

Australian Government

Commonwealth Environmental Water Office Water Management Plan 2021–22

Chapter 14 River Murray Valley Water Plan



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Acknowledgement of the Traditional Owners of the Murray-Darling Basin

The Commonwealth Environmental Water Office respectfully acknowledges the Traditional Owners, their Elders past and present, their Nations of the Murray–Darling Basin, and their cultural, social, environmental, spiritual and economic connection to their lands and waters.

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14 River Murray Valley Water Plan

14.1 Region overview

14.1.1 River system

The River Murray is Australia's longest river, running a course of 2,500 km from near Mount Kosciuszko in the Australian Alps to the Southern Ocean at Goolwa, in South Australia. A mountain stream in its upper reaches, the river turns into a meandering river lined with magnificent river red gum forests and woodlands, before ending its journey flowing through the vast Lower Lakes and Coorong, and out through the small Murray Mouth. Many creeks and anabranches flow in and out of the River Murray, the largest being the Edward/Kolety-Wakool River system.

Water for the environment managed by the Commonwealth can be ordered for delivery to sites downstream of Hume Dam, near Albury, with water also supplied from Lake Victoria (west of Wentworth) and from its various tributaries, including from the Goulburn, Loddon and Campaspe rivers in Victoria, and from the Murrumbidgee and Darling rivers in NSW (Map RM1 and Map RM2). The Ovens and Kiewa Rivers are particularly valuable to the ecology of the River Murray given their limited regulation, which means they provide natural inflows into the River Murray.

14.1.2 Traditional Owners

The River Murray flows through the traditional lands of many First Nations and the river and its floodplains have long been important for sustenance and spirituality (MDBA 2020). The upper Murray catchment includes the traditional land of the Dhudhuroa, Djilamatang, Ngarigo, Walgalu and Yaitmathang Aboriginal Nations. The Commonwealth Environmental Water Office (CEWO) respectfully acknowledges these Nations, their Elders past and present, as the Traditional Custodians of the lands on which this chapter is focused.

The Aboriginal Nations associated with the mid-Murray planning area include the Wiradjuri, extending from the River Murray to the Macquarie River in the north, and west to Balranald. The east, from the Murray and south into the Great Dividing Range, is the traditional land of the Dhudhuroa and Waywurru Nations. The region centred on Echuca, is the traditional land of the Barapa Barapa/Perepa Perepa, Wamba Wamba/Wemba Wemba and Yorta Yorta Nations. The lower stretch of the central Murray catchment includes the traditional land of the Barkindji, Maraura, Muthi Muthi, Nyeri Nyeri, Tati Tati, Wadi Wadi and Weki Weki Nations.

The Aboriginal Nations associated with land around the confluence of the Darling and Murray rivers include the Barkindji, Latji Latji, Maraura, Muthi Muthi and Nyeri Nyeri. Upstream of the confluence of the Darling and Murray includes the land of the Barkindji and Maraura nations. Along the River Murray, from about Mildura and into South Australia is also the traditional land of the Ngintait Nation. The First Peoples of the River Murray and Mallee Region are the Traditional Owners of the River Murray area from the Victorian border to Morgan. The land of the lower reaches of the Murray, the Lower Lakes and the Coorong is the traditional land of the Ngarrindjeri nation. The land west of the river and including the Mount Lofty Ranges, includes the country of the Kaurna and Peramanok Nations.



Map RM1 Mid-River Murray valley, including the Edward/Kolety-Wakool river system

Department of Agriculture, Water and the Environment

Map RM2 Lower River Murray valley



Department of Agriculture, Water and the Environment

14.1.3 Important sites and values

The River Murray valley supports a range of environmental values of local, regional, national and international significance. Examples are as follows.

Vegetation

The Mid-Murray reach includes over 90 000 ha of river red gum and over 40 000 ha of black box and extensive lignum shrublands, including Barmah-Millewa, Gunbower, Koondrook-Perricoota and Werai Forests. Together these comprise the largest complex of tree dominated floodplain wetlands in southern Australia and Australia's largest parcel of river red gum forests. Downstream, the woodlands of the Lower Murray (Hattah-Kulkyne Lakes, Lindsay-Mulcra-Wallpolla-Chowilla and Katarapko and Pike floodplains) and lignum shrublands are highly significant. There are also important non-woody vegetation communities including the Moira grasslands in the Barmah-Millewa Forest and *Ruppia tuberosa* in the Coorong.

Native fish

The River Murray, along with its anabranches, creeks and wetlands, provides habitat for a suite of native fish, including nationally listed threatened species, such as Murray cod, trout cod, silver perch and Murray hardyhead. The creeks through Barmah-Millewa Forest, the Edward/Kolety-Wakool system and Gunbower Creek (in the Mid-Murray) and the Lindsay-Mullaroo Creek system, Chowilla floodplain, Katarapko and Pike creeks and anabranches (in the Lower Murray) are also important habitat for native fish. Several small wetlands in the Lower Murray, along with the Lower Lakes, support some of the last remaining wild populations of threatened small-bodied native fish, such as Southern purple-spotted gudgeon, Southern pygmy perch and Murray hardyhead.

The Murray Mouth, the Coorong and the Lower Lakes region is a hot spot for native fish diversity, supporting marine, estuarine, freshwater and diadromous (move between both salt and freshwater) fish. This includes a range of recreational and commercial fish species such as black bream, greenback flounder, yellow-eye mullet, golden perch, and mulloway. Species like sandy sprat, small-mouthed hardyhead and congolli are also essential food sources for predatory fish and waterbirds in the region.

Birds

Floodplain ecosystems of the Murray-Darling Basin support a high diversity of migratory shore birds and waterbirds, as well as 108 species of floodplain dependent woodland birds. There are several wetlands recognised as having Basin-wide importance for waterbirds. These include the River Murray, Barmah-Millewa Forest (which includes wetlands that are significant to the nationally endangered Australasian Bittern), Gunbower-Koondrook-Perricoota Forest, Hattah Lakes, Chowilla-Lindsay-Wallpolla, Pyap Lagoon, and the Lower Lakes and Coorong (MDBA 2017). The Coorong and Lakes Albert and Alexandrina is recognised as a Wetland of International Importance for shorebirds (Paton et al. 2020), comprising the most important site in the Basin for shorebirds (MDBA 2017) and one of the most important sites in Australia. The site also supports the greatest waterbird species richness of the Murray–Darling Basin. In addition to waterbirds, the River Murray floodplain between Robinvale and Swan Reach has been identified as highly important to the nationally vulnerable regent parrot.

Ramsar Wetlands

The River Murray region contains several internationally important Ramsar listed wetlands: Barmah Forest, Gunbower Forest, New South Wales Central Murray Forests (consisting of Millewa, Koondrook-Perricoota and Werai forests), Hattah-Kulkyne Lakes, the Riverland (including Chowilla floodplain), Banrock Station Wetland Complex and The Coorong, Lakes Alexandrina and Albert Wetland. These sites are recognised for their unique and diverse wetlands, support of species of conservation significance and biological diversity, their role in providing refuge during adverse conditions, and regularly supporting large numbers of waterbirds. This includes sites listed under international migratory agreements. The significance of these sites is documented in the ecological character descriptions (http://www.environment.gov.au/cgi-bin/wetlands/alphablist.pl).

14.1.4 Stakeholder engagement

Delivery partners

The planning, management and delivery of Commonwealth water for the environment throughout the Murray valley is undertaken in collaboration with a range of partners and stakeholder groups.

All Commonwealth environmental water delivery is coordinated with other government environmental water holders: NSW Department of Planning, Industry and Environment -Environment, Energy and Science (DPIE EES), the Victorian Environmental Water Holder (VEWH), the South Australian Department for Environment and Water (SA DEW), and the Murray-Darling Basin Authority (MDBA) in its role in coordinating The Living Murray programs. In most cases, Commonwealth environmental water is transferred to these agencies, who are responsible for ordering this water for delivery. The primary coordination body is the Southern Connected Basin Environmental Watering Committee (SCBEWC), which includes representatives from each of the federal and state government environmental water holders, as well as representatives from the Murray Lower Darling Rivers Indigenous Nations. Managers of The Living Murray (TLM) icon sites provide annual watering proposals that are considered by the committee in planning and delivering water for the environment. As part of this process, the Indigenous Partnerships Program supports First Nations contribution to the planning and management of key sites and environmental watering activities.

In addition to the above organisations, the delivery of environmental water is also supported by and coordinated with:

- river operators (MDBA, WaterNSW, Goulburn-Murray Water, SA Water)
- irrigation corporations (Murray Irrigation Limited, Renmark Irrigation Trust)
- regional natural resource management agencies (North Central Catchment Management Authority, Goulburn-Broken Catchment Management Authority, North East Catchment Management Authority, Mallee Catchment Management Authority, NSW Murray Local Land Services, South Australian Murraylands and Riverland Landscape Board), NSW DPI Fisheries
- land managers (such as Parks Victoria, NSW National Parks and Wildlife Service and Forestry Corporation NSW)
- private organisations (Murray-Darling Wetlands Working Group, Banrock Station/Accolade Wines, Calperum Station/Australian Landscape Trust, Nature Foundation Limited).

Stakeholder engagement

The CEWO plans for the use of water with input from, and or consultation from many partners. These include the delivery partners listed above as well as scientists engaged in monitoring the outcomes of environmental water use and various community groups and individuals.

There are several advisory groups that draw on the expertise and experience of community members to help inform our work. Advisory groups may include water managers, recreational fishers, landholders, First Nations groups, independent scientists, local government representatives and a variety of partner agencies. Key stakeholder advisory groups include:

- CEWO's Edward-Wakool Environmental Water Reference Group
- New South Wales Murray-Lower Darling Environmental Water Advisory Group
- Victorian Environmental Water Advisory Groups
- Coorong, Lower Lakes and Murray Mouth Community Advisory Panel.

14.2 Environmental objectives

Environmental watering objectives for the Murray valley (<u>Table RM1</u>) are based on long-term environmental objectives in the Basin Plan, state long-term watering plans, site management plans, and best available knowledge.

The objectives that are targeted in a particular year may vary, depending on available water, catchment conditions, operational feasibility, and demand for environmental water. These objectives will continue to be revised as part of the CEWO's commitment to adaptive management.

Basin-wide matters	In-channel assets	Off-channel assets	End of system	
Vegetation	 Maintain riparian and in channel vegetation condition. Increase periods of growth for nonwoody vegetation communities that closely fringe or occur within river corridors. 	 Maintain the current extent of floodplain vegetation near river channels and on low-lying areas of the floodplain, including Moira grass. Improve condition of black box, river red gum and lignum shrublands. Improve recruitment of trees within black box and river red gum communities. Maintain and improve condition of wetland vegetation. 	 Ensure survival and promote growth and recruitment of <i>Ruppia</i> <i>tuberosa</i> in the south lagoon of the Coorong. Maintain or improve the diversity, condition and extent of aquatic and littoral (on the shore or lakebed) vegetation at the Lower Lakes. 	

Basin-wide matters	In-channel assets	Off-channel assets	End of system		
Waterbirds	Provide habitat and food resources to support waterbird survival and recruitment and maintain condition and current species diversity.	 Provide habitat and food resources to support waterbird survival and recruitment and maintain condition and current species diversity. Complete seasonally appropriate bird breeding events that are in danger of failing due to drying. Support naturally triggered bird breeding events. Provide habitat for migratory birds. 	 Maintain habitat and food sources to support waterbird condition and populations within the Lower Lakes and Coorong lagoons (including curlew sandpiper, greenshank, red-necked stint and sharptailed sandpiper). Complete seasonally appropriate colonial bird breeding events that are in danger of failing due to drying. 		
Native fish	 Provide flows to support habitat and food sources and promote increased movement, recruitment and survival/condition of native fish. 	 Provide flow cues to promote increased movement, recruitment and survival/condition of native fish (particularly for floodplain specialists). 	 Maintain or improve diversity, condition and population for fish populations (including estuarine-dependent and diadromous fish) through providing suitable habitat conditions within the Coorong lagoons and maintaining migration pathways that supports species recruitment and survival/condition. Provide flow cues to promote increased movement, recruitment and survival/condition of native fish. 		
Invertebrates	 Provide habitat to support increased macroinvertebrate and macroinvertebrate survival, diversity, abundance and condition. 	• Same as in channel assets.	• Same as in channel assets.		
Other vertebrates	 Provide habitat to support survival, maintain condition and provide recruitment opportunities for other vertebrates, including frogs, turtles, platypus, reptiles. 	• Same as in channel assets.	• Same as in channel assets.		
Connectivity	 Maintain baseflows and increase overall flows in the River Murray. Maintain longitudinal & lateral connectivity through contributing to an increase in the frequency of freshes, bankfull and lowland floodplain flows. 	 Maintain lateral connectivity (within constraints) to wetlands, floodplains, creeks and anabranches by contributing an increase in the frequency of lowland floodplain flows. 	• Improve the connection of the River Murray to the Coorong and the sea, through supporting increased barrage flows and Murray Mouth openness.		

Basin-wide matters	In-channel assets	Off-channel assets	End of system	
Aquatic food- webs and transport Water quality Resilience	 Increase primary productivity, nutrient and carbon cycling, biotic dispersal and movement. Increase transport of organic matter, salt and nutrients downstream. Maintain water quality and provide refuge habitat from adverse water quality events. Increase mobilisation and export of salt from the River Murray system. Provide drought refuge habitat and maintenance/condition of native biota. 	• Same as in channel assets.	• Same as in channel assets.	

Source: MDBA (2019 a); Department of the Environment (2011); MDBA (2012a-i); DELWP (2015); Department of Environment, Water and Natural Resources (2015)

14.3 First Nations environmental watering objectives

The CEWO is committed to working with First Nations groups to better understand their objectives. The CEWO will use environmental flows to contribute to these objectives where possible and where this is consistent with the Commonwealth Environmental Water Holder's statutory responsibility of protecting and restoring environmental assets in the Basin.

At the site scale, state government agencies have sought input from First Nations in the development of the annual watering proposals that feed into the Southern Connected Basin Environmental Watering Committee's annual planning process. This includes through The Living Murray's Indigenous Partnership Program.

At a broader scale, as part of planning for 2021–22, the CEWO and MDBA came together with Traditional Owners from many parts of the Southern Murray Darling Basin on Latji Latji Country, in Mildura. This forum aimed to share information about the health of Country and discuss preferred outcomes from the management of environmental water. This forum developed a statement on environmental water use which was used to guide planning for the 2021–22 water year. The Southern Connected Basin Environmental Watering Committee plans to map the alignment of environmental watering objectives with First Nations objectives identified in the forum. This work will help to guide future opportunities for strengthened alignment of water delivery to support First Nations objectives during 2021–22. At a more local scale the CEWO will also continue to work with First Nations groups and representatives to progress local watering actions. Our work with the Wamba Wamba and Perrepa Perrepa nations through Yarkuwa Indigenous Knowledge Centre, in the Edward/Kolety-Wakool River system, is an example of these partnerships.

Some of the identified First Nations objectives sit outside the scope of water for the environment to influence. Environmental flows will aim to contribute to identified objectives, where possible. The Commonwealth Environmental Water Holder is committed to continuing to strengthen engagement with all Southern Basin First Nations to support those Nations to share objectives for water management.

14.4 Recent conditions and seasonal outlook

14.4.1 Recent conditions and environmental water use

The health of rivers, wetlands and floodplains, and the plants and animals they support, can be influenced by flows and conditions in the past. In some cases, this can date back many years, with many parts of the natural environment still showing the effects of both the Millennium and more recent 2017–2020 drought.

Flows

Since the large-scale flooding of 2016–17, the River Murray has experienced three consecutive years of well below average inflows. In 2019–20, River Murray inflows were less than half the long-term average of 8,870 gigalitres and within the driest 12 per cent of years since 1891. Without water for the environment, several critical off-channel waterways would have otherwise remained dry over this three-year period. Water for the environment has supported variable flows in the River Murray, particularly in winter and spring, which were of critical importance to native fish populations. End-of-system flows have been highly dependent on water for the environment, which accounted for 100 per cent of flows through the barrages from January 2018 to August 2020, and prevented the Lower Lakes dropping below the critical threshold of 0.4 m (a trigger for the planning phase of the Drought Emergency Framework).

The dry conditions since 2016–17 continued throughout most of 2019–20, with a return to average and above average conditions in May and June resulting in higher streamflow through the mid-Murray region. This has been followed by above average rainfall over large parts of the southern Basin during 2020–21.

Vegetation

- Floodplain forests and woodlands:
 - The condition of river red gum forests at low elevation in the Mid-Murray (e.g., Barmah-Millewa and Gunbower Forests) has largely been maintained since the 2016– 17 flood. Excellent red gum (and to a lesser extent, black box) tree canopy responding positively to environmental water delivery has been recorded (GB CMA 2020b, North Central CMA 2020). Due to dry conditions and delivery constraints, woodlands at higher elevation and throughout Koondrook-Perricoota Forest, have continued to show declining health since the 2016–17 floods (New South Wales Forests 2020).
 - The internationally important Moira grass plains of Barmah-Millewa Forest have seen excellent growth during periods where environmental water has been delivered and grazing pressure has been managed. Overall, the Moira grass plains are in good condition with the extent of coverage increased through the addition of six new grazing exclusion fences (BMF SWP, 2020–21; BMF SWP, 2021–22).
 - Aquatic vegetation in wetlands that have received sufficient water is generally in good condition along the length of the River Murray. Further, the increased variability of weir pool levels has provided benefits for vegetation fringing the main river channel, anabranches and low-lying wetlands for several reaches of the River Murray (Gehrig 2018, Ye et al. 2021). Wetland vegetation condition in other locations, such as those more exposed to drought conditions, heat stress or grazing pressure, is poorer.
 - Further downstream, the condition of river red gum and black box woodlands such as at Hattah Lakes and Chowilla Floodplain has largely been maintained in areas where

infrastructure has enabled the delivery of water (Mallee CMA 2020). In higher elevation sites where water has not been delivered, particularly at Chowilla, black box is showing signs of stress following three years of dry conditions (MDBA 2019 b).

- Coorong and Lower Lakes:
 - Fringing vegetation in the Lower Lakes has become more diverse and the abundance of key taxa has increased in recent years. This represents ongoing recovery from the millennium drought as the lakeside vegetation community re-establishes.
 Improvements have likely been driven by seasonally appropriate water levels varying between higher levels in spring (approx.0.85 m) and lower levels in autumn (approximately 0.5 m) (Nicol et al. 2019, Ye et al. 2021).
 - Researchers and community members have reported improvement in *Ruppia* distribution and abundance in the southern part of Coorong North Lagoon and in certain areas in the South Lagoon.

Native fish

The 2016–17 flood was beneficial to wetland and floodplain vegetation and waterbird populations in many areas. However, the natural floods also generated a significant hypoxic blackwater event as organic material, accumulated by the lack of frequent, natural, flushing flows, was washed off the floodplain. While environmental flows were used to mitigate the impacts on native fish populations in some localities, the hypoxic blackwater still resulted in large-scale fish kills throughout the Mid-Murray and through parts of the Lower Murray. There have since been mixed outcomes for fish species across the Murray system, however achieving sustained breeding success across the various key fish species remains a challenge.

- Fish species that occupy flowing river habitats and breed independently of particular flow events are perhaps the best faring native species across the Murray. Murray cod and trout cod have bred successfully in the Mid-Murray river channel during the spring and summer of most recent years (GB CMA 2020a, Raymond 2018). The Edward/Kolety-Wakool River systems continue to be a nursery area for Murray cod, with the species' population slowly recovering since the 2016 flood (Watts et al., 2018 and 2019). Similarly, in the Lower River Murray, Murray cod successfully bred for six consecutive years following an extended period of unsuccessful breeding, considerably improving the structure of the Murray cod population in the Lower Murray (Ye et al. 2020).
- Iconic fish species that are dependent on a distinct flow 'pulse' during warmer spring or summer months for their breeding success, such as golden and silver perch, have bred in the Mid-Murray (Raymond et al. 2019., GB CMA 2020a). In the Edward/Kolety-Wakool River systems, silver perch are benefitting from nursery habitat and winter flows that allow movement throughout the year (Watts et al. 2019). Silver perch eggs and larvae were detected in the Lower Murray during the 2020 spring pulse; however no recruitment has been observed. There has been a sustained lack of breeding success for golden perch in both the Edward/Kolety-Wakool and Lower River Murray areas for several years (Ye et al. 2021, Watts et al. 2019), which is a concerning trend.
- The condition of species that occupy lakes and floodplain wetland sites is variable, dependent on location. Overall, this category of fish species has been heavily affected by reduced flows to floodplain wetland sites and introduced species, such as carp. For example, monitoring of the Lower Lakes in late 2018 failed to detect Yarra pygmy perch, which is

now considered likely to be extinct in the Murray-Darling Basin (Wedderburn et al. 2019). However, there have been some success stories resulting from the delivery of water for the environment.

- Populations of the nationally endangered Murray hardyhead have been maintained at several locations, with two new populations established in recent years.
- Increased variability in water levels in the Lower Lakes has benefited fringing and submergent vegetation (Nicol et al. 2019). In turn, small-bodied fish species have also demonstrated positive responses. Murray hardyhead have become more abundant and expanded in range after successful spawning and recruitment in the Lower Lakes in 2018–19 and 2019–20. For southern pygmy perch, high spring lake levels and improved submergent vegetation habitat have favoured spawning and after several years at stable low levels, the population quadrupled in 2020–21 (Wedderburn pers. comm).
- Diadromous fish species spend portions of their life cycles partially in fresh water and partially in salt water. Water for the environment has been solely responsible for maintaining the connection between the River Murray and its estuary, the Coorong, for extended periods since the Millennium drought. This connection is having clear benefits for diadromous fish species.
 - For example, monitoring undertaken in the Lower Lakes in late spring 2019 recorded the native congolli as the most abundant fish species for the first time since surveys began in the mid-2000's. Congolli are a key part of the Coorong and Lower Lakes food web as a major prey item for larger predators including mulloway, pelicans, cormorants and golden perch, thus the high abundance of congolli is a strong positive indicator of available food resources for other species (DEW 2020).
 - Sustained connection has supported increasing abundances of congolli and common galaxias, which need connection but are not particularly flow dependent.
 - Pouched lamprey have also been detected moving upstream during winter/spring for several consecutive years, and for the last three years short-headed lamprey were also recorded. Numbers of migrating lamprey captured during monitoring are generally increasing over time, suggesting that populations are gradually recovering (Bice et al. 2020). Recordings in winter/spring 2021 were the highest since the Millennium Drought.
- Outcomes for estuarine fish species in the Coorong have been variable, influenced by both the continuous connection between the lakes and the Coorong and low flows in ongoing drought conditions. While black bream spawned and recruited in early 2018 during a small flow pulse, recruitment has not been detected in the following years. (Ye et al. 2019, Ye pers. comm. 2020). Autumn 'pulsing' of flows from the barrages in line with tide and storm conditions has been linked to improvements in range and condition in commercial Coorong fish such as Coorong mullet.

Waterbirds

Basin scale monitoring of waterbirds in the Murray-Darling Basin indicates waterbird numbers are declining over the long term (since the 1980s). Waterbird breeding has generally been limited across the Murray system for several consecutive years. This may be due to a lack of

natural breeding cues resulting from below average rainfall conditions through most of winter and spring, as well as limited foraging and nesting habitat availability and condition.

Aerial waterbird surveys indicate a significant proportion of the waterbird breeding in 2018 and 2019 in the Murray valley (and more broadly) had occurred at the Coorong and Lower Lakes and Chowilla-Lindsay-Wallpolla (Kingsford et al. 2019). Murray-Darling Basin waterbird survey results for 2020 indicate waterbird abundance has grown by 80-100% over 2019 numbers, though waterbird numbers are down overall across south-eastern Australia (Porter et al. 2020).

Other notable points in relation to waterbirds in the Murray valley include:

- Barmah-Millewa Forest continues to provide a haven for bitterns, a species where survival is threatened by habitat loss, drought, and fire (pers. comms. NSW NPWS, 2019). Up to twenty five percent of the estimated remaining population are thought to rely on use of the Barmah-Millewa wetlands (Belcher et al. 2018).
- The nationally vulnerable regent parrot has experienced a 12 per cent population decline in recent years due to a decline in river red gum health. Survey results from 2019–20 have shown a further decrease in nesting, but there are some indications that birds are moving into areas that are receiving environmental water as this is helping to maintain or restore tree condition (SA Regent Parrot Recovery Team, pers. comm.).
- The annual summer census (January 2020) of waterbirds in the Coorong and Lower Lakes observed similar numbers of waterbirds and shorebirds (including migratory waders) to the previous two years. Abundance for many species are below long-term medians and below long-term threshold ecological targets. Birds that were present spent over 70% of time foraging, potentially indicating low food abundance within the mudflats, a consistent observation in recent years (TLM site manager pers. comm. 2020; Paton et al. 2020). The 2021 survey reported a significant reduction in abundances compared to the previous 3 years, with 8 out of 12 key migratory species below their long-term median annual abundances (TLM site manager pers. comm. 2021).

Learn more about use of water for the environment in the River Murray.

14.4.2 Seasonal outlook

According to the Bureau of Meteorology outlook (BoM 2021) above median rainfall between July and September is likely in both the River Murray valley and key other southern catchments that provide inflows to the River Murray valley.

This forecast indicates that dry conditions have somewhat eased, catchments are becoming more saturated and storage levels are improving. However, several months of above average rainfall are needed to see continual recovery from the drought.

14.4.3 Water availability

The volume of Commonwealth environmental to be carried over in the River Murray valley for use in 2021–22 was 261.6 gigalitres. Total carryover in the Southern-connected Basin was 538 gigalitres.

Allocations will vary depending on conditions. In the Murray, allocations against Commonwealth entitlements in 2021–22 (including carryover from 2020–21) could range from 688.1 gigalitres under very dry conditions, to 1,127.9 gigalitres in very wet conditions.

14.4.4 Environmental demands

For the environmental water demands for assets in the Murray valley, see Tables RM2 to RM4. The extent to which these environmental demands can be contributed to is contingent on several factors described in the table.

Indicative demand (for <u>all sources of water</u> in the system) 2021-22 **Environmental asset** Watering history (from all sources of water) **Required frequency Potential Commonwe** Environmental Flow/Volume (maximum dry demands for water contribution interval) **River Murray from Hume** 2 000-5 000 ML/day at Yarrawonga Weir Continuous requirement, therefore the environmental Annual Dam to Euston and throughout the year for native fish habitat to demands have been assessed as High. High priority for Comn **Barmah-Millewa Forest** improve recruitment and population structures, High watering (likely to rece and water quality in main river channel and low water resource av Barmah-Millewa creeks. Variable flows between 5 000 and 9 500ML/day at Annual In-channel variability in 2018-19 was limited due to Yarrawonga Weir from July to November for fish operational deliveries. Met in 2019-20 and 2020-21. High priority for Comn condition, spawning, dispersal, in-channel non-High watering (likely to rece woody vegetation and ecosystem low water resource av function/productivity. Freshes 12 000-18 000 ML/day variable flow rate 5-10 in 10 years Has been met in 6 of the last 7 years. Therefore, the environmental demand has been assessed as Moderate. for at least 5 days, measured d/s Yarrawonga Weir (2 years) during the period July to November for native fish habitat to improve recruitment and population Option to be considere structures (in-channel outcomes and resource availability. Moderate anabranches) and for core wetlands, including 15 000ML/d at Yarraw Australasian bittern habitat. Would also provide constrained by potenti carbon/productivity benefits to Edward/Kolety-Wakool system during the cooler time of the year. Small overbank of 12 000-15 000 ML/day for a 4-8 in 10 years (2 years) Has been met or partially met in 5 of the last 7 years. Therefore, the environmental demands have been minimum of 45 days measured d/s Yarrawonga between August to November, to improve native assessed as Moderate. fish recruitment and population structures Option to be considered (in-channel outcomes and giant rush wetlands). Moderate resource availability. Would also provide carbon/productivity benefits to Edward/Kolety-Wakool system during the cooler time of the year. > 25 000 ML/day at Yarrawonga Weir 6-8 in 10 years (2-3 For river red gum, the target has been met or partially (unregulated flow) for at least 7 days (river red years) met 2 in 6 years. Currently reliant on lan gum forest) and followed by flows of up to 18 000 Annual (2 years) for Commonwealth enviro ML/day or greater for three to five months For Moira grass the target has been met fully 2 in 6 years. Moira grass the depth and duration High targeting Moira grassland. current constraints (i.e ecological need, water of risk and potential, ad **Gunbower Creek** Winter low flow and summer ramp down to Met or partially met every year in the last 6 years. Annually Watering required on an annual basis therefore the support juvenile fish and maintain habitat Winter baseflow will n connectivity during off-irrigation season: environmental demand has been assessed as High. High construction of Cohuna Winter base flows (200 ML/day for 5 months). fishways.

Table RM2 Environmental demands and priority for watering, 2021–22, and outlook for coming year, Mid-Murray

Implications for future demands
Likely environmental demand in 2022–23 if watering occurred as planned in 2021–22
High
High
Moderate
Moderate
High
High

	Indicative demand (for <u>all sources of water</u> in the system)		_	2021–22		Implications for future demands
Environmental asset	Flow/Volume	Required frequency (maximum dry interval)	Watering history (from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution	Likely environmental demand in 2022-23 if watering occurred as planned in 2021–22
	Spring pulse and stable summer flows for fish breeding: Small fresh up to 400 ML/day in spring, reducing to 300 ML/day in summer.	Annually Spring fresh September to December for 122 days Summer flows Jan to March for 74 days	Met or partially met every year in the last 6 years. The environmental demand has been assessed as High.	High	Priority for Commonwealth environmental watering (likely to receive water even under low water resource availability, subject to flow constraints)	High
Gunbower Forest	Small-moderate actions (~ 100-1 000 ML/day in late winter/early spring – duration dependant on inflow rate) targeting permanent and semi- permanent wetlands, or targeted infrastructure use at the sites. Up to 2 500 ha via Gunbower Forest infrastructure.	6-9 in 10 years (2 years)	Significant watering action in 2014–15 and 2015–16 and natural flood event in 2016–17 inundated various parts of the Forest. Drying phase in 2017–18, with the exception of high value permanent wetlands. Watering action in 2018–19. Small throughflow event to targeted wetlands in 2019–20 and 2020–21. Environmental demand has been assessed as High.	High	It is anticipated that demands in Gunbower Forest will be met by other water holders in 2020–21.	High
	Infrastructure delivery to Gunbower Forest targeting river red gum forest (~1 600 ML/day for 90 days in winter/spring) Up to 4 700 ha via Gunbower Forest infrastructure.	6-7 in 10 years (3 years)	Met or partially met in 6 of the past 7 years. The environmental demand has been assessed as Moderate.	Moderate	It is anticipated that demands in Gunbower Forest will be met by other water holders in 2020–21.	Moderate
Mid-Murray Off-Channel Wetlands and ephemeral creeks Hume to Euston	Infrastructure and/or weir pool delivery targeting permanent off-channel wetlands.	Annually	Annual requirement therefore the environmental demand has been assessed as High.	High	Mid-Murray wetlands are generally watered using other water portfolios, however if additional water is required for priority wetland sites, a Commonwealth environmental water contribution	High
	Infrastructure and/or weir pool delivery targeting semi-permanent off-channel wetlands. Infrastructure and/or weir pool delivery targeting ephemeral off-channel wetlands.	3-7 in 10 years (5 years) 1 in 5 years	Variable across sites with last natural watering event in 2016. Therefore, the environmental demand has been assessed as Moderate.	Moderate	will be considered. The Lock 15 weir pool is likely to be raised during spring 2021 for environmental purposes, underwritten by Commonwealth environmental water. The raising is expected to connect the River Murray with low-lying creeks and wetlands such as a portion of the Euston Lakes complex (portions of which have not received substantial inundation since the 2016 flood).	Moderate

References for Table RM2: Murray and Barmah-Millewa Forest indicators adapted from Department of the Environment (2011), MDBA (2012c). Gunbower Creek indicators sourced from North Central CMA (2021). Gunbower-Koondrook-Perricoota Forest indicators adapted from MDBA (2012a) and MDBA (2012 g and h). Mid-Murray Off-Channel Wetlands and ephemeral creek indicators sourced from North Central CMA (2021).

Key

Potential watering in 2021-22

High priority for Commonwealth environmental watering (likely to receive water even under low water availability)

Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate – high water resource availability); or water demand likely to be met via other means

Low priority for Commonwealth environmental watering (under high – very high water resource availability); or unable to provide water because of constraints or insufficient water

Environmental demands (demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime)

High to critical demand for water (needed in that particular year or urgent in that particular year to manage risk of irretrievable loss or damage)

Moderate demand for water (water needed in that particular year, the next year, or both)

Low demand for water (water generally not needed in that particular year)

Table RM3 Environmental demand and priority for watering, 2021–22, and outlook for coming year, Edward/Kolety-Wakool River system

	Indicative demand (for <u>all sources of water</u> in the system)		Watering history	2021-22		Implications for future demands
Environmental assets	Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution	Likely environmental demand in 2022–23 if watering occurred as planned in 2021–22
Yallakool - Wakool Maintenance of native fish habitat and instream aquatic vegetation	~200 ML/day base flow for ~295 days during late winter to late Autumn (~59 GL). Note: winter base flows are a separate flow component and is included below.	Annual	Has been met 5 out of the past 5 years	Low	Likely to be met by operational flows except in <u>a</u> <u>very dry year</u> when CEW may be use to prevent system from being cut off subject to <u>NSW Extreme</u> <u>Events Policy</u>	Low
Longitudinal connectivity Fish spawning, recruitment, and movement Nutrient cycling Water quality	~580 ML/day peak for 10 days fresh over ~25 days in early spring with gradual recession (~11 GL, includes ~200 ML/day base flow. To assist in providing the spring pulse an additional ~3-4 GL through the Wakool escape may need to be needed).	Annual	Has been met 5 out of the past 5 years. Annual requirement therefore the environmental demand has been assessed as High.	High	Priority for Commonwealth environmental water to continue ecosystem recovery	High
	~430 ML/day for 41 days to maintain minimum flow for fish nesting habitat, and inundation for aquatic vegetation growth (~17.6 GL in total, includes ~200 ML/day base flow)	Annual	Has been met 5 out of the past 5 years. Annual requirement therefore the environmental demand has been assessed as High.	High	Priority for Commonwealth environmental water to continue ecosystem recovery	High
	~600 ML/day peak for 5 days undertaken as 1 to 3 freshes in late spring/early summer to stimulate silver perch breeding with a gradual recession down to 220 ML/day at end of fish nesting period (from min. 20 days to max. 84 days) (~10.5 GL min to 38 GL max., includes ~200 ML/day base flow).	Annual	Has been met 3 times for 1 fresh out of the past 5 years and has not been met for 3 freshes.	Moderate	Option to be considered under a moderate to high water resource availability.	Moderate
	~510 ML/day peak for 4 days over 51 days fresh in autumn with a gradual recession (~16 GL, includes ~200 ML/day base flow).	2 in 3 years (2 years)	Has been met 3 out of the past 5 years	Moderate	Option to be considered under a moderate to high water resource availability.	Moderate
	~170 ML/day winter base flow from early-May (irrigation shut down) until first week of July (system restarts) (~10 GL). Needs minimum of 4,000 ML/day at Yarrawonga to meet all Edward/Kolety system winter base flow requirements.	Annual	Has been met 2 out of the past 5 years. Subject to Stevens weir pool being kept in over winter to enable connection to Colligen and Yallakool regulators.	High	Priority for Commonwealth environmental water to continue ecosystem recovery.	High
	Upper Wakool over summer and autumn to maintain water quality. 14 day increase stepwise of 30 ML/day up to a peak of ~110 ML/day for 14 days followed by stepwise decrease of 30 ML/day down to 50 ML/day for 14 days, then repeat to watering season end in early May.	Annual	Has been met 1 out of the past 5 years. Annual requirement therefore the environmental demand has been assessed as High.	High	Priority for Commonwealth environmental water to continue ecosystem recovery.	High
Colligen - Niemur As per Yallakool-Wakool above	The potential flow components for the Colligen- Niemur during 2021–22, and related assessment of demands & urgency of demands are like the flow components outlined for the Yallakool- Wakool above. The primary difference is that the flows planned for the Colligen-Niemur have been scaled to fit within its constraint for environmental flows of up to 450 ML/day.	As above.	As above.	As above.	As above.	As above.
Edward/Kolety River downstream of Stevens Weir	Above 2700 ML/day (constraint downstream of Stevens Weir) early spring pulse targeting Werai Forest (~15 GL) and late spring/summer pulse (~15 GL). Will need to align with delivery of RMC	Annual	Single fresh has been met 3 out of the past 5 years by unregulated flows. Annual requirement therefore the environmental demand has been assessed as High.	High	Flows up to constraint of 2700 ML/day are likely to be met by RMC operational flows during early spring and late spring/early summer.	High

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	Indicative demand (for <u>all sources of water</u> in the system)		Watering history	2021-22		Implications for future demands
Environmental assets	Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution	Likely environmental demand in 2022-23 if watering occurred as planned in 2021-22
	flows into Yallakool-Wakool and Colligen-Niemur systems.					
Tuppal Creek	~5,500 ML in total spring fresh with variability flow during August to April (~2.75 GL of CEW + ~2.75 GL NSW).	Annual	Has been met 1 out of the past 5 years	Moderate	Priority for Commonwealth environmental water to maintain ecosystem health - undertaken in partnership with NSW.	Moderate
Merran Creek	~460 ML/day preferably in spring and comprised of: Merran Creek at Franklings Bridge (~250 ML/day), Waddy Cutting (~150 ML/day) and St Helena Creek (~60 ML/day).	Annual	Has been met 5 out of the past 5 years	Low	A low priority for watering in 2021–22. Demand may be met by other means.	Low
Jimaringle, Cockran and Gwynnes Creeks	Total flow of ~10 GL deliverable preferably in August to November. May also require high flows in receiving Niemur system to dilute potential poor water quality outflows from these systems.	1 in 2 years (2 years)	Has been met 1 (65%) in 5 years. Last significant flow was the 2016 flood event.	Moderate	Option to be considered under a moderate to high water resource availability.	Moderate
Werai Forest	Linked to Edward/Kolety River action above. May need to call on MIL Edward Escape for ~15 GL to push flows over 2,700 ML/day D/S of Stevens Wier.	2-3 in 5 years (2 years)	First fresh has been met 5 out of the past 5 years. Second fresh has not been met in past 5 years. Forest in poor health therefore the environmental demand has been assessed as High for successive years.	High	Priority for Commonwealth environmental water to maintain ecosystem health – likely to be undertaken as part of the River Murray watering action (see Table RM2 above).	High
Koondrook-Perricoota Forest	Annual watering proposals for this site are developed by Forestry NSW and can be contributed to by a number of water holders.	2-3 in 5 years (2 years)	Minimum flow has been met twice (provided in 2019–20, similar to 2014–15 commissioning event). Forest in poor health therefore the environmental demand has been assessed as High for successive years.	High	Use of CEW in scope subject to support from local stakeholders and potentially affected landholders.	High
Pollack Swamp	~3 GL per year watering proposals for pumping to this site during late spring and summer developed by Forestry NSW and DPIE.	Annual	Has been met 5 out of the past 5 years. Annual requirement therefore the environmental demand has been assessed as High.	High	Priority for Commonwealth environmental water to maintain ecosystem health - undertaken in partnership with NSW.	High
Thule Creek	~750 ML top up to maintain water quality in Aug to April.	Annual	Has been met 2 out of the past 5 years	High	Priority for Commonwealth environmental water to maintain ecosystem health - undertaken in partnership with NSW.	High
Murrain-Yarrein	Up to \sim 3 GL in total August to April	5 to 10 years in 10 years (75%)	Has not been met since 2016 flood.	High	Priority for Commonwealth environmental water to maintain ecosystem health - undertaken in partnership with NSW.	Moderate
Yarrein Creek	\sim 5 GL to 10 GL total August to November	5 to 8 years in 10 years (65%)	Has not been met since 2016 flood.	High	Priority for Commonwealth environmental water to maintain ecosystem health - undertaken in partnership with NSW.	Moderate
Whymoul Creek	~500 ML in total August to April. Maintain for native fish particularly if threatened species are released into it.	Annual (100%)	Has been met once in 2021. Prior to that was the 2016 flood.	High	Priority for Commonwealth environmental water to maintain ecosystem health - undertaken in partnership with NSW.	Moderate
Buccaneit-Cunningyeuk Creeks	~2 GL in total August to April for refuge pools.	Annual (100%)	Has been met 2 out of the past 5 years. Prior to that was the 2016 flood.	High	Priority for Commonwealth environmental water to maintain ecosystem health - undertaken in partnership with NSW.	Moderate
Lake Agnes	~1 GL in total September to December.	5 to 10 years in 10 (75%)	Has been met once in 2021. Prior to that was the 2016 flood.	High	Priority for Commonwealth environmental water to maintain ecosystem health - undertaken in partnership with NSW.	Moderate
Mortons swamp	~800 ML in total September to December	5-8 years in 10 (65%)	Has not been met since 2016 flood.	High	Priority for Commonwealth environmental water to maintain ecosystem health - undertaken in partnership with NSW.	Moderate

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	Indicative demand (for <u>all sources of water</u> in the system)		Watering history	2021-22		Implications for future demands
Environmental assets	Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution	Likely environmental demand in 2022–23 if watering occurred as planned in 2021–22
Southern Bell frog private wetlands	~4 GL in total September to December	Annual (100%)	Has been met 10 out of the past 10 years. Not all sites are watered annually black box sites are watered around 5 years in 10 depending on conditions	High	Priority for Commonwealth environmental water to maintain ecosystem health - undertaken in partnership with NSW.	High
Private wetlands supporting Wanganella waterbird habitat	~500 ML in total September to December. Black box wetlands in area south of Wanganella	3–4 years in 10 (35%)	Has not been met in past 3 years	High (Contingency: bird breeding)	Depending on timing, option to be considered if breeding event is triggered. However more likely to occur under moderate or high water resource availability	High (Contingency: bird breeding)
Private wetlands supporting KP/Pollack waterbird habitat	~1 GL in total September to December. Red gum wetlands adjoining KP forest.	5–8 years in 10 (65%)	A couple watered last season, most not watered since 2016 flood	High (Contingency: bird breeding)	Depending on timing, option to be considered if breeding event is triggered. However more likely to occur under moderate or high water resource availability	High (Contingency: bird breeding)
Edward/Kolety Wakool System - Refuge Flows Habitat flows Water quality Provision of refuges for native fish	~30-120 GL a year to manage hypoxic water quality events and other critical habitat needs.	As required - usually triggered once dissolved oxygen levels reach 4.0 mg/l in line with Basin Plan water quality requirements.	Has been met when required	High (Fish refuge flows)	High priority for Commonwealth environmental water to abate the impact of potential fish kills if triggers are met.	High (Fish refuge flows)

Note: The majority of flows listed in this table will be synchronised with flows in the River Murray (Table RM2).

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Potential watering in 2021-22

High priority for Commonwealth environmental watering (likely to receive water even under low water availability)

Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate – high water resource availability); or water demand likely to be met via other means

Low priority for Commonwealth environmental watering (under high – very high water resource availability); or unable to provide water because of constraints or insufficient water

Environmental demands (demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime)

High to critical demand for water (needed in that particular year or urgent in that particular year to manage risk of irretrievable loss or damage)

Moderate demand for water (water needed in that particular year, the next year, or both)

Low demand for water (water generally not needed in that particular year)

Indicative demand (for <u>all sources of water</u> in the system) 2021-22 Watering history **Environmental assets Required frequency Potential Commonwe** Environmental Flow/Volume (maximum dry (from all sources of water) contribution? demands for water interval) **River Murray from Euston** Elevated river baseflow of at least 10 000 ML/d at All indicators met in 2011-12, 2012-13 and 2016-17 9 in 10 years (2 years) to Lower Lakes, including SA Border for up to 60 days in spring/summer for (high flow years during the last decade). 2013–14 and A very high priority for pool level wetlands in-channel aquatic vegetation, fish, and water 2017–18 also saw high baseflows and moderate freshes. High in low resource availab quality. The drier years (2014-15, 2015-16, 2018-19, 2019-20 and 2020-21) saw contributions to the baseflows and moderate freshes in 2019-20 and 2020-21 of 15 000 Moderate fresh of 15 000-25 000 ML/day at SA 2 in 3 years (2 years) A very high priority for ML/day and 18 000 ML/day (respectively) but only for a Border for up to 90 days in spring/summer for that at least moderate short duration. perch spawning and survival and other ecological multiple water holder All indicators have a high demand for 2021–22. benefits. High required. Meeting the the duration is not pos environment alone and unregulated condition Large fresh of 25 000-35 000 ML/day at SA Border 1 in 2 years (3 years) High resource availabi for up to 60 days in spring/summer for fish unregulated tributary populations and other in-channel biota. deliver flows of this ma High water for the environn flow. Hattah Lakes All indicators met in 2016-17 (flood), followed by Small action targeting temporary wetlands 1 in 2-3 years (4 years) (inundation to 42-43 m AHD in winter/spring) environmental water delivery to 44.85 m AHD in spring up to 22 000 ML via infrastructure equivalent to 2017. High natural event of 40 000-50 000 ML/day at Euston Apart from a small watering event at Lake Kramen in for 26-60 days. 2019–20, much of the lakes complex has had a drying High priority for Com phase or been completely dry since 2017. environmental water Moderate action targeting wetlands and fringing 1 in 3 years (7 years) Environmental water delivery in April-May 2021 has river red gums (inundation to 43.5 m AHD for 90 targeted 11 of the 18 lakes in the complex, to prime the days in winter/spring) - up to 40 000 ML via High to Critical system for further planned delivery in spring 2021. infrastructure equivalent to natural event of 85 000 ML/day at Euston for 7-30 days. Large event targeting wetland and river red 1 in 8 years (12 years) gum/black box woodlands on floodplain (inundation to 45 m AHD for 90 days) - up to Environmental water Low 120 000 ML via infrastructure equivalent to extend a large natural natural event of 150 000 ML/day at Euston for 7 days anytime in the year. Floodplain and wetlands 30 000 ML/day at Lock 8 for 30-60 days targeting All indicators met in 2016-17 (flood). 2 in 5 years (4 years) Commonwealth enviro from Euston to South low lying wetlands and anabranches, or priority contribute to overbank Environmental water delivered to targeted wetland sites Australian border areas via infrastructure or weir pool raising. High availability years with in the following four years, however the majority of sites Water is likely to be de sites via infrastructure

Table RM4 Environmental demands and priority for watering, 2021–22, and outlook for coming year, Lower Murray.

	Implications for future
ealth environmental water	Likely environmental demand in 2022–23 if watering occurred as planned in 2021–22
r watering in 2021–22, even bility.	High
r watering in 2021–22, noting resource availability (and contributions) would be upper end of the flow rate and sible with water for the d will depend upon s.	High
lity and coordination with inflows would be required to agnitude and duration, with nent used to supplement the	Moderate
nonwealth (and Victorian) contribution in spring 2021.	High
vill be contributed only to overbank flow.	
onmental water is able to t flows only in high resource significant tributary inflows. livered to priority wetland and temporary pumps	High (unless natural flooding occurs)

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	Indicative demand (for <u>all sources of water</u> in the system)		Watering history	2021-22		Implications for future demands
Environmental assets	Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water	Potential Commonwealth environmental water contribution?	Likely environmental demand in 2022–23 if watering occurred as planned in 2021–22
	50 000-60 000 ML/day at Lock 8 for 60-120 days targeting river red gum forest, lignum shrubland and associated wetlands, or priority areas via infrastructure.	1 in 5 years (5 years)	have not received water since 2016–17. As such, the environmental water demand has been assessed as high.		during 2021–22. Raising of weir pools 7, 8 and 9 (which is underwritten by Commonwealth environmental water) is also expected to connect the River Murray with low lying wetlands and provide freshes down creek systems, such as the Lindsay River and Potterwalkagee and Mullaroo Creeks. Mulcra Island floodplain is very high priority and will be fed via weir pool raising and infrastructure.	
Floodplain and wetlands from South Australian border to Lower Lakes	Small overbank flow of 45 000-55 000 ML/day at SA border for at least 30 days between Sept-Dec targeting river red gum forest, tea tree, lignum, river cooba and associated wetlands, or priority areas via infrastructure	1 in 2 years (5 years)	Small and moderate flow requirements were last met in 2016–17 and 2011–12 natural flows. Small overbank flow also occurred in 2012–13 for <30 days. All overbank flow requirements were last achieved in 2010–11. Environmental water has also been delivered to some priority wetland sites each year, across all floodplain		In the absence of overbank flows, water use will be limited to delivery via infrastructure to priority wetland sites and the Pike and Katarapko floodplains. Chowilla floodplain will also receive environmental water, most likely from other sources. The Lower River Murray is expected to be	
	Moderate overbank flow of 55 000-65 000 ML/day at SA border for at least 30 days between Sept-Dec targeting river red gum forest, tea tree, lignum, river cooba and associated wetlands, or priority areas via infrastructure	1 in 2 years (5 years)	priority wetand sites each year, across an noouprain elevation levels. First operations of new floodplain regulators raised water levels across parts of the floodplain to the equivalent of a 45,000 ML/d flow at Katarapko and 55,000ML/d at Pike in spring 2020. The broader floodplain however is in poor condition wit significant tree canopy loss. There is a critical to high domand for overbank flows in 2021, 22	Critical	connected to low-lying floodplain areas via proposed raising of weir pools 2, 4, 5 and 6 (depending on the climate scenario). Commonwealth water can only contribute to overbank flows in high resource availability years with significant tributary inflows.	High/critical (unless natural flooding occurs)
	Large overbank flow of 65 000-75 000 ML/day at SA border for at least 30 days between Sept-Dec targeting black box, cooba, lignum and chenopod and associated wetlands, or priority areas via infrastructure	1 in 3 years (5 years)		High	Water is likely to be delivered to priority wetland sites via infrastructure. Commonwealth environmental water can contribute to overbank flows only in high resource availability years with significant tributary inflows.	-
Coorong, Lower Lakes and Murray Mouth	Minimum barrage flow of 650 GL/yr. (and lake water levels maintained above 0.4 m AHD) to provide suitable conditions and refuge habitat in the lakes and north lagoon for native fish, plants and internationally important migratory birds.	Annually	Lower Lakes and Coorong north lagoon in generally good condition, with salinity levels and signs of stress increasing with distance from the barrages along the north lagoon. Minimum flow (1 in 1 year) was not met in 2015–16 or	High	A very high priority for watering in 2021–22, even in low resource availability.	High
	Barrage flows of 2 000 GL/yr. required to provide suitable conditions and refuge habitat for native fish, plants and internationally important migratory birds.	Rolling 3-year average	2018–19. The period in which the three-year rolling average was last met was 2016–18.	High	A high priority for watering in 2021–22, even in low resource availability. Average barrage flows over the past four years are less than half of the rolling three-year average target. Commonwealth water likely to contribute significantly. However the three-year average target cannot be met by Commonwealth water alone.	Moderate
	Barrage flows of 6 000 GL every three to five years to maintain and improve habitat conditions within the Coorong. Lake water level range between 0.4 and 0.83 m AHD to maintain healthy lake ecology.	1 in 3 years (5 years)	Coorong south lagoon still in poor health, with a trend of increasing salinity over the past four years. While Commonwealth environmental water can help to slow the decline and minimise further damage, strong recovery in	High (last met in 2016–17)	Commonwealth water will contribute to meeting this demand. However the targets cannot be met by Commonwealth water alone and will depend upon unregulated flow event/s.	Low

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	Indicative demand (for <u>all sources of water</u> in the system)		Watering history	2021-22	
Environmental assets	Flow/Volume	Required frequency (maximum dry interval)	(from all sources of water)	Environmental demands for water	Potential Commonwea contribution?
	Barrage flows of 10 000 GL every seven to seventeen years to improve habitat conditions within the Coorong. Lake water level range between 0.4 and 0.9 m AHD to maintain healthy lake ecology.	1 in 7 years (17 years)	 the Coorong South Lagoon requires significant volumes of water and/or complementary measures and will likely only occur in high resource availability years. Large flow events in the last decade include 2010–11 (15,000+ GL), 2012–13 (6797 GL) and 2016–17 (6484 GL). 	Moderate (met in 2010–11)	

References for Table RM4: River Murray Channel indicators sourced from Wallace et al. (2014), Ecological Associates (2015), Ecological Associates (2010), DEWNR (2015) and MDBA (2012f). Hattah Lakes indicators sourced from MDBA (2012e), (2012f); Roberts and Marston (2011). Floodplain from Euston to SA indicators sourced from MDBA (2012b). Floodplain from SA to Lower Lakes indicators sourced from Kilsby and Steggles (2015), MDBA (2012d) and DEWNR (2015). Coorong, Lower Lakes and Murray Mouth indicators sourced from MDBA (2014) and DEWNR (2015).

Key

Potential watering in 2021-22

High priority for Commonwealth environmental watering (likely to receive water even under low water availability)

Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate – high water resource availability); or water demand likely to be met via other means

Low priority for Commonwealth environmental watering (under high – very high water resource availability); or unable to provide water because of constraints or insufficient water

Environmental demands (demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime)

High to critical demand for water (needed in that particular year or urgent in that particular year to manage risk of irretrievable loss or damage)

Moderate demand for water (water needed in that particular year, the next year, or both)

Low demand for water (water generally not needed in that particular year)

	Implications for future demands
ealth environmental water	Likely environmental demand in 2022–23 if watering occurred as planned in 2021–22
	Low

14.5 Water delivery in 2021–22

The use of water for the environment will be responsive to prevailing conditions, water availability, and any emergent opportunities or risks. As such, our plans are flexible (as opposed to being prescriptive) and we may deviate from them in order to maximise the achievement of environmental outcomes throughout the Basin.

Where possible, water for the environment will be managed to benefit multiple sites along the entire River Murray and will be coordinated with other sources of water. This will include other environmental water portfolios (such as The Living Murray program), consumptive and operational deliveries, natural flows, and inflows from key tributaries such as the Ovens and Kiewa Rivers.

The following summary indicates how we may manage Commonwealth environmental water deliveries under various scenarios, with a focus on scenarios that reflect current and forecast climate conditions.

Dry to moderate (a year that is in the driest 10–50% of years)

A combination of forecast water availability (see Section 1.4.3), carryover of allocations from 2021–22 and strong opening allocations has enabled planning for the following events (even in a very dry scenario:

- Maintain winter baseflows to support in-channel species (including native fish), provide drought refuge, maintain water quality and riverine functions
 - main river channel flows in winter (4 000 ML/day at Yarrawonga) and spring (8 000 ML/day at Yarrawonga)
 - flows through creeks and key wetlands of Barmah-Millewa Forest
 - flows through Gunbower Creek to promote connectivity with Gunbower forest, provide native fish habitat, and maximise spawning potential
 - flows through the Edward/Kolety-Wakool River system, including the Yallakool-Wakool and Colligen-Niemur Creek systems
 - provide continuous connection through the Lower Lakes and into the Coorong and maintain water levels in the Lower Lakes above 0.4 m (to avoid the risk of acidification).
- Provide spring freshes
 - through the River Murray to support a broad range of environmental outcomes (see Tables RM1 to RM4 above). The timing, size, duration and number of freshes will depend on water availability. Under drier scenarios, the fresh is likely to be smaller and delivered later in spring to early summer. With increasing water availability, the targeted flow height and duration is likely to increase and may start in late winter to early spring.
 - that are coordinated with tributaries flows from the Goulburn, Murrumbidgee and Baaka (Lower-Darling) and Great Darling Anabranch to support large-scale connectivity and support carbon and nutrient transport throughout the southern connected basin.

- which, where possible are coordinated to reach targeted flow rates (>20 000 ML/d) in the Lower Murray river channel to enable 'faster flowing habitat' to support breeding and recruitment of golden and silver perch.
- through Gunbower Creek.
- in the Edward/Kolety-Wakool River system, with a minimum flow target during fish nesting period as a priority, followed by increase flow variability in summer and autumn and winter flows from May to August 2021 subject to water availability.
- Maximise end-of-system flows to
 - connect the River Murray to its estuary and the ocean to allow for native fish movement between fresh and saltwater habitats to successfully reproduce
 - provide suitable food and habitat for migratory shorebirds
 - export salt out of the Basin and reduce salt import into the Coorong and reduce salinity concentrations in the Coorong
 - maintain water levels in the Lower Lakes support improved diversity and extent of fringing and submergent vegetation, improve population size of small-bodied native fish species and increase habitat for waterbirds and migratory shorebirds.
- Deliver sufficient water to SA during summer/autumn to maintain end of system flows and connection between the Lower Lakes and the Coorong.
- Use infrastructure, pumps and/or weir pool manipulation to provide water to key wetlands throughout the valley, including Koondrook-Perricoota Forest, Hattah-Kulkyne Lakes, Chowilla, Pike and Katarapko floodplains.
- Respond to poor water quality events that may result from low flows.

Wet (a year that is in the wettest 25% of years)

- Contribute to the above outcomes, where not achieved by natural flows.
- Extend the peak, duration and/or recession of natural flows (within allowable operational limits), including with 'top-up' watering for wetlands in autumn.
- Provide refuge flows in response to hypoxic blackwater events.
- Support end-of-system flows.

14.6 Monitoring and lessons learned

14.6.1 Monitoring

Operational monitoring is undertaken for all Commonwealth environmental watering actions. It involves collecting on-ground data on environmental water delivery such as volumes delivered, impact on the river systems hydrograph, area of inundation and river levels. It can also include observations of environmental outcomes. Monitoring activities for the River Murray are funded by CEWO or The Living Murray Program.

The Commonwealth Environmental Water Monitoring, Evaluation and Research program has the Lower Murray and Edward/Kolety-Wakool region as focus areas. It aims to understand the environmental response from Commonwealth environmental watering with respect to the targeted objectives by carrying out monitoring of site condition and ecological response over many years. Learn more about the <u>Commonwealth Environmental Water Office's monitoring</u> activities in the Mid-Murray and Lower Murray-Darling.

The Living Murray program funds complementary monitoring for—Barmah-Millewa Forest, Koondrook-Perricoota Forest, Gunbower Forest, Hattah Lakes, Chowilla–Lindsay–Wallpolla Floodplain and the Lower Lakes and Coorong. Monitoring results from The Living Murray icon sites are available at the <u>MDBA's water for the environment outcomes page</u>.

In addition to site-based monitoring, during 2019–20 and 2020–21 a system-scale monitoring approach for the River Murray Channel was undertaken. These projects investigated changes in productivity (aquatic food-webs) resulting from the 'Southern Spring Flow'. Reports from 2019–20 include Zooplankton response to a multi-site environmental watering event during spring 2019 in the River Murray and 2019 Southern Spring Flow – Productivity Monitoring (2020–21 reports to be published in coming months).

During 2020–21, River Murray state and Commonwealth jurisdictions collaborated to develop a five-year monitoring plan for the River Murray Channel. The plan was developed with a focus on building on existing monitoring programs to fill gaps so that fish and productivity response can be evaluated at a whole of River Murray scale. Implementation of the <u>Monitoring Plan</u> for the first year in 2021–22 is expected to significantly improve monitoring coverage in the River Murray, focusing on productivity and fish indicators that will directly inform improved management and coordination of flows.

14.6.2 Lessons learned

Outcomes from monitoring and lessons learned in previous years are a critical component for the effective and efficient use of Commonwealth water for the environment. These learnings are incorporated into the way environmental water is managed.

Landscape-scale environmental water delivery is still relatively new, which means trialling and learning by doing (informed by science) from various events and outcomes. These learnings continue to be incorporated into the way environmental water is managed. While there are many learnings relating to particular locations, types of watering actions or subsets of the Murray's ecology (some are described in Table 6), key learnings that apply throughout the River Murray valley are summarised as follows.

Environmental water coordination

- Coordinating releases of water for the environmental across multiple river systems is complex. Factors such as delivery constraints, notification requirements and site-specific environmental demands or risks make it challenging to align releases of water in multiple tributaries to achieve coordinated flows downstream, however progress is being made.
 - In spring 2019, the 'Southern Spring Flow' provided extensive environmental benefit along the River Murray, from Hume Dam to the Coorong in South Australia, enhanced by its timing aligning with a spring fresh in the Goulburn River. Full details, including environmental outcomes, are described in the '<u>Southern Spring Flow Wrap-up</u>' (CEWO 2020a).
 - A similar event was undertaken in 2020, including coordinated Murray, Goulburn and Murrumbidgee pulses and additional releases from Lake Victoria. Details are described in the flow updates on the <u>CEWO website</u> (CEWO 2020b).
- The 2019 and 2020 Southern Spring Flows, along with previous coordinated flow events and associated monitoring activities, have shown there are multiple benefits of flows

moving through the length of the river system. However, it is also becoming clear that some important environmental outcomes are challenging to achieve and likely depend upon flows being higher and/or continuing for longer than what has been delivered to date. Thus, these outcomes require delivery constraints being relaxed, significant environmental releases combined from multiple tributaries and/or natural flows. For example:

- At a maximum flow rate of 15 000 ML/day downstream of Yarrawonga, satellite images show that only 25 per cent of Barmah-Millewa Forest was inundated as a result of the Southern Spring Flow (CEWO 2020a). Though only a small proportion of the total forest is watered, benefits from this extent of inundation are significant. For example, flows at this rate enable Moira grass growth, flowering and seed-set, improved river red gum condition, and generation of food for native fish in watercourses downstream of the forest as far as South Australia (CEWO 2020a, GB CMA 2020a). However, additional benefits such as to vegetation in the remaining majority of Barmah-Millewa Forest, remains unattainable at current flow constraints.
- Sustained flows of >20 000 ML/d are important for shifting a noticeable proportion of the Lower River Murray from still water to flowing water habitat, which benefits native plants and animals that are adapted to a flowing riverine environment (Ye et al. 2020). However, despite previous success of coordinating tributary flows, outside of unregulated conditions, flow rates of this magnitude are yet to be achieved. The combined Murray and Goulburn releases in 2019 achieved a peak flow at the South Australian border of around 15 000 ML/day. In 2020, Murray and Goulburn spring flows were enhanced with Murrumbidgee return flows and a direct order at the SA border which supplemented river flows with releases from Lake Victoria, achieving a brief flow peak of around 18,000 ML/d at the SA border.
- The diverse hydraulic conditions that occur above the 20 000 ML/d flow threshold, along with water temperature >18 degrees, are expected to trigger and support spawning and recruitment of golden and silver perch. While silver perch spawned in the Lower Murray during the 2020 spring pulse, there has been negligible recruitment of silver or golden perch detected in the last seven years, resulting in a lack of fish <6 years of age (Ye et al. 2021). This result is a concern for the population health of these iconic native perch.</p>

End of system flows

The importance of delivering water for end of system flows is significant and remains among the highest priorities in the River Murray. Lessons learned regarding flows to the end of the River Murray are as follows:

- Flows through the barrages to the Coorong have been almost continuous since the Millennium Drought because of environmental flows (Ye et al. 2021). Without water for the environment, barrages would need to have been closed for extended periods, effectively disconnecting the River Murray from its estuary. Connection to the estuary and sea is vitally important for many fish species to move between fresh and saltwater habitats to successfully reproduce, and for providing suitable food and habitat for migratory shorebirds.
 - If flows are reduced to fishways-only at the barrages for extended periods (e.g., 3 months during 2019–20 summer), releases are insufficient to prevent North Lagoon salinities increasing above 45 grams per litre (g/L). This is a maximum

management threshold as salt levels above this rate are lethal for some estuarine plants and animals (Taylor 2010). Higher flows in 2020–21, with minimal periods of fishways-only deliveries, ensured salinity generally remained below 45 g/L.

- Environmental flows substantially increased salt export out of the Basin, reduced salt import into the Coorong and reduced salinity concentrations in the Coorong. Flows have prevented around 5.5 million tonnes of salt building up in the Coorong from 2017 to 2020, avoiding catastrophic impacts that would have been reminiscent of those experienced during the Millennium Drought (Ye et al. 2021). In some years, environmental water has contributed to over 500 000 tonnes of salt being exported from the river and out the Murray Mouth (Ye et al. 2021). This is the equivalent of 25 000 semi-trailers each carrying a full load of salt (around 20 tonnes).
 - While water for the environment has to-date prevented catastrophic impacts reoccurring in the Coorong, there is still a year-on-year trend of gradual salt build-up in the South Lagoon over the past 4 years. Extensive recovery of *Ruppia* has also not occurred. Current volumes of water for the environment are not sufficient to 'reset' and maintain appropriate salinities and water levels in the South Lagoon during low flow conditions. High natural flows from the river, from the South-East and/or infrastructure solutions being investigated by the Healthy Coorong, Healthy Basin project are likely required to alleviate the threat of escalating salinity and encourage a strong recovery trend.
- While large volumes of freshwater are required to manage the health of the entire Coorong, new approaches to managing small releases of water through the barrages to the Coorong can have significant benefits. For example:
 - Strategically releasing pulses of water through Tauwitchere barrages to coincide with favourable wind, tide and swell conditions has proven effective in reducing Coorong salinity levels along the full length of the North Lagoon (CEWO 2020c).
 - Lamprey have been detected migrating even under low flow conditions (e.g., 2018). As such they remain a legitimate objective in similar conditions during winter/early spring, though more moderate flows are likely to enhance attraction to barrages and passage upstream (Bice et al. 2020).
- Without water for the environment water, water levels in the Lower Lakes would have dropped to levels that are ecologically devastating several times since the Millennium Drought. Environmental water stored temporarily in the Lower Lakes, prior to its release into the Coorong, has provided significant benefits to the health of the Lower Lakes. Environmental water has increased variability in the water levels of the Lower Lakes, improving diversity and extent of fringing and submergent vegetation, boosting populations of some small-bodied native fish species and increasing habitat for waterbirds and migratory shorebirds (SA DEW, 2020).

The value of flows all year round

Over the last 10 years environmental flows have moved from having a single-site focus for limited times (during drought and when environmental water holdings were relatively small) to large-scale deliveries that aim to provide multiple benefits along the entire length of river systems. Recent experience has also demonstrated the benefit of delivering water through the entire year, particularly when ecological needs would otherwise not be met due to limited demand for operational flow resulting in flows ceasing unnaturally. For example:

- Several consecutive years of stable winter flows in Gunbower Creek, along with a spring rise, are considered to have been key to the observed improvement in the structure of Murray cod populations (Bloink et al. 2019).
- Winter flows, supported by water for the environment, in the Edward/Kolety-Wakool River system have prevented cease to flow conditions (caused by the winter shut down of the irrigation season). This has resulted in in over a hundred kilometres of perennial instream habitat throughout Yallakool Creek-Wakool River and Colligen Creek-Niemur River systems. The provision of winter flows has assisted with the movement of native fish, such as silver perch, throughout the system (Watts et. al., 2019). It is also expected that winter flows into the Edward/Kolety-Wakool River system will protect aquatic plants from frost damage and improve their rate of recovery in the following spring, this will require further monitoring over multiple seasons to confirm (Watts et al. 2018).
- Further downstream, flows through the barrages and through fishways to the Coorong in winter are essential for allowing pouched lamprey to complete their life cycle. Peak migration for pouched lamprey is understood to occur in August, however monitoring of lamprey in winter-spring of 2019 and 2020 demonstrated that the migration season for lampreys extends into late spring with peak migrations of short headed lamprey in September and October (Bice et al. 2020). During periods of limited water availability, releases through Goolwa and Mundoo barrages may elicit greater outcomes in relation to lamprey migrations compared to Tauwitchere, given the proximity of these barrages to the Murray Mouth and fresher environment downstream of these barrages (Bice et al. 2020).
- In late summer and autumn, at a time when most of the flow in the river is used for consumptive purposes, limited flows reach the end of system. Providing environmental water targeting the 'end of system' during this period is highly important, however at times, system constraints have made this difficult to achieve. Environmental flow at this time of year has been critical in maintaining Lower Lakes water levels above 0.5 m AHD while still providing some connectivity to the Coorong through fishway flows. A sharp drop in lake levels over summer and autumn 2020 may have limited recruitment and health of small bodied fish in the Lower Lakes, which had spawned strongly during the 2019 spring pulse (Wedderburn pers. comm. 2020).

Additional key findings from fish, aquatic habitat and flow monitoring in the River Murray valley are summarised in Table RM5.

Theme	Lessons learned		
Native fish	 Maintaining connectivity between the River Murray and its anabranch systems during hypoxic blackwater events is crucial—prior to, during and after—to allow fish to disperse and seek refuge and then return to the anabranch after the event has passed (Watts et al. 2019). 		
	• Small flows rates, at the right time of year can make a difference for Murray cod. Delivery constraints prevented planned flows to support large bodied native fish in Gunbower Creek in 2018. Monitoring revealed that a reduced flow rate of 200 ML/day still provided adequate habitat and connectivity for Murray cod (NCCMA, 2020).		

Table RM5 Key lessons learned in the River Murray valley

Theme	Lessons learned
	• Delivering water for the environment at the right flow rates and time of year has successfully stimulated spawning of native fish in several river systems. In the Mid-Murray, excellent recruitment has been observed across several native species over multiple years (Raymond et al. 2018).
	 Very slow flow habitats, or river reaches with less permanently flowing water show limited evidence of recruitment for large-bodied native fish (Watts et al. 2019, Ye et al. 2020).
	• Recovery of native fish populations following drought and other fish kill events is slow. It is important to seek opportunities to support re- colonisation and immigration of native fish into areas which have seen declines. Key nursery areas in the mid-Murray should be considered for reconnection (with the Darling, Murray and Goulburn) to support immigration and dispersal of species such as silver and golden perch (Watts et. al. 2018, Watts et al. 2019).
Native vegetation	• Several consecutive years of inundation area beneficial for floodplain and wetland vegetation communities:
	 In Barmah Forest, low-level overbank spring flows resulted in exceptionally good Moira grass growth and flowering since 2018, particularly within grazing exclusion zones (GB CMA 2021).
	 Improved cover and diversity of wetland vegetation in Gunbower Forest, indicates that environmental water has enabled wetland plants to germinate, flower and set seed (NCCMA 2020).
	 River red gums that have received water following the 2016–17 flood have healthier canopies than river red gums in areas that remained dry (Mallee CMA 2020, North Central CMA 2020).
	 Vegetation located at higher elevation floodplain and wetlands, or vegetation that has not been able to have follow-up water delivered, are more stressed and continue to decline in condition.
	• Providing a slow rate of recession to flows enables native water plants to avoid being stranded and drying out prior to completing their life-cycle (Watts et al. 2015).
Waterbirds	• During dry and moderate years water for the environment can assist in maintaining foraging and breeding habitat and supporting small- scale bird breeding events. While unlikely to contribute to population growth, these localised breeding events provide a regular input of new recruits into the population and are important in maintaining genetic diversity (McGuinness et al. 2019).
Water quality	• At small scales, targeted deliveries of environmental water may be used to maintain viable oxygen levels for aquatic organisms during hypoxic blackwater conditions in localised areas (Ye et al. 2018, Watts et al. 2019).
Connectivity and water delivery	• Monitoring results show that environmental watering which returns flows from major floodplain forests (e.g., Barmah-Millewa Forest) results in significant mobilisation and transport of carbon and nutrients into river systems (Watts et al. 2016, CEWO 2020a, Furst et. al. 2020, Rees et al. 2021). This is a fundamental ecological process that is crucial for supporting and maintaining aquatic food-webs and reducing floodplain carbon loads, which reduce the risk of hypoxic black water events.
	 Early season delivery of environmental water assists in avoiding delivery constraints that arise during the irrigation season (spring- summer).
	 Two successful trial delivery flows of 800 ML/day (the existing limit is 600 ML/day) in the Yallakool Creek-Wakool River system during spring have highlighted:
	 the importance of a long lead in time to planning with local land holders, agencies, community members and monitoring providers

Theme	Lessons learned
	 the need to have alternative delivery arrangements (i.e., Murray Irrigation network) to deliver target flows if WaterNSW infrastructure is unable to meet those flow rates
	 the flow inundated one low level bridge near Bookit Island (mid Wakool River) and another on Black Dog Creek, but did not limit landholders' access to their properties
	 the flow trial increased lateral connectivity within the river system.
	 Fishways at the barrages (rock ramp and trapezoidal) continued to operate when Lower Lake levels fell below 0.6 m AHD, when previously thought to become non-functional. This provides future option of managing water levels below 0.6 m while continuing releases through the fishways.

References

Belcher, C., Borrell, A., Davidson, I. and Webster, R. 2018, *Australasian Bittern Surveys in the Murray Valley and Barmah National Parks*, Canberra.

Bice, C., Zampatti, B., Ye, Q. and Giatas, G. 2020, *Lamprey migration in the lower River Murray in association with Commonwealth environmental water delivery in 2019*, South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

Bloink C., Halliday B., Robinson W. and Stevenson K. 2019, *Gunbower TLM fish monitoring 2019*, A report to the North Central Catchment Management Authority by Ecology Australia, Shepperton.

BoM 2021, <u>Climate outlooks July to October – issued 24 June 2021</u>, Bureau of Meteorology, accessed 9 July 2021.

CEWO 2020a, <u>Southern Spring Flow 2019 – Wrap-up</u>, Commonwealth Environmental Water Office, accessed 9 July 2021.

——2020b, <u>The Southern Spring Flow 2020</u>, Commonwealth Environmental Water Office, accessed 9 July 2021.

——2020c, <u>Wind, waves and wi-fi – A winning combination for the Coorong</u>, Commonwealth Environmental Water Office, accessed 9 July 2021.

DELWP 2015, *Long Term Watering Plan: Victorian Murray*, The State of Victoria Department of Environment, Land, Water and Planning, Melbourne.

DEW 2020, <u>Native fish recovery</u>, South Australia Department for Environment and Water, Adelaide, accessed 9 July 2021.

Department of the Environment 2011, *Environmental Water Delivery: Yarrawonga to Tocumwal and Barmah-Millewa*, Prepared by Ecological Associates and SKM for the Commonwealth Environmental Water Office, Canberra.

DEWNR 2015, Long Term Environmental Watering Plan for the South Australian River Murray Water Resource Plan Area, Department of Environment, Water and Natural Resources, Adelaide.

Dyer, F., Broadhurst, B., Tschierschke, A., Thiem, J., Thompson, R., Driver, P., and Bowen, S. 2018, *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Lower Lachlan river system Selected Area 2017-18 Monitoring and Evaluation Technical Report,* Commonwealth of Australia, 2018.

Ecological Associates 2015, *Environmental Water Management Plan for the River Murray from Lock 6 to Lock 10 – System Characterisation*, Ecological Associates.

Ecological Associates 2010, *The Environmental Watering Requirements of the South Australian River Murray*, Ecological Associates.

Gehrig, S. 2018, Assessment of the responses of littoral and riparian vegetation to weir pool manipulations in Weir Pools: 7, 8, 9 and 15 of the River Murray, Final Report prepared for the Murray–Darling Basin Authority by the School of Life Sciences, Albury–Wodonga and Mildura.

GBCMA 2021, *Barmah-Millewa Forest Seasonal Watering Proposal 2021-2022 (VEWH Addendum)*, Goulburn Broken Catchment Management Authority, Shepparton.

——2020a, Barmah Forest Seasonal Watering Proposal (SWP) 2020-2021 (VEWH Addendum), Goulburn Broken Catchment Management Authority, Shepparton.

——2020b, Barmah Forest Early Observations for 2019-20, Goulburn Broken Catchment Management Authority, Shepperton.

Kilsby N.N. & Steggles T. 2015, <u>Ecological objectives, targets and environmental water</u> <u>requirements for the South Australian River Murray floodplain environmental asset</u>, DEWNR Technical report 2015/15, Government of South Australia through Department of Environment, Water and Natural Resources, Adelaide.

MCMA 2020, *Hattah Lakes & Lindsay Mulcra Walpolla Early Observations for 2019-20*, Mallee Catchment Management Authority, Irymple, Victoria.

MDBA 2020, <u>Discover the Basin – Catchments</u>, Murray-Darling Basin Authority, Canberra, accessed 2 June 2020.

——2019a, *Basin-wide environmental watering strategy. Second edition*, Murray–Darling Basin Authority, Canberra.

——2019b, <u>Chowilla Floodplain Report Card 2018-19</u>, Murray-Darling Basin Authority, Canberra.

——2017, <u>Waterbirds of the Murray–Darling Basin: 2017 Basin Plan Evaluation</u>, Murray-Darling Basin Authority, Canberra.

——2014, <u>Coorong, Lower Lakes and Murray Mouth Environmental Water Management Plan.</u> <u>Murray–Darling Basin Authority</u>, Canberra.

——2012a, Assessment of environmental water requirements for the proposed Basin Plan: Gunbower-Koondrook-Perricoota Forest, Murray–Darling Basin Authority, Canberra.

——2012b, Assessment of environmental water requirements for the proposed Basin Plan: Riverland Chowilla Floodplain, Murray–Darling Basin Authority, Canberra.

——2012c, Barmah-Millewa Forest Environmental Water Management Plan. Murray–Darling Basin Authority, Canberra.

——2012d, *Chowilla Floodplain Environmental Water Management Plan*, Murray–Darling Basin Authority, Canberra.

——2012e, *Hattah Lakes Environmental Water Management Plan*, Murray–Darling Basin Authority, Canberra.

——2012f, Hydrologic modelling to inform the proposed Basin Plan: Methods and results. Murray–Darling Basin Authority, Canberra.

——2012g, Koondrook-Perricoota Forest Environmental Water Management Plan. Murray– Darling Basin Authority, Canberra. ——2012h, Gunbower Forest Environmental Water Management Plan. Murray–Darling Basin Authority, Canberra.

New South Wales Forests. (2020). Koondrook-Perricoota Forest Early Observations for 2019-20.

NCCMA 2020, *Gunbower Early Observations for 2019-20*, North Central Catchment Management Authority.

——2021, Draft Seasonal Watering Proposal for Gunbower Forest and Gunbower Creek 2021-22, North Central Catchment Management Authority, Huntly, Victoria.

——2021, *Draft Seasonal Watering Proposal for the Central Murray Wetland Complex 2021–22*, North Central Catchment Management Authority, Huntly, Victoria.

Nicol, J.M., Frahn, K.A., Gehrig, S.I., and Marsland, K.B. 2019, *Lower Lakes Vegetation Condition Monitoring – 2018-19*, South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

Paton, D.C., Paton F.L. and Bailey C.P. 2020, *Condition Monitoring of the Lower Lakes, Coorong and Murray Mouth Icon Site: Waterbirds in the Coorong and Lower Lakes 2020*, The University of Adelaide and The Department for Environment and Water.

Porter, J.L., Kingsford, R.T., Francis R. and Brandis K. 2020, *Aerial Survey of Wetland Birds in Eastern Australia - October 2020 Annual Summary Report*.

Rees G.N., Biswas T.K., Gilling D., Watts R.J., Liu X., Oliver R., Pengelly J., Zygmunt L., Ye Q., McInerney P., Thompson, R., Malthus T., Joehnk K. 2021, *River Murray Channel Productivity Monitoring 2020*, CSIRO Land & Water, Canberra.

Raymond, S. Tonkin, Z. Duncan, M. and Robinson, W. 2019, *Barmah-Millewa Fish Condition Monitoring: 2019*.

Raymond, S. Duncan, M. Tonkin, Z. and Robinson, W. 2018, *Barmah-Millewa Fish Condition Monitoring: 2018*.

Roberts, J. and Marston, F. 2011, *Water regime for wetlands and floodplain plants: A source book for the Murray–Darling Basin.*

South Australian Department for Environment and Water 2020, *Early observations from The Living Murray CLLMM Icon Site monitoring program,* Full results will be available in 2020/21 monitoring reports once published by the MDBA, Adelaide.

Taylor, B. 2010, *Ecological Justification for the South Lagoon Salinity Reduction Scheme – A Discussion Paper*, Department of Environment and Natural Resources, Adelaide, South Australia.

Wallace, T., Daly, R., Aldridge, K., Cox, J., Gibbs, M., Nicol, J., Oliver, R., Walker, K., Ye, Q. & Zampatti, B. 2014, *River Murray Channel Environmental Water Requirements: Ecological Objectives and Targets.*

Watts R.J., Bond N.R, Grace M.R., Healy S., Howitt J.A., Liu X., McCasker N.G., Thiem J.D., Trethewie J.A. 2019, *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Edward-Wakool River System Selected Area Technical Report, 2018-19*, Report prepared for Commonwealth Environmental Water Office, Canberra.

Watts, R.J., McCasker, N., Howitt, J.A., Thiem, J., Grace, M., Kopf, R.K., Healy, S., Bond, N. 2016, *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Edward-Wakool River System Selected Area Evaluation Report, 2015-16*, Report prepared for Commonwealth Environmental Water Office, Canberra.

——2015, Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Edward-Wakool Selected Area Technical Report, 2014-15, Institute for Land, Water and Society, Charles Sturt University, Prepared for Commonwealth Environmental Water, Canberra.

Watts R.J., McCasker N.G., Howitt J.A., Thiem J.D., Grace M.R., Trethewie J.A., Healy S., Bond N.R. 2018, *Commonwealth Environmental Water Office Long Term Intervention Monitoring Project: Edward-Wakool River System Selected Area Technical Report, 2017-18*, Report prepared for Commonwealth Environmental Water Office, Commonwealth of Australia, Canberra.

Wedderburn, S., Whiterod, N. and Gwinn, D. 2019, *Determining the status of Yarra Pygmy Perch in the Murray–Darling Basin*.

Ye, Q., Giatas, G., Bice, C., Brookes, J., Furst, D., Gibbs, M., Nicol, J., Oliver, R., Shiel, R., Zampatti, B., Bucater, L., Deane, D., Hipsey, M., Huang, P., Lorenz, Z., and Zhai, S. 2021, *Commonwealth Environmental Water Office Monitoring, Evaluation and Research Project: Lower Murray 2019-20 Technical Report*, A report prepared for the Commonwealth Environmental Water Office by the South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

Ye, Q., Giatas, G., Brookes, J., Furst, D., Gibbs, M., Oliver, R., Shiel, R., Zampatti, B., Aldridge, K., Bucater, L., Busch, B., Hipsey, M., Lorenz, Z., Maas, R., and Woodhead, J. 2020, *Commonwealth Environmental Water Office Long-Term Intervention Monitoring Project 2014–2019: Lower Murray River Technical Report*, A report prepared for the Commonwealth Environmental Water Office by the South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

Ye, Q., Bucater, L., Furst, D., Lorenz, Z., and Giatas, G. and Short, D. 2019, *Monitoring salt wedge dynamics, food availability and black bream (Acanthopagrus butcheri) recruitment in the Coorong during 2018-19*, South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

Ye, Q., Giatas, G., Aldridge, K., Busch, B., Brookes, J., Gibbs, M., Hipsey, M., Lorenz, Z., Maas, R., Oliver, R., Shiel, R., Woodhead, J. and Zampatti, B. 2018, *Long-term Intervention Monitoring of the Ecological Responses to Commonwealth Environmental Water Delivered to the Lower Murray River Selected Area in 2016/17*, A report prepared for the Commonwealth Environmental Water Office by the South Australian Research and Development Institute (Aquatic Sciences), Adelaide.