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3.1 Central region overview

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

Traditional Owners in the central region

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

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

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

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

Engagement

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

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

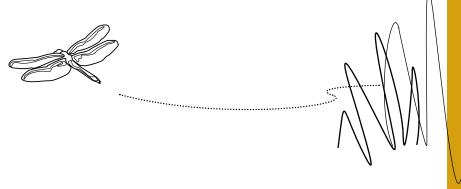


Table 3.1.1 International Association for Public Participation's Public Participation Spectrum categories and participation goals¹

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

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

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

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

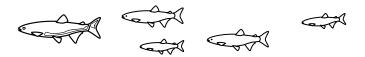


Table 3.1.2 Partners and stakeholders engaged by Melbourne Water in developing seasonal water proposals for the Yarra, Tarago, Maribyrnong and Werribee systems and other key foundation documents that have directly informed the proposals

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

Empower

Key: Inform

Consult Involve Collaborate

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

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

Key: Inform Consult Involve Collaborate Empower

Community benefits from environmental watering

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

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

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

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

- Corangamite CMA will consult with stakeholders about the timing of water deliveries to the lower Barwon wetlands to take account of duck hunting seasons declared and regulated by the Victorian Game Management Authority⁴
- Melbourne Water may time a summer fresh in the Tarago River to occur on the Australia Day long weekend in January 2020 so residents of the Glen Crombie Caravan Park alongside the river can enjoy the Australia Day weekend with additional flows in the river.

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

Integrated catchment management

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

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

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

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

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

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

Seasonal outlook 2019-20

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

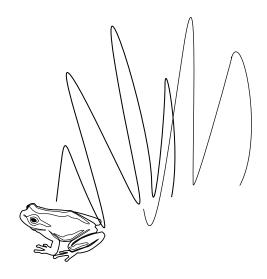
Water delivery infrastructure limits the volume of water for the environment that can be delivered to priority waterways throughout the central region, and therefore releases are usually planned to supplement unregulated flows and to make up shortfalls associated with low flows and small-tomedium-sized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

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

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

Risk management

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



3.2 Yarra system



Waterway manager – Melbourne Water Storage manager – Melbourne Water

Environmental water holder – Victorian Environmental Water Holder

Did you know ...?

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

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





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

System overview

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

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

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

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

Environmental values

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

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

Environmental objectives in the Yarra System



Protect and increase populations of native fish including threatened species (such as the Australian grayling, Macquarie perch and river blackfish)



Maintain the form of the river channel

Scour silt build-up in riffles and clean cobbles



Maintain the population of resident platypus



Increase, strengthen and maintain native riparian and aquatic vegetation on the riverbank and in the channel, as well as on the upper Yarra floodplain and in the billabongs along the river



Protect and increase communities of waterbugs, which break down dead organic matter and support the river's food chain



Improve water quality in river pools, ensuring adequate dissolved oxygen concentration in the water to support fish, crustaceans and waterbugs

Aboriginal environmental outcomes



Traditional Owners have specifically identified Aboriginal environmental outcomes associated with these watering actions

Figure 3.2.1 The Yarra system



Reach 1 Yarra River: Upper Yarra Reservoir to Armstrong Creek

Reach 2 Yarra River: Armstrong Creek to Millgrove

Reach 3 Yarra River: Millgrove to Watts River

Reach 4 Yarra River: Watts River to top of Yering Gorge

Reach 5 Yarra River: Top of Yering Gorge to Mullum Mullum Creek
Reach 6 Yarra River: Mullum Mullum Creek to Dights Falls

Reach 7 Yarra River Estuary

Reach 8 Watts River: Maroondah Reservoir to the Yarra River

Reach 9 Plenty River: Toorourrong Reservoir to Mernda

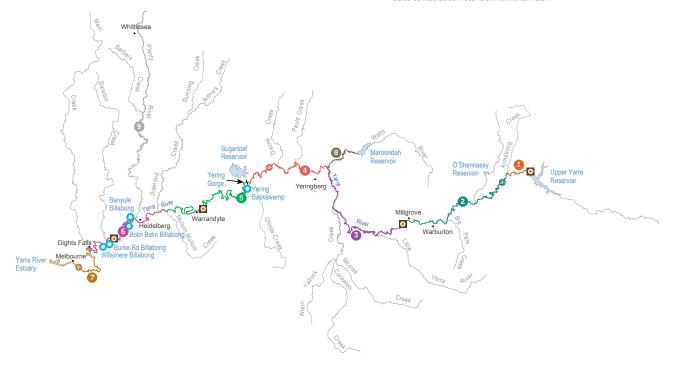
Measurement point

Town

Indicates direction of flow

Wetland

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.



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

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

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

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

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

Scope of environmental watering

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

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

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

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

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

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

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

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

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

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

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



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

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

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

3.3 Tarago system



Waterway manager – Melbourne Water Storage manager – Melbourne Water

Environmental water holder – Victorian Environmental Water Holder

Did you know ...?

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





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

System overview

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

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

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

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

Environmental values

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

Environmental objectives in the Tarago system



Increase populations of native fish including threatened species (such as the Australian grayling)



Maintain channel form and structure



Increase platypus populations

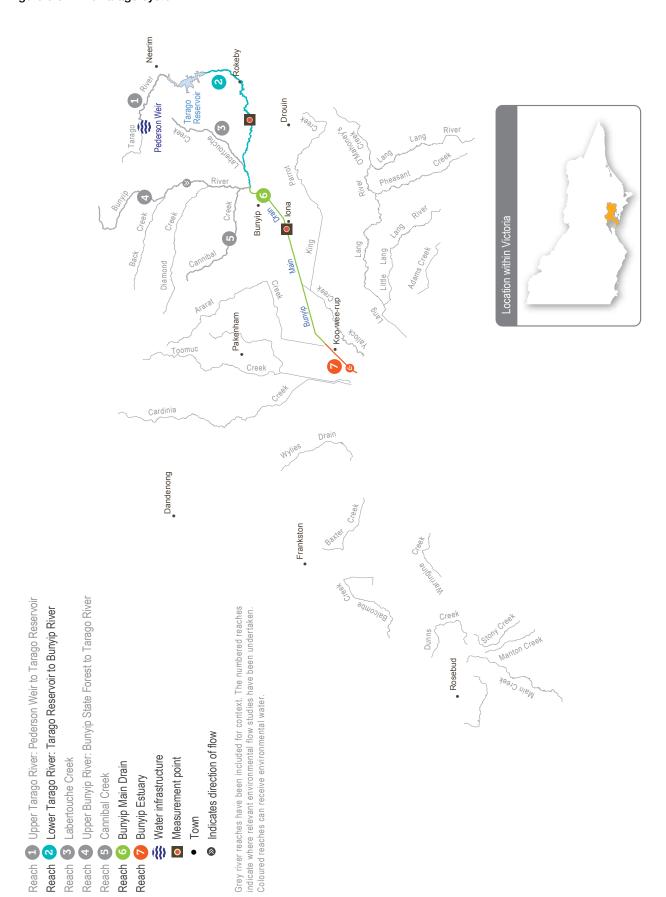


Increase and maintain native riparian and aquatic plant communities on the riverbank and in the channel



Increase the diversity and biomass of waterbugs, to support aquatic foodwebs

Figure 3.3.1 The Tarago system



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

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

Scope of environmental watering

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

Table 3.3.1 Potential watering actions and objectives for the Tarago system

Potential environmental watering action	Functional watering objective	Environmental objective
Summer/autumn freshes (up to five freshes of	Scour sediment from holes and around large woody debris to maintain habitat for native fish in low-flow periods	< < >
75 ML/day for two days each during December to May)	Allow the localised movement of resident fish	
	Prevent terrestrial vegetation growth on sandbars	* 0
	Maintain water quality by aeration through times of low flow	
Autumn high flow (one fresh	Cue spawning for diadromous fish (such as Australian grayling)	
with a peak of 100 ML/day maintained for two days in	Allow the downstream movement of Australian grayling	- Ar
a minimum seven-day fresh duration during April to May)	Assist the dispersal of juvenile platypus	
Spring high flow (one to two	Form and maintain scour holes around large wood	
freshes during September to October with two to three	Prevent the encroachment of terrestrial vegetation into the channel	
days in a minimum seven- to-10 day fresh at a peak of 200–300 ML/day)	Cue the upstream migration of juvenile diadromous fish (such as Australian grayling) from the sea or estuary into the river	₽
200-300 ML/day)	Wet higher benches to maintain the fringing aquatic vegetation and ensure vertical zonation of the fringing vegetation	
	Provide a cue for platypus to select nesting burrows above high water level	
Winter/spring freshes (two freshes of 100–200 ML/day at peak for one to two days	Prevent sediment build-up and remove biofilm from large woody debris to maintain habitat for macroinvertebrates and fish including river blackfish	< X
during June to September)	Maintain access to habitats by ensuring sufficient depth through riffles to allow fish movement between pools and reaches	*
	Cue the downstream migration of species such as eel and tupong	
	Inundate the banks, wetting the lower benches to maintain the fringing aquatic vegetation	
Winter/spring low flows	Prevent the encroachment of terrestrial vegetation in the channel	
(75 ML/day [or natural] during June to November)	Wet the banks to promote riparian vegetation growth	
	Maintain an adequate depth through riffles to allow access to habitats for fish and platypus	* 🐧
	Maintain water quality through increased low flows to flush the system and inundate additional habitat for fish and macroinvertebrates	
	Maintain foraging habitat for platypus	

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

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

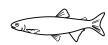
Summer/autumn freshes are critical in dry years as they top up pool habitats and improve water quality, which helps to maintain the quality and quantity of available habitat for fish, macroinvertebrates and platypus. Freshes temporarily increase river depth in riffles and run habitats between pools,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

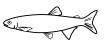
Autumn high flows are needed to cue Australian grayling to spawn. Under a dry scenario, the autumn high flow should be delivered in two out of three years; in wetter periods, it should be delivered annually. Australian grayling have a short lifespan, so continued spawning is important to maintain and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

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

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

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





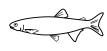


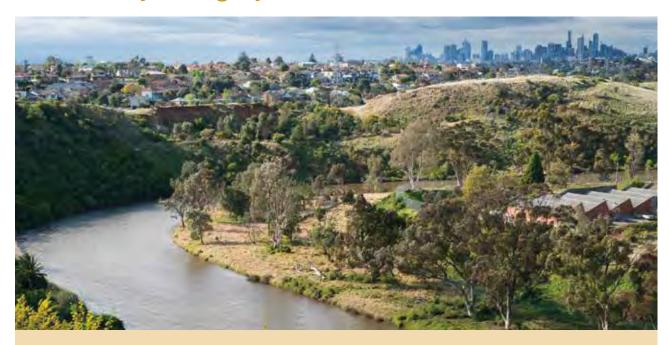


Table 3.3.2 Potential environmental watering for the Tarago system under a range of planning scenarios

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

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

3.4 Maribyrnong system



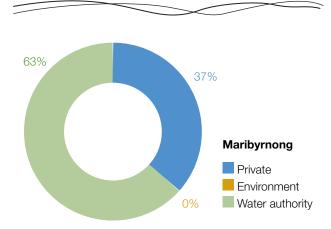
Waterway manager – Melbourne Water

Storage manager – Southern Rural Water

Environmental water holder – N/A

Did you know ...?

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



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





Top: View from Maribyrnong River to Melbourne, by Melbourne Water

Centre: Maribymong vegetation, by Melbourne Water Above: Boating on the Maribymong River, by Melbourne Water

System overview

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

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

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

Environmental values

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

Environmental objectives in the Maribyrnong system



Protect and increase populations of native small-bodied fish



Maintain channel morphology



Maintain the platypus population



Maintain and improve the condition, abundance, diversity and structure of in-stream and riparian vegetation

Prevent terrestrial vegetation encroachment into the channel



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



Maintain water quality, particularly dissolved oxygen concentrations

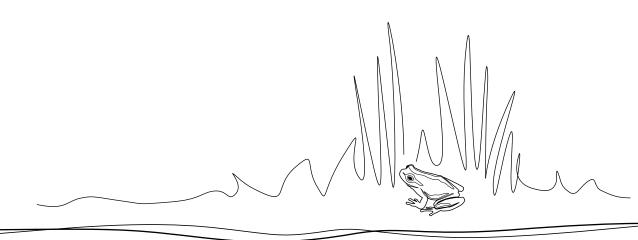


Figure 3.4.1 The Maribyrnong system





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

In 2018–19, water for the environment was used to deliver autumn freshes to reaches 6 and 7, to prevent adverse water quality conditions and to flush fine sediments from hard surfaces. These functions are critical during very

low flow periods to maintain suitable habitat and food resources for small-bodied native fish, waterbugs and platypus. The autumn freshes also provided opportunities for fish to disperse throughout each reach and helped support in-stream and riparian vegetation.

Scope of environmental watering

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

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

Potential environmental watering action	Functional watering objective	Environmental objective
Summer/autumn freshes (up to five freshes of 20–40 ML/day for up to seven days) during December to May Winter/spring high flows (20–40 ML/day) during June to November	 Flush pools to maintain water quality Scour substrates to remove fine sediment Inundate the in-stream vegetation and riparian benches to support the growth of native riparian plants and to limit encroachment by terrestrial plant species Provide passage for small-bodied native fish and platypus between habitats Inundate the in-stream vegetation and riparian benches to support the growth of native riparian plants and to limit encroachment by terrestrial plant species 	
Summer/autumn low flows (4–6 ML/day) during	 Scour substrates to remove fine sediment Provide passage for small-bodied native fish and platypus between habitats Maintain waterbug habitat by providing suitable depth over riffles, maintaining pools and inundating large woody debris. 	
December to May	 maintaining pools and inundating large woody debris Inundate the in-stream vegetation Provide passage for small-bodied native fish and platypus between habitats 	* 0

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

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

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

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

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

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

3.5 Werribee system



Waterway manager – Melbourne Water

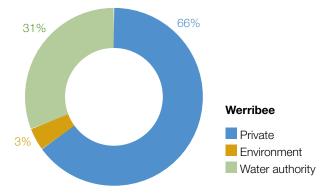
Storage manager - Southern Rural Water

Environmental water holder - Victorian Environmental Water Holder

Did you know ...?

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





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





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

System overview

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

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

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

Environmental values

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

Environmental objectives in the Werribee system



Protect and increase populations of native fish including black bream and galaxiids



Maintain the population of frogs



Maintain channel beds and pool habitats

Maintain clean substrate surfaces to support biological processes



Maintain the platypus population

Maintain the health and increase the cover of in-stream, riparian and estuary plants



Limit the spread of terrestrial plants and promote the recruitment of native water-dependent plant species on the banks and benches of waterways



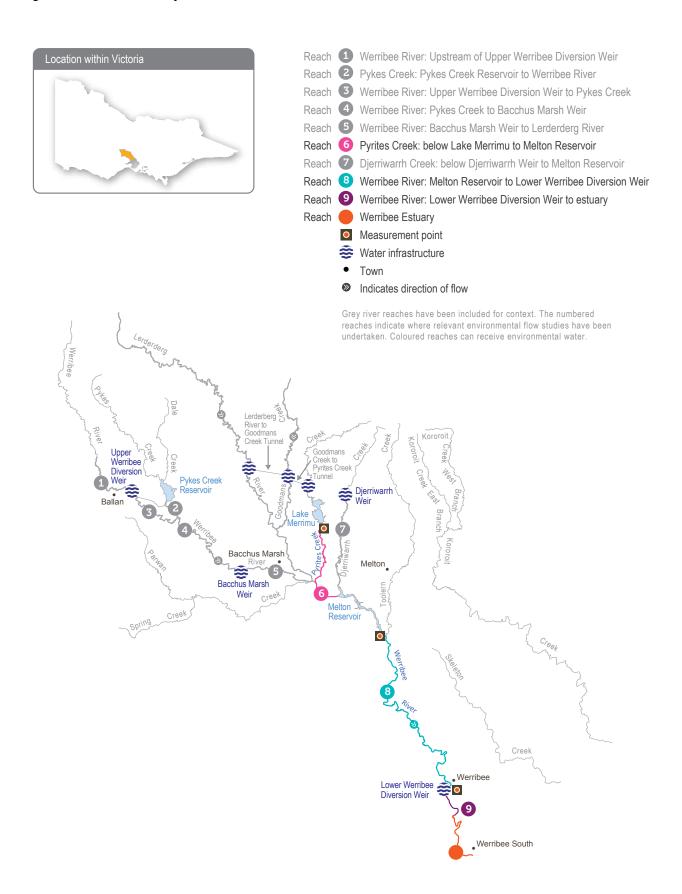
Maintain the population of waterbugs, to break down dead organic matter and support the river's food chain



Maintain dissolved oxygen and salinity levels in pools



Figure 3.5.1 The Werribee system



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

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

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

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

Scope of environmental watering

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

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

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

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

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

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

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

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

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

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

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

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

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

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

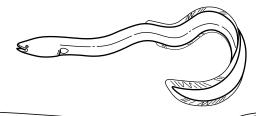


Table 3.5.2 Potential environmental watering for the Werribee system under a range of planning scenarios

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

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

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

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

3.6 Moorabool system



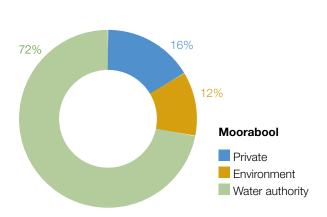
Waterway manager - Corangamite Catchment Management Authority

Storage manager - Central Highlands Water

Environmental water holder – Victorian Environmental Water Holder

Did you know ...?

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



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





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

System overview

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

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

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

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

Environmental values

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

Environmental objectives in the Moorabool River



Maintain self-sustaining populations of native fish (in particular short-finned eel, Australian grayling, spotted galaxias and tupong)



Maintain physical habitat diversity



Restore self-sustaining breeding populations of platypus and support the dispersal of juveniles



Maintain riparian vegetation communities

Maintain in-stream macrophyte communities



Maintain diverse waterbug communities



Improve water quality

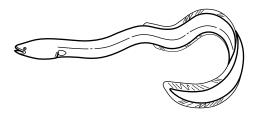
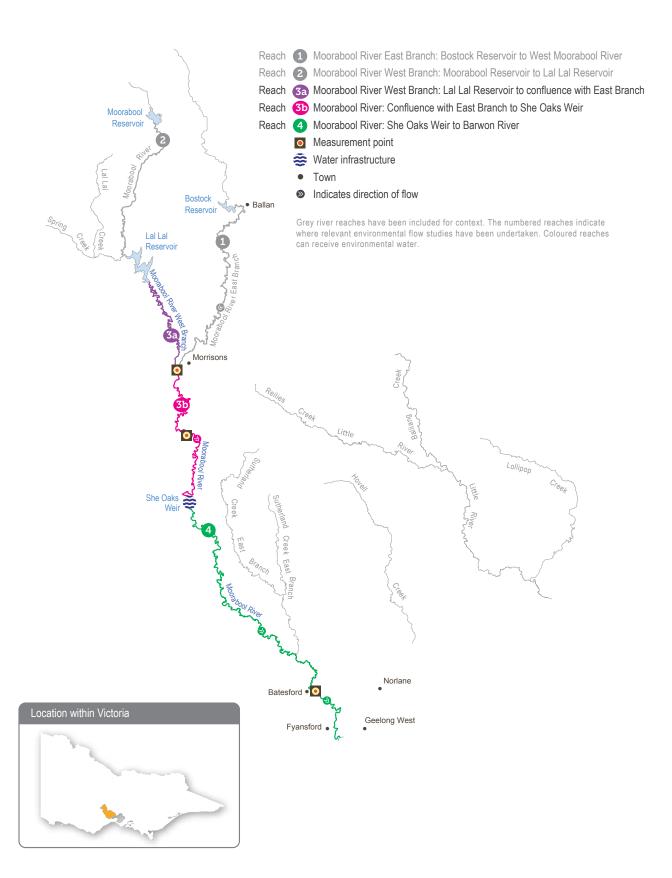


Figure 3.6.1 The Moorabool system



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

In 2019, the VEWH in partnership with Central Highlands Water, Barwon Water and the Corangamite CMA, secured additional water to use in the Moorabool River to mitigate the effects of drought. The additional water was from one-off transactions that allowed the delivery of priority watering actions including an autumn fresh, which connected habitats along the river and improved water quality. As in

previous years, the coordination of environmental flows with releases of water for operational or consumptive purposes greatly increased the efficiency of environmental watering. The ability to piggyback on operational releases means that less allocation of water for the environment is needed to meet target flows.

Scope of environmental watering

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

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

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

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

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

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

In scenarios where more water is naturally available and the risk of poor water quality lessens (transitioning from dry to

average or wet), priorities shift to delivering freshes for key fish migration cues, and connectivity for plants and animals to disperse.

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

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

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	Disconnected pools in some parts during July to December	Cease-to-flow events	 Continuous flow throughout winter Low flow over summer High peaks in winter months 	 Continuous flow year-round Bankfull flows persist throughout winter Overbank conditions in some parts in spring/ autumn
Expected availability of environmental water	• 1,200 ML	• 2,000 ML	• 3,000 ML	• 5,000 ML
Potential environmental watering – tier 1a (high priorities)	 Summer/autumn freshes (trigger- based¹) Summer low flows 	 Summer/autumn freshes (trigger based¹) Summer low flows Winter low flows Spring fresh 	Summer low flowsWinter low flowsSpring freshWinter fresh	Summer low flowsWinter low flowsSpring freshWinter freshAutumn fresh
Potential environmental watering – tier 1b (high priorities with shortfall)	Winter low flowsSpring freshesWinter freshAutumn freshSummer freshes	Winter freshAutumn freshSummer freshesAdditional spring freshes	Autumn freshSummer freshesAdditional spring freshes	Summer freshesAdditional spring freshes
Potential environmental watering – tier 2 (additional priorities)	As per tier 1, but at higher peak flows and longer durations	 As per tier 1, but at higher peak flows and longer durations 	 As per tier 1, but at higher peak flows and longer durations 	 As per tier 1, but at higher peak flows and longer durations
Possible volume of water for the environment required to achieve objectives ²	1,160 ML (tier 1a)2,240 ML (tier 1b)6,600 ML (tier 2)	1,900 ML (tier 1a)1,500 ML (tier 1b)6,600 ML (tier 2)	2,330 ML (tier 1a)1,070 ML (tier 1b)6,600 ML (tier 2)	2,330 ML (tier 1a)1,070 ML (tier 1b)6,600 ML (tier 2)
Priority carryover requirements		• up to	1,000 ML	

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

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



3.7 Barwon system



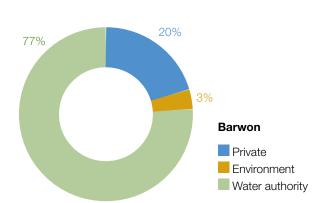
Waterway manager - Corangamite Catchment Management Authority

Storage manager - Barwon Water

Environmental water holder – Victorian Environmental Water Holder

Did you know ...?

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



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





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

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

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

3.7.1 Upper Barwon River

System overview

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

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

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

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

Environmental values

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

Environmental objectives in the upper Barwon River

Maintain the abundance, and improve the breeding and recruitment of migratory fish species including short-finned eels, Australian grayling and tupong, broad-finned galaxias and common jollytail



Maintain the abundance, and improve the breeding and recruitment of resident freshwater fish including several species of galaxias, Australian smelt, big-headed gudgeon, Yarra pygmy perch and river blackfish



Maintain the abundance, improve the condition and extend the distribution of platypus populations

Improve the condition and extent of native instream vegetation, to provide structural habitat for macroinvertebrates and various fish species



Increase the extent and diversity of emergent macrophyte vegetation, to provide structural habitat and stabilise banks

Increase the extent and diversity of native riparian vegetation

Improve the condition and extent of native floodplain vegetation



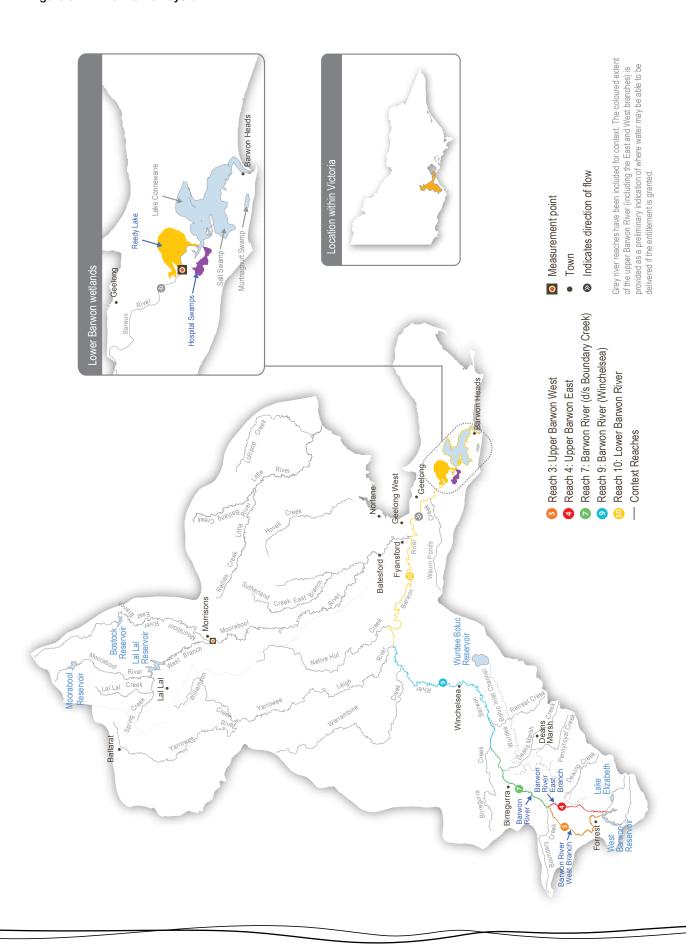
Increase the abundance of waterbugs as a food source for fish, frog and platypus populations



Maintain water quality for native fish, waterbugs, aquatic vegetation and other water-dependent animals



Figure 3.7.1 The Barwon system



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

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

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

Scope of environmental watering

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

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

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

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

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

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

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

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

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

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

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



Table 3.7.2 Potential environmental watering for the upper Barwon River under a range of planning scenarios¹

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

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

3.7.2 Lower Barwon wetlands

System overview

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

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

Environmental values

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

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

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

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

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

Environmental objectives in the lower Barwon wetlands



Provide habitat for fish breeding and growth and improved conditions for migration and dispersal, when wetlands are connected to the Barwon River



Provide varying water levels and conditions to promote soil salinisation, to support the persistence and growth of threatened saltdependent ecological vegetation communities



Maintain the high diversity of ecological vegetation communities in the wetlands Increase the growth and extent of coastal saltmarsh, herbfields and lignum shrubland ecological vegetation communities



Provide suitable foraging habitat including mud flats and shallow water for wading birds, and refuge for waterbirds and shorebirds

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

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

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

Scope of environmental watering

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

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

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



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

Potential environmental watering action	Functional watering objective	Environmental objective
Reedy Lake		
Autumn/winter/spring fill and top-ups (all year) ¹	Maintain the water level at or above 0.8 m AHD (allowing for natural fluctuations)	~
The inlet to Reedy Lake will be opened in autumn	Maintain connectivity with the Barwon River	٤
in response to a sustained increase in flows in the	Inundate the vegetation at the wetland margins to provide feeding habitat for waterbirds	A
Barwon River	Provide rising water levels to promote waterbird breeding	
	Promote major fish breeding and recruitment opportunities	
	Allow fish to move between the river, lake and estuary	
Hospital Swamps		
Autumn/winter/spring fill and top-ups (during March and April to December) ¹	Create habitat to support waterbug and fish populationsStimulate fish and waterbird breeding	< *
Hospital Swamps will be	Allow fish to access the wetland from the river	<i>S</i>
connected to the Barwon River for at least six weeks by	Dilute salt in the soil and surface water over winter	1 TI
keeping the inlet and outlet open	Promote and sustain the growth of important wetland vegetation communities	
Summer/autumn drawdown (during December to March	Reduce the threat of carp and associated impacts on native plants and animals	
and April) The inlet to Hospital Swamps will be closed to allow	Prevent the expansion of tall reeds by increasing the salt content of the water and soil	•
water levels to drop through evaporation; during this	Increase habitat diversity (including in salt pans, mudflats and shallow water)	A /#
period, the outlet will be opened for short periods	Provide wading bird habitat in early summer	
of time if a summer storm	Provide refuge and foraging habitat for waterbirds in early summer	
increases water levels above 0.85 m AHD to reduce levels.	Increase lake shore salinity and increase soil salinisation	
	Initiate the decomposition of organic matter on the wetland bed, to increase lake productivity when it is refilled	
	Improve soil health and allow weathering of heavy metals in lake fringe soils	
	Provide suitable conditions for threatened vegetation communities (such as coastal saltmarsh, herbfields and lignum shrubland)	
	Allow seasonal recruitment of aquatic macrophytes at the wetland fringes	

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

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

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

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

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

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

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