South Australian River Murray Water for the Environment Report 2020-21

Government of South Australia
Department for Environment and Water

Acknowledgement of the Traditional Owners

The Department for Environment and Water acknowledges Traditional Owners of Country throughout Australia and recognises the continuing connection to lands, waters and communities. We pay our respect to Aboriginal and Torres Strait Islander cultures and to Elders both past and present.

The First Nations of South Australia, the Aboriginal Traditional Owners, have occupied, enjoyed and managed their customary lands and waters since time immemorial and continue their deep cultural, social, environmental, spiritual and economic connection today. The Government of South Australia acknowledges and pays respect to the Traditional Owners and their Nations. The Government of South Australia also acknowledges and respects the rights, interests and obligations of Traditional Owners to speak and care for their Country – lands and waters – in accordance with their laws, customs, beliefs and traditions. In acknowledging this history and connection we also recognise the deep and irreversible damage and dislocation that Aboriginal and Torres Strait Islander people have experienced and continue to experience through European colonisation, settlement and displacement. Aboriginal Nations have advocated strongly for a healthier Murray–Darling Basin and just settlement of their land and water rights. This commitment led to a stronger Basin Plan for South Australians and asks us as a state government to better recognise Traditional Owner interests in our water resource management. The Department for Environment and Water seeks to enable partnerships with Aboriginal Nations built upon mutual respect and trust. We recognise the differences between Nations and their preferred approaches for engagement with Government and will work through these arrangements to support Traditional Owners to meet their customary rights and obligations in natural resource planning and implementation.

First Nations peoples should be aware that this publication may contain images of deceased persons or culturally sensitive material.

Acknowledgments

The South Australian River Murray Water for the Environment Report was prepared by staff in the Department for Environment and Water with contributions from the Murraylands and Riverland Landscape Board, Accolade Wines, Australian Landscape Trust, Nature Foundation, and Renmark Irrigation Trust. A draft was provided to the Commonwealth Environmental Water Office and The Living Murray Program, with their feedback improving the quality of the Report.

The following agencies and organisations are acknowledged for their important role in management of water for the environment:

- Accolade Wines, Banrock Station
- Australian Landscape Trust, Calperum Station
- BirdsSA
- Chowilla Community Reference Committee
- Commonwealth Environmental Water Office
- Coorong, Lower Lakes and Murray Mouth Community Advisory Panel
- First Peoples of the River Murray and Mallee Region
- Flinders University
- Investigator College
- Katarapko Community Advisory Panel
- Lower Lakes, Coorong and Murray Mouth Scientific Advisory Group
- Murray-Darling Basin Authority including The Living Murray program
- Murraylands and Riverland Landscape Board (MRLB)
- Nature Foundation
- Nature Glenelg Trust
- New South Wales Department of Planning, Industry and Environment (NSW DPIE)
- Ngarrindjeri Aboriginal Corporation and Ngarrindjeri Regional Authority
- Pike Community Reference Committee
- Pike Mundic Irrigators Group
- Pike River Land Management Group
- Raukkan Community Council
- Renmark Irrigation Trust
- River Murray and Mallee Aboriginal Corporation
- South Australian Research and Development Institute (SARDI)
- The Conservation and Hunting Alliance of SA
- The Goolwa to Wellington Local Action Planning Inc.
- The Mannum Aboriginal Community Association Incorporated
- The National Trust (Overland Corner)
- Treasury Wines
- University of Adelaide
- Victorian Environmental Water Holder
- Wetland Habitats Trust

Cover Image: *Ardea modesta* (great egret) at Lake Limbra, Chowilla. Credit: Helga Kieskamp

Foreword

The 2020-21 water year saw moderate rainfall across the Murray-Darling Basin, resulting in the first unregulated flow conditions in the South Australian River Murray since 2016. Approximately 980 gigalitres (GL) of water for the environment was delivered to South Australia, which was equivalent to 32% of all flows across the South Australian Border. This water for the environment was delivered through a collaborative effort and from a variety of sources. A great example of this is the coordination of the 2020 Southern Spring Flow, which saw two Commonwealth and three state agencies, including the South Australian Department for Environment and Water, deliver almost 500 GL of water for the environment to South Australia from late September through to the end of December 2020.

Monitoring of watering events is a collaborative effort, with monitoring undertaken by the South Australian Government, scientists, local community members and landholders providing information on environmental outcomes and supporting future water delivery planning.

Additional highlights of 2020-21 include:

- first operations of the environmental regulators on the Pike and Katarapko floodplains, inundating over 2,235 hectares of floodplain;
- the tenth consecutive year of flows out of the barrages, connecting the River to the Coorong and Southern Ocean and delivering multiple ecological benefits as a result; and
- managing over 100 permenant and ephemeral wetlands, providing important habitat for threatened species.

Further work and collaboration is required to continue the recovery of the River Murray system in South Australia and across the Basin more broadly. The continuing degraded state of the Coorong South Lagoon is of significant concern and continues to be the focus of efforts to restore the site through the joint Commonwealth and South Australian Government funded *Healthy Coorong, Healthy Basin* initiative.

Ben Bruce
Executive Director, Water and River Murray
Department for Environment and Water, South Australia

Malacorhynchus membranaceus (pink-eared ducks) at Werta Wert, Chowilla. Credit: Helga Kieskamp

Abbreviations

AHD	Australian Height Datum
AOO	Annual Operating Outlook
AWA	Aboriginal Waterway Assessment
BWEWS	Basin-Wide Environmental Watering Strategy
CAMBA	China-Australia Migratory Bird Agreement
CEWH	Commonwealth Environmental Water Holder
CEWO	Commonwealth Environmental Water Office
COAG	Council of Australian Governments
DEW	Department for Environment and Water
EC	Electrical conductivity
EPBC	*Environment Protection and Biodiversity Conservation Act 1999*
Flow-MER	CEWO's Monitoring, Evaluation and Research (Flow-MER) Program
GL	gigalitre (a billion litres)
ha	hectare
IPP	Indigenous Partnerships Program
JAMBA	Japan-Australia Migratory Bird Agreement
LLCMM	Lower Lakes, Coorong and Murray Mouth Icon Site
m	metre
MDBA	Murray–Darling Basin Authority
ML	megalitre (a million litres)
MRLB	Murraylands and Riverland Landscape Board
NAC	Ngarrindjeri Aboriginal Corporation
PIT	Passive Integrated Transponders
QSA	Flow at the South Australian border
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
RMIF	River Murray Increased Flows
s	seconds
SA River Murray LTWP	Long-Term Environmental Watering Plan for the South Australian River Murray
SCBEWC	Southern Connected Basin Environmental Watering Committee
TLM	The Living Murray Program
VEWH	Victorian Environmental Water Holder

Lengths of layflat hose delivering water to Nilkra Wetland. Credit: Kate Mason, Murraylands and Riverland Landscape Board.

Contents

List of Figures

List of Tables

Flowering *Duma florulenta* (lignum) at Tolderol Game Reserve wetland. Credit: Sam Hardy, Murraylands and Riverland Landscape Board.

Introduction and Purpose

The planning, delivery, monitoring, reporting and evaluation of water for the environment within the South Australian River Murray is coordinated by the Department for Environment and Water (DEW) and undertaken in partnership with other government agencies including the Murray-Darling Basin Authority (MDBA) and Commonwealth Environmental Water Office (CEWO), research organisations, non-government organisations and community groups.

The delivery of water for the environment to South Australia in the 2020-21 water year was guided by the 2020-21 Annual Water for the Environment Plan for the South Australian River Murray (DEW, 2020a), the Long-Term Environmental Watering Plan for the South Australian River Murray (River Murray LTWP) and the Basin-Wide Environmental Watering Strategy (BWEWS; MDBA, 2019). These documents, together with site-based management plans, describe key ecological targets and objectives for annual water for the environment delivery to South Australia.

Management of water for the environment is becoming increasingly complex with a range of techniques now being used to provide much-needed water to a growing number of locations supported by the work of numerous stakeholders. Water for the environment delivered to South Australia is provided by a number of water holders including the Commonwealth Environmental Water Holder (CEWH), The Living Murray (TLM) program, the South Australian Minister for Environment and Water and the Victorian Environmental Water Holder (VEWH). Along with DEW, there are a number of non-government organisations also involved in delivering this water to sites located throughout the South Australian River Murray. This report serves the important purpose of providing a complete and public record of all water for the environment actions, regardless of water holder or manager, undertaken in the region throughout the 2020-21 water year. It is in addition to the reporting undertaken by DEW to meet the requirements of the Murray-Darling Basin Plan (Basin Plan). It also fulfils the South Australian government's commitment to the Council of Australian Governments (COAG) to publish an annual report on the use of River Murray water for the environment in South Australia for public information sharing (National Water Initiative Policy Guidelines for Water Planning and Management 2010).

This report provides a record of environmental watering activities along the South Australian River Murray during the 2020-21 water year and includes:

- an overview of river conditions in 2020-21
- a summary of the water for the environment actions that were undertaken including sites and volumes
- a summary of key environmental outcomes
- a list of reports that provide detailed information about monitoring and ecological outcomes.

Throughout this report, 'water for the environment' refers to held environmental water available under a water access right (e.g. water licence) that is actively managed for the purposes of achieving environmental outcomes. Planned environmental water, which is water protected from being used for non-environmental purposes (e.g. unregulated flows), plays a critical role in supporting environmental outcomes, but is not the focus of this report.

Litoria raniformis (southern bell frog) juvenile at Hogwash Bend. Credit: Stephanie Robinson, Murraylands and Riverland Landscape Board

Planning for Environmental Watering

As part of the planning process, environmental watering proposals for the major South Australian sites were developed and submitted to the MDBA Southern Connected Basin Environmental Watering Committee (SCBEWC) and the CEWO in early 2020 to inform and support whole of Murray system planning. These proposals form the basis of the 2020-21 Annual Water for the Environment Plan and Annual Priorities for the South Australian River Murray (DEW, 2020a; DEW, 2020b) summarised in Appendix A, and the Basin Environmental Watering Priorities (MDBA, 2020).

All environmental water and site managers in the region are encouraged to participate in this planning process which also benefits from the input of Traditional Owner groups, scientific experts and community groups, including the Lower Lakes, Coorong and Murray Mouth (LLCMM) Community Advisory Panel, Chowilla Community Reference Committee, the LLCMM Scientific Advisory Group, the Ngarrindjeri Aboriginal Corporation and the First Peoples of the River Murray and Mallee. The annual plan and priorities are published on the DEW website and indicate the proposed watering actions for the upcoming water year.

When undertaking planning, environmental managers use a scenario-based approach that takes into account the variety of possible future water resource conditions such as climate, storage levels and water availability. The scenarios that were used in the planning for 2020-21 are shown in Figure 1.

Planning for Flexible Management

To facilitate the planning process, MDBA provide annual operating outlooks (AOOs) for the water year ahead, which describe hypothetical flow conditions under a range of climate scenarios. DEW and site managers plan for environmental watering actions based on these flow scenarios, as described in the 2020-21 Annual Water for the Environment Plan for the South Australian River Murray (DEW, 2020a). The flow conditions that South Australia would have experienced without the addition of water for the environment (see dashed line in Figure 1) indicate that the 'moderate' and 'near average' planning scenarios were most relevant to 2020-21 (Figure 1).

All watering actions proposed under a moderate scenario were achieved, while some actions proposed under a near average scenario were not achieved as flow conditions were not sufficient. More information on the planned actions, and an indication of which of these were achieved, is shown in Appendix A.

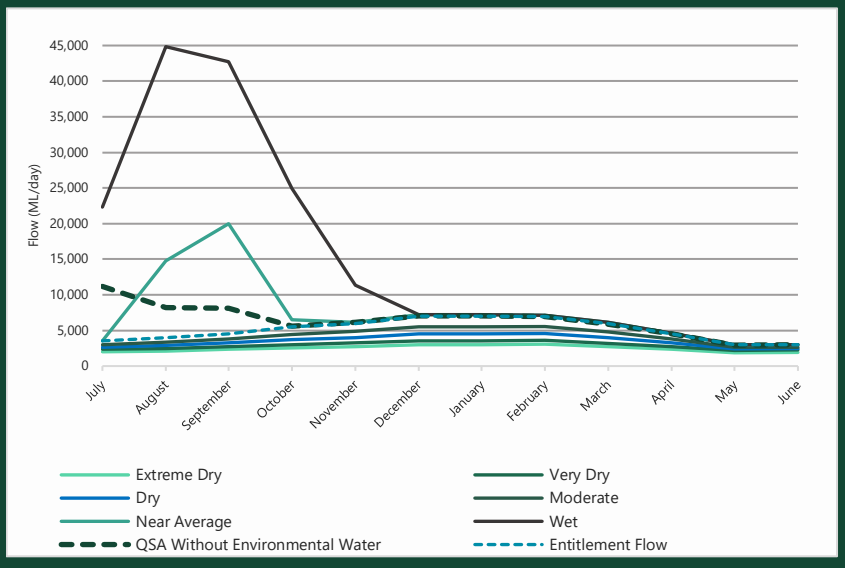


Figure 1. Actual flows to South Australia (QSA) in 2020-21 without water for the environment compared to planning scenarios. Flows in in megalitres per day (ML/day)

System-scale planning and delivery of water for the environment for the southern Murray-Darling Basin is coordinated by the SCBEWC. Representatives from South Australia, as well as from New South Wales, Victoria, MDBA, the VEWH, the CEWH and the Commonwealth Government are members of SCBEWC[1].

More detailed information on planning is in the 2020-21 Annual Water for the Environment Plan for the South Australian River Murray available on the DEW website.

[1] For more information regarding SCBEWC, refer to their annual reports

Overview of Flow Conditions in 2020-21

Moderate conditions

2019-20 Dry
2018-19 Dry

3,080 GL total flow across the South Australian border

2019-20: 2,389 GL
2018-19: 2,442 GL

The 2020-21 water year saw moderate climatic conditions across the Murray-Darling Basin, following 3 consecutive dry years. Temperatures across the Basin were generally above average, creating warm, dry conditions for much of the year (Figure 3). Overall, Basin inflows were greater than the previous water year, although they remained below the long-term average (MDBA, 2021).

The water year commenced with volumes in MDBA storages well below the long-term average for the end of June and South Australian River Murray water allocations opened at 54%. Much-needed rain and improved inflows across the Basin saw allocations increase to 100% on 19 August 2020, although, large areas of the Basin continued to experience average to very much below average rainfall conditions.

Winter and early spring rainfall in the Murray and Goulburn River catchments resulted in unregulated flows at the South Australian border for the first time since 2016-17. This unregulated flow event continued from 27 June to 25 September 2020, filling Lake Victoria and contributing over 460 GL to the total volume of 3,080 GL that arrived in South Australia in 2020-21. The highest flows in South Australia occurred between November and December 2020 during a targeted environmental flow event where flows to South Australia exceeded 15,000 ML/day for 19 consecutive days, peaking at approximately 18,000 ML/day on 25 November 2020 (Figure 2). Modelling by the MDBA indicates that flow at the South Australian border would have exceeded 25,000 ML/day for most of spring and peaked above 35,000 ML/day in early summer under natural flow conditions.

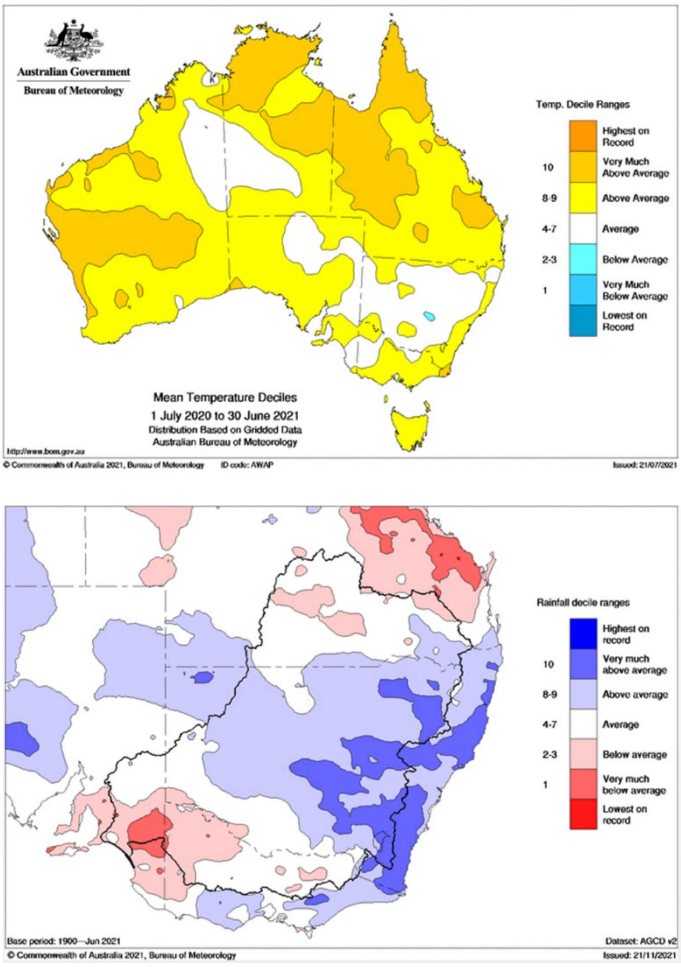


Figure 3. Australian mean temperature deciles (top) and Murray-Darling Basin rainfall deciles (bottom) 1 July 2020 to 30 June 2021. Source: Bureau of Meteorology

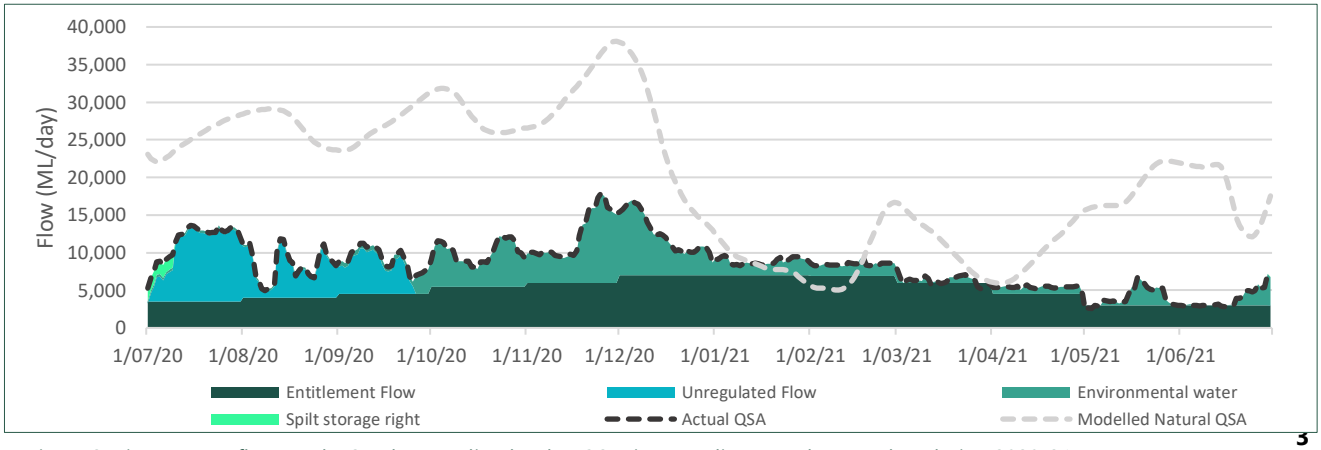


Figure 2. River Murray flows at the South Australian border (QSA) in mega litres per day (ML/day) during 2020-21.

Environmental Water Delivery

980 GL water for the environment

20 GL pumped to wetlands and floodplains

894 GL over the barrages

2 floodplain regulators operated

123 sites managed for the environment

1 coordinated spring flow through the channel

In total, approximately 980 GL of water for the environment was delivered to South Australia (Figure 4). The CEWH provided approximately 699 GL (including approximately 162 GL held on licences in South Australia) and TLM provided approximately 175 GL (including 45 GL held on licences in South Australia). South Australia also received approximately 56 GL of water for the environment in the form of return flows from upstream watering actions undertaken by the VEWH and 5 GL of River Murray Increased Flow (RMIF) was also delivered. Approximately 44 GL of water for the environment held by the South Australian Minister for Environment and Water was delivered. An additional 14 GL of consumptive water held by the SA Minister was used to contribute to environmental outcomes. A small volume of water for the environment held on a private licence was also delivered for the management of the pool-connected Banrock Station Wetland (Appendix B).

The majority of water for the environment (922 GL or ~94%) received by South Australia made its way along the River Murray, providing water quality and ecological benefits along the length of the South Australian River Murray Channel, with approximately 906 GL arriving at the Lower Lakes, Coorong and Murray Mouth (LLCMM)[1]. The remaining 6% (58 GL) of water for the environment was shared between 123 sites that ranged in size from 0.25 hectares to 1,495 hectares.

Some of the Water for the Environment Events in South Australia in 2020-21:

- A coordinated delivery from multiple upstream catchments including the Murray, Goulburn and Murrimbidgee, saw approximately 497 GL of water for the environment arrive in South Australia as part of the 2020 Southern Spring Flow.
- Environmental regulators on Pike and Katarapko floodplains operated for the first time, inundating over 2,235 ha of floodplain that has remained dry since 2016.
- The management of over 100 wetlands, including many that provide habitat for threatened species such as Murray hardyhead (*Craterocephalus fluviatilis*) and the southern bell frog (*Litoria raniformis*).
- The tenth consecutive year of flows out of the barrages, connecting the River to the Coorong and Southern Ocean for native fish movement and exporting salt from the Basin.

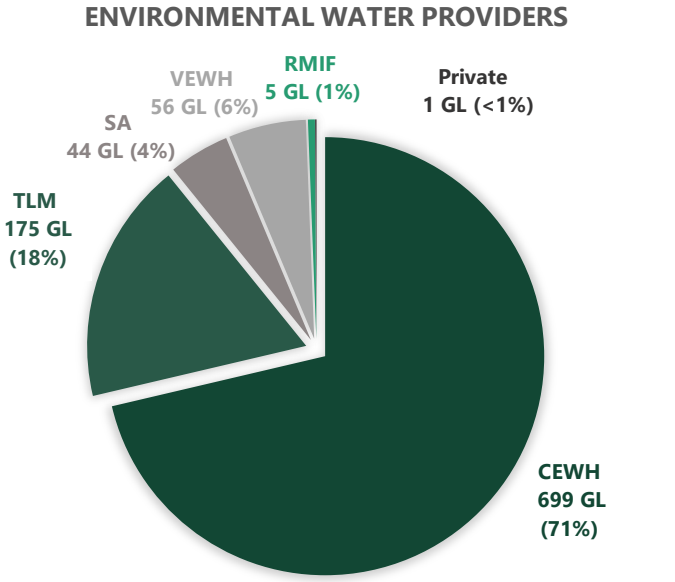


Figure 4. Volumes contributed by each environmental water provider (Commonwealth Environmental Water Holder (CEWH), The Living Murray (TLM), SA Minister for Environment and Water (DEW), Victorian Environmental Water Holder (VEWH), River Murray Increased Flow (RMIF) and Accolade Wines) in 2020-21.

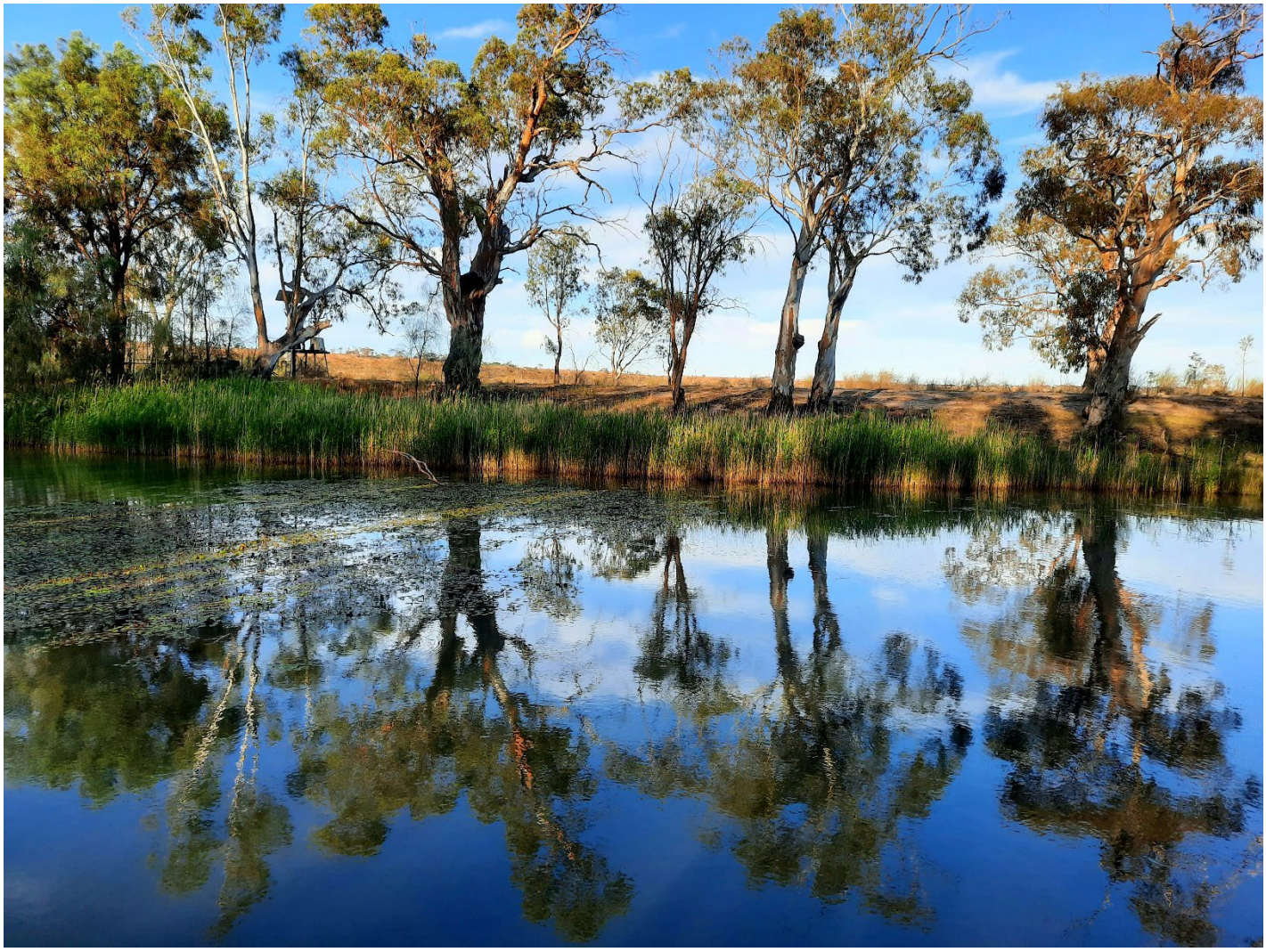
[1] There was 16 GL of losses due to the additional area inundated as water for the environment travelled from the SA border to the LLCMM

First regulator operations at Pike floodplain. Credit: DEW

Outcomes of Water Delivery

In order to understand the ecological outcomes of these watering events, various monitoring programs have been implemented. These monitoring programs vary from a whole-of-Basin scale, such as CEWO's Monitoring, Evaluation and Research (Flow-MER) Program, to smaller site-scale programs funded variously by federal and state governments.

The following section provides a snapshot of outcomes observed at key watering sites.



Water for the environment at a temporary wetland basin at Overland Corner. Credit: DEW

South Australian River Murray Channel and Floodplain

503,343 ML for the environment

2,235 ha watered

2 floodplain sites watered

Three major water for the environment events occurred across the South Australian River Murray channel and floodplain in 2020-21. These are a coordinated spring pulse through the River Murray channel, and first operations of the Pike and Katarapko floodplain regulators, which were undertaken in conjunction with raising of main channel Weirs 5 and 4. The outcomes of these watering actions are summarised in this section.

River Murray Channel

~497,000 ML delivered Sept -Dec

>600 River km watered

Site Water Manager: DEW

Source of water: CEWH, TLM, VEWH, RMIF

Specific Ecological Objectives:

- Increase availability of moderate-fast (0.18 – 0.25 metres per second (m/s)) velocity habitat to support suspension and downstream transport of native seeds and eggs/larvae.
- Water level variability in the upper section of each weir pool resulting in improved aquatic and littoral vegetation and groundwater freshening.
- Support spawning and recruitment of golden perch and silver perch by creating conditions conducive to reproductive activity when temperature thresholds (20 degrees) are exceeded.

Outcomes:

In 2020-21, the management of flows from 4 major rivers in the southern Murray-Darling Basin was coordinated to create the 2020 Southern Spring Flow, involving the efforts of two Commonwealth and three state agencies, including DEW. Almost 500 GL of water for the environment was delivered to South Australia from late September through to end December as part of the event, building on water for the environment already delivered as part of South Australia's annual Entitlement flow.

River Murray channel at Berri. Credit: DEW

The water came from multiple sources, including Hume Dam (an Upper Murray storage located over 1,500 km upstream of the South Australian border) and the Goulburn, Murrumbidgee and Baaka (Lower Darling) Rivers, travelling hundreds of River kilometres over several weeks and providing numerous environmental outcomes as it moved through the system.

The initial part of the 2020 Southern Spring Flow was mainly aimed at outcomes in areas upstream of South Australia but still saw flows in the Lower Murray averaging 10,000 ML/day from late September to mid-November. These types of flows help to keep the water column mixed, preventing thermal stratification (where surface water warmed by the sun, forms a layer on top of denser, cool water) and reducing the risk of harmful algal blooms.

The latter part of the 2020 Southern Spring Flow created a flow pulse in South Australia from mid-November to the end of December, deliberately targeting the time of year when water temperatures in the lower Murray are expected to reach levels that support breeding by large-bodied native fish such as *Macquaria ambigua* (callop or golden perch). During this time, flows peaked around 18,000 ML/day and remained above 15,000 ML/day for 19-days. This was also supported by a direct release of Commonwealth environmental water from Lake Victoria in December to extend the duration and slow the recession of the channel pulse.

A key outcome of this action was the improvement in average water velocities to above 0.2 m/s in much of the River channel. This indicates a temporary transition back to a more 'lotic' or flowing river in the Lower Murray, which has been significantly impacted by River regulation. These conditions help with the downstream transport of seeds and eggs, as well as preferred food resources for native fish such as rotifers (a type of microinvertebrate). Results from an extensive food web monitoring project undertaken by DEW in South Australia from August to December 2020 are described elsewhere in this report.

The coordination effort continued within South Australia, with opportunities to alter weir operations and support outcomes from the pulse undertaken where possible. This included returning Weirs 1, 2 and 6 to their normal pool level, after they had been raised slightly earlier in 2020. Water levels at both Weir 1 and 2 were temporarily managed slightly below normal pool level in December to optimise flow velocity outcomes. Weir 4, which was being raised to support the operation of the Katarapko floodplain regulator (see section below), was also returned to normal pool level earlier than planned to coordinate with the channel pulse.

The flow rate, velocity and timing of the channel pulse was aimed at improving the population of golden perch and *Bidyanus bidyanus* (silver perch) in the Lower Murray by generating a spawning response and supporting survival through to their juvenile life stage (called recruitment). From mid-November 2020 to early January 2021, silver perch larvae and golden perch eggs and larvae were detected in the Lower Murray by South Australian Research and Development Institute scientists during sampling for the CEWO Flow-MER Program, indicating spawning had occurred. Unfortunately, autumn sampling in the main river channel failed to detect young-of-year golden perch or silver perch. This suggests limited recruitment in 2021, but follow-up sampling in 2022 will provide greater confidence in the recruitment response. Nevertheless, these results demonstrate that by working together across multiple borders and catchments, coordinated delivery of water for the environment throughout the southern Murray-Darling Basin can be successfully achieved.

More information about the 2020 Southern Spring Flow is available in updates published on the Commonwealth Environmental Water Office website (CEWO, 2020).

Monitoring Microinvertebrate Responses to the Spring Pulse

Microcrustacean species *Ceriodaphnia dubia* (top) and *C. cornuta* (bottom) observed during the 2020 microinvertebrate monitoring. Credit: Russell Sheil.

In late 2020, microinvertebrate monitoring was undertaken as the coordinated spring pulse passed through the South Australian River Murray channel. This monitoring provided an important opportunity to better understand the productivity benefits of the spring pulse, occurring alongside the first operations of environmental regulators on Pike and Katarapko floodplains.

A total of 49 sites were sampled between Lock 1 and Lock 6 over 13 weeks, producing over 600 samples. Results indicated an increase in zooplankton species richness in response to the increased flows and changes in water quality associated with the spring pulse. The increasing water temperatures over the sampling period likely impacted the zooplankton community make-up with a shift from microcrustacean-dominance in winter to rotifer-dominance in summer. It was, however, difficult to separate the impact of floodplain operations on zooplankton productivity and diversity within the main River Murray channel as opposed to the impact of the spring pulse.

This project highlighted the importance of timing of water for the environment events on the microinvertebrate community and provided recommendations on future watering events and monitoring projects.

This project was undertaken in partnership with the University of Adelaide and complements recent studies undertaken via the Murray-Darling Basin Authority and the Commonwealth Environmental Water Office that have focused on whole of Murray River system productivity responses.

Pike Floodplain and Lock 5 Weir Pool

5,921 ML delivered
Sept - Dec

1,495 ha watered

Site Water Manager: DEW

Source of water: CEWO, DEW

Specific Ecological Objectives:

- Establish and maintain a diverse floodplain plant community.
- Support long-lived vegetation (e.g. river red gum, black box, river cooba and lignum).
- Provide refuge habitats and breeding opportunities for a range of biota, including waterbirds.
- Facilitate the movement of carbon and nutrients from the floodplain to the river channel.

Outcomes:

First operations of the Pike floodplain regulator took place during spring 2020, in conjunction with the raising of Weir 5. The Pike floodplain regulator was raised by 0.7 m, while Weir 5 was raised by 0.46 m to support flows into Pike floodplain and provide inundation upstream.

A positive response was observed in *Eucalyptus largiflorens* (black box) and *Duma florulenta* (lignum) plants which were inundated during the Pike floodplain inundation event, while vegetation outside the area of inundation remained stressed (DEW, 2021a). The floodplain understorey plant community also showed a strong positive response to watering.

Fishway trapping was undertaken during the Pike floodplain inundation event to determine the efficiency of the new fishways at assisting the movement of fish across floodplain regulators. During these surveys, a variety of fish species were sampled, including the small-bodied species *Retropinna semoni* (Australian smelt), indicating successful performance of the fishways (Bice & Fredberg, 2021).

Six species of frog were recorded across the floodplain, including the southern bell frog, listed as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

During the inundation and drying phases of the Pike floodplain inundation event, 29 waterbird species were observed during surveys and there were opportunistic sightings of *Podiceps cristatus* (great crested grebe) and *Anhinga novaehollandiae* (Australasian darter), which are listed as rare under the South Australian *National Parks and Wildlife Act 1972* (NPW Act). Inundated wetlands provided habitat for juvenile waterbirds, including *Cygnus atratus* (black swan) cygnets (Cale, 2021). During the floodplain's drying phase, species which forage on the mudflats or in shallow water, such as *Chenonetta jubata* (maned ducks), *Tribonyx ventralis* (black-tailed native hens) and *Erythrogonys cinctus* (red-kneed dotterels) were commonly observed.

Woodland bird surveys observed 54 species, including rare species such as *Corcorax melanorhamphos* (white-winged chough), *Philemon citreogularis* (little friarbird), *Entomyzon cyanotis* (blue-faced honeyeater), and *Melanodryas cucullata* (hooded robin) (Warnock, 2020). Opportunistic sightings were also recorded of juvenile *Dromaius novaehollandiae* (emu; 9 chicks), *Eolophus roseicapilla* (galah), and *Aquila audax* (wedge-tailed eagle).

Positive Plant Production at Pike

The understorey plant community on Pike floodplain showed a strong response to watering in areas that received increased inundation, including Pike River, Snake Creek and Mundic Creek (i.e. Inner Mundic Floodrunner). Various amphibious and floodplain species were recorded, including *Ammania multiflora* (jerry-jerry), *Austrobryonia micrantha* (desert cucumber), *Centipeda minima* (spreading sneezeweed) and *Phyllanthus lacunarius* (lagoon spurge). Additionally, the aquatic species *Vallisneria spiralis* (ribbonweed) was observed in Pike River.

Amphibious and floodplain plant species at Pike River. Credit: DEW

Katarapko Floodplain and Lock 4 Weir Pool

1,433 ML delivered Sept - Dec

740 ha watered

Site Water Manager: DEW

Source of water: CEWO, DEW

Specific Ecological Objectives:

- Establish and maintain a diverse floodplain plant community.
- Support long lived vegetation (e.g. river red gum, black box, river cooba and lignum).
- Provide refuge habitats and breeding opportunities for a range of biota, including waterbirds.
- Facilitate the movement of carbon and nutrients from the floodplain to the river channel.

Outcomes:

First operations of the Katarapko floodplain regulator took place during spring 2020, in conjunction with the raising of Weir 4. The Katarapko floodplain regulator was raised by 2.8 m, while Weir 4 was raised by 0.34 m to support flows into Katarapko floodplain.

A positive response was observed in *Eucalyptus camaldulensis* (river red gum), black box and lignum plants across the floodplain, particularly in areas which were inundated during the Katarapko floodplain inundation event (DEW, 2021a; Wallace, 2021). The floodplain understorey plant community showed a strong response to watering, with higher abundances of amphibious and flood dependent species than recorded in the previous year (Walsh, 2021).

Five species of frog were recorded across Katarapko floodplain, with *Litoria peronii* (Peron's tree frog), *Limnodynastes fletcheri* (long-thumbed frog) and eastern sign-bearing froglet observed at all survey sites. *Limnodynastes dumerilii* (eastern banjo frog) were also recorded in high numbers at all sites, showing an increase in abundance compared with 2019. Overall, frog abundance and species richness across Katarapko floodplain was higher in 2020 when compared to the 2019 survey results.

Waterbird surveys during the inundation and drying phases of the Katarapko floodplain inundation event recorded 34 species, including three species listed as vulnerable or rare in South Australia (NPW Act); *Stictonetta naevosa* (freckled duck), *Oxyura australis* (blue-billed duck), and Australasian darters (Cale, 2021). Inundated sections of the floodplain also provided habitat for juvenile *Anas gracilis* (grey teal), *Chenonetta jubata* (maned duck) and black swans.

Massive Murray Hardyhead Response at Lyrup Lagoon

Lyrup Lagoon is home to a recently discovered subpopulation of Murray hardyheads, a small bodied fish native to the southern Murray-Darling Basin. Through collaboration between the Department for Environment and Water, Murraylands and Riverland Landscape Board, Nature Foundation, Commonwealth Environmental Water Office, and Berri Barmera Landcare, weir pool raising at Lock 4 connected Lyrup Lagoon to the River Murray channel, providing fresh water inflows into the Lagoon and prompting a breeding response.

In total, 76,102 Murray hardyheads were recorded during the inundation event, a massive increase from the previous year's record of 82 individuals (Whiterod, Gannon, & Robinson, 2021). This goes to show that with careful management and expert knowledge, we can get some impressive outcomes for the species.

Craterocephalus fluviatilis (Murray hardyhead) sampling at Lyrup Lagoon. Credit: DEW

Lilies at Gum Flat, Chowilla floodplain. Credit:

Wetlands

50,693 ML for the environment

>5,000 ha watered

119 wetland sites watered

The delivery of water for the environment to important wetland sites along the South Australian River Murray was facilitated by various organisations and water holders, including the Murraylands and Riverland Landscape Board, Department for Environment and Water, Accolade Wines, Nature Foundation, Renmark Irrigation Trust and Australian Landscape Trust. A full list of the wetland sites watered in 2020-21 is presented in Appendix C and D.

This section outlines the ecological outcomes observed during the delivery of water to both managed pool-connected wetlands and ephemeral wetlands in 2020-21.

Pool-connected Wetlands

~30,762 ML delivered

~3,408 ha watered

Site Water Managers: DEW, Murraylands and Riverland Landscape Board, Accolade Wines, Australian Landscape Trust, Nature Foundation

Source of water: DEW, Accolade Wines

In 2020-21, fifty-five pool-connected wetlands across forty wetland complexes were managed by various organisations, including DEW, the Murraylands and Riverland Landscape Board, Accolade Wines, Australian Landscape Trust, and Nature Foundation.

Wetland infrastructure was managed to generate more variable water levels, including undertaking partial or complete dry phases. Dry phases helped to consolidate sediments and improve riparian vegetation communities, which prompted improved water quality and clarity upon refilling. This provided foraging and breeding habitat for waterbirds, frogs and other water-dependant fauna.

Varying water levels in pool-connected wetlands was also found to improve tree health in river red gum, black box, and *Acacia stenophylla* (river cooba) trees, providing habitat for species such as the nationally threatened *Polytelis anthopeplus* (regent parrot), which is listed as Vulnerable under the EPBC Act as well as the South Australian NPW Act. Frog populations were also supported, with 7 frog species recorded across a number of pool-connected wetlands along the South Australian River Murray.

Plants Galore at Sugar Shack

Sugar Shack Wetland Complex is a collection of pool-connected lagoons, creeks and ephemeral wetlands managed by the Mannum Aboriginal Community Association. In 2020, assisted by the Murraylands and Riverland Landscape Board and Department for Environment and Water, a number of pool-connected lagoons underwent managed dry phases. As water levels receded, native plants colonised the wetland beds including sedges, rushes, herbs and mudworts. The drying helped consolidate soft sediments into firm, cracking clays. Upon re-inundation, carp screens prevented *Cyprinus carpio* (common carp) re-entering the wetland. The resulting clear water assisted aquatic plant growth and the fringing vegetation provided ideal frog, small-bodied fish, and waterbird habitat.

Aquatic vegetation at Sugar Shack Wetland Complex. Credit: Casey O'Brien, Murraylands and Riverland Landscape Board.

Ephemeral Wetlands

~19,931 ML delivered[1]

~1,939 ha watered

Site Water Managers: DEW, Murraylands and Riverland Landscape Board, Accolade Wines, Australian Landscape Trust, Nature Foundation, Renmark Irrigation Trust

Source of water: CEWH, TLM, DEW

In 2020-21, 64 ephemeral wetlands received water for the environment, including three wetlands in the Lower Lakes region. Management of ephemeral wetlands is undertaken by six organisations; the Murraylands and Riverland Landscape Board, DEW, Accolade Wines, Nature Foundation, Australian Landscape Trust, and Renmark Irrigation Trust. Below is a summary of the key ecological outcomes observed by each organisation at their ephemeral wetland sites.

Recurvirostra novaehollandiae (red-necked avocets) at Lake Limbra, Chowilla floodplan. Credit: Helga Kieskamp

Murraylands and Riverland Landscape Board

Water for the environment was delivered to thirty temporary wetlands in 2020-21. This water stimulated an extensive vegetation response, with submerged plants covering 25% to 85% of some wetlands including Murtho Park and Berri Evaporation Basin. *Myriophyllum verrucosum* (red milfoil), ribbonweed and *Potamogeton crispus* (curly pondweed) were the dominant species observed.

The watering and vegetation responses prompted waterbird breeding events at numerous sites, including Murtho Park and Yabby Creek. Species such as *Malacorhynchus membranaceus* (pink-eared duck), *Poliocephalus poliocephalus* (hoary-headed grebe), and black swans were among those found breeding across the floodplain.

Long-lived vegetation, such as river red gum, black box, and river cooba responded positively to watering, with increased canopy growth observed at wetlands such as Nikalapko and Maize Island. River red gum germination from previous watering was also observed at some sites.

Murray hardyhead breeding and recruitment was observed at Disher Creek, while at Berri Evaporation Basin pest species such as common carp likely reduced habitat quality and competed for resources, reducing recruitment success.

Success for Southern Bell Frogs

Successful recruitment of southern bell frogs was observed at a number of wetlands in 2020-21. By managing water levels to support tadpole development, abundant tadpoles and juvenile frogs were recorded at wetlands such as Overland Corner and Hogwash Bend (Robinson, 2021). This work builds on early trials in 2019-20 at Overland Corner.

Litoria raniformis (southern bell frog) juveniles at Hogwash Bend. Credit: Annie Kriesl, Murraylands and Riverland Landscape Board.

[1] An additional 1035 ML of All Purpose Consumptive (Class 3) water held by the SA Minister for Environment and Water was pumped to Tolderol Game Reserve Wetlands for environmental outcomes

DEW – Chowilla Floodplain Icon Site

Water for the environment from The Living Murray was delivered via pumping to six temporary wetlands within the Chowilla Floodplain Icon Site in 2020-21. Aquatic, understorey, and long-lived vegetation responded well to watering at all sites, with river cooba flowering prolifically along flow paths and wetland edges (Hodder, 2021). Frog abundances were in the hundreds at each wetland, with six species, including the nationally threatened southern bell frog, recorded across the inundation period.

As water levels receded, approximately 3,000 waterbirds were observed at Gum Flat, including *Recurvirostra novaehollandiae* (red-necked avocet), and a *Tringa glareola* (wood sandpiper). Watering at Gum Flat also attracted a variety of migratory birds from arid and semi-arid landscapes further north, including *Epthianura tricolor* (crimson chat) and *Lalage tricolor* (white-winged triller), with *Geopelia cuneata* (diamond dove), *Melopsittacus undulatus* (budgerigar) and *Turnix velox* (little buttonquail) also seen around the site.

Werta Wert and Lake Limbra also attracted high numbers of waterbirds, and at Lake Limbra, *Tadorna tadornoides* (Australian shelduck), black swans and *Himantopus leucocephalus* (white-headed stilt) were observed with dependent young.

Potamogeton tricarinatus growing at Monomon Creek, Chowilla floodplain. Credit: DEW

Accolade Wines

Two wetlands were inundated at Banrock Station in autumn and winter of 2020-21, including one pool-connected and one temporary wetland. Lignum and understorey plant communities responded positively to watering, with increased plant growth observed along wetland edges. Regent parrots, a national and state listed threatened species, were observed using the floodplain surrounding watering sites for the third consecutive year, indicating that the floodplain is providing important habitat for the species.

Nature Foundation

Nature Foundation oversaw the delivery of water for the environment to ten temporary wetlands in 2020-21. Watering at Lyrup Lagoon complemented Weir 4 raising and saw a significant breeding event of Murray hardyhead (see Katarapko floodplain and Lock 4 Weir Pool section for more information). Additionally, watering at Qualco Lagoon triggered a black swan breeding event, with over twenty nests and three groups of cygnets observed.

Cygnus atratus (black swans) at Qualco Lagoon.
Credit: Nature Foundation.

White-bellied Sea Eagle Breeding Attempt

A pair of *Haliaeetus leucogaster* (white-bellied sea eagles), considered endangered in South Australia (NPW Act), made an unsuccessful breeding attempt at Lake Merreti in 2020, the first attempt on Calperum Station since 1968.

Haliaeetus leucogaster (white-bellied sea eagle) pair on Calperum Station. Credit: Australian Landscape Trust.

Australian Landscape Trust

Ten wetlands received water for the environment on Calperum Station in 2020-21. Wetland watering prompted a significant black swan breeding event, with 230 nests and over 1000 cygnets observed. Temporary wetlands provided essential feeding habitats for these cygnets during their development.

Numerous Japan, China, and Republic of Korea – Australia Migratory Bird Agreement (JAMBA; CAMBA; ROKAMBA) listed migratory bird species were observed using wetland sites, including *Calidris acuminata* (sharp-tailed sandpipers), wood sandpipers, and *Hydroprogne caspia* (Caspian terns). Following inundation, widespread germination of various rare and endangered plant species were observed, including fields of the rare *Calocephalus sonderi* (pale beauty-heads) at Amazon and Reny wetland sites.

Renmark Irrigation Trust

Water for the environment was pumped to seven temporary wetlands by Renmark Irrigation Trust in 2020-21. Long lived vegetation such as river red gums and black box responded well to watering, with young trees becoming established around sites such as Johnsons Waterhole. Understorey vegetation health also improved around wetland sites, with natural revegetation occurring along wetland edges and dis-used vehicle tracks. Following inundation, increased observations of various waterbird and frog species were recorded at all sites.

Tadorna tadornoides (Australian shelducks) at Widerwaters West, Calperum Station. Credit: Australian Landscape Trust.

Sand dredging at the Murray Mouth. Credit: DEW

Lower Lakes, Coorong and Murray Mouth

906 GL water for the environment delivered to the CLLMM

142,670 ha watered

894 GL water for the environment released out the barrages

Lake Level Management and Barrage Releases

Ecological Objectives:

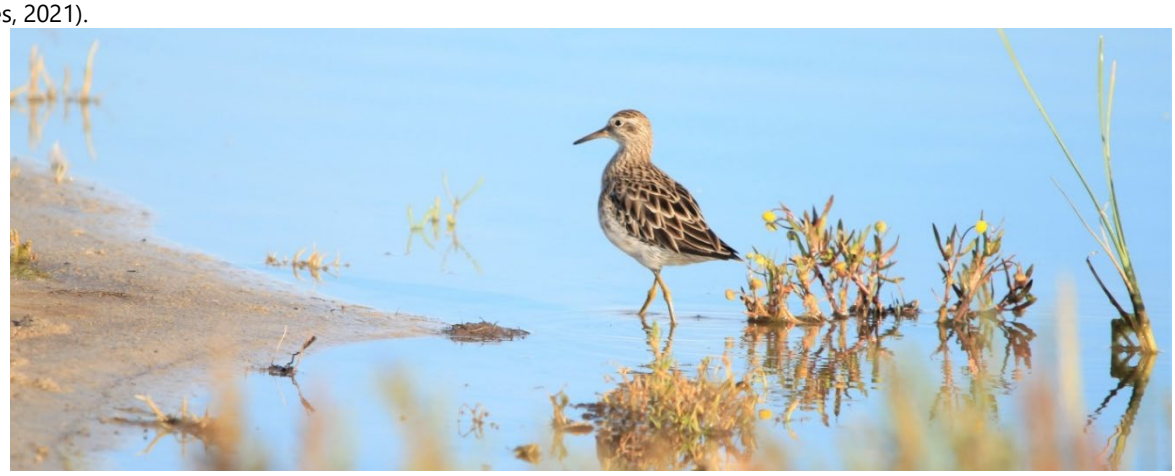
- Facilitate movement and recruitment of diadromous fish.
- Support recruitment of threatened fish and frog populations in the Lower Lakes wetlands.
- Create favourable conditions in the Coorong North Lagoon to support estuarine fish and benthic invertebrate populations.
- Establish and maintain diverse aquatic vegetation in the Lower Lakes wetlands.

Tauwitchere Barrage fishway. Credit: DEW

Outcomes:

Approximately 894 GL of water for the environment was released out the barrages, and when combined with the unregulated flow event, resulted in over 1,330 GL of continuous flow through the barrages in 2020-21. These barrage releases helped to export salt from the Murray-Darling Basin, and maintain salinities in Lake Alexandrina below 1,000 electrical conductivity (EC). Barrage fishways were operational all year round, providing continuous connectivity between the River Murray and Coorong Estuary and maintaining habitable Coorong mudflats for benthic invertebrates.

Unregulated flows in winter created a freshwater signal through the Murray Mouth to the Southern Ocean, prompting adult lamprey to migrate upstream (via barrage fishways) in search of spawning sites. In total, 102 *Geotria australis* (pouched lamprey) and 4 *Mordacia mordax* (short-headed lamprey) were observed passing through the fishways (Bice & Fredburg, 2020). A total of 91 lamprey were fitted with Passive Integrated Transponder (PIT) tags to monitor their movement upstream, with one pouched lamprey travelling over 878 km past Lock 11. Barrage releases also facilitated the downstream migration of adult female *Pseudaphritis urvilli* (congolli) moving from freshwater into the Coorong to spawn (C. Bice, pers comm. 2021). The increased lake levels created by the unregulated flows also contributed to a large spawning event of *Nannoperca australis* (southern pygmy perch) which saw a four-fold increase in recruitment compared to previous years (Wedderburn & Barnes, 2021).



Calidris acuminate (sharp-tailed sandpiper) at Tolderol Game Reserve wetlands. Credit: Casey O'Brien, Murraylands and Riverland Landscape Board.

High spring flows brought about by the 2020 Southern Spring Flow provided increased barrage flows and lake levels, helping to reduce salinity and support the Coorong North Lagoon food web. These flows also supported vegetation communities along the Lower Lakes and Coorong (Nicol et al. 2021; Paton et al. 2021a), leading to the widespread and prolific flowering of *Ruppia tuberosa* in the Coorong – the largest flowering event of this species observed since before the Millennium Drought (Paton et al. 2021a). However, filamentous green algae impacts prevented the flowering event from translating to an increase in seed density (Paton et al. 2021a).

Despite carefully managed barrage flows in spring and summer to create salt wedge conditions downstream of Goolwa Barrage, *Acanthopagrus butcheri* (black bream) recruitment was not detected. Low water temperatures and windy/storm conditions were the likely cause of impeded recruitment (DEW, 2021).

During January-February 2021, waterbird numbers in the Lower Lakes and Coorong were substantially lower than the previous 3 years, with 8 out of 12 key shorebird species below their long-term abundance targets (Paton et al. 2021b). Furthermore, the Coorong South Lagoon mudflats continue to provide limited food resources to waders, particularly in comparison to the Coorong North Lagoon (Dittmann et al. 2021).

Local Knowledge Supports Threatened Fish Recruitment

The small-bodied threatened fish Murray hardyhead and southern pygmy perch reside in Lake Alexandrina and surrounding tributaries. Following the Millennium Drought, populations of these fish, along with Yarra pygmy perch became threatened and localised extinctions took place as water levels in the Lower Lakes reduced to a metre below sea level.

Attempts to rescue these fish resulted in a captive breeding and release program. The populations of Murray hardyhead and southern pygmy perch that now reside in the Lower Lakes are likely the generations of offspring from this program. Unfortunately, Yarra pygmy perch has not been detected in recent years, with restocking efforts being unsuccessful to date.

Following the devastating impacts of the Millennium Drought, water level management in the Lower Lakes is now critical to the survival and recovery of Murray hardyhead and southern pygmy perch populations. DEW, in partnership with key reference groups including the LLCMM Community Advisory Panel, Ngarrindjeri Aboriginal Corporation, and LLCMM Scientific Advisory Group, developed annual watering priorities that included supporting recruitment and survival of threatened small-bodied fish.

Following the advice provided by these groups, DEW water managers worked closely with staff from the MDBA, CEWO, and SA Water via the Barrage Operations Advisory Group, to ensure lake levels and barrage releases were managed to maintain a minimum autumn lake level of 0.6 m Australian Height Datum (AHD).

In April 2021, threatened fish monitoring in the Lower Lakes and surrounding tributaries detected a significant increase in the southern pygmy perch population. The advice for future operations is that this water regime should be replicated at least every 2-3 years to ensure successful recruitment and survival of southern pygmy perch in the Lower Lakes.

Threatened fish monitoring at a Mundoo wetland. Credit: DEW

Partnering with First Nations

Ngarrindjeri Yarning Circles

A Yarning Circles Project was initiated in 2020-21 by the Ngarrindjeri Aboriginal Corporation and DEW, to create awareness about water for the environment in the wider Ngarrindjeri community; whilst also learning about important cultural history and values through the sharing of stories. The information gained throughout these Yarning Circles will help to inform future planning and delivery of water for the environment to the LLCMM Icon Site.

A Ngarrindjeri Yarning Circle. Credit: Miriam Yip

DEW and partner agencies involved in delivering water for the environment in South Australia acknowledge and pay respect to the First Nations of the Murray–Darling Basin, who have a deep cultural, social, environmental, spiritual, and economic connection to their lands and waters. DEW and partner agencies work with members of the River Murray and Mallee Aboriginal Corporation, the Mannum Aboriginal Community Association Incorporated, and the Ngarrindjeri Aboriginal Corporation (NAC) to ensure cultural priorities and local knowledge are incorporated into environmental watering programs. Many groups are directly involved with operating water management infrastructure such as regulating structures and pumps, and collecting monitoring data to support decision-making.

The MDBA's The Living Murray's Indigenous Partnerships Program (TLM – IPP) ensures First Nations knowledge and cultural values can be incorporated into icon site management, supporting the employment of Indigenous Facilitators at the Chowilla and LLCMM icon sites, and broader engagement with local community members to support The Living Murray's watering programs.

Collaborative engagement between DEW and the Ngarrindjeri has strengthened in 2020-21 with increased community participation through the sharing of important Ngarrindjeri cultural values. The Yarning Circles project involved six workshops on Country stretching from Tailem Bend to Meningie, and was instrumental in starting these conversations. These discussions not only aided in gaining a better understanding of what is important to Ngarrindjeri, but also fostered an understanding of the importance of water for the environment for the health of the River Murray system. It is important to build relationships and gain trust amongst the Ngarrindjeri community to help achieve ecological and cultural objectives. The Yarluwar-Ruwe Project Coordinator (employed on behalf of MDBA's TLM – IPP) who represents the NAC, has been influential in guiding this process.

Round table discussions with NAC staff in the early planning phase for developing annual watering proposals was also successful, with cultural values and ideas put forward to aid delivery of water for the environment to the LLCMM Icon Site. Although this process has been undertaken annually for many years, 2020-21 saw increased involvement and a willingness to discuss important Ngarrindjeri cultural values.

The Ngarrindjeri community continue to assist DEW and The University of Adelaide with on-ground threatened fish monitoring in the Lower Lakes, encouraging the two-way sharing of information which is blending western science with traditional Ngarrindjeri cultural knowledge. Timely and adequate delivery of water for the environment can be directly linked to the health and habitat condition for key species, including the threatened small-bodied fish southern pygmy perch and Murray hardyhead.

The Yarluwar-Ruwe Project Coordinator is also an active member of the LLCMM Community Advisory Panel, which meets once every two months to discuss barrage and lake-level management along with engagement activities. At each meeting updates were provided to the group on Ngarrindjeri engagement activities undertaken on behalf of TLM – IPP, but also additional activities undertaken between the NAC and DEW, Landscape Boards SA, local Councils and the private sector.

Aboriginal Waterway Assessments (AWA) continue to be undertaken by the First Peoples of the River Murray and Mallee Region to assess the cultural values of wetlands and other important sites within the South Australian River Murray. This continues to be an important input to water for the environmental and wetland management planning. Workshops were also held to review a Cultural Heritage Management Plan and to discuss and decide how AWA data is to be collected, stored, reported and shared with others.

During 2021, First Peoples Working Group meetings included discussions about planning for watering actions across wetlands, floodplains and the River Murray channel, and sharing information from monitoring. The Working Group provides a valuable forum for engagement and involvement in a range of projects related to water for the environment. Following a number of site visits and workshops, the First Peoples Working Group finalised a video *Tjowilla (Chowilla) Water and Culture* and started work on their own floodplain plant identification and cultural uses guide.

The Australian Landscape Trust's Riverland Indigenous Ranger team managed all pumps involved in providing water for the environment to Calperum temporary wetlands, along with collecting delivery data, assisting with environmental monitoring, and leading wetland tours for various groups. The Australian Landscape Trust also developed a two-day Ecology in Action program for indigenous students in collaboration with the South Australian Research and Development Institute.

Aboriginal Waterway Assessments

Aboriginal Waterway Assessments (AWA's) are a tool used by First Peoples of the River Murray and Mallee Region to assess the cultural values of wetlands and other important floodplain sites. Twenty four AWA's were undertaken during 2020-21 by the First Peoples Working Group, including six sites on Chowilla floodplain, with some sites assessed before, during and/or following delivery of water for the environment.

Aboriginal Waterway Assessment at Punkah Creek, Chowilla floodplain. Credit: DEW

Communication and Engagement

Water for the environment managers in South Australia strive to maintain community input and engagement throughout the water year. Planning annual delivery of water for the environment starts early and involves workshops with environmental water holders, scientific experts, First Nations, non-government organisations and river operators. These workshops consider the water resource forecast for the year ahead, facilitating discussions around what watering events may be possible and aiding in the development of watering proposals aimed to meet site specific and basin wide targets.

Further community and non-government organisation consultation took place during the development of watering proposals for all major watering actions. For the Chowilla Floodplain and LLCMM Icon Sites, established reference groups with an in-depth knowledge of the region, its infrastructure and ecological processes, provided valuable input to help plan for the delivery of water for the environment. Additionally, site tours, meetings and presentations were undertaken with various stakeholders to gain feedback on proposed actions. One-on-one conversations with landholders and industry representatives were also undertaken.

Community consultation and engagement continued throughout the water year from the initial planning to the seasonal delivery of water for the environment. Methods of communication and engagement included radio and television interviews, the development of videos, volunteer surveys, and presentations to various interest groups and Universities. Various tours involving MDBA graduates, community groups and Traditional Owners were undertaken on the Chowilla and Katarapko floodplains, and within the Lower Lakes, Coorong and Murray Mouth region.

A Decade of Connection

September 2020 marked 10 years of continuous flows from the River Murray to the Coorong, following 3 years of disconnection during the Millennium Drought. The local ecology and community have recovered significantly in the past 10 years, thanks to the delivery of water for the environment flowing down the river. In particular, fish such as congolli and lamprey were on the brink of local extinction during the Millennium Drought. In 2020-21, lamprey numbers were the highest ever observed through targeted monitoring. This ecological recovery has been enabled by a lot of hard work and strong collaboration between government, the local community and scientists. Although the region has shown significant signs of improvement in the last 10 years, much of the area, particularly the Coorong, are still in a period of recovery, with continued flows required to see this progress followed through.

To celebrate the region's recovery over the last 10 years, and to celebrate World Fish Migration Day, the Department for Environment and Water held a community celebration event. For more information on the event and the continuous flows, check out the media release and video.

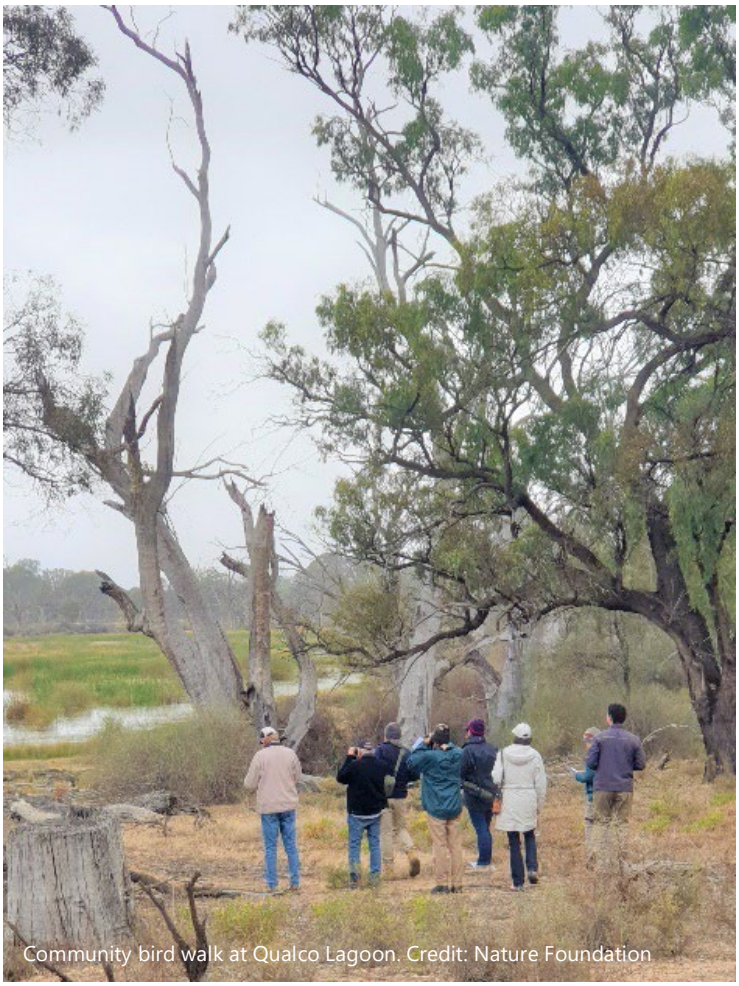
Attendees at the Decade of Connection and Healing event. Credit: DEW

In an effort to reach the wider community, DEW staff worked closely with CEWH and MDBA to have a range of information publicised about environmental watering activities and outcomes in the region, as well as the coordinated 2020 Southern Spring Flow which provided ecological benefits all along the River Murray. These covered:

- Where in the MDB is Larry the Lamprey? (DEW, 2021)
- Lamprey numbers predict promising comeback for spooky blood-sucking fish (ABC, 2021).
- Ngarrindjeri lead community on tour of the Kurangk (Coorong) (DEW, 2021).
- Find out how 10 years of connectivity have helped the Lower Lakes and Coorong (DEW, 2020).
- Environmental works at Pike and Katarapko floodplains begin operations (DEW, 2020).
- Delivery of water for the environment at Lake Limbra (ABC, 2021).
- Murray hardyhead seen in record numbers following weir pool raising (DEW, 2021).
- Critically endangered Murray River fish population booms in SA Riverland (ABC, 2021).
- Southern Spring Flow 2020 - Update #1 - 9 October 2020 (CEWO, 2020).
- Southern Spring Flow 2020 - Update #2 - 23 October 2020 (CEWO, 2020).
- Southern Spring Flow 2020 - Update #3 - 14 December 2020 (CEWO, 2020).

Non-government organisations were also actively involved in community engagement, with the Nature Foundation, Renmark Irrigation Trust and Australian Landscape Trust (Calperum Station) promoting the importance of water for the environment through mainstream and social media.

The Nature Foundation engaged with local school and community groups, continuing to roll out the community driven program Water For Nature, which receives hands-on involvement and advice from private landholders and community groups. Berri Barmera Landcare, Cadell Community Tourism Association, Cadell Training Centre, Central Irrigation Trust, Gerard Community Cultural Rangers, Goolwa to Wellington Local Action Planning Association, and Treasury Wine Estates also provided advice and assistance across the year for Nature Foundation wetland watering. Renmark Irrigation Trust ran a tour with Renmark North Primary School at their new Warrego Street watering site, which was covered by ABC Riverland.



Community bird walk at Qualco Lagoon. Credit: Nature Foundation

Renmark Irrigation Trust watering site trial and school tour. Credit: Renmark Irrigation Trust

Monitoring

A number of monitoring programs aim to capture the ecological responses to water for the environment along the South Australian River Murray. These include:

- CEWO's Flow-MER Program, which collects data along the South Australian River Murray Channel
- Condition and intervention monitoring at the Chowilla Floodplain and Lower Lakes, Coorong and Murray Mouth Icon Sites through the MDBA's TLM Program
- Condition and intervention monitoring associated with weir pool manipulation and floodplain regulator operations coordinated by DEW
- Monitoring of selected South Australian River Murray wetlands and floodplain areas by the Murraylands and Riverland Landscape Board
- Monitoring by non-government organisations.

Monitoring reports are produced for many of these projects (Appendix E), with many available on the CEWO Flow-MER and MDBA websites.

Clear waters at Pipeclay wetland. Credit: Courtney Monk, Murraylands and Riverland Landscape Board.

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Appendix A

2020-21 Water for the Environment Priorities

Table 1: Summary of water for the environment priorities proposed for moderate and near average conditions in 2020-21

Moderate conditions

Site	Action	Status for 2020-21
LLCMM	Increase base flows year round.	**Achieved**
Channel and Floodplain	Boost flow at the South Australian border in November, December and February to discharge equivalent to South Australia's normal entitlement, and in January to 8,000 ML/day.	**Achieved**
Weir Pool Manipulation	Raise Weir 4 to 13.5 m Australian Height Datum (AHD; 0.3 m above normal pool level).	**Achieved,** operated to 13.5 m AHD in conjunction with Katarapko floodplain regulator
Chowilla Floodplain	Pump to priority wetlands.	**Achieved,** water pumped to 6 priority wetlands
	Manage inflows via Pipeclay Creek and Slaney Creek weirs to optimise outcomes for native fish through the anabranch.	**Achieved**
Pike Floodplain	Operate Pike floodplain regulator to 15.0 m AHD to generate a low extent managed floodplain inundation.	**Achieved**, operated to 15.25 m AHD
Katarapko Floodplain	Operate Katarapko floodplain regulator to 11.5 m AHD to generate a low extent managed floodplain inundation.	**Achieved**, operated to 12.8 m AHD
Ephemeral Wetlands	Delivery of water to up to 41 priority ephemeral wetlands located along the River Murray from the border to the Lower Lakes.	**Achieved,** delivered to 32 priority ephemeral wetlands
	Additional delivery of water to wetland sites by Non-Government Organisations including Renmark Irrigation Trust, Accolade Wines, Nature Foundation and the Australian Landscapes Trust.	**Achieved**

Near average conditions

Site	Action	Status for 2020-21
LLCMM	Increase base flows directly following a small spring unregulated flow event between October and December 2020.	**Not achieved** as there were no unregulated flows between October and December 2020
	Increase base flow between January and June 2021.	**Achieved**
Channel and Floodplain	Extend duration of flow at the South Australian border of 15,000 – 20,000 ML/day into late October/early November	**Not achieved** due to insufficient River Murray flows
Weir Pool Manipulation	Raise Weir 2 and potentially also Weirs 6 and 4.	**Partially achieved**, Weirs 4 and 5 raised in conjunction with Pike and Katarapko floodplain regulators
	Raise Weir 5 16.8 m AHD (0.5m above normal pool level).	**Partially achieved**, raised to 16.76 m AHD

Chowilla Floodplain	Operate Chowilla floodplain regulator to generate a medium to high floodplain inundation.	**Not achieved** due to insufficient River Murray flows
Pike Floodplain	Operate Pike floodplain regulator to 15.25 m AHD to generate a low extent managed floodplain inundation.	**Achieved**, operated to 15.25 m AHD
Katarapko Floodplain	Operate Katarapko floodplain regulator to 12.8 m AHD to generate a low medium extent managed floodplain inundation.	**Achieved**, operated to 12.8 m AHD
Ephemeral Wetlands	Delivery of water to up to 37 priority pool-connected wetlands located along the River Murray from the border to the Lower Lakes.	**Achieved,** delivered to 32 priority ephemeral wetlands
	Additional delivery of water to wetland sites by Non-Government Organisations including Renmark Irrigation Trust, Accolade Wines, Nature Foundation and the Australian Landscapes Trust.	**Achieved**

Appendix B

SA River Murray Water for the Environment Actions 2020-21

Table 2: Volume of water for the environment delivered across South Australia from different water holders (e.g. Commonwealth Environmental Water Holder (CEWH), The Living Murray (TLM), South Australian Minister for the Environment and Water (SA), Victorian Environmental Water Holder (VEWH), River Murray Increased Flow (RMIF) and private holdings in SA (Private)) in 2020-21[1].

Watering Action/ Location	CEWH	TLM	SA	VEWH	RMIF	Private	Total Volume (ML)
Lower Murray (Channel)[2, 3, 4]	680,967	167,864	12,065	55,664	4,984		**921,544**
Floodplain Regulators / Weir Raising	5,343	-	2,011	-	-	-	**7,354**
Pool connected wetlands [5]	-	-	29,382	-	-	1,380	**30,762**
Wetland pumping[6, 7]	12,534	6,720	677	-	-	-	**19,931**
	698,844	**174,584**	**44,135**	**55,664**	**4,984**	**1,380**	**979,591**

[1] The volumes in this report reflect 'calculated environmental delivery to SA' volumes provided by the MDBA and may therefore differ slightly from delivered volumes reported elsewhere.
[2] Includes the coordinated 2020 Southern Spring Flow and 905,588 ML delivered to the Coorong, Lower Lakes and Murray Mouth.
[3] An additional 220 ML of Commonwealth Environmental Water Holder return flows from Overland Corner Wetland were delivered to the Coorong, Lower Lakes and Murray Mouth.
[4] An additional 12,000 ML of All Purpose Consumptive (Class 3) water held by the SA Minister for Environment and Water were delivered to the Coorong, Lower Lakes and Murray Mouth.
[5] An additional 94 ML of privately held All Purpose Consumptive (Class 8) water was delivered to Paiwalla wetland.
[6] An additional 2,267 ML of All Purpose Consumptive (Class 3) water held by the SA Minister for Environment and Water was delivered to Tolderol Game Reserve wetland and Loveday Basins (North and South).
[7] Includes Bookmark Creek, Dishers Creek, Berri Evaporation Basin which are gravity-fed rather than pumped.

Appendix C

Managed Pool-connected Wetlands

Table 3: Pool-connected wetland complexes managed in 2020-21 by Accolade Wines, SA Department for Environment and Water (DEW), Murraylands and Riverland Landscape Board (MRLB), Australian Landscape Trust (ALT) and Nature Foundation.

Wetland Complexes	Actions	Manager
Banrock Wetland	Filled in spring	Accolade Wines
Big Bend	Filled in autumn	DEW
Brenda Park	Filled in spring, commenced dry in autumn	MRLB
Causeway Wetland Complex	Filled in spring	MRLB
Devon Downs South	Connected to the River all year	MRLB
Hart Lagoon	Filled in spring	MRLB
Irwin Flat	Connected to the River all year	MRLB
Kroehn's Landing	Connected to the River all year	MRLB
Lake Merreti	Commenced dry in summer	ALT
Lake Woolpolool	Commenced dry in summer	ALT
Loveday Basins	Filled in summer, commenced dry in winter	DEW
Loveday Mussels Lagoons	Connected to the River all year	MRLB
Martin Bend	Filled in autumn	MRLB
Morgan Conservation Park	Filled in spring	MRLB
Morgans' Lower Murray	Connected to the River all year	MRLB
Murbko South	Remained dry all year	MRLB
Murbpook Lagoon	Filled in autumn, commenced dry in spring	Nature Foundation
Narrung	Connected to the River all year	MRLB
Nelwart	Connected to the River all year	MRLB
Ngak Indau	Filled in spring, commenced dry in autumn	MRLB
Nigra Creek/ Schillers Lagoon	Filled in spring	MRLB
North Caurnamont	Commenced dry in autumn	DEW
North Purnong	Commenced dry in summer, filled in autumn	DEW
Paiwalla	Commenced dry in spring	MRLB
Pilby Complex	Filled in spring, commenced dry in autumn	MRLB
Pipeclay Billabong	Filled in winter, commenced dry in autumn	MRLB
Pyap Horseshoe	Commenced dry in summer, filled in winter	DEW
Ramco Lagoon	Commenced dry in summer, filled in autumn	MRLB
Reedy Creek	Connected to the River all year	MRLB
Riverglades	Connected to the River all year	MRLB
Silver Lea	Commenced dry in autumn	DEW
Slaneys Billabong	Remained dry all year	MRLB
Spectacle Lakes /Beldora	Commenced dry in autumn	MRLB
Sugar Shack Complex	Commenced dry in summer, filled in autumn	DEW
Sweeny's Lagoon	Brief connections to the River in spring and summer	DEW
Teal Flat Complex	Filled in winter	DEW
Teringie	Connected to the River all year	MRLB
Waltowa	Filled in summer, commenced dry in autumn	MRLB
Wongulla Lagoon	Connected to the River all year	MRLB
Yatco Complex	Filled in Summer	MRLB

Appendix D

Pumped Wetlands

Table 4: Volume of water for the environment pumped to wetlands by the SA Department for Environment and Water (DEW), Murraylands and Riverland Landscape Board (MRLB), Nature Foundation, Renmark Irrigation Trust (RIT), Accolade Wines, Australian Landscape Trust (ALT) and Gerard Rangers in the South Australian River Murray region in 2020-21.

Watering Action/ Location	Volume (ML)	Manager
Above Lock 6		
Chowilla Island Loop	8	DEW
Gum Flat	1,598	DEW
Lake Limbra	4,256	DEW
Monoman Creek Depression	32	DEW
Punkah Creek Depression	28	DEW
Werta Wert	798	DEW
Lock 5 to Lock 6		
Amazon (includes 16 ML re-used at Amazon Uplands West and 2 ML re-used at Thookle Dune))	353	ALT
Amazon Upland Woodlands East	5	ALT
Begara Street	9	RIT
Bookmark Creek[1]	452	MRLB
Jane Eliza Woodlot	198	RIT
Johnsons Waterhole	206	RIT
Merreti East Floodplain	396	ALT
Murtho Park Flats	270	MRLB
Murtho/Wiela Connector	98	MRLB
Paroo Street	16	RIT
Pike Floodrunner	84	Nature Foundation
Reny Lagoon (includes 16 ML re-used at Reny Lagoon Uplands)	94	ALT
Squiggly Creek	<1	MRLB
Templeton	23	MRLB
Warnock/Lescheid Wetland	34	Nature Foundation
Whirlpool Corner	20	MRLB
Widewaters West	162	ALT
Wiela Shedding Basin	130	MRLB
Woolpolool South	15	ALT
Woolpolool Swamp (includes 22 ML re-used at Woolpolool Swamp South West)	587	ALT
Lock 4 to Lock 5		
Berri Evaporation Basin[1]	1,327	MRLB
Disher Creek	70	MRLB
Disher Street	30	RIT
Katarapko Creek	6	MRLB
Katarapko Regent Parrot Floodrunner	14	MRLB
Lyrup Lagoon	46	Nature Foundation
Martins Bend Temporary 1 & 2	80	MRLB
Martins Bend Temporary 3	210	MRLB
Nelwart	35	RIT

[1] Bookmark Creek and Berri Evaporation Basin are gravity fed rather than pumped

Plush's Bend	69	RIT
Lock 3 to Lock 4		
Clarks Floodplain	48	Nature Foundation
Clarks Georges Creek	13	Nature Foundation
Putjeda Blackbox	1	Gerard/MRLB
Yabby Creek	969	MRLB
Lock 2 to Lock 3		
Akuna	75	MRLB
Maize Island	185	MRLB
Old Parcoola	572	MRLB
Overland Corner	2,016	MRLB
Overland Corner Lignum	130	MRLB
Toolunka Temporary	44	MRLB
Wigley Reach	27	MRLB
Wigley Reach Central Basin	55	Accolade Wines
Wigley Reach Main Basin	971	Accolade Wines
Lock 1 to Lock 2		
Cadell Ephemeral Wetlands	57	Nature Foundation
Hogwash Bend	61	MRLB
Markaranka Regent Parrot Strip	154	MRLB
Morgan CP South Lagoon	113	MRLB
Morgan East	197	MRLB
Nikalapko	1,153	MRLB
Nilkra	637	MRLB
Qualco Temporary Lagoon	534	Nature Foundation
Riversleigh	14	Nature Foundation
Schimitdke Floodrunner	4	Nature Foundation
Lock 1 to Wellington		
Sugar Shack Wetland 6	81	MRLB
Lower Lakes		
Investigator College Currency Creek Wetland	9	MRLB
Milang Snipe Sanctuary	8	Nature Foundation
Tolderol Game Reserve Wetland[1]	50	MRLB

[1] An additional 1,034.880 ML from Water Licence #1332 held by the SA Minister for Environment and Water was pumped to Tolderol Wetland for environmental outcomes

Appendix E

List of Monitoring Reports for 2020-21

Bice, C., & Fredberg, J. (2021). *Assessment of passage efficiency at the Tanyaca and Pike regulator fishways*. Adelaide: South Australian Research and Development Institute (Aquatic Sciences).

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