranging from river red gum swamps to cane grass wetlands.

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

Gaynor Swamp is a cane grass wetland situated on paleosaline soils: soils formed from historic oceans. The wetland supports thousands of waterbirds including brolga and intermediate egrets when wet. Gaynor Swamp has a higher salt concentration than other wetlands in the region and it attracts a different suite of feeding waterbirds as it draws down. One of the most significant species that feed on exposed mudflats at Gaynor Swamp is the red-necked avocet.

Horseshoe Lagoon is a paleochannel of the Goulburn River that has tall marsh, floodway pond herbland and floodplain streamside woodland vegetation communities. The lagoon supports numerous waterbird species and is home to three species of turtle including the Broad-shelled Turtle.

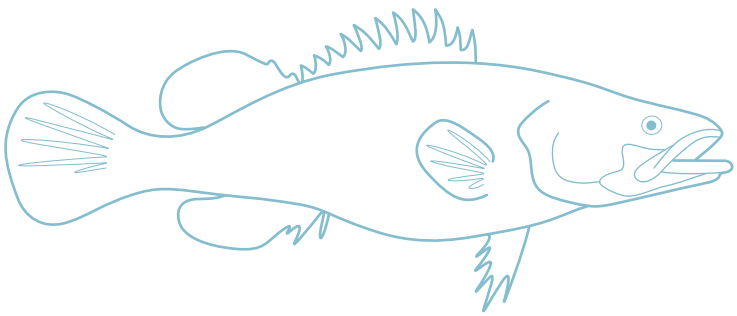
Kanyapella Basin is a shallow, freshwater marsh that provides habitat for numerous plant and animal species including the threatened intermediate egret. Historically, it has been a popular breeding site for ibis, heron and cormorants.

Loch Garry is a paleochannel of the Goulburn River that provides deep, open-water habitat. The channel is surrounded by shallow, vegetated wetland depressions, red gum forest and sand ridges. It is an important site for waterbird feeding and roosting, and it is a drought refuge for eastern great egrets, musk ducks, nankeen night herons and royal spoonbills.

Reedy Swamp contains a mosaic of vegetation types including tall marsh, floodway pond herbland and rushy riverine swamp. It is an important drought refuge, nesting site for colonial waterbirds and stopover feeding site for migratory birds (such as sharp-tailed sandpiper and marsh sandpiper).

Environmental watering objectives in the Goulburn wetlands

	Maintain or increase the diversity and abundance of frog species
	Maintain turtle populations
	Increase the diversity and cover of native wetland plant species consistent with ecological vegetation class benchmarks Reduce the cover and diversity of exotic plants Maintain populations of rigid water-milfoil, slender water milfoil and river swamp wallaby grass
	Provide breeding habitat for waterbirds Provide feeding and roosting habitat for waterbirds



Traditional Owner cultural values and uses

Goulburn Broken CMA sought input from the Taungurung Land and Waters Council and Yorta Yorta Nation Aboriginal Corporation during the development of plans for water for the environment for the Goulburn wetlands. Both groups indicated they support the watering action priorities planned for the year ahead and will continue to work with the CMA to implement these actions while exploring further opportunities to support their cultural values.

Increasing the involvement of Traditional Owners in environmental water planning and management, and ultimately providing opportunities to progress towards self-determination within and beyond the environmental watering program, is a core commitment of the VEWH and its agency partners. This is reinforced by a range of legislation and policy commitments (for example the *Water Act 1989*, the Victorian Aboriginal Affairs Framework, *Water for Victoria* (2016)) and, in some cases, agreements under the *Traditional Owner Settlement Act 2010*. Where Traditional Owners are more deeply involved in the planning and/or delivery of environmental flows for a particular site, their contribution is acknowledged in Table 5.4.3 with an icon. The use of this icon is not intended to indicate that these activities are meeting all the needs of Traditional Owners but is incorporated in the spirit of valuing that contribution, and indicating progress towards this objective.

Watering planned and/or delivered in partnership with Traditional Owners to support cultural values and uses

The Taungurung Land and Waters Council has been involved in planning for water for the environment at Gaynor Swamp and Horseshoe Lagoon. Healing Country and Healing Knowledge are key values outlined in the Cultural and Natural Resource Management Strategy, and they align closely with outcomes achieved with the delivery of water for the environment.

The first delivery of water for the environment to Horseshoe Lagoon in winter 2019 was celebrated by Taungurung women: the lagoon is a significant site and this was an excellent example of working together to protect cultural values and heal Country. The Taungurung water knowledge group Baan Ganalina (Guardians of Water) has worked closely with Goulburn Broken CMA, the VEWH and other partners to bring water back to the lagoon, to restore habitats and see birds and other animals return to the site. The Taungurung Land and Waters Council also participated in the development of the environmental water management plan for the site in 2019. In addition to this, the Taungurung Land and Waters Council has identified that water for the environment assists in:

- supporting the health of cultural values at the site by protecting intangible cultural heritage and valued species, traditional food and medicine plants
- exploring opportunities to reintroduce culturally informed management tools and practices
- supporting and securing access for Taungurung contemporary cultural practices and uses, teaching places, reconnection to Country and camping sites
- actively fulfilling Caring for Country responsibilities through restoring a more natural watering regime to degraded significant sites and rehabilitation of habitat for native species
- supporting contemporary Living Biocultural Knowledge exchange and integration through involvement in natural resource management decisions
- increasing Taungurung water literacy and understanding of conservation and water management within their Country
- increasing Taungurung internal capacity and confidence in water management following self-determination principles via engagement and joint management arrangements with Goulburn Broken CMA and Parks Victoria.

Taungurung has a special interest in the rehabilitation of floodplain wetlands associated with the Goulburn River (*Waring*), but which are now largely disconnected from the main river channel due to the impacts of river flow regulation. Taungurung Land and Waters Council is currently working on assessing habitat conditions at six of the disconnected wetlands. This process and their findings will inform future seasonal watering proposals and planning for water for the environment. Currently, Taungurung is working to enhance habitat conditions for native species in the area, and healthy Country assessments will provide important information about cultural objectives and indicators.

The Yorta Yorta Nation Aboriginal Corporation has been involved in planning for environmental flows at Doctors Swamp, Kanyapella Basin, Loch Garry and Reedy Swamp including by participating in the development of environmental water management plans for the sites.

- Yorta Yorta identified key cultural values at Doctors Swamp. Water for the environment supports *Nardoo* (a food source), native grasses, Old Man Weed (which has medicinal uses) and weaving (using sedges/rushes). Watering also supports a wide range of bird and animal species that provide a variety of cultural values.
- Kanyapella Basin plays an important role in Yorta Yorta's cultural and spiritual connections. It supports the health of cultural values in the landscape (such as Creation Story and traditional food and medicine plants). Before a delivery of environmental flows in winter 2020, Yorta Yorta Peoples conducted a cultural burn at the site, helping to enable direct delivery of the water and help the growth of Old Man Weed.
- Environmental flows delivered to Loch Garry in April 2020 initiated a resurgence of culturally important food, fibre and medicinal plants. Giant rush thrived, providing nesting opportunities for important bird species. The site is rich in cultural values identified by Yorta Yorta, with stone scatters, marked trees and significant sand hills in the higher elevations.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.4.3, Goulburn Broken CMA considered how environmental flows could support values and uses including:

- water-based recreation (such as canoeing)
- riverside recreation and amenity (such as birdwatching, camping, cycling, hiking, photography and walking)
- community events and tourism (such as community birdwatching events, the Nature Scripts Initiative and outdoor classroom learning).

Recent conditions

The Goulburn catchment received above-average rainfall in late winter and early spring 2020 but mostly below-average rainfall over the remainder of 2020-21. Monthly temperatures remained close to the long-term average throughout the year.

Large rain events between autumn and spring 2020 naturally filled or partially filled Doctors Swamp, Horseshoe Lagoon, Loch Garry and Reedy Swamp. Water for the environment was used to water Gaynor Swamp and Kanyapella Basin and to top up Horseshoe Lagoon as required during 2020-21.

Doctors Swamp filled naturally in autumn 2020 and received an additional top-up of water for the environment in May 2020. Water persisted in the deeper areas of the wetland until February 2021. Magpie geese and Sloane's froglet were recorded while it held water.

Gaynor Swamp received water for the environment in 2018 and was allowed to dry out during 2019-20. Water for the environment was used to re-fill the wetland in spring 2020, and subsequent monitoring indicated the watering event triggered flowering of the vulnerable-listed spiny lignum and cane grass and provided foraging habitat for brolga. Lewin's rail was also heard calling at the swamp, which was the first record of the species at this site.

Horseshoe Lagoon filled naturally in autumn 2020. A small volume of water for the environment was used to top up the wetland in September 2020, to protect the nests of eastern long-neck turtles, but unfortunately the nests were then raided by foxes. Additional protections will accompany future watering actions at the lagoon.

Kanyapella Basin was inundated with unregulated flows in 2011-12 and 2016-17, and it received its first delivery of water for the environment in winter 2020. The wetland held water for three months, supporting frogs and aquatic vegetation. Monitoring detected the rigid water-milfoil, which is listed under the *Environment Protection and Biodiversity Conservation Act 1999* and was last recorded at the site in 1982.

Loch Garry and Reedy Swamp filled naturally in April 2020, and water levels were maintained by further rain in late winter and early spring. These natural events meant that environmental watering actions planned for autumn 2021 were not required.

Environmental watering in the Goulburn wetlands in 2020-21 was undertaken in line with an average climate scenario, and all required planned watering actions were achieved.

Scope of environmental watering

Table 5.4.3 describes the potential environmental watering actions in 2021-22, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objective(s) they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.4.3 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Goulburn wetlands

Potential environmental watering action	Expected watering effects	Environmental objectives
Doctors Swamp (partial fill in autumn 2022)	• Inundate the deeper and fringing margins of the swamp to wet and promote the condition and growth of the vegetation • Provide refuge habitat and breeding conditions for frogs • Support plant species used for Yorta Yorta traditional medicines and weaving at a significant cultural site	
Gaynor Swamp (fill in autumn 2022)	• Inundate to less than 1 m depth to promote conditions for vegetation growth and flowering, particularly of southern cane grass and spiny lignum and planted river red gum saplings • Provide nesting, breeding and feeding habitat for waterbirds, in particular for brolga	
Horseshoe Lagoon (partial fill or top-up as required in winter 2021)	• Inundate to the wetland margins to provide soil moisture to maintain wetland vegetation communities by supporting their growth and recruitment • Promote the growth of river swamp wallaby grass • Suppress the growth of weeds • Provide feeding and breeding habitat for turtle populations	
Kanyapella Basin (partial fill in winter 2021)	• Promote diverse vegetation communities to establish • Support the growth of rigid water-milfoil and river swamp wallaby grass populations • Support plant species used for Yorta Yorta traditional medicines and weaving at a significant cultural site	
Loch Garry (partial fill in spring 2021)	• Inundate deeper and fringing wetlands areas to promote and improve the growth of native wetland vegetation communities including threatened flora • Provide feeding and breeding habitat for frogs, turtles and waterbirds • Support plant species used for Yorta Yorta traditional medicines and weaving at a significant cultural site	
Reedy Swamp (fill in autumn 2022)	• Inundate to less than 1 m to promote the growth of and maintain native wetland vegetation • Provide refuge and feeding and breeding habitat for frogs • Support plant species used for Yorta Yorta traditional medicines and weaving at a significant cultural site	

Scenario planning

Table 5.4.4 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Proposed watering actions at Doctors Swamp, Gaynor Swamp, Horseshoe Lagoon, Loch Garry and Reedy Swamp are considered a high priority in 2021-22 under all climate scenarios. All of these wetlands filled naturally or with water for the environment in 2019-20 or 2020-21, and they are currently dry or drying. A short dry phase is beneficial at these wetlands for various ecological processes, but follow-up watering will be needed to consolidate and build on the benefits of recent watering actions.

Native wetland plants were actively planted at Gaynor Swamp and Horseshoe Lagoon in 2020-21, and follow-up watering is required in 2021-22 to ensure those plants survive and become established. The proposed watering actions at Loch Garry and Reedy Swamp are deferred actions from 2020-21, and they are needed in 2021-22 to avoid stressing the plants and animals that rely on those wetlands. Doctors Swamp was mostly dry by February 2021, and it is proposed to be filled in autumn 2022 after it has completed a year in a dry phase.

Watering Kanyapella Basin is considered a high priority under dry and average climate scenarios, to consolidate vegetation outcomes associated with water for the environment in 2020-21. This site would not naturally receive water as often as some of the other Goulburn wetlands, and it is therefore a lower priority under a drought scenario. Goulburn-Murray Water uses Kanyapella Basin as a flood-retarding basin, so deliberate environmental watering is not planned under a wet climate scenario.

Doctors Swamp and Horseshoe Lagoon are likely to fill naturally in 2021-22 under a wet climate scenario and Loch Garry may be used as a flood-retarding basin, but the other wetlands will need to be actively watered with water for the environment unless there is widespread flooding throughout the Goulburn catchment. The potential contribution from natural fills has been factored into the expected volume of water for the environment that will be required for the proposed watering actions in 2021-22.

No specific carryover volume has been identified for the Goulburn wetlands for 2022-23.

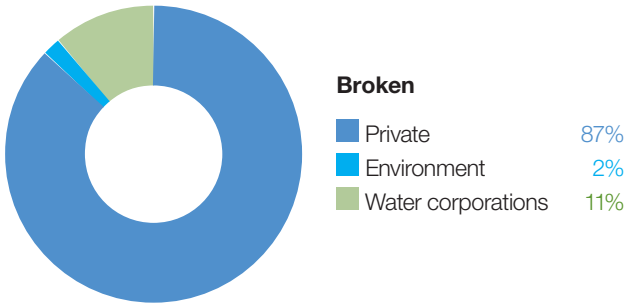
Table 5.4.4 Potential environmental watering for the Goulburn wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Catchment run-off and natural flow into the wetlands are highly unlikely	• Catchment run-off and natural flow into the wetlands are unlikely	• Some catchment run-off and natural flow into some wetlands are likely, particularly in winter/spring	• Catchment run-off and natural flow into the wetlands is likely to partially or completely fill them, particularly during winter/spring
Potential environmental watering – tier 1 (high priorities)[1]	• Doctors Swamp • Gaynor Swamp • Horseshoe Lagoon • Loch Garry • Reedy Swamp	• Doctors Swamp • Gaynor Swamp • Horseshoe Lagoon • Kanyapella Basin • Loch Garry • Reedy Swamp	• Doctors Swamp • Gaynor Swamp • Horseshoe Lagoon • Kanyapella Basin • Loch Garry • Reedy Swamp	• Doctors Swamp • Gaynor Swamp • Horseshoe Lagoon • Loch Garry • Reedy Swamp
Possible volume of water for the environment required to achieve objectives	• 3,220 ML (tier 1)	• 4,220 ML (tier 1)	• 4,020 ML (tier 1)	• 2,100 ML (tier 1)

1 Tier 1 potential environmental watering at the Goulburn wetlands is not classified into tier 1a and 1b, because the water available for use is shared across various systems and it is not possible to reliably estimate supply.

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



Proportion of water entitlements in the Broken basin held by private users, water corporations and environmental water holders on 30 June 2020.

Did you know...?

'The Broken River (and upper Broken Creek) hold many cultural values. Common reed contained within the slack water provides important material for tools, while also providing refuge for culturally important fish species (large and small-bodied). The river also has significant stands of old growth river red gum containing important habitat and exhibiting scars made from carving out canoes and coolamons.'
— *Yorta Yorta Nation Aboriginal Corporation*

Top: Broken Creek, by Goulburn Broken CMA
Above: Murray cod release, by Arthur Rylah Institute

The Broken system includes the Broken River, upper Broken Creek, lower Broken Creek and the Broken wetlands.

5.5.1 Broken River and upper Broken Creek

System overview

The Broken River is a tributary of the Goulburn River, rising in the Wellington-Tolmie highlands and flowing north-west to Benalla and then west for a total distance of 190 km before it joins the Goulburn River near Shepparton (Figure 5.5.1). Lake Nillahcootie is the main storage on the Broken River. It is about 36 km upstream of Benalla and harvests water from the river to support stock and domestic supply and irrigated agriculture. The main tributaries of the Broken River are Hollands Creek, Ryans Creek and Lima East Creek.

Lake Nillahcootie has a storage capacity that is about half the mean annual flow of its upstream catchment, so it fills in most years. The operation of Lake Nillahcootie has modified the river's natural flow pattern: winter/spring flow is less than natural because a large proportion of inflow is harvested, while summer/autumn flow is higher than natural because water is released to meet downstream irrigation demands. These impacts are most pronounced in the reach between Lake Nillahcootie and Hollands Creek. Below Hollands Creek, the river retains a more natural flow pattern, due to flows from unregulated tributaries, although total annual flow is considerably less than natural. The catchment has been extensively cleared for agriculture including dryland farming (such as livestock grazing and cereal cropping) and irrigated agriculture (such as dairy, fruit and livestock).

Water is released from Lake Nillahcootie to meet downstream demand and minimum-flow requirements specified under the bulk entitlement for the Broken River system. Releases from storage may be less than 30 ML per day as tributary inflows immediately below the storage (such as from Back Creek) can supply much of minimum-flow requirements specified in the bulk entitlement.

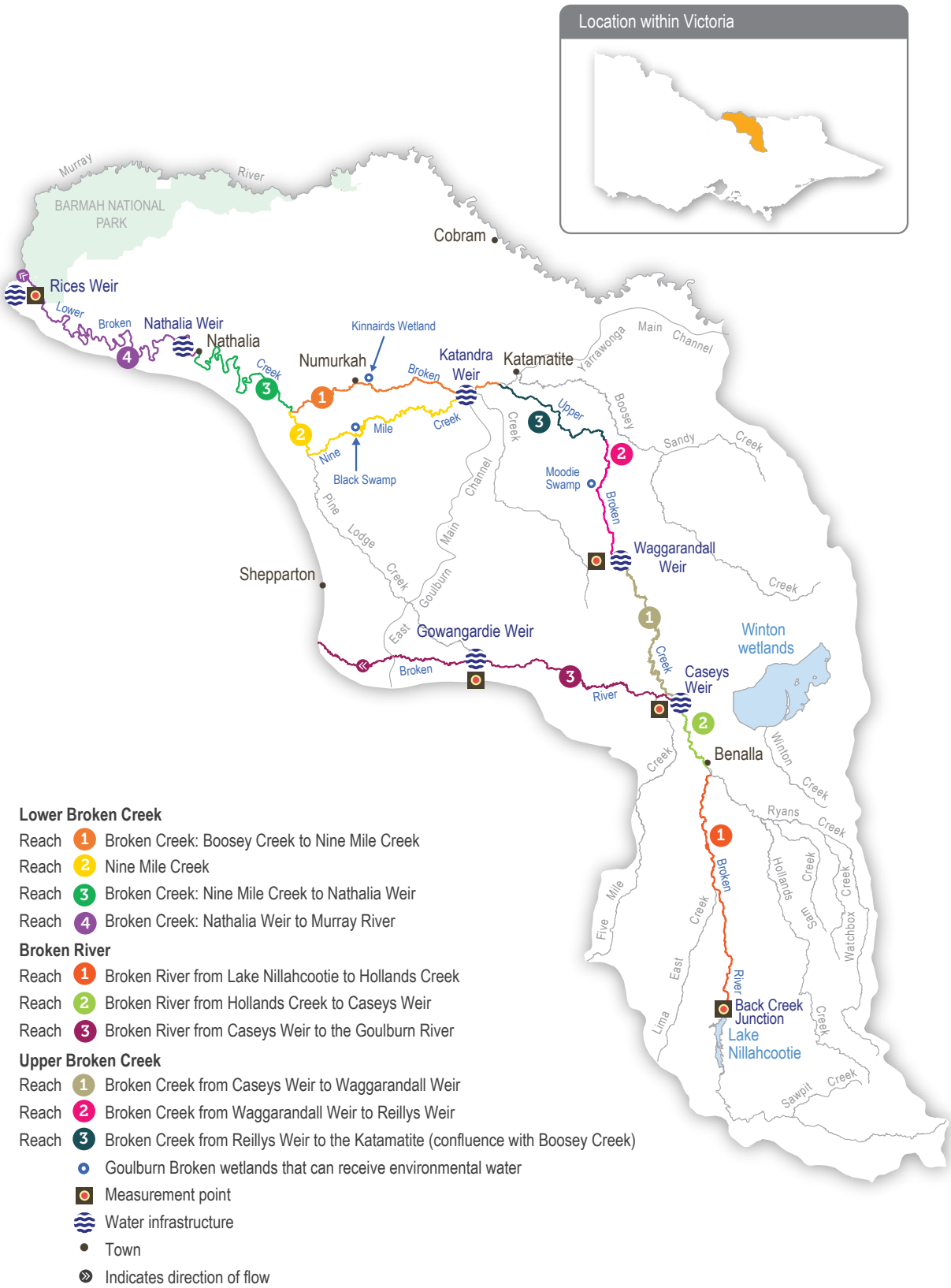
Upper Broken Creek is defined as the 89-km stretch of creek from the Broken River (at Caseys Weir) to the confluence with Boosey Creek near Katamatite. Upper Broken Creek flows across a flat, riverine plain and has naturally low run-off from its local catchment. It receives flood flows from the Broken River, although the frequency of these floods has been reduced by river regulation, earthworks and road construction.

Upper Broken Creek has been regulated for more than a century. Before 2007, water was diverted into upper Broken Creek at Casey's Weir to meet local demand, but recent water savings projects have reduced the demand on the creek. There is now low flow throughout the year between Caseys Weir and Waggarandall Weir. The flow below Waggarandall Weir is mainly influenced by rainfall and catchment run-off. These changes have reduced the amount of permanent aquatic habitat.

Delivery of water for the environment to the Broken River is primarily constrained by the availability of water due to the small volume of Water Holdings in the Broken system. Environmental water holders can trade it into the Broken system from other trading zones subject to relevant limits and conditions, to meet critical environmental needs.

The bulk entitlement for the Broken system held by Goulburn-Murray Water stipulates that minimum environmental flows — also known as passing flows — are to be maintained in the Broken River when there are natural flows into the system. The bulk entitlement also allows Goulburn-Murray Water and the VEWH to agree to reduce minimum flows and to accumulate the unused volumes for later releases that will provide a greater environmental benefit. In recent years, passing flows have been reduced, accumulated and delivered to maintain low flow (on days when there are no passing flows due to no natural flow into the system) and for freshes in the Broken River. In 2020-21, accumulated passing flows were used to supplement the flow in upper Broken Creek for the first time. Accumulated passing flows are the first volumes lost when the storage spills. Environmental flows in upper Broken Creek are restricted by the volume of available supply, channel capacity and the need to avoid flooding low-lying, adjacent land.

Figure 5.5.1 The Broken system



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

Environmental values

The Broken River retains one of the best examples of healthy in-stream vegetation in a lowland river in the region. A range of native submerged and emergent plant species including eelgrass, common reed and water ribbons populate the bed and margins of the river. These plants provide habitat for a range of animals including small- and large-bodied native fish. Murray cod, Macquarie perch, golden perch, silver perch, river blackfish, mountain galaxias and Murray-Darling rainbowfish all occur in the Broken River. The river also supports a large platypus population.

Upper Broken Creek is dominated by unique box streamside vegetation and remnant plains grassy woodland. The creek and its streamside zone support numerous threatened species including brolga, Australasian bittern, buloke and rigid water-milfoil. Much of the high-quality native vegetation in the region is set aside as a natural features reserve. Upper Broken Creek supports a variety of native fish species including carp gudgeon, Murray cod, golden perch and Murray-Darling rainbowfish, as well as platypus and common long-necked turtle.

Both the Broken River and upper Broken Creek are listed in the Directory of Important Wetlands in Australia.

Environmental watering objectives in the Broken River


Increase native fish populations


Turn over bed sediments and scour around large wood to maintain in-channel habitat diversity


Maintain platypus populations


Maintain in-stream vegetation


Maintain a wide range and high biomass of waterbugs to break down dead organic matter and support the river's food web


Maintain water quality

Traditional Owner cultural values and uses

Traditional Owners value implementing more natural flow regimes in the landscape's waterways and wetlands as a way of caring for Country, supporting culturally important plants and providing opportunities to practice culture. Goulburn Broken CMA consulted with the Yorta Yorta Nation Aboriginal Corporation for upper Broken Creek and the Broken River downstream of Benalla, and the Taungurung Land and Waters Council for the Broken River upstream of Benalla.

The Taungurung Land and Waters Council plan to assess cultural values and objectives for the Broken River through healthy Country assessments like Aboriginal Waterway Assessments. These will assist Taungurung Land and Waters Council to identify more specific cultural objectives for the system in future. Taungurung Land and Waters Council has been part of the Broken system advisory group meetings since 2018 and is continuing to work with Goulburn Broken CMA to identify cultural objectives and develop culturally informed recommendations for water for the environment in the Broken system. Water for the environment in the Broken system supports the health of cultural values and landscapes including intangible cultural heritage, valued species and traditional food and medicine plants.

The Yorta Yorta Nation Aboriginal Corporation advised that water for the environment in the Broken River and upper Broken Creek supported the following Yorta Yorta values:

- common reed contained within the slack water provides important material for tools, while also providing refuge for culturally important large and small-bodied fish species
- significant stands of old-growth river red gum containing important habitat and exhibiting scars made from carving-out canoes and coolamons.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.5.1, Goulburn Broken CMA considered how environmental flows could support values and uses including:

- water-based recreation (such as canoeing, fishing, kayaking and swimming)
- riverside recreation (such as birdwatching, bushwalking, camping, duck hunting and picnicking)
- amenity: green spaces are important to the community for wellbeing and mental health
- community events and tourism (such as markets around Benalla Lake)
- socio-economic benefits (such as consumptive water; water for irrigation and stock and domestic use; and water to support terrestrial birds that help control agricultural pests).

Recent conditions

Rainfall and daily maximum temperatures across the Broken catchment in 2020-21 were close to the long-term average. Allocations against high-reliability water shares in the Broken system started the year at 17 percent and rose to 100 percent in October, due to consistent inflows that caused Lake Nillahcootie to fill and spill. Accumulated passing flows carried over from 2019-20 in the Broken River were used to supplement low flow on days when there was no passing flow in the Broken River and to deliver winter/spring low flow in upper Broken Creek before Lake Nillahcootie spilled.

While recent conditions in the Broken catchment aligned with an average climate, water for the environment was managed in the Broken system in line with a dry climate scenario during 2020-21. Due to low operational flows in upper Broken Creek, water for the environment was used to maintain low flow throughout the year in the creek, and there was insufficient water to deliver a fresh. Minimum low-flow targets in all reaches of the Broken River were largely met with a combination of operational releases, tributary inflows and the use of accumulated passing flows. There were several natural freshes between July and October 2020, but recommended summer and autumn freshes could not be delivered, due to limited environmental Water Holdings.

A combination of accumulated passing flows and water for the environment was used to maintain winter and spring low flow in upper Broken Creek until October when the banked passing flows were lost with the spill of Lake Nillahcootie. After October, water for the environment was used (with additional water traded into the system) to meet summer and autumn low flow in upper Broken Creek. This low flow maintained water quality within target levels, so additional summer and autumn freshes were not required.

Scope of environmental watering

Table 5.5.1 describes the potential environmental watering actions in 2021-22, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objective(s) they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

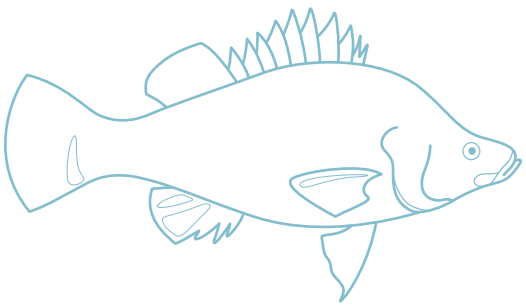
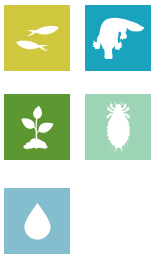


Table 5.5.1 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Broken River and upper Broken Creek

Potential environmental watering action	Expected watering effects	Environmental objectives
Upper Broken Creek (reach 1)		
Winter low flow (1-10 ML/day during June to August) Spring low flow (1-10 ML/day during September to November) Summer low flow (1-5 ML/day during December to February) Autumn low flow (1-5 ML/day during March to May)	• Maintain aquatic habitat and connections between weir pools for native fish and platypus • Inundate benthic surfaces and large wood located in the bottom of the channel, which serves as habitat for waterbugs • Maintain water quality and oxygen levels for native fish, platypus and waterbugs	
Summer/autumn fresh (one fresh of 50-100 ML/day for 10 days during December to May)	• Flush pools to improve their water quality and increase oxygen levels	
Broken River (reach 1, 2 and 3)		
Winter low flow (15-30 ML/day during June to August) Spring low flow (15-30 ML/day during September to November) Summer low flow (15-30 ML/day during December to May) Autumn low flow (15-30 ML/day during March to May)	• Maintain habitat for in-stream and fringing vegetation, and prevent terrestrial vegetation from colonising the stream bed • Maintain riffles, pools and slackwater to provide diverse hydraulic habitat for native fish, aquatic plants, platypus and waterbugs • Maintain water quality and oxygen levels for native fish, platypus and waterbugs	
Summer/autumn fresh (one fresh of 400-500 ML/day for two to five days during December to May)	• Scour sediments around large wood, turn over bed sediments, replenish biofilms and maintain macrophyte habitat • Provide flow cues to stimulate native fish to breed and migrate • Maintain longitudinal connectivity for native fish passage	

Scenario planning

Table 5.5.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

There are two sets of watering actions: one for upper Broken Creek and another for the Broken River. Delivering flow to upper Broken Creek is a higher priority, because upper Broken Creek has no inflows from tributaries and is more reliant on flows from operational deliveries. The potential watering actions for upper Broken Creek require less water than the potential watering actions for Broken River, and any environmental flows delivered to upper Broken Creek will pass through reaches 1 and 2 of the Broken River, where they will provide some environmental benefit.

All potential watering actions in the Broken River and upper Broken Creek are required under all climate scenarios, but there is not enough water for the environment to meet most of the potential actions, and no allocations of water for he environment are expected for the Broken system in 2021-22 under a drought climate scenario. The VEWH may elect to trade water into the system to meet potential watering actions if there is a trade opportunity available.

The main objective of environmental flows for upper Broken Creek is to maintain low flow throughout the year, to maintain water quality and habitat for native fish, platypus, waterbugs and aquatic vegetation. Maintaining adequate flow during spring is particularly important to achieve ecological outcomes, because the native fish, platypus, waterbugs and vegetation are most active and productive at this time. The recommended spring low flow will provide adequate connectivity, habitat and water quality during the breeding seasons of fish and platypus. The small volume of water for the environment expected under a dry climate scenario should be used to deliver the recommended spring low flow, to maintain conditions for aquatic animals. Larger allocations of water for the environment under average and wet climate scenarios should be prioritised for summer low flow, to reduce the risk of poor water-quality outcomes during warmer weather.

Year-round low flow is needed to support the environmental objectives for the Broken River, but there is little capacity to do so with environmental water, especially under drought and dry climate scenarios. Operational deliveries and natural tributary inflows will likely meet a large proportion of the recommended flow in the Broken River under average and wet climate scenarios, but water for the environment may be used to supplement the recommended low flow or summer/autumn freshes if needed.

The small environmental entitlement in the Broken system will be prioritised for use in 2021-22, and no carryover target has been set for 2022-23.

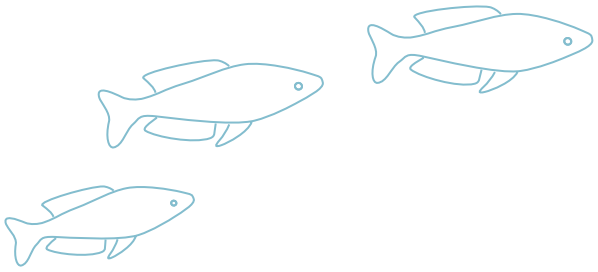
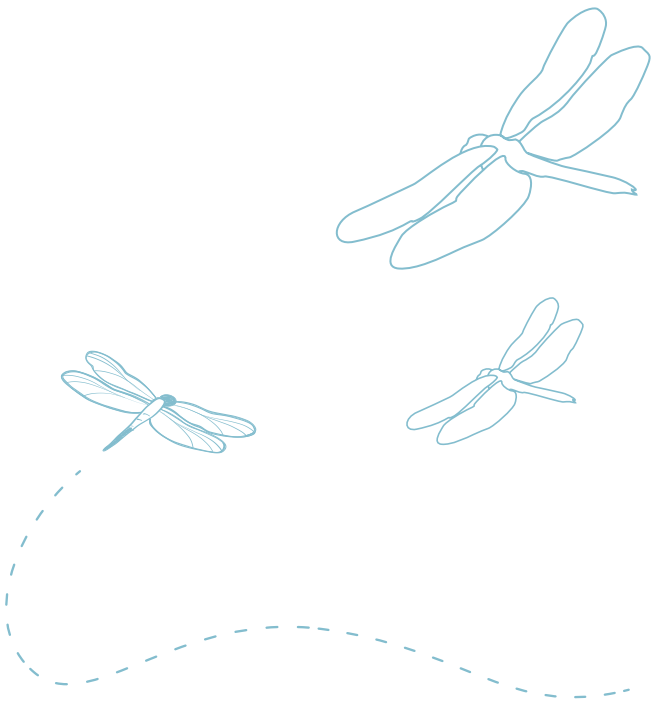


Table 5.5.2 Potential environmental watering for the Broken River and upper Broken Creek under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No unregulated winter/spring flow in Broken River • No natural flow in upper Broken Creek • Low and cease-to-flow events possible throughout the year in all reaches	• Low, unregulated flows and odd freshes in Broken River • No natural flow in upper Broken Creek • Low and cease-to-flow events possible throughout the year in all reaches	• High winter/spring flow in Broken River • Some natural winter/spring flow in upper Broken Creek	• High winter/spring flow in the Broken River • Winter/spring freshes in upper Broken Creek
Predicted supply of water for the environment	• 0 ML	• 226 ML	• 647 ML	• 647 ML
Upper Broken Creek (targeting reach 1)				
Potential environmental watering – tier 1 (high priorities)	**Tier 1a (can be achieved with predicted supply)**			
	• N/A	• Spring low flow (partial)	• Spring low flow • Summer low flow (partial)	• Spring low flow • Summer low flow (partial)
	Tier 1b (supply deficit)			
	• Winter low flow • Spring low flow • Summer low flow • Summer/autumn fresh (as required) • Autumn low flow	• Winter low flow • Spring low flow (remaining volume) • Summer low flow • Autumn low flow • Summer/autumn fresh (as required)	• Winter low flow • Summer low flow (remaining volume) • Autumn low flow • Summer/autumn fresh (as required)	• Winter low flow • Summer low flow (remaining volume) • Autumn low flow • Summer/autumn fresh (as required)
Potential environmental watering – tier 2 (additional priorities)	• N/A			

Table 5.5.2 Potential environmental watering for the Broken River and upper Broken Creek under a range of planning scenarios *(continued)*

Planning scenario	Drought	Dry	Average	Wet
Broken River (targeting reach 1, 2 and 3)				
Potential environmental watering – tier 1 (high priorities)	**Tier 1a (can be achieved with predicted supply)**			
	• N/A		• Winter low flow • Spring low flow • Summer low flow • Autumn low flow	• Winter low flow • Spring low flow • Summer flow • Autumn low flow • Summer/autumn fresh
	Tier 1b (supply deficit)			
	• Winter low flow • Spring low flow • Summer low flow • Autumn low flow	• Winter low flow • Spring low flow • Summer low flow • Summer/autumn fresh • Autumn low flow	• Summer/autumn fresh	• N/A
Potential environmental watering – tier 2 (additional priorities)	• N/A			
Possible volume of water for the environment required to achieve objectives	• 0 ML (tier 1a) • 6,676 ML (tier 1b)	• 226 ML (tier 1a) • 11,450 ML (tier 1b)	• 647 ML (tier 1a) • 7,791 ML (tier 1b)	• 647 ML (tier 1a) • 353 ML (tier 1b)



5.5.2 Lower Broken Creek

System overview

The Lower Broken Creek system is found with in Yorta Yorta country and their knowledge is evident throughout the landscape. The lower Broken Creek system includes the section of Broken Creek that flows from the confluence of Boosey Creek near Katamatite to the Murray River; and Nine Mile Creek, which is an anabranch of lower Broken Creek that flows from the East Goulburn Main Channel to below Numurkah.

Lower Broken and Nine Mile creeks have been regulated for over a century. Before regulation, the creeks would have had most of their flow in winter/spring and contracted to isolated pools or dried out during summer/autumn. The adjacent floodplain would have also flooded regularly. The creeks now have numerous weirs that maintain a relatively constant flow from mid-August until mid-May to support irrigated agriculture and little flow during the non-irrigation season. These modifications have changed the way native species use the creek and have introduced invasive species such as arrowhead (*Sagittaria graminea*). Previously, native fish would have moved into the creek when it was flowing and returned to the Murray River as it dried. Both creeks now provide year-round habitat for native fish, and fish passage structures allow fish to move between weir pools. Water for the environment is used to support these permanent fish habitats, by providing flows to trigger fish movement and support fish passage, encourage the growth of native plants, promote in-stream productivity, control water quality and flush the water fern azolla as necessary.

Regulated water is delivered to lower Broken Creek from the Goulburn and Murray systems via the irrigation channel network. Lower Broken Creek is operated separately from upper Broken Creek and Broken River, which are both supplied from Lake Nillahcootie on upper Broken River.

Water for the environment can be provided to lower Broken Creek from the Goulburn system through the East Goulburn Main Channel and from the Murray system through the Yarrawonga Main Channel. Water is released into lower Broken Creek from several irrigation regulators along the length of lower Broken Creek. The main priority for environmental flows in the lower Broken Creek system is to maintain minimum flows throughout the year. Particular attention is given to reaches 1 and 2 during the non-irrigation season when flow can stop. The next priority is to deliver freshes in winter/spring to trigger fish movement and spawning, maintain water quality and manage azolla accumulations in reaches 3 and 4. The measurement point for environmental flows in lower Broken Creek is at Rices Weir.

Some of the environmental flow targets for lower Broken Creek are partly or wholly met by operational water releases — inter-valley transfers (IVTs) from the Goulburn to the Murray or Barmah Choke bypass flows — that are delivered to meet downstream demands. These operational deliveries mainly occur during peak irrigation demand between spring and autumn. Water for the environment may be used to supplement these operational releases and to deliver recommended flow components that are not met by operational releases.

Environmental values

Lower Broken Creek and Nine Mile Creek support a diverse and abundant native fish community including the threatened Murray cod, golden perch, silver perch, unspecked hardyhead and Murray-Darling rainbowfish.

Sections of lower Broken and Nine Mile creeks have been reserved as state park and natural feature reserves. The associated floodplain and wetland habitats support box-dominated grassy woodland communities and numerous species of state and national conservation significance including river swamp wallaby grass and the Australasian bittern.

Environmental watering objectives in lower Broken Creek

	Protect and increase native fish populations including the threatened Murray cod, golden perch and silver perch
	Protect platypus populations, particularly outside the irrigation season Protect rakali (water rat) populations, particularly outside the irrigation season
	Protect turtle populations, particularly outside the irrigation season
	Avoid the excessive build-up of azolla Promote the cover and condition of native in-stream and littoral vegetation communities
	Increase the diversity and abundance of waterbug populations
	Maintain oxygen levels suitable for aquatic animals

Traditional Owner cultural values and uses

Goulburn Broken CMA consulted with the Yorta Yorta Nation Aboriginal Corporation (YYNAC) during the planning of deliveries of water for the environment in lower Broken Creek. The following cultural values were identified for lower Broken Creek.

"The Broken Creek holds many cultural values. Common reed contained within the slack water provides important material for tools whilst also providing refuge for culturally important fish species (large and small-bodied). The creek also has significant stands of old growth river red gum containing important habitat and exhibiting scars made from carving out canoes and coolamons" (YYNAC, 4 March 2021).

Yorta Yorta Nation Aboriginal Corporation continues to pursue their inherent rights to water for country to improve their spiritual, cultural, environmental, social and economic needs *Yorta Yorta Whole of Country Plan 2021-2030*, (YYNAC).

The environmental objectives in the lower Broken Creek seasonal watering proposal are supported by Yorta Yorta and align with their values of caring for Country. Flows have been specifically targeted to support in-stream vegetation and native fish, along with other aquatic biota. The Goulburn Broken CMA will continue to work with Yorta Yorta people to identify how the management of water for the environment can best support water for their country, enhancing cultural values.

Yorta Yorta Nation Aboriginal Corporation has raised concerns around flow regulation in all their waterways, which is having an impact on their country and cultural knowledge.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.5.3, Goulburn Broken CMA considered how environmental flows could support values and uses including:

- water-based recreation (such as canoeing, fishing, game hunting and kayaking)
- riverside recreation and amenity (such as aesthetic and amenity values that are particularly important for the community's mental health and wellbeing during dry periods, and passive recreation)
- socio-economic benefits (such as consumptive water users, Goulburn-Murray Water irrigators and diverters and Goulburn Valley Water customers).

Recent conditions

The Goulburn Broken region experienced average rainfall and above-average temperatures for most of 2020-21. Unregulated flow from upper Broken Creek provided minimal contribution to lower Broken Creek throughout the season, but inflows to Goulburn and Murray storages that supply lower Broken Creek saw high-reliability entitlements reach 100 percent allocation by November and February respectively.

Flow in lower Broken Creek was restricted during winter 2020-21 due to maintenance works on the Yarrawonga Main Channel and the East Goulburn Main Channel. The flow dropped below the recommended winter target of 40 ML per day in all reaches, and fishways were closed between May and June 2020 to maintain water levels in the weir pools. Extended high flows were delivered from the start of the irrigation season in August 2020, which helped flush accumulated azolla through the system. Water for the environment was used to deliver a fresh in September 2020, to cue native fish movement. This was followed by a period of stable, high flow to optimise available habitat during the Murray cod breeding season. IVTs from the Goulburn system, Barmah Choke bypass flows and other operational transfers to the Murray system maintained an average flow of about 380 ML per day (with peaks up to 540 ML per day) in lower Broken Creek from mid-November 2020 to early autumn 2021. Water for the environment was delivered in conjunction with operational deliveries from late March 2021, to maintain a flow of about 200 ML per day until the end of the irrigation season.

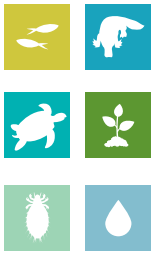
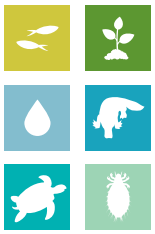
Deliveries of water for the environment in lower Broken Creek were managed in line with an average climate scenario during 2020-21. All planned environmental watering actions from spring 2020 until May 2021 were partially or fully achieved, but the inability to meet the minimum winter low-flow target for the second consecutive year has potentially compromised some environmental objectives for young-of-year fish and platypus. Any channel maintenance works that prevent the delivery of minimum low-flow targets outside the main irrigation season in 2021-22 will further compromise these environmental objectives.

There is little ecological monitoring in lower Broken Creek, but members of the Broken Environmental Water Advisory Group and other community members have reported a marked improvement in water quality since targeted deliveries of water for the environment started in 2010-11. There are also anecdotal reports of improvements to the native fish population. Higher flows associated with IVTs and Murray bypass deliveries help maintain oxygen levels in the creek, but their impact on bank health is a potential concern, and it is currently being investigated.

Scope of environmental watering

Table 5.5.3 describes the potential environmental watering actions in 2021-22, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objectives they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.5.3 Potential environmental watering actions, expected watering effects and associated environmental objectives for lower Broken Creek

Potential environmental watering action	Expected watering effects	Environmental objectives
Winter low flow (20-40 ML/day during May to August)[1]	• Provide native fish with passage through fish ladders • Provide suitable foraging habitat for platypus and rakali (water rats), and support the movement of juveniles of both species • Provide habitat for turtles including protection from exposure to the cold in winter • Provide flowing-water habitat and avoid winter drying of weir pools for fish, vegetation, waterbugs, platypus and turtles • Maintain water over submerged aquatic plants, so they are protected from drying and frosting • Reduce the stagnation of weir pools and maintain suitable oxygen concentrations	
Spring/summer/autumn low flow (70-150 ML/day in reaches 1 and 2 and 200 to 250 ML/day in reaches 3 and 4 during July to May)	• Provide habitat for native fish, platypus, rakali, turtles and waterbugs • Support the movement and recruitment of fish • Mobilise azolla and maintain oxygen levels in summer	
Winter/spring fresh(es) (one to three freshes of 300-450 ML/day for one to two weeks during July to September)	• Flush and mobilise azolla if it has accumulated, to maintain water quality • Trigger the movement and spawning of fish • Encourage the germination and growth of littoral and in-stream vegetation	

1 This flow may be difficult to achieve when channel maintenance work is being completed. If maintenance work is required, waterway managers will work with the storage manager to minimise impacts where possible. Possible mitigation actions include adjusting weir pool levels ahead of planned maintenance work and scheduling works to minimise the duration of impacts on flow.

Scenario planning

Table 5.5.4 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The high degree of regulation in the lower Broken Creek system means flow patterns in the lower Broken and Nine Mile creeks is the same under most climate scenarios. Water for the environment in the lower Broken Creek system is primarily used to guard against reduced flow during the non-irrigation season.

The potential watering actions under all climate scenarios include maintaining flow above 40 ML per day outside the irrigation season, ameliorating sudden fluctuations in irrigation demand during the irrigation season and delivering spring freshes to trigger fish movement or flush excessive accumulations of azolla.

A carryover target of 5,000 ML applies under all climate scenarios, to ensure minimum low flow and also that a small fresh can be delivered in 2022-23.

Table 5.5.4 Potential environmental watering for lower Broken Creek under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No unregulated flow in winter • No unregulated flow throughout the irrigation season (mid-August to May) • No diversion of unregulated Murray River flow available	• Some unregulated flow in winter • No unregulated flow throughout the irrigation season (mid-August to May) • No diversion of unregulated Murray River flow available	• Unregulated flow in winter/spring • Unregulated flow unlikely during October to May • Diversion of unregulated Murray River flow available during mid-August to October	• Unregulated flow in winter/spring • Unregulated flow unlikely during November to May • Diversion of unregulated Murray River flow available during mid-August to November
Potential environmental watering – tier 1 (high priorities)[1]	• Winter low flow • Spring/summer/autumn low flow • Winter/spring freshes			
Possible volume of water for the environment required to achieve objectives	• 45,000 ML			
Priority carryover requirements	• 5,000 ML			

1 Tier 1 potential environmental watering for the lower Broken Creek is not classified as tier 1a or 1b because the water available for use is shared across various systems, and it is not possible to reliably determine the supply specifically available for lower Broken Creek.

5.5.3 Broken wetlands

System overview

Of some 2,000 natural wetlands in the Goulburn Broken area, only three in the Broken catchment have infrastructure that allows them to receive environmental water: Black Swamp, Kinnairds Wetland and Moodie Swamp.

These wetlands are found on Yorta Yorta country, whose knowledge is evident throughout the landscape. Kinnairds Wetland and Black Swamp are red gum swamps near Numurkah. Moodie Swamp is a cane grass wetland adjacent to upper Broken Creek at Waggarandall that provides excellent breeding habitat for brolga.

The water regimes of these wetlands are influenced by their position in the landscape. The development and operation of the Shepparton and Murray Valley irrigation districts have changed the natural flow paths and the timing, frequency, volume and duration of natural flooding to these and other wetlands in the region. Existing irrigation system infrastructure enables water for the environment to be delivered to the three nominated wetlands, but under existing agreements, irrigation deliveries have priority within the channel system. This limits the volume of water that can be delivered to the wetlands, but the VEWH, waterway managers and storage managers adjust the timing and rate of environmental deliveries where possible to optimise environmental outcomes within current system constraints.

Environmental values

Moodie Swamp, Kinnairds Wetland and Black Swamp support a high diversity of vegetation communities ranging from river red gum to cane grass dominated. The wetlands contain state and nationally threatened vegetation communities and species including ridged water milfoil and river swamp wallaby grass. The wetlands also provide food resources and breeding habitat for bird species of high conservation significance (such as eastern great egret, Latham's snipe, white-bellied sea eagle, Australasian bittern, brolga, royal spoonbill, yellow-billed spoonbill, Australasian shoveler and glossy ibis). Many of these species are listed in international agreements and conventions.

Environmental watering objectives in the Broken wetlands

- Maintain or improve the cover, diversity, recruitment/regeneration and growth of native wetland plant species consistent with ecological vegetation class benchmarks
- Reduce the cover and diversity of exotic plant species
- Maintain populations of rigid water-milfoil

- Provide breeding habitat for waterbirds
- Provide feeding and roosting habitat for waterbirds

Traditional Owner cultural values and uses

Goulburn Broken CMA consulted with the Taungurung Land and Waters Council and Yorta Yorta Nation Aboriginal Corporation during the planning of deliveries of water for the environment in the Broken system. Currently, water for the environment can only be delivered to Broken wetlands in Yorta Yorta Country.

The Yorta Yorta Nation Aboriginal Corporation and Goulburn Broken CMA are working to ensure that planned watering actions at Black Swamp, Kinnairds Wetland and Moodie Swamp align with the conservation and protection of cultural sites and allow for connection to Country and establishing strong linkages. The Yorta Yorta Nation Aboriginal Corporation has been involved in planning through online meetings and on-Country visits and by providing content for, reviewing and endorsing the Broken wetlands seasonal watering proposal.

Increasing the involvement of Traditional Owners in environmental water planning and management, and ultimately providing opportunities to progress towards self-determination within and beyond the environmental watering program, is a core commitment of the VEWH and its agency partners. This is reinforced by a range of legislation and policy commitments (for example the *Water Act 1989*, the Victorian Aboriginal Affairs Framework, *Water for Victoria* (2016)) and, in some cases, agreements under the *Traditional Owner Settlement Act 2010*. Where Traditional Owners are more deeply involved in the planning and/or delivery of environmental flows for a particular site, their contribution is acknowledged in Table 5.5.5 with an icon. The use of this icon is not intended to indicate that these activities are meeting all the needs of Traditional Owners but is incorporated in the spirit of valuing that contribution, and indicating progress towards this objective.

Watering planned and/or delivered in partnership with Traditional Owners to support cultural values and uses

Black Swamp, Kinnairds Wetland and Moodie Swamp have significant diversity within the landscape, multiple varieties of *Nardoo* (a food source), native grasses such as Old Man Weed, *sneezeweed*, (medicinal) and basket weaving sedges/rushes are in the area. The sites support a wide array of bird life and other animals that provide a variety of cultural values including for food and clothing. At Black Swamp, there is also evidence of cooking mounds around the perimeter.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.5.5, Goulburn Broken CMA considered how environmental flows could support values and uses including:

- water-based recreation (such as canoeing)
- riverside recreation and amenity (such as birdwatching, camping, picnicking, photography and walking)
- community events and tourism (such as Walk and Squawk)
- socio-economic benefits (such as tourism).

If the timing or management of planned environmental flows may be modified to align with a community benefit, this is acknowledged in Table 5.5.5 with the following icon.

Watering planned to support waterbird-related recreational activities

Environmental flows will provide a winter/spring fill at Kinnairds Wetland, improving the growth of vegetation at the site and enhancing its amenity and aesthetics for locals and tourists. The fill will be timed to ensure conditions are optimal for 'Walk and Squawk', an event that aims to improve the community's understanding of the ecology, flora and fauna at the site.

Recent conditions

The Broken catchment had very high rainfall in autumn 2020, but rainfall and temperatures throughout 2020-21 were close to the long-term average.

Black Swamp and Kinnairds Wetland were partially filled using water for the environment in autumn 2020, and they held water for three and five months respectively. Moodie Swamp filled naturally in autumn 2020 and held water until November 2020. These watering events triggered the germination and growth of wetland plants at all three wetlands, and brolga were observed feeding and courting at Moodie Swamp during its wet phase.

All three wetlands are ephemeral systems that rely on wet and dry phases to support various ecological processes. No water for the environment was delivered to any of the Broken wetlands in 2020-21, to allow them to draw down and dry. Planned watering actions in 2021-22 will stimulate wet-phase processes and prevent wetland vegetation communities from exceeding their optimal dry-phase duration.

Scope of environmental watering

Table 5.5.5 describes the potential environmental watering actions in 2021-22, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objective(s) they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.5.5 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Broken wetlands

Potential environmental watering action	Expected watering effects	Environmental objectives
Black Swamp (partial fill in winter/spring and top-up as required)	• Promote the growth of planted river red gum saplings and improve the condition of Red Gum Swamp Ecological Vegetation Class (EVC) vegetation including river swamp wallaby grass	
Kinnairds Wetland (fill in winter/spring)	• Promote the growth and improve the condition of Red Gum Swamp EVC and Plains Grassy Wetland EVC vegetation including rigid water-milfoil	
Moodie Swamp (fill in autumn and top-up as required)	• Promote the growth and improve the condition of Cane Grass Wetland EVC vegetation • Promote the growth of rigid water-milfoil • Provide feeding, nesting and breeding habitat for brolga and other waterbird species	

Scenario planning

Table 5.5.6 outlines the potential environmental watering and expected water use under a range of planning scenarios.

A partial fill of Black Swamp and a complete fill of Kinnairds Wetland in winter/spring are high priorities under all climate scenarios, because the vegetation communities at each site will have reached the end of their optimal dry phases. Without the proposed watering actions, the condition of Red Gum Swamp EVC at both sites and Plains Grassy Wetlands EVC at Kinnairds Wetland may decline.

The optimal dry-phase duration for Moodie Swamp is between 15 and 30 months. Filling the wetland in autumn 2022 is likely to benefit native vegetation and waterbirds, but the proposed watering action could be delayed until 2022-23 without causing significant environmental harm. Moodie Swamp may be opportunistically watered in autumn 2022 if water is available, to reduce the need to water it in 2022-23.

Table 5.5.6 Potential environmental watering for the Broken wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Catchment run-off and natural flow into the wetlands are highly unlikely	• Catchment run-off and natural flow into the wetlands are unlikely	• Some catchment run-off and natural flow into some of the wetlands are likely, particularly in winter/spring	• Catchment run-off and natural flow into the wetlands may significantly contribute to water levels in the wetlands, particularly during winter/spring
Potential environmental watering – tier 1 (high priorities)[1]	• Black Swamp • Kinnairds Wetland	• Black Swamp • Kinnairds Wetland	• Black Swamp • Kinnairds wetland	• Black Swamp • Kinnairds wetland
Potential environmental watering – tier 2 (additional priorities)	• Moodie Swamp	• Moodie Swamp	• Moodie Swamp	• Moodie Swamp
Possible volume of water for the environment required to achieve objectives	• 680 ML (tier 1) • 1,000 ML (tier 2)	• 680 ML (tier 1) • 1,000 ML (tier 2)	• 680 ML (tier 1) • 1,000 ML (tier 2)	• 0 ML (tier 1) • 700 ML (tier 2)

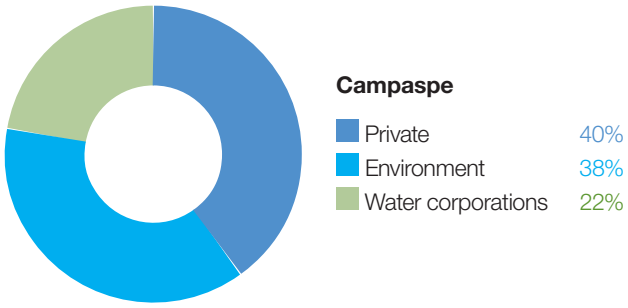
1 Tier 1 potential environmental watering at the Broken wetlands is not classified into tier 1a and 1b, because the water available for use is shared across various systems and it is not possible to reliably estimate supply.

5.6 Campaspe system

Waterway manager – North Central Catchment Management Authority

Storage manager – Goulburn-Murray Water

Environmental water holders – Victorian Environmental Water Holder (including the Living Murray program), Commonwealth Environmental Water Holder



Proportion of water entitlements in the Campaspe basin held by private users, water corporations and environmental water holders on 30 June 2020.

Did you know...?

Taungurung's Baan Ganalina Advisory Group and Dja Dja Wurrung's Kapa Gatjin Advisory Group recently completed an Aboriginal waterway assessment along the Campaspe River. This will help feed into future water management plans, and it highlights valuable ways to collaboratively work together to understand how environmental values and cultural values align.

Top: Campaspe River, by Arthur Rylah Institute
Above: Campaspe River aquatic vegetation, by the VEWH

The Campaspe system includes the Campaspe River and Coliban River.

5.6.1 Campaspe River

System overview

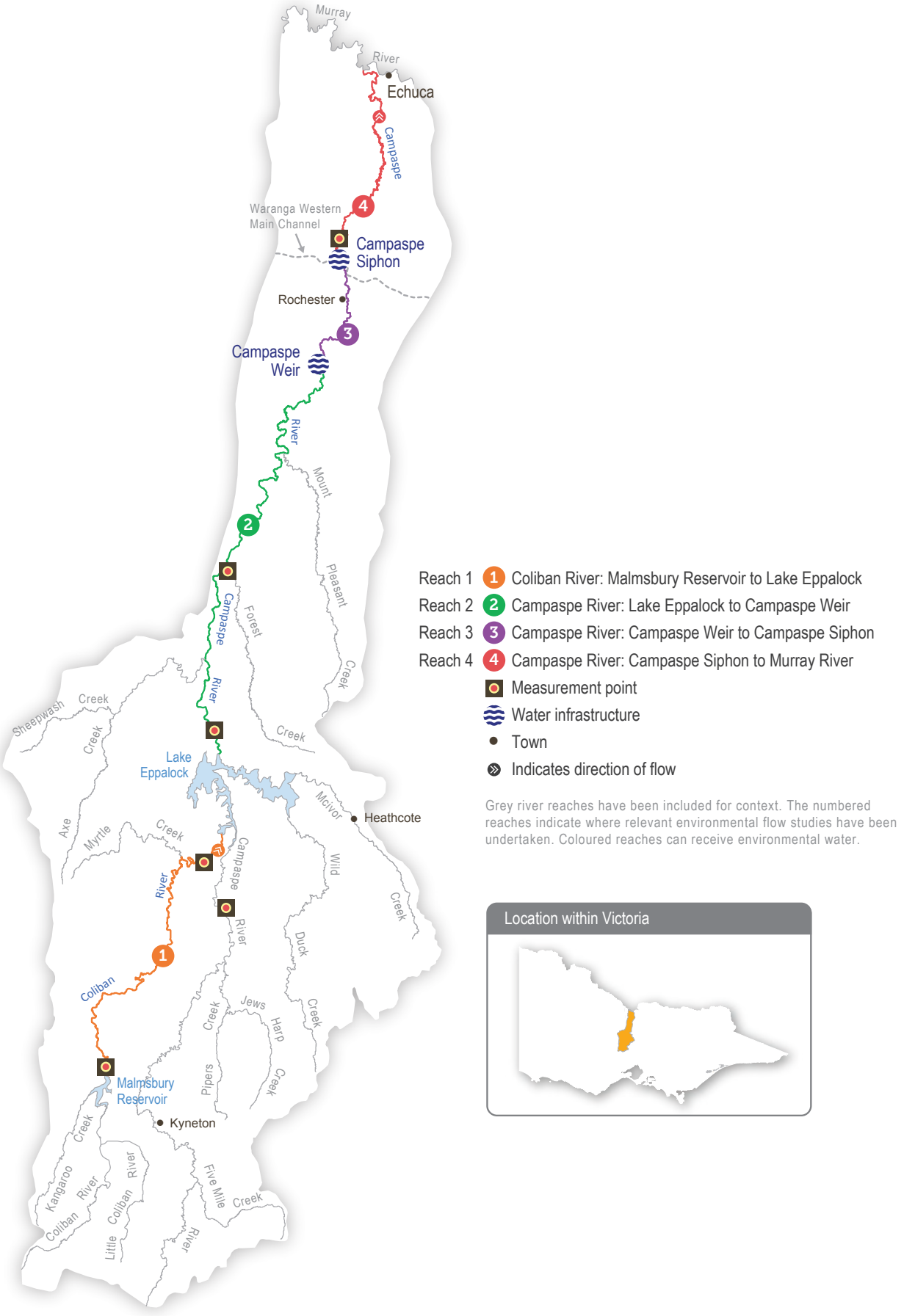
Natural inflows in the upper Campaspe River catchment are harvested into Lake Eppalock, which is located near the townships of Axedale and Heathcote. The main tributaries of the Campaspe River are the Coliban River, McIvor and Wild Duck creeks above Lake Eppalock and Mount Pleasant, Forest and Axe creeks below Lake Eppalock (Figure 5.6.1). Below Lake Eppalock, the major in-stream structure is the Campaspe Weir, which was built to divert water to the Campaspe Irrigation District. It is no longer used for water diversion but is a barrier to fish migration. Higher flows spill over the weir. The Campaspe Siphon, just below Rochester, is part of the Waranga Western Channel, which carries water from the Goulburn system to western Victoria. Water can be released from the Waranga Western Channel into the lower reaches of the Campaspe River, but the siphon is another barrier to fish migration when there is low-to-moderate flow.

The flow below Lake Eppalock is largely influenced by releases from storage and the operation of the Campaspe Weir and the Campaspe Siphon. The Campaspe's major tributary (the Coliban River) flows through the three Coliban Water storages (the Upper Coliban, Lauriston and Malmsbury reservoirs) before reaching Lake Eppalock. Water for the environment is held and released from Lake Eppalock, with some limited ability to regulate flow further downstream at the Campaspe Weir.

Water for the environment is released from Lake Eppalock to support aquatic plants and animals in and along the Campaspe River. It can be supplemented by water for the environment delivered via the Waranga Western Channel at the Campaspe Siphon, which provides important flexibility to meeting reach 4 demands. Water for the environment is primarily used to improve the magnitude and variability of flows during winter and spring. Primary flow measurement points are at Barnadown (reach 2) and below the Campaspe Siphon (reach 4).

Goulburn-Murray Water transfers operational water from Lake Eppalock or through Waranga Western Channel to customers in the Murray River and to downstream storages (such as Lake Victoria). These inter-valley transfers (IVTs) usually occur in summer and autumn and, depending on the rate of delivery, can either support or compromise environmental flows objectives. High IVT flows delivered at a time when the Campaspe River would naturally have a low flow 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. Sustained high IVT flows in summer can also drown recruiting streamside vegetation. Storage managers and the North Central CMA have been working cooperatively to enhance the positive effects and limit the negative effects of IVTs on native plants and animals in the Campaspe River. For example, IVTs are sometimes delivered in a pattern that meets summer low flow and fresh requirements, thereby reducing demand on the environmental entitlement. IVTs have also been released in a pattern to support native fish migration from the Murray River into reach 4 of the Campaspe River, without affecting delivery to downstream users.

Figure 5.6.1 The Campaspe system



Environmental values

The Campaspe River below Lake Eppalock provides important habitat for several native fish species including Murray cod, silver perch, golden perch, Murray-Darling rainbowfish and flat-headed gudgeon. Murray-Darling rainbowfish were presumed lost from the system during the Millennium drought, but since 2011, they have been recorded at many sites on the Campaspe River and are now abundant below Elmore. Environmental flows help native fish migrate and disperse throughout the Campaspe system.

Platypus, rakali (water rats), turtles and frogs are also present along the length of the Campaspe River. The streamside vegetation zone is narrow and dominated by large, mature river red gum trees that support wildlife (such as the swift parrot and squirrel glider).

Environmental watering objectives in the Campaspe River

	Protect and increase populations of native fish Facilitate recolonisation by native fish species that have been presumed lost
	Protect the resident platypus population
	Maintain adult river red gums and increase the recruitment of immature trees Maintain the extent and increase the diversity of streamside vegetation Increase the extent of in-stream aquatic plants
	Increase the diversity and biomass of waterbugs
	Maintain water quality in deep pools and prevent stratification in summer Reduce the risk of hypoxic blackwater events in summer

Traditional Owner cultural values and uses

In planning for environmental flows in the Campaspe River, North Central CMA has worked with Dja Dja Wurrung Clans Aboriginal Corporation, Taungurung Land and Waters Council and Yorta Yorta Nation Aboriginal Corporation to discuss how cultural values and uses can be supported by environmental water and the importance of Traditional Owner involvement in environmental water management. These discussions included:

- meetings between Dja Dja Wurrung Clans Aboriginal Corporation's Kapa Gatjin (water advisory) Group and North Central CMA. Kapa Gatjin expressed their aspirations and environmental objectives for the Campaspe River. Dja Dja Wurrung Traditional Owners have highlighted the significance of native fish, turtles, medicine plants and pest control.
- meetings between Taungurung Clan Aboriginal Corporation's Baan Ganalina Advisory Group and North Central CMA. Baan Ganalina have highlighted the importance of native fauna and identified the importance of overstorey, mid-layer and aquatic vegetation in creating healthy habitat and preventing flows that might erode or damage cultural sites.
- regular meetings between the Yorta Yorta Nation Aboriginal Corporation Consultation group and Goulburn Broken, North East and North Central CMAs, where the three CMAs and the Yorta Yorta representatives discussed CMA activities on Country. Yorta Yorta Traditional Owners have raised concerns regarding the impacts of groundwater extraction on river flows and gold mining in the Campaspe Valley, and support flows that will mitigate the impacts of consumptive water delivery over summer and provide conditions to improve habitat for platypus breeding.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.6.1, North Central CMA considered how environmental flows could support values and uses including:

- water-based recreation (such as canoeing, kayaking, fishing and water sports)
- riverside recreation and amenity (such as birdwatching, bushwalking, camping, cycling, duck hunting and picnicking)
- community events and tourism (such as visitors travelling to canoe and kayak on the river)
- socio-economic benefits (such as diversions for irrigation, domestic and stock uses, local and regional economic benefits from increased visitation, ecosystem services [such as carbon storage, groundwater recharge and water-quality regulation], lower salinity costs and blackwater and blue-green algae risks for landholders, and contributions to community enjoyment, health and recuperation).

If the timing or management of planned environmental flows may be modified to align with a community benefit, this is acknowledged in Table 5.6.1 with the following icon.

Watering planned to support peaks in visitation (e.g. camping or other public activities on long weekends or school holidays)

There are many places along the Campaspe River where visitors can camp. Aysons Reserve is a very popular camping site near Elmore, and it draws hundreds of campers during the autumn school holiday period. Where possible, delivery of summer/autumn freshes will be timed to improve river conditions for campers and for water-related activities during peak visitation periods (such as the March and April long weekends).

Recent conditions

Rainfall in the Campaspe River region in 2020-21 was close to the long-term average, with above-average rainfall and catchment inflows in August 2020, October 2020 and January 2021. Temperatures were also close to average overall: November was exceptionally hot, but December and January were cooler than average. Allocations against high-reliability water shares in the Campaspe system were 32 percent at the start of 2020-21 and increased to 100 percent in October 2020.

Water for the environment was used to maintain low flow through winter and spring. There were two small natural freshes in July and August 2020, and unregulated flow during August and September was higher than the planned low flow. Water for the environment was used to deliver a fresh in September 2020. IVTs started in mid-November 2020 and kept flow above the recommended environmental flow throughout most of summer and autumn.

Deliveries of water for the environment in the Campaspe system in 2020-21 were managed in line with an average climate scenario. All planned watering actions for the year were largely met. Additional freshes to mitigate poor water quality were not required.

Scope of environmental watering

Table 5.6.1 describes the potential environmental watering actions in 2021-22, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objective(s) they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.6.1 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Campaspe River

Potential environmental watering action	Expected watering effects	Environmental objectives
Winter/spring low flow (50-200 ML/day during June to November)	• Increase longitudinal connectivity to allow native fish to access new habitats • Facilitate long-distance movement by male platypus, especially in the August–October breeding season • Provide foraging opportunities across a wide range of habitats for female platypus to develop fat reserves before breeding • Maintain water quality by preventing pools from stratifying • Discourage terrestrial plants from colonising the lower sections of the riverbank and low benches in the channel • Maintain soil moisture in the riverbank to water established river red gums and woody shrubs • Help establish littoral vegetation	
Winter/spring freshes (two freshes of 1,000-1,800 ML/day for two to three days during June to November)	• Flush accumulated leaf litter from the banks and low benches, to reduce the risk of blackwater events during high river flow in summer • Maintain soil moisture for established river red gum and woody shrubs (such as bottlebrush and tea tree) • Maintain connectivity to allow native fish movement and access new habitats, especially during the Murray cod nesting period • Encourage female platypus to select a nesting burrow higher up the bank, to reduce the risk of high flow later in the year flooding the burrow when juveniles are present	
Summer/autumn low flow (10-50 ML/day during December to May)	• Maintain slackwater habitats for zooplankton and nursery habitats for native fish • Maintain water depth and prevent stratification in deep pools in summer, to maintain habitat for native fish and platypus • Allow platypus to safely move between pools while foraging and ensure there is adequate food for lactating females	
Summer/autumn freshes (three freshes of 50-200 ML/day for one to three days during February to April)	• Increase longitudinal connectivity to allow native fish to access new habitats • Wet submerged wood and flush fine silt and old biofilms to promote new biofilm growth and increase waterbug productivity for native fish and platypus • Facilitate the downstream dispersal of juvenile platypus in April/May to colonise other habitat areas	
Year-round fresh (trigger-based, 5-200 ML/day, as required) *Triggers* • *oxygen levels are below 5 mg/L* • *air temperatures are above 28°* • *there are high water temperatures and/or low river flow*	• De-stratify pools and improve water quality (increase oxygen levels) along the river in reach 4, ensuring there is adequate oxygen to support aquatic animals (such as native fish and platypus)	

Scenario planning

Table 5.6.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The Campaspe River requires low flow and freshes throughout the year under all climate scenarios, but not all the recommended flows can be delivered with available supply under drought and dry to below-average climate scenarios. Under a drought scenario, available water will be used to deliver a summer/autumn low flow at the lower end of the recommended range. The summer/autumn low flow is the highest priority, because there is a high risk of poor water quality and critically low habitat availability in the warmer months. Delivering the low flow at the lower end of the recommended range will aim to maintain critical habitat to prevent significant loss of fish and platypus populations, but it will not support any breeding or improvement in environmental condition. Any additional water that is available under a drought scenario will be primarily used to deliver freshes if any of the poor water-quality triggers are met. Under a dry to below-average climate scenario, available water will be used to deliver as much of the recommended low flow and freshes as possible during summer and autumn, and a portion of the recommended winter/spring flow. The winter/spring fresh is particularly important under a dry to below-average scenario, to flush organic material from the banks and reduce the likelihood that this material could contribute to a hypoxic blackwater event if there is a high flow or fresh in summer. This fresh will be delivered in October if possible, to support Murray cod nesting.

Delivering the full range of recommended flows at the upper end of their range will be important under average and wet climate scenarios, to increase the quantity and quality of habitat to support native fish and platypus breeding and to improve the condition of in-stream and streamside vegetation.

The carryover target for 2022-23 is based on the volume required to deliver priority low flow during 2022-23 if there is a return to dry or drought conditions.

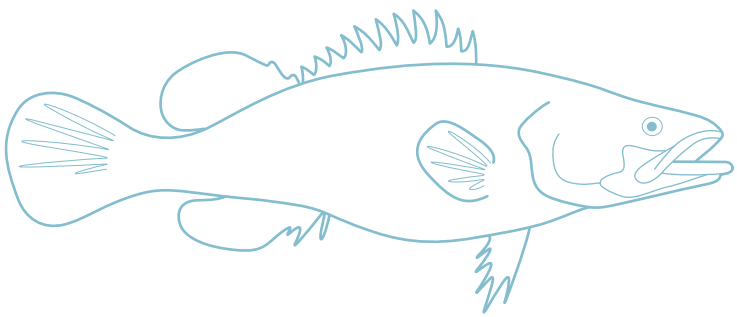


Table 5.6.2 Potential environmental watering for the Campaspe River under a range of planning scenarios

Planning scenario	Drought	Dry to below-average	Average	Wet
Expected river conditions	• Little to no natural flow • No passing flows in winter • Operational water deliveries	• Some natural flow • Increased passing flows • Operational water deliveries	• Some natural flow • Increased passing flows • No expected spills from storage, except under extremely wet conditions	
Predicted supply of water for the environment	• 7,500 ML	• 26,000 ML	• 27,300 ML	
Campaspe River (targeting reach 4)				
Potential environmental watering – tier 1 (high priorities)	• **Tier 1a (can be achieved with predicted supply)**			
	• Summer/autumn low flow (low on the magnitude range)	• Winter/spring low flow (lower magnitude) • Winter/spring fresh (one fresh) • Summer/autumn low flow (high on the magnitude range) • Summer/autumn freshes (three freshes)	• Winter/spring low flow • Winter/spring freshes (two freshes) • Summer/autumn low flow (high on the magnitude range) • Summer/autumn freshes (three freshes)	
	• **Tier 1b (supply deficit)**			
	• Winter/spring low flow • Winter/spring freshes (two freshes) • Summer/autumn freshes (three freshes) • Year-round fresh (if required)	• Winter/spring low flow (increased magnitude) • Winter/spring fresh (one fresh) • Year-round fresh (if required)	• N/A	
Potential environmental watering – tier 2 (additional priorities)	• N/A			
Possible volume of water for the environment required to achieve objectives	• 5,400 ML (tier 1a) • 9,800 ML (tier 1b)	• 21,500 ML (tier 1a) • 7,000 ML (tier 1b)	• 26,100 ML (tier 1a)	
Priority carryover requirements	• 5,500 ML			

5.6.2 Coliban River

System overview

The Coliban River is the major tributary of the Campaspe River, and it flows into Lake Eppalock. It is highly regulated with three storages harvesting water primarily for urban use.

Flow in the Coliban River below Malmsbury Reservoir is regulated by the operation of the Malmsbury, Lauriston and Upper Coliban reservoirs. An important distinction between the Coliban River and other regulated Victorian systems is the lack of irrigation demand that may be met by managed releases downstream of system storages. Flow in the river is influenced by the passing-flow entitlement, which depends on catchment inflows and major flood events in the catchment.

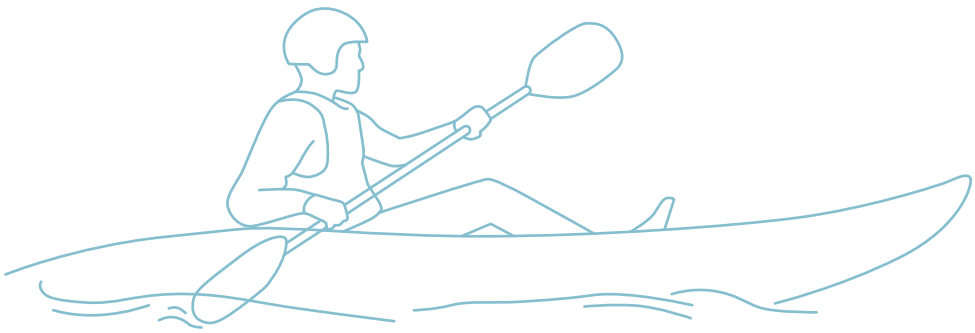
The VEWH does not have any environmental entitlements in the Coliban system, but passing flows can be managed — for example, they can be accumulated and released when most needed — to help mitigate some risks associated with critically low summer/autumn flow including low oxygen levels in the river between Malmsbury Reservoir and Lake Eppalock. A small volume of Commonwealth water for the environment is held in the system, but the high cost of delivery means there is no plan to use it in 2021-22.

Environmental values

The Coliban River provides important habitat for platypus, rakali (water rats) and small-bodied native fish (such as flat-headed gudgeon and mountain galaxias). The Coliban River also contains a diverse range of waterbugs supported by stands of emergent and submergent aquatic vegetation. It is bordered by remnant patches of stream bank shrubland vegetation and woodland containing river red gum, callistemon, woolly tea-tree and inland wirilda, which provide habitat for terrestrial animals.

Environmental watering objectives in the Coliban River

	Increase the abundance and diversity of small-bodied native fish
	Increase the platypus population
	Increase the cover and diversity of aquatic plants Increase the cover and diversity of fringing vegetation, while limiting encroachment into the middle of the channel Maintain streamside woody vegetation and facilitate recruitment
	Maintain an adequate diversity and biomass of waterbugs, to break down dead organic matter and supply the river's food chain
	Improve water quality and maintain healthy levels of oxygen in pools



Traditional Owner cultural values and uses

In planning for environmental flows in the Coliban River, Dja Dja Wurrung Clans Aboriginal Corporation and North Central CMA have considered how environmental water management assists with the preservation of historical and contemporary cultural values including promoting a sense of place and spiritual connection.

The *Dja Dja Wurrung Country Plan 2014-2034* describes their aspirations around the management of rivers and waterways and articulates Dja Dja Wurrung peoples' support for the reinstatement of environmental flows as an overall objective for the management of water on Country.

The Kapa Gatjin and North Central CMA have been working together to identify opportunities and sites where water for the environment can support the Dja Dja Wurrung's aspirations for the Coliban River.

Activities to further this work have been suspended due to COVID-19 restrictions, but it is anticipated that activities on Country will be undertaken as restrictions ease in 2021-22.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.6.3, North Central CMA considered how environmental flows could support values and uses including:

- water-based recreation (such as canoeing, fishing and water sports)
- riverside recreation and amenity (such as birdwatching, bushwalking, camping and cycling)
- socio-economic benefits (such as diversions for domestic and stock uses, benefits to the local and regional economies from recreational activities, ecosystem services [such as carbon storage, groundwater recharge and water-quality regulation], lower salinity costs and blackwater and blue-green algae risks for landholders, and contributions to community enjoyment, health and recuperation).

Recent conditions

Total annual rainfall in the Coliban River catchment in 2020-21 was slightly above the long-term average, and the temperature was slightly cooler than average. August, October and January were significantly wetter-than-average months. November was hotter and dryer than average. Accumulated passing flows that make up the holdings of water for the environment were lost when Malmsbury Reservoir spilled in October 2020, but high rainfall in January 2021 allowed additional passing flows to be accumulated to replenish the supply for planned environmental flows.

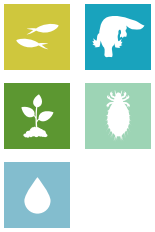
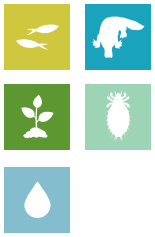
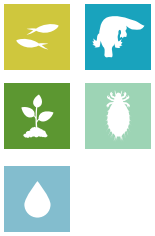
Passing flows, natural inflows and the managed release of accumulated passing flows maintained a continuous flow from Malmsbury Reservoir to Lake Eppalock throughout most of the year, and the summer cease-to-flow period at the downstream end of the reach was shorter than in previous years. High-rainfall events delivered moderate-sized freshes, and more variable flow in the lower reach in August, September and November 2020 and the October spill of Malmsbury Reservoir delivered a high flow through the whole system.

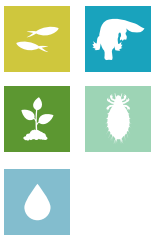
Releases of water for the environment in the Coliban River were delivered in line with an average climate scenario in 2020-21. One of the planned watering actions for the average scenario — the summer and autumn low flow — was partly achieved, while the summer and autumn fresh was not delivered. In particular, the wetter-than-average conditions provided additional flow in the system and helped maintain water quality, which meant summer/autumn low flows could be delivered continuously rather than as pulses.

Scope of environmental watering

Table 5.6.3 describes the potential environmental watering actions in 2021-22, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objectives they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.6.3 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Coliban River

Potential environmental watering action	Expected watering effects	Environmental objectives
Winter/spring low flow (2.5 to 25 ML/day during June to November)	• Maintain a connected river that allows small-bodied native fish and platypus to disperse throughout the river • Increase wet areas for native aquatic and streamside plants, while limiting terrestrial species encroaching the river channel • Increase flow to mix water in pools, to prevent stagnation and a decline in water quality • Increase the wetted area for habitat for waterbugs	
Winter/spring fresh (one fresh of up to160 ML/day for three to five days during June to November)	• Maintain up to 65 cm water depth between pools, so native fish can disperse throughout the river and colonise sites • Encourage female platypus to select a nesting burrow higher up the bank, to reduce the risk of a higher flow later in the year flooding the burrow when juveniles are present • Increased the wetted river perimeter for fringing and edge vegetation • Increase the wetted river perimeter to increase habitat for waterbugs • Flush organic matter to reduce the risk of declining water quality in summer	
Summer/autumn low flow (four to 10 ML/day during December to May)	• Maintain 3-6 cm water depth between pools for native fish movement, and maintain river pool depth • Wet the channel to maintain in-stream aquatic and fringing vegetation • Maintain aquatic habitat that supports waterbugs, native fish and platypus • Maintain water quality including oxygen levels	

Summer/autumn freshes (two freshes of 25 to 160 ML/day for three to five days during December to May)	• Maintain the water depth through riffle-run habitats of 8-20 cm for 25-50 ML/day event to maintain water quality and habitat for waterbugs
	• Maintain water depth through riffle-run habitats of 45-61 cm for a 160 ML/day event to:
	  • increase the water depth to facilitate the movement of fish and platypus
	  • clean sediment and biofilms from river substrates
	  • wet the benches and low banks to promote the growth and recruitment of fringing vegetation
		

Pulsed summer/autumn low flow (five to 15 ML/day for 14 days during December to May, trigger-based) *Triggers:* • *oxygen level is below 5 mg/L* • *water temperature is above 28°* • *there are low or cease-to-flow river conditions*	• Improve water quality including oxygen levels • Maintain refuge habitat for aquatic animals, including fish and platypus	

Scenario planning

Table 5.6.4 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The potential environmental watering actions required for the Coliban River are the same under all climate scenarios, but the magnitude of the low flow and the magnitude and duration of freshes vary across the scenarios. By lowering the magnitude, duration and frequency, water can be delivered for more environmental flows and for longer, to help prevent water-quality events and support platypus populations. With more water available to deliver larger flows, more environmental objectives can be achieved.

The highest-priority watering action in the Coliban River is the low flow in summer and autumn, to provide sufficient depth for native fish movement and aquatic habitats for fish, platypus and waterbugs. Releases of water for the environment in summer and autumn help maintain water quality (especially when oxygen levels are low) and maintain pools in the upper reaches for platypus. Passing flows that were banked but not used in 2020-21 will be carried over and used to help maintain continuous low-flow targets under all climate scenarios in 2021-22. If the continuous flow cannot be maintained, shorter, pulsed flows will be delivered to maintain refuge habitats. Where possible, summer and autumn freshes will be delivered, to facilitate fish and platypus movement and support fringing vegetation. Such a fresh is most important in March to April, to support juvenile platypus dispersal and reduce predation.

Accumulated passing flows will be set aside to cover high-priority summer and autumn low flow in 2022-23. The carryover target under all climate scenarios is 720 ML, but the actual carryover will depend on accumulated passing flows through the year, the potential watering actions delivered and the climatic outlook for the following year. Setting aside water for next year is a priority, once the low flow and at least one summer/autumn fresh have been delivered.

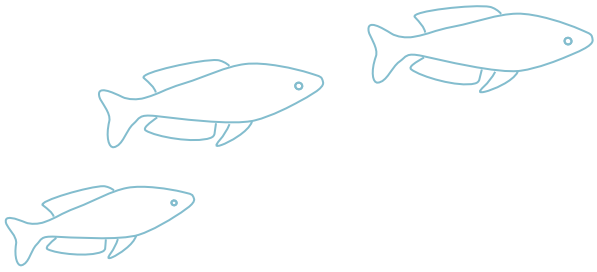
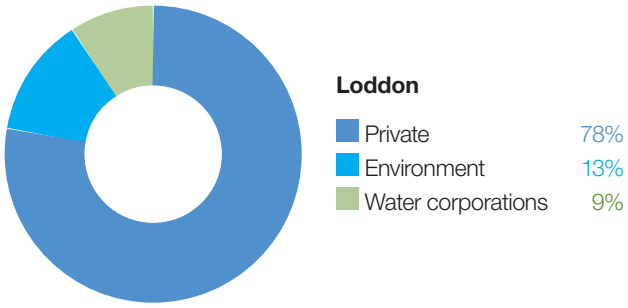


Table 5.6.4 Potential environmental watering for the Coliban River under a range of planning scenarios

Planning scenario	Drought	Dry	Average and Wet
Expected river conditions	• Little to no natural flow	• Some natural flow	• Some natural flow
Predicted supply of water for the environment	• 1,800 ML	• 2,100 ML	• 2,900 ML
Coliban River (targeting reach 1)			
Potential environmental watering – tier 1 (high priorities)	**Tier 1a (can be achieved with predicted supply)**		
	• Winter/spring low flow (lower magnitude in the range) • Summer/autumn low flow (lower magnitude in the range) • Summer/autumn fresh (one fresh) • Pulsed summer/autumn low flow (trigger-based)	• Winter/spring low flow (lower magnitude in the range) • Summer/autumn low flow (lower magnitude in the range) • Summer/autumn fresh (one fresh)	• Winter/spring low flow (lower magnitude in the range) • Summer/autumn low flow (lower magnitude in the range) • Summer/autumn fresh (one fresh)
	Tier 1b (supply deficit)		
	• Winter/spring low flow • Summer/autumn low flow (higher magnitude) • Summer/autumn fresh (one fresh)	• Winter/spring low flow (higher magnitude in the range) • Winter/spring fresh (one fresh) • Summer/autumn low flow (higher magnitude in the range) • Summer/autumn fresh (one fresh)	• Winter/spring low flow (higher magnitude in the range) • Winter/spring fresh (one fresh) • Summer/autumn low flow (higher magnitude in the range) • Summer/autumn fresh (one fresh)
Potential environmental watering – tier 2 (additional priorities)	• N/A		
Possible volume of water for the environment required to achieve objectives	• 1,740 ML (tier 1a) • 3,000 ML (tier 1b)	• 1,980 ML (tier 1a) • 4,400 ML (tier 1b)	• 2,300 ML (tier 1a) • 5,500 ML (tier 1b)
Priority carryover requirements	• Accumulate passing flows for 2022-23 (720 ML)		

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



Proportion of water entitlements in the Loddon basin held by private users, water corporations and environmental water holders on 30 June 2020.

Did you know...?

Lake Boort is a highly significant area for Dja Dja Wurrung. The floodplain contains some of the highest densities of scarred trees in the world as well as numerous cooking mounds and other remainders of past productivity. The connection continues through to this day and is embedded in the plants, animals, *Gatjin* (water), *Wi* (fire) and *Djandak* (land).

Top: Loddon River at Kerang, by the VEWH
Above: Ducks at Lake Meran, by Kevin Mah, North Central CMA

The Loddon system includes the Loddon River system (including Tullaroop, Serpentine and Pyramid creeks), the Boort wetlands and Birchs Creek.

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

System overview

The Loddon River flows from the Great Dividing Range in the south to the Murray River in the north. Tullaroop Creek is the main tributary in the upper Loddon River system (Figure 5.7.1). The middle section of the Loddon River is characterised by many distributary streams and anabranches that carry water away from the river onto the floodplain. The lower Loddon River is joined by Pyramid Creek at Kerang, at which point the Loddon becomes part of the Murray River floodplain.

Two main storages are located on the Loddon River: Cairn Curran and Tullaroop reservoirs, with Laanecoorie Reservoir used to regulate water from the main storages to the Loddon River. Below Laanecoorie Reservoir, the flow is regulated by the operation of the Bridgewater, Serpentine, Loddon and Kerang weirs.

Water for the environment can be delivered to the Loddon River from Cairn Curran or Tullaroop reservoirs or from the Goulburn system via the Waranga Western Channel, which intersects with the Loddon River at Loddon Weir. Water is provided to Pyramid Creek through releases from Kow Swamp, which receives water diverted from the Murray River at Torrumbarry Weir. Water is diverted from the Loddon River to Serpentine Creek and to the Loddon Valley Irrigation Area to supply agriculture.

The highly regulated nature of the Loddon system provides both challenges and opportunities for effective management of water for the environment. The ability to manipulate the timing of releases at multiple locations provides opportunities to accomplish environmental outcomes at discrete locations. However, coordinating environmental flows and consumptive flows is difficult through the irrigation season, especially when irrigation demand is high or flow in the river is highly variable. This can lead to constraints in the timing and delivery of water for the environment or higher-than-recommended flows above Loddon Weir. The structures used for managing irrigation water form barriers in the waterway, restrict flow reliability and create barriers to aquatic animal movement throughout the river – impacting the ability to achieve outcomes for native fish and possibly platypus.

Environmental values

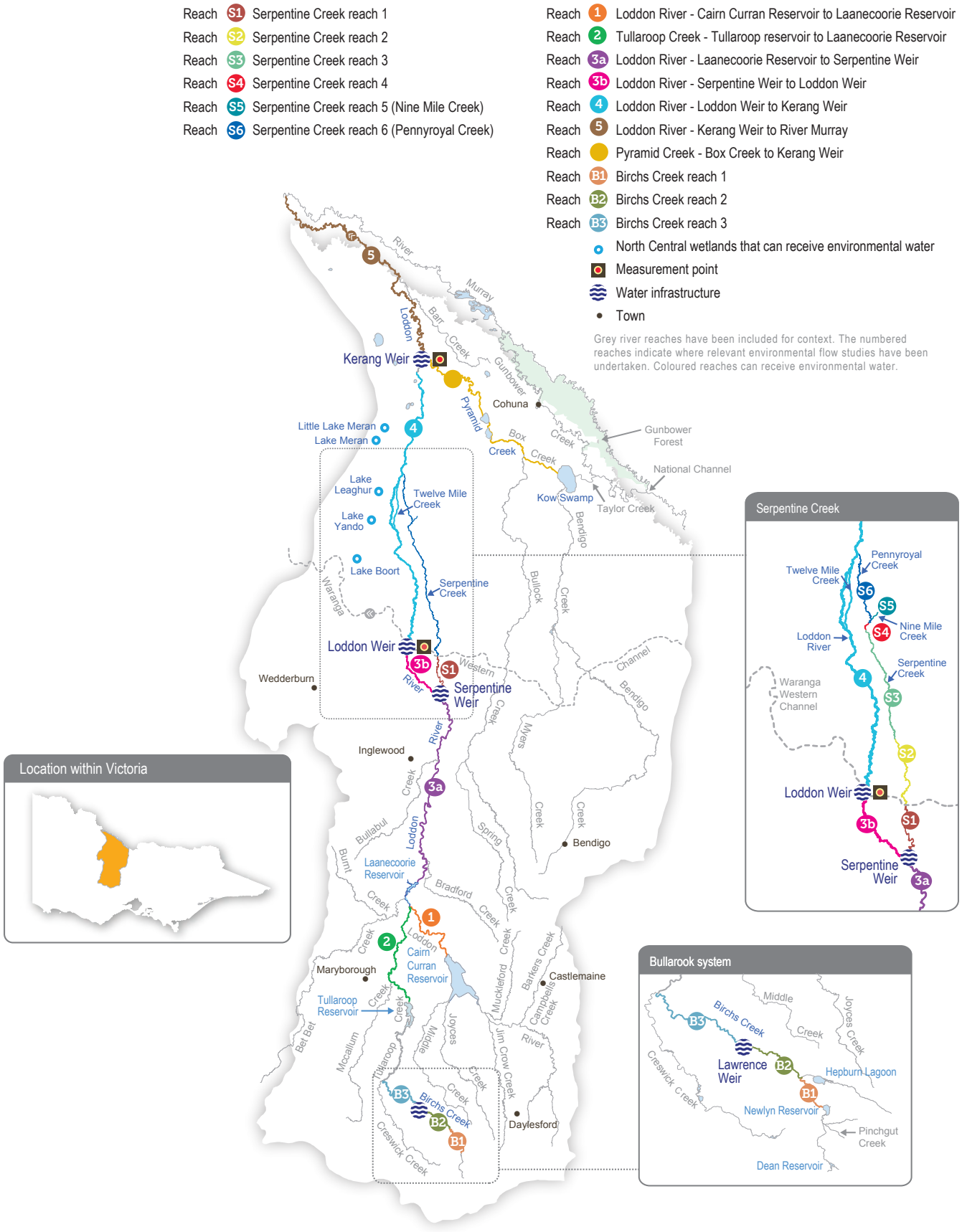
The Loddon River system supports platypus, rakali (water rats) and several species of native fish (such as Murray cod, golden perch, silver perch, river blackfish and Murray-Darling rainbowfish). Streamside vegetation varies in condition depending on the recent water regime, the extent of clearing and historic and current land management practices. The areas that remain relatively intact support a variety of woodland birds and other native animals. Important plant species across the system include cane grass, tangled lignum, black box and river red gum.

Although fish populations in the Loddon system are affected by the many barriers caused by weirs and reservoirs, a large range of species are still found through the catchment. Native fish are most abundant and diverse in the upper catchment. River blackfish are found in Serpentine Creek and rare Murray-Darling rainbow fish are found in the middle and lower sections of the Loddon River.

The highest-priority reach for water for the environment is from Loddon Weir to Kerang Weir. The reach does not carry irrigation water, and it relies heavily on environmental flows to maintain its environmental condition. Environmental flows to this reach aim to improve the condition of streamside vegetation, maintain water quality and increase the abundance and diversity of native fish. Environmental flows are delivered to the upper Loddon River, Tullaroop Creek and Serpentine Creek to maintain or increase populations of river blackfish and platypus.

Pyramid Creek and the lower Loddon River support large-bodied fish (such as golden perch, Murray cod and silver perch) and are important corridors for fish migration between the Loddon and Murray systems. Engineering works to provide fish passage at the Chute, Box Creek regulator, Kerang Weir, Fish Point Weir and Little Murray Weir on the Little Murray River in recent years have been important in reopening these migration routes. The Arthur Rylah Institute has monitored fish movement and populations in Pyramid Creek and the lower Loddon River since 2017, and results have indicated that the combined Loddon-Pyramid flow is stimulating native fish movement through the fishways.

Figure 5.7.1 The Loddon system



Environmental watering objectives in the Loddon River system

Increase populations of small and large-bodied native fish

Provide habitat for fish to feed and breed and opportunities for movement between habitats

Enhance the channel form and features including deep pools and benches

Maintain the condition of suitable substrate, to maintain ecosystem processes

Engage floodrunners, distributary channels, anabranches and backwaters

Increase the population and recruitment of resident platypus

Maintain a stable rakali (water rat) population in the long term

Maintain productive and dynamic food webs

Maintain/increase the diversity and abundance of biofilms

Maintain the condition of streamside and floodplain vegetation

Maintain and increase the extent of in-stream vegetation

Maintain/increase the diversity and abundance of waterbugs and waterbug functional feeding groups

Maintain water quality, to support aquatic animals and minimise the occurrence of blackwater events

Traditional Owner cultural values and uses

In planning for environmental flows in the Loddon River system, Dja Dja Wurrung, Barapa Barapa and Wemba Wamba and North Central CMA have considered how environmental flows in the Loddon system can be managed to support their respective values and uses.

Environmental water management assists with preservation of historical and contemporary values held highly by the Dja Dja Wurrung. This includes promoting a sense of place and spiritual connection. The Kapa Gatjin and North Central CMA have been working together to identify opportunities and sites where water for the environment can support the Dja Dja Wurrung's aspirations for the Loddon River.

The Barapa Barapa and Wemba Wamba are the Traditional Owners in the northern part of the Loddon catchment, and artefacts of cultural practices are present throughout the Loddon and Pyramid system and its floodplain.

In early 2021, the Barapa Barapa Wemba Wamba Water for Country Steering Committee joined North Central CMA staff on Country to discuss the cultural values of the river and floodplain and how environmental water can contribute to achieving cultural objectives. The Steering Committee members emphasised the importance of supporting fish populations, particularly Murray cod and golden perch. The Traditional Owners also identified evidence of occupation such as clay balls and mussel shells in Sheepwash Creek, supporting similar observations in the Pennyroyal Creek-Bannacher Creek network on a previous field visit and providing evidence that environmental flows can help the distribution and health of plants and tubers for food and medicine.

These values will be supported in 2021-22 through flows that are designed to support food and fibre species of cultural value and to facilitate cultural activities.

Barapa Barapa Traditional Owners have also communicated their cultural objectives for the Loddon River and other waterways in the Barapa Barapa Healthy Country Plan. Objectives that relate to the Loddon River system include:

- all wetlands surrounding the Murray River, Gunbower Forest, Loddon River and associated lakes have good plant life and healthy native fish (cod and yellow belly), mussels and turtle populations by 2033
- by 2033, the Murray, Gunbower, Loddon and associated lakes will have enough water. Water quality is improving and water is clear for most of the year in good years
- Barapa people are actively involved in water management
- reduce the number of major fish and plant deaths from toxic blackwater events to improve water quality.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.7.1, North Central CMA considered how environmental flows could support values and uses including:

- water-based recreation (such as fishing, powered and non-powered boating, water skiing and water sports)
- riverside recreation and amenity (such as birdwatching, bushwalking, camping and cycling)
- community events and tourism (such as water skiing competitions at Bridgewater and associated visitation)
- socio-economic benefits (such as diverters for domestic and stock uses, local and regional economic benefits from increased visitation and ecosystem services [such as carbon storage, groundwater recharge and nutrient recycling]).

If the timing or management of planned environmental flows may be modified to align with a community benefit, this is acknowledged in Table 5.7.1 with the following icon.

Watering planned to support water sports activities (e.g. water skiing)

If possible, North Central CMA will work with Goulburn-Murray Water to manage the delivery of low flow rates and the timing of freshes over summer/autumn, to support optimum conditions for annual water skiing competitions at Bridgewater weir pool, where possible.

Recent conditions

Despite dry conditions in July, rainfall and temperatures in the Loddon catchment were close to the long-term average throughout most of 2020-21. Inflows to major storages in autumn 2020 resulted in opening season allocations of 35 percent for high-reliability water shares in the Loddon and Goulburn systems, which was higher than the previous year. Allocations increased regularly through spring and reached 100 percent in mid-November. No low-reliability water share allocation was issued in 2020-21.

A small natural fresh occurred in September 2020 and again in February 2021, but otherwise there were relatively few natural high-flow events in the Loddon River system in 2020-21. Low flow was delivered to all reaches throughout the year using mandated passing flows, environmental water or a combination of both. Water for the environment was used to deliver spring freshes in the Loddon River, Serpentine Creek and Pyramid Creek. The Loddon River and Pyramid Creek freshes were coordinated to provide a higher flow at Kerang Weir, to cue native fish to move into the system from the Murray River. Water for the environment was also used to deliver two summer/autumn freshes in the Loddon River; a third summer/autumn fresh occurred naturally in February.

In 2020-21, water for the environment in the Loddon system was managed initially in line with a dry climate scenario, shifting to an average climate scenario from spring onwards. Most planned watering actions for the Loddon River and Pyramid Creek were achieved. The only event that was not delivered to these systems was a higher autumn flow that aimed to facilitate platypus and native fish migration. The lack of this flow is not considered a major problem, because a large autumn flow occurred naturally in April 2020. The potential flooding of private land at the end of Serpentine Creek prevented the delivery of planned summer/autumn freshes, and the winter/spring low flow in Serpentine Creek was delivered at less than the recommended magnitude at times during 2020-21. The North Central CMA, storage manager and the VEWH will undertake to resolve this issue in 2021-22 to allow a wider range of watering actions to be delivered in future.

Results of fish monitoring surveys conducted by the Arthur Rylah Institute as part of the Victorian Environmental Flows Monitoring and Assessment Program in 2020-21 indicated that native fish are moving and using fishways in response to medium-to-high environmental flows in the Loddon system. This information resulted in the recommended low-flow magnitude in Pyramid Creek and the lower Loddon River increasing, compared to previous years.

Scope of environmental watering

Table 5.7.1 describes the potential environmental watering actions in 2021-22, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objectives they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.7.1 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Loddon River system

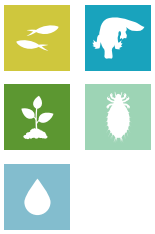
Potential environmental watering action	Expected watering effects	Environmental objectives
Loddon River (targeting reach 4)		
Winter/spring low flow (50-100 ML/day during June to November)[1]	• Increase the water depth for fish, platypus and rakali (water rat) dispersal (especially for male juvenile platypus to colonise new breeding territory in winter) and to provide foraging habitat • Prevent silt and fine sediment settling on submerged wood and other hard surfaces • Inundate a variety of habitats, to increase the growth of biofilms and support waterbug productivity • Water the native fringing bank vegetation, to support seed germination and growth and prevent the encroachment of exotic terrestrial plants in the river channel	
Winter/spring high flow (one high flow of 450 ML/day for six to 10 days during August to November)	• Provide sufficient velocity to scour accumulated sediment from pools and scour biofilms • Flush accumulated organic matter from the bank and benches, to increase productivity and reduce the risk of a hypoxic blackwater event in summer • Wet the banks to promote the recruitment and growth of streamside and emergent vegetation • Stimulate native fish movement and breeding	
Summer/autumn low flow (25-50 ML/day during December to May) 	• Maintain an adequate depth in pools for aquatic plants and to provide habitat for waterbugs, fish and rakali (water rats) • Provide continuous flow through the reach, to maintain water quality • Wet the banks and shallow riffles, to support the growth of in-stream and fringing non-woody vegetation	
Summer/autumn freshes (three to four[2] freshes of 50-100 ML/day for three days during December to May) 	• Increase the water level, to promote seed germination and the growth of fringing emergent macrophytes • Increase connectivity between deep pools to promote the local movement of fish and to prompt the dispersal of juvenile platypus in autumn • Generate sufficient force to flush fine sediment and old biofilms from submerged wood and other hard surfaces, promoting the growth of new biofilms and increasing waterbug productivity • Freshen water quality and reoxygenate pools	

Table 5.7.1 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Loddon River system *(continued)*

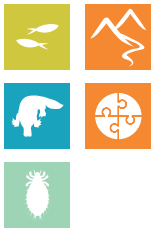
Potential environmental watering action	Expected watering effects	Environmental objectives
Autumn high flow (one high flow of 400 ML/day for six days[3] during March to May)	• Trigger and facilitate the upstream movement of golden perch, silver perch and Murray cod older than one year • Facilitate the dispersal of juvenile platypus • Generate sufficient force to flush fine sediment and old biofilms from submerged wood and other hard surfaces, promoting the growth of new biofilms and increasing waterbug productivity	
Serpentine Creek (targeting reach 1)[4]		
Winter/spring low flow (20-50 ML/day[5] during June to November)	• Maintain habitat for native fish and facilitate movement for aquatic animals • Wet exposed roots, woody debris, emergent vegetation and leaf packs, to provide habitat for aquatic animals • Maintain water quality by preventing stagnation • Provide flow variability, to maintain the diversity of fringing vegetation • Provide a sufficient depth of water and variability of flow to maintain microbial biofilms	
Winter/spring fresh (one fresh of 40-150 ML/day[5] for two days during August to November)	• Maintain the channel form and scour pools (an augmented response is expected when delivered at 120-150 ML/day) • Provide connectivity for fish and waterbugs to access different habitat areas, supporting a diversity of functional feeding groups • Transport organic matter that has accumulated in the channel, to increase the breakdown of organic matter in winter/spring and reduce the risk of a hypoxic blackwater event in summer (an augmented response is expected when delivered at 120-150 ML/day) • Encourage female platypus to select nesting burrows higher up the bank (when delivered at 120-150 ML/day) to reduce the risk of higher flow later in the year flooding burrows when juveniles are present	
Summer/autumn low flow (10-20 ML/day[5] during December to May)	• Provide connectivity between pools to allow the dispersal of small-to-medium-bodied native fish • Wet exposed roots, leaf packs and woody debris, to provide habitat for aquatic animals • Provide sufficient flow to maintain water quality by oxygenating pools • Maintain foraging habitat for platypus • Maintain the wetted area to support in-stream aquatic vegetation (such as water ribbons, eel weed and milfoil)	

Table 5.7.1 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Loddon River system *(continued)*

Potential environmental watering action	Expected watering effects	Environmental objectives
Summer/autumn freshes (three freshes of 40 ML/day[5] for two days during December to May)	• Maintain the channel form by inundating benches • Generate sufficient force to flush fine sediment and old biofilms from submerged wood and other hard surfaces, to increase productivity and replenish the food supply for aquatic animals • Transport organic matter that has accumulated in the channel providing carbon and nutrients downstream • Provide flow variability to maintain the diversity of fringing vegetation such as emergent macrophytes • Freshen water quality by diluting salt and re-oxygenate pools	
Pyramid Creek (targeting Box Creek regulator) and lower Loddon River (targeting Kerang Weir)		
Year-round low flow (90-300 ML/day at Box Creek regulator)	• Maintain connectivity between pools and provide habitat for aquatic animals • Improve water quality by reducing salinity levels • Enhance the wetted area to maintain and promote the growth of fringing emergent (non-woody) vegetation along the lower banks of the channel	
Winter/spring high flow (one high flow of 700 ML/day at Kerang Weir for 10 days)[6]	• Trigger the migration, spawning and recruitment of native fish species including Murray cod • Maintain connectivity between habitats and improve water quality • Provide sufficient energy to flush accumulated sediment from pools and substrates	
Autumn high flow (one high flow of 700 ML/day[7] at Kerang Weir for six days[3] during March to April)[6]	• Trigger and facilitate the upstream movement of golden perch, silver perch and Murray cod older than one year • Maintain connectivity between habitats and improve water quality • Facilitate platypus dispersal	

1 Winter/spring low flow of 50 ML per day is below the passing flow magnitude and will result in the VEWH banking passing flows savings for use in other potential watering actions.

2 A fourth summer/autumn fresh may be delivered under drought or dry climate scenarios. The recommended magnitude and duration may be increased if needed, to prevent a decline in oxygen levels.

3 The peak magnitude of this event is planned to be delivered for six days, but there is an extended, 10-day ramp-down period.

4 Flow in Serpentine Creek may be allowed to either return to the Loddon River or continue down Pennyroyal and Bannacher creeks or Nine Mile Creek with the agreement of landholders.

5 Flow delivered from Serpentine Weir may be restricted to manage end-of-system outfalls, to avoid third-party impacts, until an alternate solution is determined.

6 Winter/spring and autumn freshes are planned to occur at the same time in the Loddon River and Pyramid Creek, with the peak timed to meet at Kerang Weir. 700 ML/day is the total combined target at Kerang Weir.

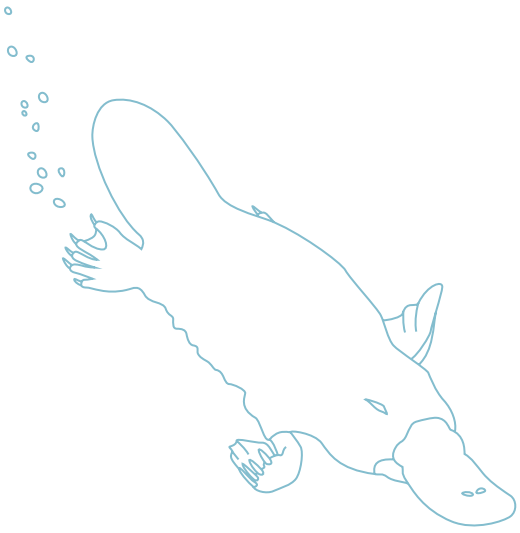
7 The autumn high flow may be delivered at a reduced rate under seasonal or operational conditions, which could heighten the risk of third-party impacts.

Scenario planning

Table 5.7.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

In the Loddon River, delivery of three summer/autumn freshes and continuous low flow year-round is a high priority under all climate scenarios, to freshen water quality and maintain connectivity throughout the system for aquatic animals. Flows will likely be delivered at the lower end of the recommended range under drought and dry conditions, to conserve supply. Lower-magnitude flows will aim to prevent critical harm to aquatic plants and animals rather than improve their condition, and either a temporary increase in low-flow magnitude or an additional fresh may need to be delivered during very low-flow periods to manage water quality. Some contingency water has been factored into estimated demands under a drought climate scenario, to provide these additional deliveries if needed.

Under the drought climate scenario, winter/spring low flow in the Loddon River may be reduced to 50 ML per day — prescribed passing flows from May to October are 77 ML per day — to accumulate a portion of the passing flows to supplement flows in summer and autumn when there are higher risks of poor water quality and cease-to-flow events. Under a dry climate scenario, the winter/spring low flow will likely be delivered at the passing-flow rate, and, while the upper magnitude is preferred, this may also be the rate delivered under an average climate scenario, to reserve supply for high-priority demands in the Boort wetlands system. If additional water becomes available or a wet scenario occurs, water for the environment may be used to increase winter/spring low flow to 100 ML per day, to improve the condition of vegetation higher up the bank.



Coordinated winter/spring high flow in the Loddon River and Pyramid Creek is a high priority under all climate scenarios (and may be achieved with natural flow under wet conditions) to trigger the upstream movement of native fish from the Murray system for feeding and breeding as well as remove accumulated organic matter on the banks and benches. The duration of these events may be reduced to six days, which is sufficient to trigger a moderate fish response, under a drought or dry climate scenario, to conserve supply. A similar-sized event in autumn is recommended for average and wet climate scenarios, but it is a lower priority under drought and dry climate scenarios, because such a flow is not required every year and a large natural event occurred in autumn 2020. It is also more important to deliver the autumn high flow in average and wet years, because there are likely to be more fish moving in the Murray River that can detect and respond to the flow cue.

The other high-priority flow for Pyramid Creek is the low flow. Modelling after fish surveys conducted by the Arthur Rylah Institute indicates that maintaining a low-flow magnitude of at least 200 ML per day throughout the year will be most beneficial for supporting native fish populations in Pyramid Creek. This flow is needed under all climate scenarios, to maintain habitat for native fish and other aquatic animals, especially during the non-irrigation season. Operational deliveries maintain water in Pyramid Creek during the irrigation season, but these deliveries cease between May and August, and without water for the environment during this period there is unlikely to be enough flow to support fish populations.

In Serpentine Creek, the main priority will be to maintain low flow throughout the year to provide habitat for native fish, waterbugs, rakali (water rats) and platypus and to deliver freshes to improve water quality, allow fish and platypus movement and improve the condition of streamside vegetation. Flow will likely be delivered at the lower end of the recommended range under drought and dry climate scenarios, to conserve available supply.

Carryover of 2,000 to 4,430 ML is prioritised into 2022-23 under drought and dry climate scenarios. This water will help meet early-season, low-flow demands in all waterways.

Table 5.7.2 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, consumptive water deliveries in the irrigation season (and none in reach 4) • Reduced passing flows in autumn/ winter possible	• Small inflows from unregulated reaches and tributaries of the Loddon River contributing to low flow, consumptive water deliveries in the irrigation season (but not in reach 4)	• Natural flow will provide low flow and multiple freshes, most likely in winter/ spring • Consumptive water deliveries in the irrigation season (but not in reach 4) • No spill likely	• Spills from Loddon system storages will provide extended-duration high flow and overbank flow most likely in late winter/spring
Predicted supply of water for the environment[1]	• 15,269[2] ML	• 18,037 ML	• 21,124 ML	• 21,124 ML
Loddon River (targeting reach 4)				
Potential environmental watering – tier 1 (high priorities)	**Tier 1a (can be achieved with predicted supply)**			
	• Winter/spring low flow (delivered at lower magnitude[3]) • Winter/spring high flow (one high flow, delivered at lower duration) • Summer/autumn low flow (delivered at lower magnitude[4]) • Summer/autumn freshes (three to four freshes[5])	• Winter/spring low flow (delivered at passing-flow rate) • Winter/spring high flow (one high flow, delivered at lower duration) • Summer/autumn low flow (delivered at lower magnitude[4]) • Summer/autumn freshes (three freshes)	• Winter/spring low flow (delivered at passing-flow rate) • Winter/spring high flow (one high flow) • Summer/autumn low flow • Summer/autumn freshes (three freshes)	• Winter/spring low flow • Winter/spring high flow (one high flow) • Summer/autumn low flow • Summer/autumn freshes (three freshes) • Autumn high flow (one high flow)
	Tier 1b (supply deficit)			
	• N/A[6]	• Winter/spring low flow delivered at higher magnitude • Summer/autumn low flow (delivered at higher magnitude)	• Winter/spring low flow (delivered at upper magnitude) • Autumn high flow (one high flow)	• N/A
Potential environmental watering – tier 2 (additional priorities)	• N/A			

Table 5.7.2 Potential environmental watering for the Loddon River system under a range of planning scenarios *(continued)*

Planning scenario	Drought	Dry	Average	Wet
Serpentine Creek				
Potential environmental watering – tier 1 (high priorities)	**Tier 1a (can be achieved with predicted supply)**			
	• Winter/spring low flow (lower magnitude) • Winter/spring fresh (one fresh, at lower magnitude) • Summer/autumn low flow (lower magnitude) • Summer/autumn freshes (three freshes)	• Winter/spring low flow (lower magnitude) • Winter/spring freshes (three freshes) • Summer/autumn low flow (lower magnitude) • Summer/autumn freshes (three freshes)	• Winter/spring low flow • Winter/spring fresh (one fresh) • Summer/autumn low flow • Summer/autumn freshes (three freshes)	• Winter/spring low flow • Winter/spring fresh (one fresh) • Summer/autumn low flow • Summer/autumn freshes (three freshes)
	Tier 1b (supply deficit)			
	• Tier 1a winter/spring fresh delivered at higher magnitude • Summer/autumn low flow delivered at higher magnitude	• Winter/spring low flow delivered at higher magnitude • Summer/autumn low flow delivered at higher magnitude	• N/A	
Potential environmental watering – tier 2 (additional priorities)	• N/A			

Table 5.7.2 Potential environmental watering for the Loddon River system under a range of planning scenarios *(continued)*

Planning scenario	Drought	Dry	Average	Wet
Pyramid Creek and Loddon River (reach 5)				
Potential environmental watering – tier 1 (high priorities)	**Tier 1a (can be achieved with predicted supply)**			
	• Year-round low flow • Winter/spring high flow (one high flow)		• Year-round low flow • Winter/spring high flow (one high flow) • Autumn high flow (one high flow)	
	Tier 1b (supply deficit)			
	• N/A			
Potential environmental watering – tier 2 (additional priorities)	• N/A			
Possible volume of water for the environment required to achieve objectives	**Loddon River (reach 4) and Serpentine Creek**			
	• 3,656-7,436 ML (tier 1a) • 0-7,749 ML (tier 1b) • 0 ML (tier 2)	• 9,937 ML (tier 1a) • 4,209 ML (tier 1b) • 0 ML (tier 2)	• 14,446 ML (tier 1a) • 8,609 ML (tier 1b) • 0 ML (tier 2)	• 11,320 ML (tier 1a) • 0 ML (tier 1b) • 0 ML (tier 2)
	Pyramid Creek and lower Loddon River (reach 5)[7]			
	• 4,000 ML (tier 1a) • 0 ML (tier 1b) • 0 ML (tier 2)		• 6,000 ML (tier 1a) • 0 ML (tier 1b) • 0 ML (tier 2)	
Priority carryover requirements	• 4,430 ML	• 2,000 ML	• 0 ML	

1 Loddon system entitlements are shared between the Loddon River system and the Boort wetlands. Expected availability is used to meet demands in both systems.

2 Under a drought scenario, the VEWH may request a reduction in passing-flow volume at Loddon Weir and accumulate the savings for use at other times of the year. The combined volume in Cairn Curran and Tullaroop reservoirs must exceed 60,000 ML, in order to enable passing-flows savings.

3 Delivering at a lower magnitude would accumulate passing-flow savings if the combined volume in storage exceeds 60,000 ML. If the volume in storage is less than 60,000 ML, the winter/spring passing-flow rate reverts to the summer passing-flow rate, and the demand for this event increases. Depending on when this occurs, this action may move from tier 1a to tier 1b.

4 The low-flow magnitude may be increased if needed, to prevent a decline in oxygen levels.

5 A fourth summer/autumn fresh may be delivered (and the recommended magnitude and duration may be increased) if required, to prevent a decline in oxygen levels.

6 Unless reduced passing flows over winter/spring are triggered (which occurs if the combined volume in storage is less than 60,000 ML), which would result in a far greater demand for achieving winter/spring low flows.

7 Each environmental watering event in Pyramid Creek has an estimated demand of 2,000 ML for underwriting losses associated with delivering consumptive water en route to downstream locations via Pyramid Creek. Actual demand for each event is expected to be a much lower volume.

5.7.2 Boort wetlands

System overview

The Boort wetlands are on the floodplain west of the Loddon River, below Loddon Weir. They consist of temporary and permanent freshwater lakes and swamps: Lake Boort, Lake Leaghur, Lake Yando, Little Lake Meran and Lake Meran. Together, the Boort wetlands cover over 800 ha. There are numerous other wetlands in the district, but they are not currently managed with water for the environment.

The natural watering regimes of wetlands throughout the broader Loddon system have been substantially modified by the construction of levees and channels across the floodplain and by the construction and operation of reservoirs and weirs along the Loddon River. Water is delivered to the Boort wetlands through Loddon Valley Irrigation Area infrastructure.

The availability of water for the environment for the Boort wetlands is closely linked to water available for the Loddon River system. The ability to deliver water for the environment to the wetlands is sometimes limited by channel capacity constraints. The VEWH and North Central CMA work with the storage manager (Goulburn-Murray Water) to best meet environmental objectives within capacity constraints.

Environmental values

The Boort wetlands provide habitat for a range of plant and animal species. At Lake Yando, 12 rare plant species have been recorded including the jerry-jerry and water nymph. Bird species recorded at Lake Boort, Lake Leaghur and Lake Meran include the white-bellied sea eagle, Latham's snipe and eastern great egret. Little Lake Meran is a swampy woodland with black box trees on the highest wet margins and river red gums fringing the waterline.

Environmental watering objectives in the Boort wetlands

- Increase the population of large and small-bodied fish species
- Increase the diversity and population of native frogs including by enhancing breeding opportunities
- Maintain the population of freshwater turtles, in particular Murray River turtles
- Rehabilitate and increase the extent of emergent and aquatic vegetation (aquatic herblands, tall marsh), intermittent swampy woodland and riverine chenopod woodland
- Maintain the health and restore the distribution of river red gums and associated understorey species
- Maintain the extent and restore the health of black box vegetation on the fringes of the wetlands
- Support a high diversity of wetland birds by enhancing feeding and breeding conditions

Traditional Owner cultural values and uses

In planning for environmental flows in the Boort wetlands, North Central CMA has worked with Barapa Barapa and Wemba Wamba Traditional Owners and Dja Dja Wurrung Clans Aboriginal Corporation to identify opportunities to engage on environmental water planning and delivery, now and in future.

The wetlands and surrounding land in the Boort region are rich in cultural heritage, with sites and artefacts of cultural practices present throughout the landscape. The rivers and floodplains are valued as food and fibre sources and contain many sites of significance (such as camp sites and meeting places). Environmental watering supports values such as native fish, waterbirds and turtles, and promotes the growth of culturally important plants that provide food, medicine and weaving materials. The presence of water itself can be a cultural value, as well as the quality of the water, as healthy water promotes a healthy Country.

The *Dja Dja Wurrung Country Plan 2014-2034* describes their aspirations around the management of rivers and waterways and articulates Dja Dja Wurrung peoples' support for the reinstatement of environmental flows as an overall objective for the management of water on Country.

Increasing the involvement of Traditional Owners in environmental water planning and management, and ultimately providing opportunities to progress towards self-determination within and beyond the environmental watering program, is a core commitment of the VEWH and its agency partners. This is reinforced by a range of legislation and policy commitments (for example the *Water Act 1989*, the Victorian Aboriginal Affairs Framework, *Water for Victoria* (2016)) and, in some cases, agreements under the *Traditional Owner Settlement Act 2010*. Where Traditional Owners are more deeply involved in the planning and/or delivery of environmental flows for a particular site, their contribution is acknowledged in Table 5.7.3 with an icon. The use of this icon is not intended to indicate that these activities are meeting all the needs of Traditional Owners but is incorporated in the spirit of valuing that contribution, and indicating progress towards this objective.

Watering planned and/or delivered in partnership with Traditional Owners to support cultural values and uses

The Dja Dja Wurrung clan (family group) the Yung Balug are preparing a water management plan for Lake Boort, the connected wetland Lake Lyndger and the Kinypanial Creek (a branch of the Loddon River), as part of the larger Djandak, Gatjin and Wi (Land, Water and Fire) Healthy Country Planning project which they are conducting with the support of Djandak, the commercial arm of Dja Dja Wurrung Clans Aboriginal Corporation. North Central CMA has committed to asking the Yung Balug family group for informed consent for the watering actions proposed for Boort in 2021-22 while moving towards self-determined management in the long term.

A key priority for Barapa Barapa and Wemba Wamba Traditional Owners in the Boort and central Murray region wetlands is maintaining or improving the condition of wetland vegetation health. North Central CMA and Barapa Barapa Traditional Owners are collaborating to deliver the DELWP-funded Decision Support Tool (DST) project which focuses on McDonalds Swamp (central Murray wetlands, see section 5.2.3), Lake Leaghur and Lake Yando. The project has tested the revegetation DST and also aims to incorporate cultural aspirations into revegetation outcomes. Barapa Barapa and Wemba Wamba Traditional Owners were involved in physical planting, plant selection and site selection for the project, and decisions around water for the environment at these wetlands have been able to support the DST project by delivering the watering requirements of the revegetation, resulting in a positive vegetation response and enabling monitoring to be completed by Barapa Barapa.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.7.3, North Central CMA considered how environmental flows could support values and uses including:

- water-based recreation (such as fishing and water sports)
- riverside recreation and amenity (such as birdwatching, camping and duck hunting)
- community events and tourism (such as attracting locals and visitors for birdwatching and hunting)
- socio-economic benefits (such as aesthetic benefits for landholders who are interested in learning about the ecological values of wetlands, diverters for domestic and stock use and irrigation, and ecosystem services like groundwater recharge, flood mitigation, nutrient treatment and carbon storage).

Recent conditions

Rainfall in the Boort wetlands catchment was variable throughout 2020-21, but average rainfall and temperatures were experienced through most of the year. There were no natural flows into wetlands, with managed released required to achieve all environmental watering priorities. Inflows to major storages in autumn 2020 resulted in opening season allocations of 35 percent for high-reliability water shares in the Loddon and Goulburn systems (both systems influence available Water Holdings for the Boort wetlands), which was higher than in the previous year. Allocations increased regularly through spring and hit 100 percent in mid-November. No low-reliability water share allocation was issued in 2020-21.

Water for the environment at the Boort wetlands was managed in line with the average climate scenario in 2020-21. A partial fill was provided to Lake Yando in spring, followed by a top-up in summer/autumn to support observations of waterbird breeding. Top-ups were provided to Lake Meran in December, February and April to maintain the water level within a critical range that provides habitat for aquatic animals while enabling the growth of herbland vegetation on the wetland fringe. A planned spring fill of Lake Leaghur was deferred, due to channel upgrade works. A priming fill was delivered in autumn 2021 ahead of a planned fill in winter/spring 2021, which is a high priority to ensure the condition and composition of wetland plant communities at Lake Leaghur do not decline.

Scope of environmental watering

Table 5.7.3 describes the potential environmental watering actions in 2021-22, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objective(s) they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.7.3 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Boort wetlands

Potential environmental watering action	Expected watering effects	Environmental objectives
Lake Boort (partial fill in autumn) 	• Prime the wetland for spring watering in 2022-23 by breaking the dormancy of aquatic vegetation propagules so they can grow and reproduce • Grow zooplankton and waterbug communities to provide winter feeding conditions for waterbirds and frogs • Reduce the volume of water required to fill the wetland in spring 2022-23 • Support the growth of culturally significant plants on the wetland fringe including spiny flat sedge and river red gum	
Lake Meran (fill in winter/spring)	• Wet soils around the wetland fringe that have been dry for the last two seasons, to encourage a boom in zooplankton and macroinvertebrate productivity enhancing food resources for waterbirds and turtles • Provide moisture to maintain mature trees in the intermittent swampy woodland on the wetland fringe • Provide deep, open water to maintain refuges for freshwater turtles (in particular Murray River turtles), support the feeding of deep-water foraging waterbirds and support the breeding of colonial nesting birds	
Lake Meran (top-ups, as required to maintain water level between 77.3 m Australian Height Datum [AHD] and 77.8 m AHD)	• Increase the water depth to maintain an appropriate water temperature for aquatic animals and provide a refuge for freshwater turtles, waterbirds and fish • Provide dry areas (above 77.8 m AHD) to promote the growth and increase the extent of herbland vegetation around the wetland fringe	
Lake Leaghur (fill in winter/spring) 	• Increase water depth around the wetland fringe to promote the germination and recruitment of fringing vegetation (such as river red gums and cane grass) • Support the growth of aquatic and semi-aquatic plants • Provide increased habitat area and grow zooplankton and waterbug communities to provide food resources for frogs and waterbirds	
Lake Leaghur (top-up, if triggered by waterbird breeding) 	• Maintain shallow-water habitat under tree canopies to ensure adequate food resources for nesting waterbirds and their chicks	

Scenario planning

Table 5.7.4 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Delivering a fill to Lake Leaghur in late winter/early spring is a high priority under all climate scenarios. A priming fill was completed in autumn 2021 in preparation for this event. The minimum recommended filling regime for Lake Leaghur requires two fill events every 10 years. Lake Leaghur last filled in 2010-11 and vegetation communities at the lake are at risk of exceeding their maximum dry interval tolerance. Filling Lake Leaghur will also provide alternative habitat for waterbirds, given Lake Yando is currently drawing down. There is likely to be enough supply in the Loddon system to fill Lake Leaghur under dry to average climate scenarios, but there may not be enough supply under a drought scenario. Additional top-ups may be required at Lake Leaghur to support waterbird breeding if it occurs. Waterbird breeding is more likely to occur in average or wet climate scenarios.

Watering Lake Meran is also a high priority in 2021-22. The recommended (optimum) water regime for Lake Meran is to fill once every five years and maintain the fill for eight to 10 months, then draw down to 77.80 m AHD and maintain it at a level between 77.30 m AHD and 77.80 m AHD for two years before re-starting the cycle. Lake Meran last filled in 2016 (year one) with natural flows, was allowed to draw down between year two (2017-18) and year three (2018-19), and it has received top-ups of water for the environment since year four (2019-20) to maintain water levels within the target range of 77.30 AHD to 77.80 m AHD. The lake is due to be filled again in year six (2021-22) under the optimum regime, but it can withstand top-ups at the lower level until 2023-24 under its minimum recommended filling regime. Filling the lake before 2023-24 is preferred where possible, so a fill in 2021-22 is a high priority under an average and wet climate scenario. Filling Lake Meran is always subject to water availability, trade restrictions and delivery capacity constraints in the channel system. Under a drought climate scenario or if there is not enough available supply to fill Lake Meran under average and dry climate scenarios, it will be necessary to deliver smaller top-ups to prevent the water level from dropping below 77.30 m AHD.

Lake Boort is due to be filled in 2022-23, and a partial fill in autumn 2022 is highly recommended to prime the wetland and stimulate some ecological processes before the larger watering event. A partial fill in 2021-22 will likely improve the environmental outcomes from the subsequent filling event and also reduce the total volume of water that will need to be delivered in 2022-23. The partial fill may occur naturally under a wet climate scenario, or it could be delivered with available environmental water. Based on current estimates, there may not be enough available supply to partially fill Lake Boort under drought to average climate scenarios, but the watering action may proceed if water becomes available.

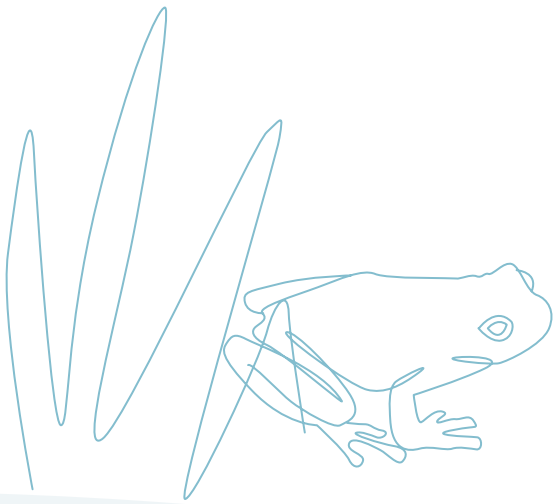


Table 5.7.4 Potential environmental watering for the Boort wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected conditions	• No natural inflow to wetlands	• Minimal natural inflow to wetlands from local catchment run-off possible	• Periods of high flow combined with localised catchment contributions, which are expected to provide minor inflow to wetlands	• Extended durations of high flow and overbank flow from creeks and flood runners, which fill most wetlands
Predicted supply of water for the environment[1]	• 3,403-7,183 ML	• 6,100 ML	• 6,678 ML[2]	• 9,804 ML
Potential environmental watering – tier 1 (high priorities)	**Tier 1a (can be achieved with predicted supply)**			
	• Lake Meran (top-ups)	• Lake Meran (top-ups) • Lake Leaghur (fill) • Lake Leaghur (top-up, if triggered)	• Lake Meran (top-ups) • Lake Leaghur (fill) • Lake Leaghur (top-up, if triggered)	• Lake Boort (partial fill) • Lake Meran (fill) • Lake Leaghur (fill) • Lake Leaghur (top-up, if triggered)
	Tier 1b (supply deficit)			
	• Lake Boort (partial fill) • Lake Leaghur (fill) • Lake Leaghur (top-up, if triggered)	• Lake Boort (partial fill)	• Lake Boort (partial fill) • Lake Meran (fill [instead of top-ups])	• N/A
Potential environmental watering – tier 2 (additional priorities)	• N/A	• Lake Meran (fill [instead of top-ups])	• N/A	
Possible volume of water for the environment required to achieve objectives	• 2,500 ML (tier 1a) • 7,200 ML (tier 1b) • 0 ML (tier 2)	• 4,900 ML (tier 1a) • 4,500 ML (tier 1b) • 3,500[3] ML (tier 2)	• 4,900 ML (tier 1a) • 8,000[3] ML (tier 1b) • 0 ML (tier 2)	• 12,800[4] ML (tier 1a) • 0 ML (tier 1b) • 0 ML (tier 2)

1 Loddon system entitlements are shared between the Loddon River system and the Boort wetlands. The expected availability referenced in this table is an estimate of remaining supply after the Loddon River tier 1a demands and critical carryover requirements have been removed.

2 Large increases in tier 1a demands in the Loddon River system under average conditions will likely result in the available supply for the Boort wetlands being similar to the dry scenario.

3 Demand for Lake Meran is in addition to tier 1a.

4 While the demand is in excess of available supply, it is expected that some of the fill events will be at least partially met with natural inflows under a wet climate scenario.

5.7.3 Birchs Creek

System overview

Birchs Creek is a tributary of the Loddon River located in the southern-most part of the catchment. The creek rises in the ranges north-east of Ballarat and flows north-west through Newlyn and Smeaton before joining Tullaroop Creek near Clunes. The lower parts of the catchment are extensively cleared where the creek meanders through an incised basaltic valley. The creek contains a regionally significant platypus community and a vulnerable river blackfish population.

Birchs Creek is part of the broader Bullarook system which contains two small storages — Newlyn Reservoir and Hepburn Lagoon — which provide water for irrigation and urban supply. The storages fill and spill during winter or spring in years with average or above-average rainfall. The VEWH holds water for the environment in Newlyn Reservoir, but there is no water held in Hepburn Lagoon.

Birchs Creek receives tributary inflows from Rocky Lead, Langdons, Lawrence and Tourello creeks. Groundwater provides reliable baseflows to the downstream reaches of Birchs Creek in most years.

The VEWH is allocated 100 ML in Newlyn Reservoir on 1 December each year, provided that seasonal determinations in the Bullarook system are at least 20 percent. Any unused allocation from 1 December can be carried over until 30 November of the following water year, but if Newlyn Reservoir spills from 1 July to 30 November, the volume held in carryover is lost. Any water remaining on 30 November is forfeited. When seasonal determinations are below 20 percent, the VEWH does not receive an allocation, and the system's resources are shared equitably to protect critical human and environmental needs.

Environmental values

Birchs Creek supports threatened aquatic plants and its deep pools provide habitat for aquatic animals during dry periods. The creek contains native fish including regionally significant populations of river blackfish and mountain galaxias as well as flat-headed gudgeon and Australian smelt. Recent monitoring indicates that platypus are present throughout the entire creek.

The removal of willows along the creek in 2018 has improved in-stream vegetation and populations of small-bodied fish.

Environmental watering objectives in Birchs Creek

	Increase the population and diversity of small- and medium-bodied native fish including river blackfish, mountain galaxias, flat-headed gudgeon and Australian smelt
	Maintain the breeding population of platypus and increase the number of individuals to improve the population's resilience to future droughts and floods Provide surplus juvenile platypus that can disperse to Creswick and Tullaroop creeks
	Maintain and improve the diversity and abundance of in-stream aquatic plants Maintain a diverse variety of fringing and streamside native vegetation communities
	Increase the population of waterbugs and the diversity of functional groups to drive productive and dynamic food webs
	Maintain water quality to support aquatic life and ecological processes

Traditional Owner cultural values and uses

In planning for environmental flows in Birchs Creek, Dja Dja Wurrung Clans Aboriginal Corporation and North Central CMA have identified the creek as a potential site for future projects.

The *Dja Dja Wurrung Country Plan 2014-2034* describes their aspirations around the management of rivers and waterways and articulates Dja Dja Wurrung peoples' support for the reinstatement of environmental flows as an overall objective for the management of water on Country.

The North Central CMA and Dja Dja Wurrung Clans Aboriginal Corporation continue to work towards increased engagement on planning and delivery of environmental watering activities, including identifying opportunities for Dja Dja Wurrung involvement.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.7.5, North Central CMA considered how environmental flows could support values and uses including:

- water-based recreation (such as fishing)
- riverside recreation and amenity (such as cycling and walking, diversion for domestic and stock use and improving amenity at key community spaces like Anderson's Mill).

Recent conditions

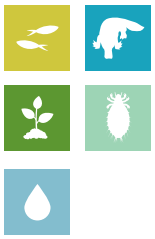
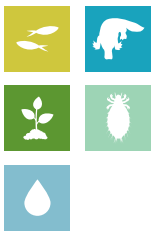
Although July rainfall was well-below average, near-average rainfall was observed during late winter to early summer, and January rainfall was well above average. Water for the environment allocated in December 2019 was carried into the 2020-21 water year, but it was lost due to regular spills at Newlyn Reservoir throughout winter and spring 2020. The full 100 ML allocation was again received on 1 December 2020.

Regular storage spills and contributions from groundwater led to all of the winter and spring flow requirements for Birchs Creek being met or exceeded. Low flow and freshes over summer and autumn were met with a combination of natural flow from summer storms and groundwater baseflow, as well as consumptive releases in reaches 1 and 2. No additional freshes were required in Birchs Creek in 2020-21, so the allocation from December 2020 will be carried over to support watering actions in 2021-22.

Scope of environmental watering

Table 5.7.5 describes the potential environmental watering actions in 2021-22, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objectives they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.7.5 Potential environmental watering actions, expected watering effects and associated environmental objectives for Birchs Creek

Potential environmental watering action	Expected watering effects	Environmental objectives
Birchs Creek (targeting reach 3)		
Winter/spring fresh (one fresh of 27 ML/day for three days during June to November)	• Maintain and support the growth and germination of streamside vegetation by increasing soil moisture and depositing sediment on the bank and benches • Scour old biofilms and organic matter that has accumulated in the channel, and cycle nutrients throughout the creek • Wet benches and banks, to increase habitat and refuge for small fish • Improve water quality by freshening refuge pools and provide connectivity between pools for fish and platypus movement	
Summer/autumn freshes (three freshes of 10 ML/day for three days during December to May)	• Increase the water depth, to maintain and support seed germination and the growth of in-stream aquatic vegetation • Expand riffle/run areas to provide waterbug habitat • Top up pools to refresh water quality (particularly oxygen levels) and enhance connectivity between pools, for fish and platypus movement	

Scenario planning

Table 5.7.6 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The entitlement for water for the environment in Birchs Creek is primarily used to deliver winter/spring freshes and summer/autumn freshes if they are not met by the natural flow or consumptive water deliveries. The volume of available water for the environment is not sufficient to deliver any of the other recommended environmental flows in the system. The Birchs Creek Environmental Water Advisory Group has advised that it is better to use the available water to deliver recommended freshes in full, rather than a small proportion of recommended low flows.

Winter/spring freshes are important to cycle nutrients throughout the system and wet higher channel features to increase connectivity between types of habitat for aquatic animals. Summer/autumn freshes are needed to maintain water quality in the warmer months and ensure pools do not dry out. Both these watering actions are important and if required and where allocation allows, summer/autumn freshes may be prioritised to avoid critical loss of environmental values in the system, especially when considering this system can quickly shift climate scenarios in the warmer months.

Table 5.7.6 Potential environmental watering for Birchs Creek under a range of planning scenarios

Planning scenario	Drought	Dry	Average and Wet
Expected river conditions	• Reservoir spill unlikely • Flow extremely low in winter/spring • Limited irrigation releases due to low allocations	• Reservoir spill possible • Low flow in winter/spring if no spills occur • Moderate irrigation releases	• Reservoir spills are certain in winter/spring • Some natural flow through summer/autumn • Groundwater contributes to baseflow throughout the year
Predicted supply of water for the environment	• 100 ML (2020 carryover)	• 100-200 ML (2020 carryover and possible 2021 allocation)	• 100 ML (2021 allocation)[1]
Potential environmental watering – tier 1 (high priorities)	**Tier 1a (can be achieved with predicted supply)**		
	• Winter/spring fresh (one fresh, at lower duration)	• Winter/spring fresh (one fresh) • Summer/autumn freshes (three freshes)	• Winter/spring fresh (one fresh) • Summer/autumn freshes (three freshes)
	Tier 1b (supply deficit)		
	• Summer/autumn freshes (three freshes)	• N/A	
Potential environmental watering – tier 2 (additional priorities)	• N/A		
Possible volume of water for the environment required to achieve objectives	• 100 (tier 1a) • 100 ML (tier 1b) • 0 ML (tier 2)	• 200 ML (tier 1a) • 0 ML (tier 1b) • 0 ML (tier 2)	• 100 (tier 1a) • 0 ML (tier 1b) • 0 ML (tier 2)
Priority carryover requirements	• If the 100 ML allocation is received on 1 December 2021 and Birchs Creek is in good condition over summer/autumn, carry over 100 ML allocation into 2022-23 for use by 30 November 2022		

1 Under an average or wet scenario, it is likely that Newlyn Reservoir will spill before 30 November 2021, losing the 100 ML carryover from December 2020.