Australian Government

MURRAY–DARLING BASIN AUTHORITY

Basin environmental watering priorities 2019–20

Overview and technical summaries

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Acknowledgement of the Traditional Owners of the Murray–Darling Basin

The Murray−Darling Basin Authority pays respect to the Traditional Owners and their Nations of the Murray−Darling Basin. We acknowledge their deep cultural, social, environmental, spiritual and economic connection to their lands and waters.

The guidance and support received from the Murray Lower Darling Rivers Indigenous Nations, the Northern Basin Aboriginal Nations and our many Traditional Owner friends and colleagues is very much valued and appreciated.

Aboriginal people should be aware that this publication may contain images, names or quotations of deceased persons.

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Executive summary

The Basin annual environmental watering priorities (the priorities) guide the annual planning and prioritisation of environmental watering across the Murray–Darling Basin. They represent the annual steps needed to achieve the long-term environmental outcomes in the Basin-wide environmental watering strategy and through them, the Basin Plan's ecological objectives and targets.

With conditions across much of the Basin dry to very dry and expected to remain so in coming months, the focus for environmental water managers in 2019–20 will be on avoiding irreversible impacts on species, vegetation communities and important sites, and managing the risks to water quality. Where reasonable carryover volumes are available, which is most likely in some southern catchments, opportunities may arise to improve conditions rather than just manage for drought.

Environmental water holders also need to be in a position to respond to rainfall events and the opportunities they present. Early refreshing flows are a critical component of how the ecosystem responds and recovers from dry periods. Active management and protection of early flows, particularly in unregulated rivers, will be critical.

The annual watering priorities are set out as rolling multi-year frameworks to guide environmental watering over the medium-term (i.e. the next three-to-five years) to achieve the expected environmental outcomes identified in the strategy.

This document outlines annual environmental watering priorities and annual watering guidance by four themes:

- river flows and connectivity
- native vegetation
- waterbirds, and
- native fish.

It also outlines guidance to achieve priorities for sites with multiple ecological needs in 2019–20:

- Barwon Darling and lower Darling
- Narran Lakes
- Koondrook-Perricoota Forest, and
- the Coorong, Lower Lakes and Murray Mouth.

The Basin is a complex, dynamic system. We are still learning about it, including how it responds to environmental water. Achieving the vision encapsulated in the Basin Plan requires long-term commitment and action from governments and the communities that rely on a healthy river system.

Introduction

The Murray–Darling Basin Authority (MDBA) has developed Basin annual environmental watering priorities to guide the planning of environmental watering across the Basin. The priorities are the actions needed to help achieve the Basin Plan's long-term objectives of protecting and restoring the Basin's rivers, wetland and floodplains set out in the Basin-wide environmental watering strategy (the strategy).

Under the Basin Plan, the Australian and state governments have recovered 2,118 gigalitres (GL) of water (at 30 November 2018) for the environment that sustains Basin communities and benefits the nation.

While the 2017 Basin Plan Evaluation showed that there are early signs of local improvement in the environmental condition of the Basin's rivers, achieving broad system-scale improvements will require many more years of careful management.

The first of the targets in the strategy and the Basin Plan to measure progress towards the overall environmental objectives for water-dependent ecosystems is that there is *no loss or degradation* by 30 June 2019. This is followed by *improvements* in subsequent years.

Prevailing climatic conditions are a major influence on opportunities to use water recovered for the environment under the Basin Plan. For much of the period between 2012 (when the Basin Plan took effect) and 2019, dry conditions have dominated the Basin climate.

Temperatures across the Basin have been above average for the past six years. Large parts of the Basin are entering their third consecutive dry water year and water storage levels continue to decline: in the northern Basin, storage levels are lower than at any point during the millennium drought and in the southern Basin are approaching their lowest levels in three years. Heavy rainfall in parts of the northern and southern Basin in late summer and mid-autumn of 2019 has delivered some ecological benefits but the deficit in soil moisture is of such magnitude that it will take significant above-average rainfalls across a widespread area to redress.

Dry conditions have created challenging circumstances for the Basin's environment and for environmental water managers, illustrated most dramatically in the multiple fish death events in the northern and southern Basin in the summer of 2018–19. These events are a vivid reminder of why it is important to provide water for the environment in dry times.

From mid-January to early April 2019, Basin states and the Commonwealth Environmental Water Holder (CEWH) provided water to reduce the risk of further fish deaths in the lower Murrumbidgee River. When water became available in the northern Basin, the CEWH and the NSW government pooled their water allocations in April 2019 to replenish critical waterholes and support five endangered native fish species along the Dumaresq, Macintyre, Gwydir, Mehi and Barwon rivers to survive the drought.

Managing the Basin's rivers, floodplains and wetlands as a single, dynamic system requires water holders, managers and river operators to coordinate across catchments. Cooperative and coordinated water management is a key aim of the Basin Plan, and this is particularly important

when conditions are dry, to make the most of opportunities with limited water volumes. This is demonstrated in the coordinated watering actions mentioned above which have delivered real benefits for a river system under considerable stress.

Lessons from recent fish deaths have been captured in the report to government of the independent panel chaired by Professor Rob Vertessy. The findings and recommendations will inform the development of a native fish management recovery strategy over the coming water year.

With dry to very dry conditions across much of the Basin and these conditions anticipated to continue in coming months (Figure 1) the focus for environmental water managers in 2019–20 will be on avoiding irreversible impacts on species, vegetation communities and important sites, and managing the risks to water quality. Where reasonable carryover volumes are available, which is most likely in some southern catchments, opportunities may arise to improve conditions rather than just manage for drought.

New sustainable limits on water diversion take effect across the Basin on 1 July 2019. Progress is also being made on other work that will complement the increased flow volumes for the environment. This includes addressing physical constraints to higher water flows, implementing works and measures associated with the adjustment to sustainable diversion limits in both the northern and southern Basin, and changing some of the ways the river is managed, including strengthening protection of water for the environment.

The MDBA is also updating the Basin-wide environmental watering strategy published in 2014, it has commenced a review of the environmental watering provisions of the Basin Plan, and is looking at the implications of climate change for the Basin's environment.

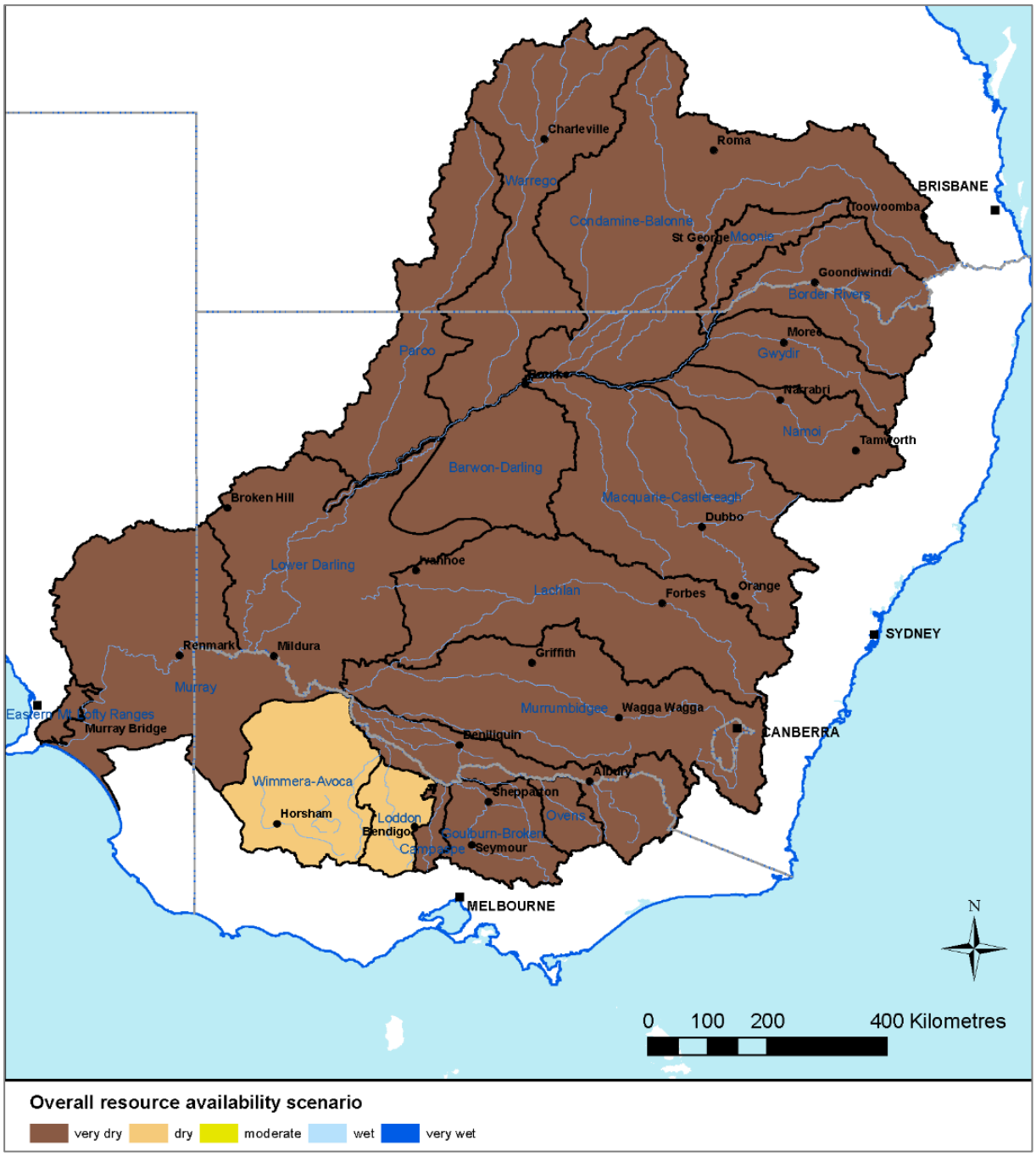

Figure 1 Resource availability scenario as at 1 April 2019[1]

[1] This figure has been produced using the results of the RAS calculation presented in Table 13 (appendix 1). Where the RAS is expressed as a range e.g. 'wet to very wet', the lower value (i.e. 'wet', in this example) has been used in the production of this figure. Where the RAS in Table 13 spans three values, the middle value is used in the production of the map (e.g. if the results in table 13 span 'dry to wet' then, the RAS used in the production of the map would be 'moderate'.

Overview of the Basin environmental watering priorities

The Basin annual environmental watering priorities (the priorities) guide the annual planning and prioritisation of environmental watering across the Murray–Darling Basin. They represent the annual steps needed to achieve the long-term outcomes in the Basin-wide environmental watering strategy and through them, the Basin Plan's ecological objectives and targets.

This report has been produced principally for managers of environmental water (the CEWH and Basin states), who will be guided by the priorities outlined in this report when they undertake the planning and coordination of environmental watering.

These are the seventh Basin annual environmental watering priorities prepared in accordance with the requirements of the Environmental Watering Plan (Chapter 8) of the Basin Plan, including consultation with members of the Environmental Watering Working Group representing Basin governments, water holders and managers, and with river operators.

Current conditions

Since record-breaking rain fell across the Basin from May to September 2016, climate conditions have been predominately much warmer and drier than average. Rainfall over the two years to 1 April 2019 has been in the lowest 10% of years in the historical record since 1900, with many regions in the Basin experiencing severe drought (Figure 2).The Bureau of Meteorology reports the dry conditions are occurring against a longer drying trend over recent decades. Rainfall for April to October periods has been below average for 17 of the last 20 years. The scale of the decrease is around 11% in April to October rainfall in south-eastern Australia for the period 1999 to 2018 when compared to the 1900 to 1998 period.

The decrease in rainfall during the April to October periods has particular hydrological importance for the Basin. In the southern Basin, the decrease coincides with what is commonly referred to by water resource managers as 'the filling season', resulting in a corresponding decrease in streamflow and water resource availability for communities, industries and the environment. In the northern Basin, the decreased rainfall over these months means conditions are less favourable for saturating the ground and priming soil moisture levels for generating runoff during the following wet season.

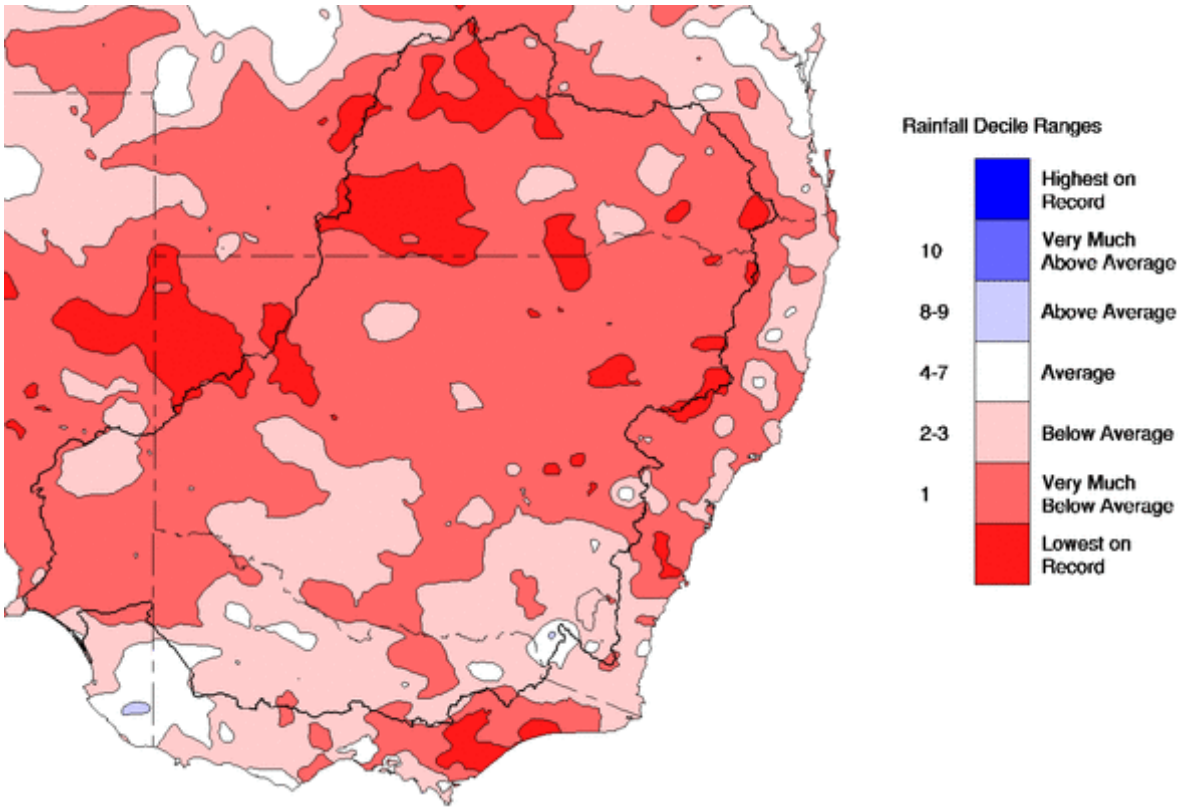

Figure 2 Rainfall deciles for the Murray-Darling Basin, 1 April 2017 to 31 March 2019

Consequently, low flow and cease-to-flow conditions were experienced in many northern Basin catchments over the 2018–19 water year, including cease-to-flow conditions in the, Barwon–Darling, Namoi, Macquarie–Castlereagh, Border Rivers, Moonie, Condamine–Balonne and Warrego catchments. Storage levels in the northern Basin are lower than during the millennium drought. Observed inflows in the Macquarie and Namoi valleys were below the lowest inflows on record extending back more than a century. Between August 2017 and March 2019, observed inflows into Burrendong Dam in the Macquarie were 37% of the previous record low inflow.

Heavy rainfall in northern parts of the Basin in late March 2019 associated with Ex-Tropical Cyclone Trevor resulted in minor flooding in the Warrego as well as some good streamflows in the Namoi and Macquarie–Castlereagh catchments. For the Warrego catchment, follow-up rain in the first and last weeks of April 2019 in northern and western parts of the northern Basin enhanced flows in that system. Subsequently, flows from the Warrego entered the Darling River before reaching Louth in late April 2019 and then Tilpa in May 2019. As at late May, there was a chance flows might contribute a small volume into Lake Wetherell at Menindee over the coming weeks. Rainfall in the Maranoa and Nebine systems is also providing inflows into the Darling via the Culgoa River, and has provided some relief for refuge water pools through parts of the lower Balonne rive network. For the Macquarie River, flows had reached Brewarrina Weir in April–May 2019, replenishing refuge pools along the way. Flows from the Namoi reached Walgett but did not fill the Barwon River Weir. The NSW government embargo on extraction in place at the time allowed the flows to travel long distances through these rivers.

Around this time, the NSW Office of Environment and Heritage and the CEWH ordered releases of up to 36 GL of environmental water from the Border and Gwydir catchments as part of the collaborative

and coordinated Northern Fish Flow event. By mid-June, the 'Northern Fish Flows' had travelled over 1,000 km along the Dumaresq, Macintyre, Gwydir and Mehi and Barwon rivers, and was expected to reach at least the junction of the Macquarie and Barwon rivers.

For the two years to 1 April 2019, the Basin experienced much warmer conditions, with record-breaking temperatures experienced for Australia in December 2018, January and March 2019, and for summer 2018–19 (Figure 3). The 2018 calendar year was the third warmest year on record for Australia since 1900 and is the sixth consecutive year that temperatures have been well above average across the Basin.

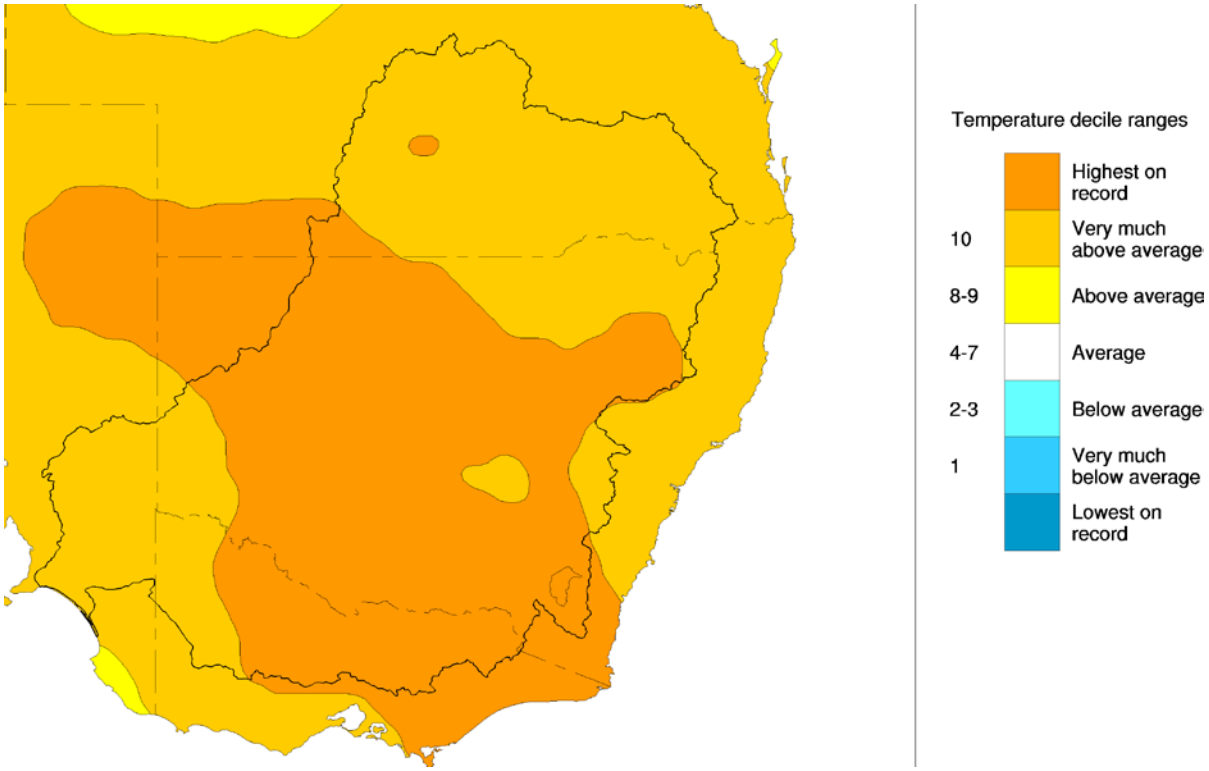

Figure 3 Mean temperature deciles for the Murray-Darling Basin, summer 2018-19

Persistent high temperatures over 2018 contributed to record rates of observed pan evaporation for April to August 2018 across large parts of the Basin. For the northern Basin, evaporation rates over summer 2018–19 were also the highest over the last 30 year-period. The high evaporation rates exacerbated drought conditions across the Basin, leading to higher water demands in irrigation areas over the growing season.

Climate context for 2019–20

The MDBA assesses seasonal conditions for the upcoming water year (the water resource availability scenario) in each Basin catchment based on the past year's climate conditions (rainfall, runoff and soil moisture) and current surface water availability in public dams in regulated catchments. We also consider the Bureau of Meteorology's climate outlook and El Niño–Southern Oscillation wrap up. In addition, we consult with environmental water managers.

The objectives sought from providing water for the environment are influenced by seasonal conditions. The annual watering priorities are expressed so that they can adapt to the prevailing climatic conditions that will appear throughout the watering year.

Identifying which priorities to use will depend on the resource availability scenario and the condition of the area in question.

The assessment of the current resource availability scenario for Basin catchments has been updated since the MDBA published the Basin environmental watering outlook 2019–20 (the Outlook). The assessment of water resource availability based on conditions as at 1 April 2019 is as follows:

- the Warrego, Paroo, Condamine–Balonne, Border Rivers, Gwydir, Namoi, Macquarie–Castlereagh, Barwon–Darling, Lower Darling, Lachlan, Murrumbidgee, Murray, Ovens, Goulburn–Broken, Campaspe and Eastern Mount Lofty Ranges were assessed as being 'very dry'; and
- the Loddon and Wimmera–Avoca catchments were assessed as being 'dry'.

More information on this assessment of the water resource availability scenarios is provided in Appendix 1. Since this assessment was undertaken, minor flooding in the Warrego described above, as well as above average rainfall in some catchments in Victoria during May, mean that water availability in these catchments has increased and opportunities for environmental watering may have improved.

Influence of climate forecasts

While seasonal and longer-term climate forecasting are not included in the assessment of water resource availability in the Basin, the MDBA uses this contextual information to provide an indication of changes in water resource availability that may emerge over coming months.

As at 30 May 2019, the Bureau of Meteorology's seasonal forecast for the Basin from June to August 2019 is that conditions are likely to be drier than average. Over the same period, the chances of above average daytime temperatures are high, exceeding 80% for much of the Basin. Night time temperatures are likely to be warmer, with the chance of warmer conditions increasing during August. There is an increased risk of frost over the winter months for susceptible regions, associated with drier soil profiles and the increased likelihood of cloud-free nights.

The Bureau of Meteorology announced on 9 October 2018 that the El Niño–Southern Oscillation (ENSO) Outlook had been raised from El Niño WATCH to ALERT. While Tropical Pacific sea surface temperatures remained close to El Niño levels from late February until mid-April, there has not been a consistent El Niño-like response. As at end May 2019, the Pacific Ocean temperature and the overlying atmosphere remain close to El-Niño thresholds, with the ENSO Outlook currently set to WATCH, and the models indicating conditions will ease back further to neutral over winter.

Over the coming months, the Indian Ocean Dipole (IOD) is expected to become the dominant influence on climate in the Basin, with the models predicting that a positive phase will develop. While the IOD index exceeded the positive threshold value in the last week of May, for conditions to be considered an IOD event requires the values to be sustained for at least two months.

Models currently suggest positive IOD levels will be maintained throughout winter. A positive IOD typically means drier-than-average conditions for southern and central Australia during winter-spring.

Overall, and according to the latest seasonal outlook from the Bureau for June to August 2019, conditions are likely to be mostly warmer and drier across the Basin over winter when compared to historical records. With the possibility of a positive IOD event developing over the months ahead, dry conditions may persist over winter and into spring 2019.

Basin environmental watering priorities

This document lists environmental watering priorities by four themes: river flows and connectivity, native vegetation, waterbirds, and native fish. The priorities are set out as rolling multi-year frameworks to guide environmental watering over the medium-term (i.e. the next 3-5 years) to achieve the expected environmental outcomes identified in the strategy.

To assist in achieving the multi-year priorities, Basin annual environmental watering priorities have been developed for each of the resource availability scenarios. The annual watering priorities for any given time are dictated by the current best estimate of the resource availability scenario over the next year. If conditions change across catchments within the year, the annual priorities can transition to reflect seasonally appropriate priorities. The framework also provides insight to the likely annual watering priorities in the forthcoming water years to assist in future planning.

Annual guidance has also been provided to assist water managers to implement the annual priorities in the coming water year, based on anticipated seasonal conditions and emerging issues that need to be supported or ameliorated with environmental water. Where particular sites or rivers have been identified as priorities with multiple ecological needs, these have been grouped together to provide a more integrated view.

While implementation of actions to contribute to these priorities should be straightforward, it will require careful application by water managers. The MDBA's recommended approach is that water managers first have regard to the annual guidance, since it is specific in nature, and second have regard to the multi-year frameworks, as these are general in nature.

A range of factors will influence the achievement of the Basin annual environmental priorities. In addition to water availability, these factors include operational rules, physical constraints and natural resource management issues.

Implementing the priorities will also require effective use of all water, including consumptive water on route to users. Any watering decision made to meet these priorities will need to consider current constraints and include consultation with stakeholders.

The rolling, multi-year priorities are:

- Support lateral and longitudinal connectivity along the river systems.
- Support freshwater connectivity through the Lower Lakes, Coorong and Murray Mouth.

- Maintain the extent, improve the condition and promote recruitment of forests and woodlands.
- Maintain the extent and improve the condition of lignum shrublands.
- Expand the extent and improve the condition of Moira grass in Barmah–Millewa Forest.
- Expand the extent and improve resilience of *Ruppia tuberosa* (Ruppia) in the southern Coorong.
- Improve the abundance and maintain the diversity of the Basin's waterbird population.
- Maintain the abundance of key shorebird species in the Lower Lakes and Coorong.
- Support Basin-scale population recovery of native fish by reinstating flows that promote key ecological processes across local, regional and system scales in the southern connected Basin.
- Improve flow regimes and connectivity in northern basin rivers to support native fish populations across local, regional and system scales.
- Support viable populations of threatened native fish, maximise opportunities for range expansion and establish new populations.

The MDBA has identified the current resource availability scenario (see Appendix 1) and will advise if it changes substantially. Planning for the forthcoming water year anticipates dry to very dry conditions across the Basin, noting that in some southern catchments where carryover water will likely be available, and where there has been recent rainfall, it may be possible to improve ecological condition in these regions.

Providing water to the environment in dry times is critical to protecting and restoring the long-term condition of the Basin's rivers, wetland and floodplains and maintaining and, where possible, improving the health and abundance of native fish, waterbirds and native vegetation that rely on a healthy river system.

Within a dry to very dry resource availability scenario, the MDBA anticipates the focus for environmental water managers in 2019–20 will be:

- Avoiding irretrievable loss of species and habitat, and providing drought refuges in very dry catchments
- Maintaining the condition of species and habitat where water is available in dry catchments
- Improving the condition of species and habitat in catchments where environmental water allocations have been higher and reasonable carryover volumes are available, most likely in parts of the southern Basin.

Environmental water managers are encouraged to be ready to respond if conditions change.

The outcomes sought through these Basin-scale priorities are complemented by outcomes targeted at local and regional scales through the work of the CEWH and Basin states managing water for the environment.

Annual guidance for 2019–20

River flows and connectivity

- Coordinate environmental watering to increase longitudinal connectivity in connected catchments.
- Mitigate irreversible environmental impacts associated with extended drought.
- Prevent dry spell durations exceeding refuge tolerances.

Native vegetation

- Provide flows to maintain core wetland areas and provide refuge habitat.
- Improve vegetation condition in areas of high habitat and conservation value.

Waterbirds

- Provide flows to maintain and where possible improve habitat and support waterbird breeding where naturally triggered.
- Maximise availability of productive foraging habitat for shorebirds.

Native fish

- Support, and where possible, build upon populations of large-bodied native fish species in the southern connected Basin.
- Protect critical populations and habitats and improve connectivity in northern Basin rivers to support native fish populations.
- Maintain and improve existing populations of threatened native fish.

As part of the annual guidance this year, priorities that were identified by multiple themes as being in need of water for the 2019–20 water year were seen as being important for targeting delivery, enhancement or protection of water and are listed with the needs of the sites below. These are likely to be high-need areas that can be watered in order to achieve the broader priorities but are not an exclusive set. Wherever possible, all relevant sites, communities and species should be considered for watering in line with the broader rolling multi-year priorities and the thematic annual guidance.

Annual guidance to achieve priorities for sites with multiple ecological needs:

Barwon–Darling and lower Darling

- Support any opportunities to increase longitudinal connectivity with the Barwon–Darling and through to the lower Darling by protecting and enhancing unregulated events.
- Provide flows that protect refuges, maintain river connectivity and support population recovery of native fish in the Barwon–Darling and lower Darling rivers.

Narran Lakes

- Support replenishment flows to maintain habitat at Narran Lakes.
- Support flows to maintain and where possible improve habitat and support waterbird breeding where naturally triggered.
- Support flows that replenish refuge waterholes for native fish in the Narran system.

Koondrook–Perricoota Forest

- Use works infrastructure to connect the floodplain-wetland ecosystem of Koondrook–Perricoota Forest and manage associated risks.
- Provide flows through creek systems and low-lying wetlands to support critical understorey vegetation communities.
- Provide flows to maintain and where possible improve habitat and support waterbird breeding where naturally triggered.
- Provide flows that improve habitat for floodplain specialist fish in Koondrook–Perricoota Forest.

The Coorong, Lower Lakes and Murray Mouth

- Coordinate the management of environmental water with barrage operation to provide flows to the Coorong and assist the maintenance of Lower Lake levels above 0.4 m.
- Maintain inflows to the Coorong through spring to support resilience of ruppia.
- Provide flows to maintain and where possible improve habitat and support waterbird breeding where naturally triggered.
- Maximise availability of productive foraging habitat for shorebirds.
- Provide flows and manage lake levels so that habitat for threatened fish species is maintained.

State priorities

The Basin states are required to provide the MDBA with annual environmental watering priorities for each water resource plan area by 31 May each year. The MDBA has received annual priorities from Queensland, New South Wales, Victoria and South Australia that list priorities at a regional scale. The MDBA had regard to these regional priorities as it finalised the Basin priorities.

The 2019–20 Basin state priorities generally complement the Basin annual priorities in this report. This is the result of consultation on the needs and opportunities for environmental watering within the framework provided by the Basin Plan and the Basin-wide environmental watering strategy.

The MDBA and Basin states have different but complementary roles in planning for environmental watering. This means that the Basin-priorities are not an exclusive list – state priorities may be more detailed at the regional scale. Additionally, many regional priorities will support and contribute to the expected environmental outcomes outlined in the Basin-wide environmental watering strategy.

First Nations environmental outcomes

The MDBA recognises that First Nation peoples' knowledge of Country can contribute to better environmental water planning. The MDBA has committed to incorporating First Nations' objectives into environmental watering planning and management, which includes improved ecological services and benefits for First Nations' peoples across the Murray–Darling Basin.

Independent, culturally authoritative and strategic input from First Nation peoples into environmental water planning can improve environmental watering decisions. Managing environmental water in ways that incorporate First Nation peoples' objectives for healthier rivers and wetlands will improve wellbeing and cultural resilience. Considering First Nations' local knowledge in environmental water planning decisions will also help to improve outcomes of environmental watering and the health of Country.

The MDBA has also committed to co-designing a framework that will meaningfully and transparently incorporate First Nations input into environmental watering policy. This work will provide a platform for First Nations to provide long-term strategic advice on their environmental values and outcomes at the Basin scale.

Working in partnership with the Northern Basin Aboriginal Nations (NBAN) and the Murray Lower Darling Rivers Indigenous Nations (MLDRIN) will facilitate knowledge sharing between First Nations peoples and water planners. The MDBA will seek opportunities to work with emerging Aboriginal natural resource managers from NBAN and MLDRIN to develop their skills in environmental water planning and management. Progress with this work is described below.

Northern Basin

In 2018, the MDBA worked in partnership with NBAN and the Commonwealth Environmental Water Office (CEWO) to facilitate knowledge sharing between First Nation peoples and water planners. This progressed the inclusion of First Nation objectives into environmental water planning and facilitated the development of a framework for incorporating First Nation Environmental Watering Guidance (FNEWG) into Basin environmental water planning. In March 2019, NBAN launched the FNEWG project, which aims to gather the environmental watering objectives of 21 northern Basin Aboriginal Nations across five environmental watering themes. NBAN are partnering with the MDBA and CEWO to integrate these First Nations' objectives into the 2020–21 Basin annual watering priorities and long-term environmental water planning.

First Nation's objectives describe tangible physical benefits that can be derived from environmental watering for First Nations' people, such as improved populations of culturally significant fish and other water-dependent species, native vegetation, waterbirds, restoring flows and connectivity, and rehabilitating the landscapes to which First Nations have an inherent right.

Southern Basin

In 2018, the MDBA worked in partnership with MLDRIN and the CEWO to develop an effective and equitable mechanism for First Nations environmental watering objectives to be included in the environmental watering framework for the Murray–Darling Basin.

MLDRIN's First Nations' Environmental Water Objectives (FNEWO) project will employ a staged approach, throughout 2019–20, aiming towards inclusion of detailed objectives in the 2020–21 Basin annual environmental watering priorities and long-term environmental water planning.

MLDRIN believes the development of an enduring approach to including First Nations' objectives in environmental water planning requires an understanding of the variable and evolving interests,

capabilities and preferences of First Nations across the MLDRIN region. The first stage of the FNEWO project involves a dialogue with all MLDRIN Nations to identify their capacity and willingness to provide detailed information about watering objectives.

MLDRIN has prepared a collaborative design report, which documents sources of information available to Nations to develop watering objectives, the resources required by Nations to undertake this work and relevant decision-making structures.

The report highlights that most Nations see benefits in contributing their objectives to inform environmental water planning. Most Nations have access to research and information that outlines preferred outcomes from watering. However, there is significant disparity between Nations in terms of the human resources, information, financial resources and expertise available to develop detailed watering objectives. The collaborative design report identifies options for building Nations' capabilities to contribute to environmental water planning, through projects underway across the southern Basin.

The first stage of the FNEWO project will build a foundation for effective and equitable inclusion of First Nations' objectives in the 2020–21 Basin annual environmental watering priorities and long-term environmental water planning.

Technical summaries of the Basin environmental watering priorities

This section of the report describes the rolling, multi-year priorities for river flows and connectivity, native vegetation, waterbirds and native fish. It also includes annual guidance to achieve the priorities for these four themes in the forthcoming water year, having regard to what ecological assets most need watering.

Where multiple ecological needs were identified for the same asset, these have been grouped together for the purpose of providing annual guidance to achieve the priorities in the forthcoming water year. This approach aims to provide a more integrated overview of the priority and thereby to assist water managers.

Guidance to achieve priorities for sites with multiple ecological needs in 2019–20

Barwon–Darling and lower Darling

The pattern of flows in the Barwon–Darling system has always been variable, however the number and length of cease-to-flow periods in the Barwon–Darling have increased significantly in the past 18 years while the floods that follow them have been smaller (Figure 4). This trend has also affected water availability in Menindee Lakes and the flow characteristics downstream through the lower Darling. These changes are having significant impacts on the river system and the plants and animals it supports. For more information, see Ecological needs of low flows in the Barwon–Darling (March 2018).

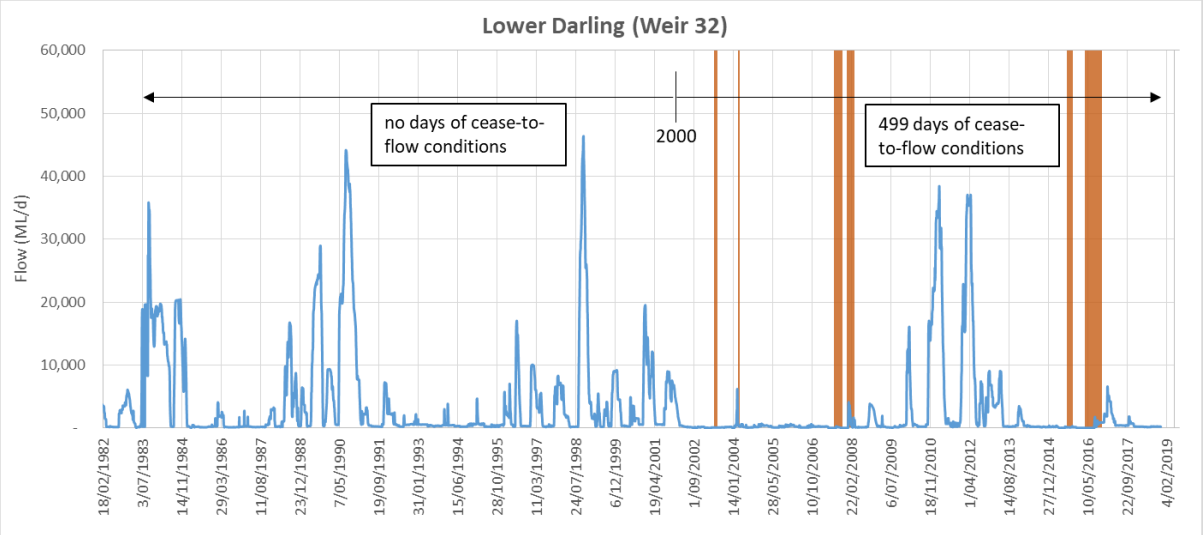

Figure 4 - Observed flows at U/S Weir 32 from 1982 -2018, showing cease-to-flow periods (of less than 5ML/d)

In 2018, there were record low flows along the Barwon–Darling; flow at Bourke was the lowest on record at 1.3% of the long-term average. Given that rainfall was well below average across the northern Basin in 2018, and temperatures were well above average, very little of the rain that fell in the upper-catchments made its way to the lower Darling. The long distances and travel times along the Barwon–Darling further intensify the reduction of flow from evaporation and seepage.

By January 2018, more than 1,000 km of the Barwon–Darling downstream of Brewarrina had ceased to flow. As water quality deteriorated into stagnant waterholes, blue green algae alerts increased and native fish and other instream life were put under significant stress.

In response to the worsening river conditions, State and Commonwealth agencies worked together to protect and deliver 23 GL of water through coordinated releases from storages in the Border Rivers and Gwydir catchments to connect up the valleys and provide water to 2,000 km of the Barwon–Darling. The flow managed to flush blue-green algae from the rivers, improving water quality and providing food and habitat for plants, fish and birds. However, only a small proportion made its way to Menindee Lakes and there was no measurable effect on lower Darling flows. The volume of water available was not enough to connect all waterholes or provide effective connection with the lower Darling. The recent fish deaths in the lower Darling are a graphic demonstration of the stresses that are still experienced by the river system and the work that remains to be done to restore the river to health.

It is suspected that the fish deaths in early January 2019 were caused by stratification that led to low oxygen levels in deep water which was then mixed with surface water when a sudden drop in temperature de-stratified the water. This was a large scale event, affecting approximately 45 km of the Darling River below the Menindee main weir.

The Menindee Lakes storage was at 1% of capacity at 3 June 2019 and Water NSW ceased releases from Menindee in mid-February. Block banks have been installed through the lower Darling, providing temporary local water storage. However, throughout both the Barwon–Darling and lower Darling rivers, drought refuges are stratifying and fresh water is needed to avoid anoxic conditions. April 2019 was characterised by blue-green algae alerts at locations extending from Brewarrina down through the lower Darling, with multiple red alerts through the lower Darling and many sites along the Barwon–Darling were reaching cease-to-flow periods in excess of 200 days, including Walgett, Bourke, Louth, Tilpa and Wilcannia. However, the northern fish flow event along with natural flow from tributaries has provided flows to parts of the Barwon–Darling, breaking cease-to-flow events at many locations (such as Mungindi, Collarenebri, Louth, and Tilpa) and improving water quality in these reaches. Further information on these events can be found in the priority relating to native fish below.

Support any opportunities to increase longitudinal connectivity with the Barwon–Darling and through to the lower Darling by protecting and enhancing unregulated events

Dry conditions are continuing across the northern Basin and based on current environmental water availability, there is limited capacity to provide further delivery of regulated flows to the Barwon–

Darling and down to Menindee Lakes. However, if the opportunity arises in response to rainfall, environmental water managers and water access right holders should consider coordinating flows to improve connectivity of the tributaries to the Barwon–Darling and, if possible, through to Menindee Lakes.

Other options to support flows into and along the Barwon–Darling include the enhancement of unregulated flows through passive management and the use of supplementary entitlements to protect parts of supplementary events through regulated tributaries.

If water managers are able to deliver water for the environment through the Barwon–Darling, the MDBA anticipates that this water would be protected from extraction. In the case of any unregulated flows, consideration should also be given to protecting any first flush events through the Barwon–Darling system, subject to the NSW Minister's discretion.

Over the last two years NSW has proactively protected similar flows by instituting temporary water restrictions under section 324 of the NSW *Water Management Act* (2000). This approach has been effective, providing substantial and measurable relief for communities and the ecosystem along large lengths of the northern rivers during extreme dry periods. However, it is inherently a temporary mechanism that does not provide long-term security for entitlement holders (both consumptive and environmental). Furthermore, this approach cannot be applied to a 'mixed event' — that is, a pre-existing flow that has been supplemented by water for the environment. The MDBA therefore anticipates that NSW will transition to an active management approach over the coming year to protect held environmental water from extraction in unregulated catchments on an enduring basis.

Similarly, for the lower Darling, in response to any inflows, water managers should seek opportunities to supplement operational releases from Menindee Lakes to increase connectivity and enhance environmental outcomes such as supporting fish passage, replenishing drought refuges and increasing nutrient and organic matter supply to the main river channel.

Coordinated environmental releases by the CEWH in partnership with NSW Office of Environment and Heritage and other NSW agencies from April to June will have helped to replenish critical waterholes (see section on native fish below). If dry conditions continue, it will be important for water holders, river operators and resource managers to continue to make efforts to protect critical drought refuge sites and avoid further losses.

Provide flows that protect refuges, maintain river connectivity and support population recovery of native fish in the Barwon–Darling and lower Darling rivers

With the continued dry conditions across the northern Basin, remnant populations of native fish are becoming concentrated within a limited number of persistent waterholes. Satellite imagery shows these refuges are becoming more disconnected and smaller, putting water quality and fish populations at further risk.

Given the resource availability scenario (RAS) across all northern Basin catchments is 'very dry' the main focus should be on actions that protect refuges and instream habitats, maintain river connectivity and secure water supply to key populations. Flows can be provided to ensure that

essential functions for these populations can be met as well as allowing small-scale movements to occur. For example, if the opportunity arises, flows should be provided to support valuable native fish populations that will provide for future repopulation and recovery. The past month has seen natural flows occurring in the Condamine–Balonne, Border Rivers, Namoi, Warrego and Macquarie–Castlereagh valleys which are likely to have replenished waterholes, provided opportunities for fish to move between waterholes, and in the case of the Warrego system, opportunities for recruitment of species such as golden perch. Consideration should be given to supplementing these flows for the purpose of supporting fish to develop through their first year of life (after which the chances of survival to adulthood are increased), and dispersing young fish into the Barwon–Darling system should flows be sufficient to provide connections between systems.

The CEWH and state governments also provided flows for fish by delivering flows to the Gwydir River from Copeton Dam (around 1 May); and flows down the Border Rivers from Glenlyon Dam (around 24 April). These releases have been coordinated to ensure they complement each other once reaching the Barwon River, maximising the associated environmental outcomes. The aim of these flows is to top up waterholes, some of which are at their lowest water level in fifty years. It is hoped that the flows will make it to the Macquarie–Barwon junction and possibly the Brewarrina weir pool. This event is expected to be larger in volume than the Northern Connectivity Event last year, however it is not expected to make it nearly as far downstream due to the persistent dry conditions which intensifies losses due to evaporation and seepage. This flow would improve the survival, protection, and health of native fish within these northern rivers.

Narran Lakes

Narran Lakes is a Ramsar-listed wetland of almost 8,500 ha that provides valuable breeding and feeding habitat for waterbirds and supports a diverse assemblage of native fish. The site meets the Ramsar criteria for being a representative wetland type characteristic of the Murray–Darling Basin, containing a considerable diversity of habitats, including some of the largest expanses of the native plant lignum in New South Wales. It also meets the criteria for presence of threatened species (Australasian bitterns, Murray cod and winged peppercress) and the criteria for supporting species at a critical stage of their life cycle (through bird breeding habitat) and by providing drought refuge. The site supports 40 migratory bird species, including 19 listed under international agreements.

Narran Lakes has been identified as an important Basin environmental asset for waterbird abundance and diversity, colonial waterbird breeding and shorebird abundance. There has been almost no flow into the lakes since April 2017 and it is a priority for receiving water. Analysis has shown that none of the site-specific flow requirements for Narran Lakes have been met since 2012–13, however 2016 came close to meeting the 25 GL indicator which will have provided partial outcomes for some parts of the ecosystem (Figure 5). As these water requirements are inundation thresholds to achieve outcomes for the Narran Lakes, they are an indicator of the high risk to the environmental values of the site and waterbird populations across the Basin.

The nature of water resource management within the Condamine–Balonne and Narran systems can limit active use of environmental water. As discussed below, the MDBA encourages the use of innovative approaches such as event-based mechanisms, to enhance flows into Narran Lakes if the opportunity arises.

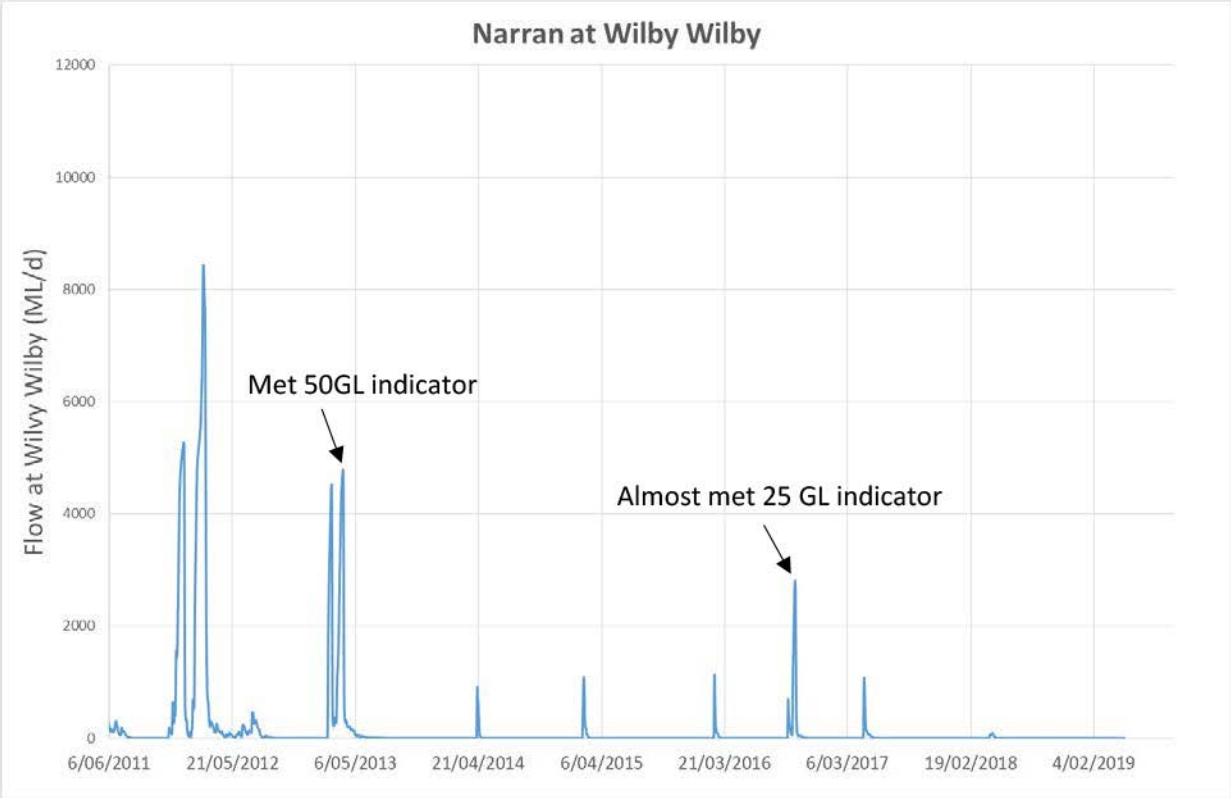

Figure 5 Flow rates for the Narran River at Wilby Wilby

Support replenishment flows to maintain habitat at Narran Lakes

Should rainfall in the upper catchments produce flows which trigger an unsupplemented (unregulated) event in the Lower Balonne, an event-based mechanism could be used to protect a portion of the event and provide additional flow to Narran Lakes. A volume of approximately 25 GL over two months would provide for full connectivity along the Narran River, allowing fish migration and inundation of the northern lakes, wetland channels and surrounding riparian vegetation. These outcomes would help in sustaining vital habitat for bird breeding and nursery sites.

Support flows to maintain and where possible improve habitat and support waterbird breeding where naturally triggered

Data from the 2018 Aerial Survey of Basin Environmental Assets (undertaken in October–November 2018) is pending. However, observations from the survey team found that in the northern Basin, many of the wetlands were dry and bird counts correspondingly low, with little breeding activity.

The Narran Lakes was one of these dry wetlands. No waterbirds were observed at the Narran Lakes, and as at May 2019, the lakes had not received any significant flows for over two years. A significant colonial breeding event has not occurred since 2011–12.

Being an important breeding site, any opportunity to improve waterbird breeding habitat to ensure habitat is maintained and able to support breeding events in the future should be sought for 2019–20. If a breeding event is initiated, support should be provided to ensure successful breeding and recruitment if possible, noting the resources required to provide for adequate nesting, roosting and foraging needed for successful recruitment. As mentioned above, with the exception of a small

flow event in spring 2016 of around 25 GL which likely reached a portion of vital habitat, the last significant inflow to Narran Lakes since the breeding event in 2011–12 was in April 2013.
This flow would have come close to watering all the vital habitat for waterbirds. Watering of this habitat is generally required every one-to-two years.

Support flows that replenish refuge waterholes for native fish in the Narran system

Reports about the Narran system indicate that of more than 30 refuge waterholes for native fish in that system, water remains in only three. In the event that flow cannot be delivered to the Narran Lakes as outlined above, the focus in the Narran system should be on replenishing refuge waterholes to provide adequate water quality and sufficient habitat to allow existing native fish to survive.

Koondrook–Perricoota Forest

Koondrook‑Perricoota Forest covers 34,500 ha of floodplain on the NSW side of the Murray, downstream of Torrumbarry Weir. It forms a mosaic of river red gum, black box and grey box communities interspersed by wetland ecosystems at lower elevations. Koondrook–Perricoota Forest is a NSW Central Murray State Forest Ramsar site, recognised for its genetic and ecological diversity. The forest meets Ramsar criteria relating to representative and/or rare wetland types due to the extensive river red gum forests and woodlands, and also to the criteria relating to the presence of threatened species (swamp wallaby grass, Murray cod, and potentially the Australasian bittern).

Use works infrastructure to connect the floodplain-wetland ecosystem of Koondrook–Perricoota Forest and manage associated risks

The absence of larger floodplain watering (natural or using environmental water) between 2012 and 2016 in Koondrook–Perricoota Forest has meant the benefits of natural flooding in 2010–11 and 2011–12 have not been sustained. The works at this site have been operated only once, in 2014–15 when 26 GL was delivered to test them. As a result, most of the indicators of condition at Koondrook–Perricoota are poor or showing signs of decline. The health of this site is currently poor and is likely to decline further if there is no floodplain watering in the coming years. Addressing constraints and ongoing policy and legal issues would enable operation of the works, which could provide the required connectivity to the floodplain in this area.

Provide flows through creek systems and low-lying wetlands to support critical understorey vegetation communities

It is particularly important to achieve lateral connectivity at the site to inundate permanent and semi-permanent wetlands, floodplain understorey and river red gum sites. All other icon sites in the Upper Murray are generally improving as a result of natural flooding and subsequent watering using regulators installed at the sites. Therefore, if seasonal conditions are appropriate and the opportunity arises within the context of the available water resources, getting water into Koondrook–Perricoota and overcoming constraints that limit effective use of the works with water delivery is seen as a priority.

High flows in 2016 improved canopy health of river red gum forest and black box woodlands throughout Koondrook–Perricoota. Dry conditions since 2016 have limited the inundation of forest and woodland communities. While the majority of Koondrook–Perricoota river red gum and black box have maintained reasonable crown condition since the 2016 floods, understorey vegetation cover and species richness has been declining, particularly outside of wetland depressions.

In the absence of a return of natural high-flow events through the Koondrook–Pericoota Forest, deliveries through creek systems and low-lying wetlands communities will maintain condition in riparian woodlands, and support critical understorey and wetland communities, assisting to maintain the ecological character of this component of the Ramsar site.

Provide flows to maintain and where possible improve habitat and support waterbird breeding where naturally triggered

Koondrook–Perricoota Forest has been identified as an important Basin environmental asset for colonial waterbird breeding. The habitat on the lower to mid-floodplain received some natural flows in 2012 and 2016–17, however monitoring of vegetation suggests that it is still in poor condition. Importantly, the habitat on higher elevations in the forest, which is required to support large scale breeding events, is also in poor condition. Should conditions improve and watering opportunities arise, watering of this habitat will improve colonial waterbird breeding success in future years.

Provide flows that improve habitat for floodplain specialist fish in Koondrook–Perricoota Forest

At the end of the 2016–17 water year, despite natural flooding in the area, native fish populations and recruitment in Koondrook–Perricoota Forest continued to be poor. The proportion of native fish compared to non-native fish, was the lowest since monitoring began in 2011 and recruitment levels for native fish declined. With the site being important for providing habitat for a number of fish species (including several threatened species), efforts should be focused on protecting and enhancing viable floodplain fish communities to support foodwebs and increase diversity within the forest.

The Coorong, Lower Lakes and Murray Mouth

Being at the end of the system, the Coorong, Lower Lakes and Murray Mouth (CLLMM) complex has been affected by decades of reduced flow. Improving conditions in the Coorong requires a long-term approach as many of the key species and ecological processes within the system require specific flow regimes over multiple years.

As a Ramsar-listed wetland of international importance, the CLLMM is referred to multiple times in the Basin-wide environmental watering strategy with expected outcomes relating to all four ecological themes (being river flows and connectivity, native vegetation, waterbirds and native fish). The CLLMM meets eight of the nine Ramsar site criteria, relating to a broad range of categories such as its unique representation of wetland types and supporting a broad range of waterbirds, fish and ecological communities. The CLLMM is referred to in the Environmental Water Plan targets including the intermediate target of *no loss of, or degradation in the condition of the Coorong and Lower Lakes*

ecosystems and Murray Mouth opening regime up to 30 June 2019, with improvements sought from 1 July 2019 onwards.

With much of the 2012-18 period dominated by dry conditions, River Murray flows and flows into the Coorong and Lower Lakes generally remained below their long-term average. In 2018 the southern Basin inflows into the River Murray were around one third of the long-term average, or in the lowest 10% of years over the historical record since 1891. This has resulted in low flows to the Coorong and poor connectivity. Without sufficient connectivity from the River Murray to the sea, vital ecosystem functions are likely to be compromised. These include moving salt, nutrients and sediment through the Murray Mouth and allowing native fish to move between marine, estuarine and freshwater environments. Without sufficient flows, salinity increases and connectivity between the ecosystems declines. Waterbirds and key vegetation communities are also put at risk when the Coorong, Lower Lakes and Murray Mouth are under stress.

Achieving priority actions at the site is complex due to the often competing hydrological needs of the various ecological elements of the CLLMM system. The delivery of flows to the system needs to balance many interdependent and complex interactions including lake levels and salinity, Murray Mouth openness, barrage operations and inundation, and salinity requirements in the Coorong. These factors need to be considered when providing for a particular ecological requirement or outcome. This process is further complicated when the hydrological needs of key ecological priorities are in misalignment, such as when inundation requirements for ruppia conflict with those of the shorebirds or the fringing vegetation around the Lower Lakes. At the annual scale it is difficult to anticipate which of these priorities will take precedence over the coming year as they are highly dependent on the prevailing climatic conditions and available water. So water managers will need to carefully consider trade-offs when optimising outcomes in the CLLMM.

Coordinate the management of environmental water with barrage operation to provide flows to the Coorong and assist the maintenance of Lower Lake levels above 0.4 m

Environmental water throughout 2018–19 has been critical to maintaining continued flows and connectivity between the Lower Lakes and Coorong, with environmental water accounting for 100% of flows over the barrages. These flows provide numerous benefits to small bodied native fish, estuarine and diadromous fish species. Freshwater flows through the barrages also provides a diversity of habitat for macroinvertebrates, waterbird and migratory wading bird species.

Maintaining adequate water levels within the Lower Lakes is important for maintaining key ecological outcomes, both within the lakes and the Coorong. If these drop below 0.4 m, then the planning phase of the 'Drought Emergency Framework for Lakes Alexandrina and Albert' will need to be initiated by the MDBA and South Australia. It is possible that these levels cannot be maintained above 0.4 m if extended dry conditions prevail over the next water year.

During this planning phase of the Drought Emergency Framework, the barrages will not be operational and would be closed as early as possible to recover lake levels. However, the closure of the barrages has significant ecological implications; stopping migration of fish from the estuary to

freshwater, and limiting the export of salt and sediments which could lead to increasing salinity in the Coorong. Prolonged closure of the barrages and barrage fishways should be avoided.

Capacity to supply environmental water to meet the environmental demands at the Lower Lakes, Coorong and Murray Mouth in 2019–20, is likely to be dependent on a combination of the below:

- return flows from the multi-site watering actions upstream, both within the Murray and from its tributaries;
- channel capacity constraints and the supply of water orders specifically for the Lower Murray, Lower Lakes and Coorong; and
- effective management of environmental allocations within the South Australia entitlement, including the profiling of its use.

Any opportunities to coordinate watering events in the River Murray and from the tributaries to the River Murray should be used to help build flow events that provide a spring pulse for the River Murray Channel, and support maintenance of lake levels above 0.4 m and connectivity with the Coorong. This should be complemented by appropriate policy and operational procedures such as return flow provisions and seasonally appropriate operation of the Lower Lakes to allow flows to pass through the barrages.

This priority for 2019–20 builds on priorities from previous years with the aim of maintaining minimum hydrological connectivity between the freshwater, estuarine and marine environments in the Coorong.

Maintain inflows to the Coorong through spring to support resilience of ruppia

Ruppia (*Ruppia tuberosa*) is sensitive to changes in water levels, particularly during spring when falling water levels reduce the time available for plants to establish, grow and reproduce. Favourable conditions during the 2016–17 water year resulted in an increase in the extent of ruppia in the Coorong's south lagoon, in line with the expected outcome of the Basin-wide environmental watering strategy (*by 2019, R. tuberosa to occur in at least 80% of sites across at least a 50 km extent*). Ruppia monitoring data from summer 2018 and 2019 indicate that falling water levels during spring in 2017 and 2018 (as well as overabundant filamentous algae) have hampered reproduction of the species, and the extent of occurrence may again be declining.

Maintaining inflows to the Coorong (subject to water levels in the Lower Lakes) to slow the decline in water level over the spring growing period in 2019–20 will help to build population resilience and arrest the decline in ruppia extent.

Provide flows to maintain and where possible improve habitat and support waterbird breeding where naturally triggered

The Coorong and Lower Lakes, identified as an important Basin environmental asset for waterbird abundance and diversity, colonial waterbird breeding and shorebird abundance, supported the largest area of breeding in 2018. If conditions allow, watering to support juvenile waterbirds should be done to build upon limited breeding that occurred in 2018, helping to increase the abundance of waterbirds in the Basin.

Maximise availability of productive foraging habitat for shorebirds

The Coorong, Lake Alexandrina and Lake Albert is an East Asian Australasian Flyway site, highlighting its international importance for migratory shorebirds. The 2018 and 2019 waterbird surveys conducted for the MDBA in the Coorong and Lower Lakes generally demonstrated a gradual increase in the four key shorebirds from the 2017 surveys, where numbers for two of the species had dropped to their lowest on record (refer Figure 6). A priority in 2019–20 will be to actively manage water levels and other threats, particularly water quality and algal blooms, to improve foraging and roosting habitat for shorebirds in the Coorong.

Provide flows and manage lake levels so that habitat for threatened fish species is maintained

Management of flows and water levels in the Lower Lakes and Coorong for native fish is particularly challenging. The fringing habitats of the Lower Lakes contain a number of small-bodied threatened species. To maintain habitat for these species requires lake levels to be kept above particular levels.

However, to support species that move between the estuary and freshwater requires flows through barrages and barrage fishways.

Connectivity between the estuary and freshwater is critical to maintain a functional fish community at the end of the river system. Flows through the barrage fishways in winter and early spring allow estuarine and diadromous fish to move between fresh and saline water as required to complete their recruitment. Barrage flows in late spring/early summer can support movement of young congolli and galaxias from the estuary into suitable habitat in the Lower Lakes. Where possible, efforts should be made to avoid any irreversible change to the fringing habitat that supports threatened fish species by maintaining water levels above 0.4 m. In some cases, water managers may need to prioritise one action over the other. This prioritisation should be done with careful consideration based on levels of risk and in consultation with relevant parties.

River flows and connectivity

River regulation and consumptive use has intensely modified the natural flow regime in many of the Basin's rivers, to the detriment of water-dependent ecosystems and risking the sustainability of the river system. The Basin Plan has returned water to the river, to arrest further decline and restore the river system to health.

Returning parts of the natural flow pattern is a central element of river restoration and a concept adopted by the Basin Plan to restore and protect environmental assets and functions. To achieve this, the Basin-wide environmental watering strategy sets objectives for river flow regimes, the connectivity of rivers and their floodplains, and the condition of the environment at the end of the Basin.

For more information about the current condition of river flow and connectivity in the Basin, see the Basin environmental watering outlook for 2019–20.

Rolling multi-year priorities for river flows and connectivity

Building towards these objectives, the MDBA has included specific priorities for lateral and longitudinal connectivity and end-of-basin flows. These priorities aim to return river flows to a more natural pattern (flow regimes) and re-establish connections along the river, and between the river and its floodplains and estuary (connectivity).

The rolling, multi-year priorities for river flows and connectivity are to:

- *Support lateral and longitudinal connectivity along the river systems.*
- *Support freshwater connectivity through the Lower Lakes, Coorong and Murray Mouth.*

Support lateral and longitudinal connectivity along the river systems

Many plants and animals in the Basin rely on river flows for water, food and habitat, as well as to support the cycle of wetting and drying that underpins various stages of their life cycle. The connection between rivers and their anabranches, wetlands and floodplains is referred to as *lateral connectivity*, which is associated with in-channel pulses, bankfull and overbank flow events. These events support a range of ecosystem functions including providing habitat, cycling nutrients and carbon, and providing a natural cue for feeding, breeding and movement – which underpin the food web for native fish, waterbirds and native vegetation.

The connection along a river and between a river and its tributaries is referred to as *longitudinal connectivity.* These flows are usually described in volumetric terms with objectives focused on maintaining sufficient flow volumes to sustain ecosystem functions that maintain water quality, support movement, import nutrients and export salt and pollutants.

Table 1 Rolling, multi-year priority framework for lateral and longitudinal connectivity

Rolling, multi-year priority	**Support lateral and longitudinal connectivity along the river systems**				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
Basin annual environmental watering priorities	Coordinate environmental watering to increase longitudinal connectivity in connected catchments. Mitigate irreversible environmental impacts associated with extended drought. Prevent dry spell durations exceeding refuge tolerances.	Maintain natural cycles of wetting and drying. Where possible, maintain baseflow volumes at 60% of natural levels. Provide replenishment flows to maintain habitat condition and regulate water quality, carbon and nutrients. Use works infrastructure to connect floodplain-wetland ecosystems and manage associated risks.	Coordinate regulated releases with tributary flows (regulated and unregulated) to increase longitudinal connectivity in the Barwon–Darling and Murray rivers. Coordinate regulated releases with timing of tributary flow events to increase flow variability and the frequency of in-channel pulses and bankfull flow events. Extend the duration and magnitude of natural events to promote the movement of biota nutrients, sediments and salt.	Manage water in harmony with natural cues to maximise connectivity and flow variability to reinstate key elements of the flow regime. Provide flow regimes that allow opportunities for high ecological productivity. Supplement unregulated flow events to promote hydraulic diversity and facilitate natural geomorphic processes and groundwater replenishment.	Maximise ecological responses by adaptively managing the recession of high-flow events. Maximise the export of sediments, pollutants and salt. Mitigate water quality impacts associated with natural flood events.

Support freshwater connectivity through the Lower Lakes, Coorong and Murray Mouth.

The Lower Lakes (Albert and Alexandrina), Coorong and Murray Mouth region support freshwater, estuarine and marine ecosystems which provide vital habitat for many unique, rare and threatened species. The area is Ramsar listed in recognition of the wetland's international importance, particularly in relation to its diversity of wetland types and diversity and abundance of waterbirds and native fish

As for many of the Basin's rivers, the flow regime at the end of the system has been modified as a result of development. Building and managing the barrages, and the cumulative impacts of water regulation and extraction upstream have altered the volume, timing and quality of the water reaching the Lower Lakes, Coorong and Murray Mouth.

The Basin Plan provides for environmental water planning and delivery to achieve end-of-basin outcomes, provide conditions to protect and restore the health of water-dependent ecosystems and ensure they are resilient by reinstating important parts of its natural flow regime.

The expected environmental outcomes in the Basin Plan and Basin-wide environmental watering strategy aim to maintain suitable water and salinity levels in the Lower Lakes and provide sufficient flows through the barrages to facilitate freshwater exchange to the Coorong estuary and Murray Mouth. Continued fresh water flow through the barrages supports migration of diadromous fish, reduces salinity levels in the Coorong, assists flushing of salt and sediments, maintains an open Murray Mouth, and provides suitable habitat for native fish, vegetation, waterbirds and macroinvertebrates.

Environmental water managers and planners should consider the interactions with priorities for native vegetation, waterbirds and native fish, and obligations to maintain the ecological character of this Ramsar wetland when working to achieve these end-of-basin priorities.

Table 2 Rolling, multi-year priority framework for end-of-basin flows

Rolling, multi-year priority	Support freshwater connectivity through the Lower Lakes, Coorong and Murray Mouth				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
Basin annual environmental watering priorities	Where possible, mitigate adverse environmental impacts associated with extended dry and drought conditions through the following priorities. Assist the maintenance of Lower Lake levels above sea level (0m AHD). Support the maintenance of suitable estuarine conditions around the barrages by managing balance between lake levels and barrage outflows (supporting by additional freshwater inflows where possible). Manage water quality in the Lower Lakes with additional freshwater inflows, having regard to the Basin Plan salinity targets. Where possible, provide flows to Coorong to avoid water quality exceeding tolerances of listed or threatened species.	Continuously connect the Lower Lakes, Coorong and Southern Ocean via the Murray Mouth. Coordinate the management of environmental water with barrage operation to apportion environmental water between sites above and below the barrages. Improve water quality in the Lower Lakes with additional freshwater inflows, having regard to the Basin Plan salinity targets. Assist the maintenance of Lower Lake levels above 0.4m. Manage estuarine conditions around the barrages and in the Coorong's North Lagoon. Facilitate migratory fish movement via barrage fishways.	Continuously connect the Lower Lakes, Coorong and Southern Ocean via the Murray Mouth. Coordinate the management of environmental water with barrage operation to increase the resilience of end- of-basin ecosystems. Supplement barrage flow events to enhance salt export and maintain estuarine water quality in the Coorong's North Lagoon. Provide seasonal water level variability within the Lower Lakes, and cues for migratory fish movement via flows through the barrages.	Continuously connect the Lower Lakes, Coorong and Southern Ocean via the Murray Mouth. Supplement unregulated barrage flow events to export salt from the Murray–Darling Basin and scour sediments from the Murray Mouth. Assist the maintenance and variability of Lower Lake levels to maximise ecological productivity. Provide seasonal flow variability within the Lower Lakes, and cues for migratory fish movement via flows through the barrages. Where possible, coordinate additional barrage flows to provide a suitable salinity gradient between the North and South lagoons.	Continuously connect the Lower Lakes, Coorong and Southern Ocean via the Murray Mouth. Increase barrage flow volumes to maximise salt export and the scouring of sediment from the Murray Mouth and provision of cues for migratory fish movement. Harmonise barrage releases to provide conditions conducive to high ecological productivity in the Coorong.

Guidance to achieve flows and connectivity priorities in 2019–20

The current RAS for all catchments has been classified as “very dry”, aside from Wimmera-Avoca and Loddon which have been classified as “dry”. After an incredibly hot and dry year with record breaking conditions, the focus for watering actions in all areas will be to:

- Coordinate environmental watering to increase longitudinal connectivity in connected catchments.
- Mitigate irreversible environmental impacts associated with extended drought.
- Prevent dry spell durations exceeding refuge tolerances.

In more regulated parts of the Basin, connectivity can be enhanced by augmenting and coordinating tributary flows to help in meeting downstream needs, while in less regulated areas, the focus should be on maintaining flows throughout the length of a river by protecting from re-regulation, extraction or substitution with other water. This could be achieved through rules, special arrangements, or through temporary purchases of water access licences.

Where possible, in-stream releases, or use of infrastructure could be used to extend natural events to achieve a more natural pattern of flow.

If dry conditions prevail over the coming months, it will be important to provide further replenishment flow events to maintain the integrity of refuge habitats, subject to environmental water availability.

Guidance for flows and connectivity for key priority areas (Coorong, Lower Lakes and Murray Mouth, Barwon–Darling and lower Darling, Narran Lakes and Koondrook–Perricoota Forest) identified by multiple themes can be found in the section ’Guidance to achieve priorities for sites with multiple ecological needs in 2019–20’.

Native vegetation

The Basin-wide environmental watering strategy includes expected outcomes for water-dependent vegetation in the Basin, which are plant species that require inundation for at least part of their life cycle. The goal is to maintain and improve these vegetation communities, many of which are ecologically important components in significant areas such as Ramsar wetlands.

It is important to maintain a diverse range of vegetation types and ensure plant communities across the Basin remain healthy. Plants provide shelter, habitat, food and shade for a range of animals. They are vital for nutrient cycling, improving water quality and stabilising soil and riverbanks.

Healthy floodplain forests, woodlands and wetlands rely on periods of wetting and drying to thrive. The water requirements of a plant community are determined by the timing, frequency and duration of inundation required to maintain condition, and support ongoing recruitment including the maintenance of viable seedbanks. These water requirements can vary greatly between plant community types, from core wetland areas that require almost permanent inundation, to woodlands and ephemeral wetlands higher up on the floodplain that can persist for many years without inundation.

River regulation and consumptive use have changed natural wetting and drying cycles. This affects the type, diversity and health of vegetation communities along the rivers and floodplains of the Basin.

For more information about the condition of the Basin's water-dependent native vegetation, see the Basin environmental watering outlook for 2019–20.

Rolling multi-year priorities for native vegetation

The native vegetation rolling, multi-year priorities focus on opportunities to improve the condition and extent of native vegetation. These address the expected environmental outcomes for native vegetation in the Basin-wide environmental watering strategy and are described below.

The rolling, multi-year priorities for native vegetation are to:

- *Maintain the extent, improve the condition and promote recruitment of forests and woodlands.*
- *Maintain the extent and improve the condition of lignum shrublands.*
- *Expand the extent and improve the condition of Moira grass in Barmah–Millewa Forest.*
- *Expand the extent and improve resilience of ruppia in the southern Coorong.*

Maintain the extent, improve the condition and promote recruitment of forests and woodlands

River red gum, black box and coolibah forests grow on riverbanks and floodplains, and many of these areas are of high conservation value such as Ramsar sites and national or state parks. These forests provide habitat and resources for aquatic, amphibious and terrestrial animals. They also assist with nutrient cycling within the Basin's ecosystems by contributing organic carbon into the nearby rivers.

Roots and branches of the forests' trees can provide shelter and habitat for fish and help moderate water temperature by providing shade.

Inundation requirements differ across river red gum, black box and coolibah forests. River red gum forests and woodlands growing near rivers, creeks, wetlands and lakes are widespread throughout the Basin and regular flooding is vital to maintain them. Black box is a common drought-tolerant and flood-responsive species that grows throughout the Basin. Black box generally occurs higher on the floodplain than river red gums and can source water from rainfall, floods, rivers and groundwater. Coolibah grows in the northern part of the Basin in riverine habitats and on floodplains, sourcing its water from rainfall, floods and groundwater.

This priority aims to provide water to maintain healthy forest and woodland vegetation communities, with regular recruitment supporting sustainable river red gum, black box and coolibah populations into the future.

Table 3 Rolling, multi-year priority framework for water-dependent forests and woodlands

Rolling, multi-year priority	**Maintain the extent, improve the condition and promote recruitment of forests and woodlands**				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
Basin annual environmental watering priorities	Identify critical river red gum, black box and coolibah communities to maintain condition or where saplings require water to survive. Where possible, manage or deliver water to these areas. This priority is dependent on the target species and is more critical the longer the preceding dry spell.	Identify important river red gum, black box and coolibah communities to maintain condition or where saplings require water to survive. Where possible, manage or deliver water to these areas. This priority is dependent on the target species and the condition of new recruits and is more critical the longer the preceding dry spell.	Promote growth and improve condition of desirable river red gum, black box or coolibah recruitment, where possible, to ensure their survival. Target low lying river red gum, black box and coolibah communities adjacent to rivers where water can be delivered to promote growth and improve condition.	Inundate in line with optimal duration, timing and depth to support desirable recruitment and improve condition of river red gum, black box and coolibah communities.	Support inundation in line with optimal duration, timing and depth, as required, to promote desirable recruitment and improve condition of river red gum, black box and coolibah communities.
Basin significant sites	The MDBA may identify locations/regions based on state annual environmental watering priorities, state long-term environmental watering plans, vegetation monitoring outcomes, Basin-wide environmental watering strategy, to name a few. The MDBA may stipulate environmental water requirements for these locations using information from long-term watering plans, published scientific or other government reports.				

Maintain the extent and improve the condition of lignum shrublands

Lignum grows along riverbanks, on floodplains and in wetlands across the Basin. It can grow in woodland communities or as the dominant species in shrublands. Lignum shrublands provide important habitat and resources for a range of animals, with dense, tall shrublands acting as ideal nesting and nursery habitat for many waterbird species during both wet and dry times. Lignum is also a critical component defining the ecological character of a number of the Basin's Ramsar sites.

Inundation frequency directly influences the size and condition of lignum shrublands. They can withstand extended periods without inundation, but inundation over sequential years will improve condition and growth, and facilitate recruitment.

Lignum requires periodic flooding to maintain good condition, promote growth and support reproduction. It is found in a range of habitats which means that lignum shrublands across the Basin experience a variety of inundation frequencies. For example, lignum growing in low-lying wetlands will often be inundated more frequently than those shrublands growing on higher areas of the floodplain.

Table 4 Rolling, multi-year priority framework for water-dependent lignum shrublands

Rolling, multi-year priority	*Maintain the extent and improve the condition of lignum shrublands*				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
Basin annual environmental watering priorities	Where possible, limit any loss or decline in condition of lignum shrublands. This priority is more critical the longer the preceding dry spell. Where lignum shrublands have been inundated in recent years, they are likely to be in a reasonable condition to withstand a dry period.	Where possible, limit any loss or decline in condition of lignum shrublands. This priority is more critical the longer the preceding dry spell. Where lignum shrublands have been inundated in recent years, they are likely to be in a reasonable condition to withstand a dry period.	Maintain the condition of lignum shrublands by providing inundation in line with the optimal duration, timing and depth. The necessity of this priority is more critical the longer the preceding dry spell. Where lignum shrublands have been inundated in previous years, they are likely to be in a reasonable condition to withstand a dry period.	Improve the condition of lignum shrublands by providing inundation in line with the optimal duration, timing and depth. Where lignum shrublands have been inundated in previous years, they are likely to be in a reasonable condition to withstand a dry period. The necessity of this priority is more critical the longer the preceding dry spell.	Improve the condition of lignum shrublands by providing inundation in line with the optimal duration, timing and depth. Where lignum shrublands have been inundated in previous years, they are likely to be in a reasonable condition to withstand a dry period. The necessity of this priority is more critical the longer the preceding dry spell.
Basin significant sites	Environmental water managers and planners should prioritise lignum shrublands located within the regions listed in the Basin-wide environmental watering strategy, which are: the Lower Lachlan; Lower Murrumbidgee; Lower Darling; Lower Condamine–Balonne (including Narran Lakes); Lower Gwydir; Macquarie Marshes; lower Border Rivers; and the River Murray from the junction of Wakool River to downstream of Lock 3 (including Chowilla and Hattah Lakes). The MDBA may identify locations/regions based on state annual environmental watering priorities, state long-term environmental watering plans, vegetation monitoring outcomes and the Basin-wide environmental watering strategy, to name a few.				

Expand the extent and improve the condition of Moira grass in Barmah–Millewa Forest

Moira grass is a rapidly growing, semi-aquatic grass that thrives in wetlands and floodplains. The Barmah–Millewa Forest has one of the largest inland plains of Moira grass in Australia.

These floodplain marshes act as a drought refuge in an otherwise arid to semi-arid region and support threatened species of plants and animals. The Moira grass marshes are an important part of the Barmah Forest Ramsar convention listing, bilateral migratory bird agreements including JAMBA, CAMBA, ROKAMBA, and the Bonn Convention on Migratory Species.

Moira grass requires flooding across winter and spring to promote growth. River regulation has caused a decline in the depth and duration of flooding across Barmah–Millewa Forest, which has impaired the growth and recruitment of Moira grass and caused river red gum and spiny rush to encroach onto Moira grass plains. Environmental flows are often used to mimic the natural flood regime to better meet the flow requirements of Moira grass.

There has been a continual decline in Moira grass extent; only 182 ha of Moira grass in the floodplain marshes in Barmah Forest was recorded in early 2014 (the most recent survey). Of this, only 50 ha of the monospecific swards that were a historically important part of the floodplain remain. This is about 12% of the amount recorded at the time of its Ramsar listing in 1982. The significant reduction in Moira grass is threatening the ecological character of the Barmah Forest Ramsar site.
Recent studies have also indicated that the Moira grass seedbank in Barmah–Millewa Forest is declining and is not self-sustaining. Research has shown that Moira grass may rely on the preservation and maintenance of existing rootstock and stem fragments to re-establish its population as flow conditions improve.

Expansion of Moira grass extent is likely to take several years. The current trajectory of decline indicates that without the return of a more favourable flow regime, Moira grass plains could be locally extinct within years.

In addition to ensuring an appropriate inundation frequency, securing a healthy and sustainable Moira grass population in the Barmah-Millewa Forest requires management of other threats such as impacts from feral animals, particularly horses, and the encroachment of invasive plants onto the floodplain marshlands.

Table 5 Rolling, multi-year priority framework for Moira grass in Barmah–Millewa Forest

Rolling, multi-year priority	*Expand the extent and improve the condition of Moira grass in Barmah–Millewa Forest*				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
Basin annual environmental watering priorities	Where possible, limit any loss of Moira grass extent through the operation of forest regulators. The necessity of this action will become more critical the longer the preceding dry spell.	Maintain the condition and extent of Moira grass through the operation of forest regulators. Where possible, aim to improve condition of Moira grass. This action will be more likely in a Dry RAS following Moderate to Very Wet RAS years.	Improve the condition and maintain the extent of Moira grass by providing an opportunity for growth of existing plants. Where possible, aim to increase Moira grass extent by optimising the duration and depth of inundation.	Improve the condition and extent of Moira grass by providing inundation in line with optimal duration and timing. If a flowering event occurred in the previous water year, promote seed germination if/where possible. If seed germination occurred in the previous water year, support the consolidation of growth of new plants.	Improve the condition and extent of Moira grass by providing inundation in line with optimal duration and timing. If a flowering event occurred in the previous water year, promote seed germination if/where possible. If seed germination occurred in the previous water year, support the consolidation of growth of new plants.

Expand the extent and improve resilience of ruppia tuberosa in the southern Coorong

Ruppia, a submerged aquatic plant that was once widespread along the length of the southern Coorong, is a defining component of the ecological character of the Coorong, Lake Alexandrina and Lake Albert Ramsar site. Many species in the Coorong, such as waterfowl and migratory waders, rely on the plant as a food resource. Ruppia also provides habitat for other species in the southern Coorong, such as Murray hardyhead and aquatic invertebrates.

Ruppia's water requirements vary between each stage of its life history. By late summer, ruppia persists as seeds and turions on the ephemeral mudflats on the shores of the southern Coorong. These seeds and turions germinate or sprout when the water levels rise during late autumn, and the plants continue to grow through winter. If the water levels in the southern Coorong remain adequate, the plant reproduces sexually (producing seeds) and asexually (producing turions) during spring and early summer.

The condition and extent of ruppia is influenced by a range of factors, such as water levels, water quality and the presence of filamentous algae within the Coorong. The millennium drought had a significant impact on the condition of the species, with ruppia disappearing from the southern Coorong. Although the species is showing signs of recovery, providing suitable habitat conditions and flow regimes for ruppia is essential to maintain this species that underpins the ecology of the ecosystem.

Table 6 Rolling, multi-year priority framework for ruppia in the southern Coorong

Rolling, multi-year priority	*Expand the extent and improve resilience of ruppia tuberosa in the southern Coorong*				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
Basin annual environmental watering priorities	Where possible, limit loss of ruppia extent through the delivery of freshwater through barrages. Where possible, improve water quality to maintain ruppia habitat conditions and mitigate risks to population health. The necessity of this action will become more critical the longer the preceding dry spell.	Maintain the extent of ruppia through the delivery of freshwater through barrages. Where possible, improve water quality to maintain ruppia habitat conditions and mitigate risks to population health. The necessity of this action will become more critical the longer the flows across the barrages are at lower volumes.	Maintain the extent of ruppia by providing opportunities for growth and support the completion of the plants life cycle. Where possible, promote ruppia sexual and asexual reproduction by providing inundation in line with optimal duration, timing and depth of flooding. Where possible, improve habitat conditions and salinity gradient in the Coorong to maintain ruppia condition and mitigate risks to population health. This includes considering options to manage the flow regime within the end-of-basin system to reduce the chance of filamentous algae outbreaks in the southern Coorong.	Improve the extent and support the reproduction of ruppia by providing inundation in line with optimal duration, timing and depth of flooding. This includes: Increasing inundation of mudflats over early spring. Reaching peak inundation over late spring/early summer months. Easing drawdown of water during mid-late summer. Where possible, operate barrages to enhance optimal ruppia inundation, including slowing the rate at which water levels drop over late spring and early summer. Improve habitat conditions and salinity gradient in the Coorong to maintain ruppia condition and mitigate risks to population health. This includes considering options to manage the flow regime within the end-of-basin system to reduce the chance of filamentous algae outbreaks in the southern Coorong.	Improve the extent and support the reproduction of ruppia by providing inundation in line with optimal duration, timing and depth of flooding. Where possible, operate barrages to enhance optimal ruppia inundation, including slowing the rate at which water levels drop over late spring and early summer. Where possible, improve habitat conditions and salinity gradient in the Coorong to maintain ruppia condition and mitigate risks to population health. This includes considering options to manage the flow regime within the end-of-basin system to reduce the chance of filamentous algae outbreaks in the southern Coorong.

Guidance to achieve native vegetation priorities in 2019–20

The MDBA provides the following guidance to achieve the priorities for native vegetation in 2019–20.

Provide flows to maintain core wetland areas and provide refuge habitat

Providing water to core wetland areas during dry periods will support non-woody vegetation communities, and secure refuge habitat in the drying landscape.

Where opportunity exists, flow rates that deliver water out of main channels into distributary channels and low-lying wetlands will help to support riparian forests and woodlands, and also vulnerable understorey and wetland communities.

Ensuring adequate fresh water inflows to the Coorong over the spring growing period in 2019–20 will help to provide stable conditions for flower and turion development, and maintain ruppia extent within the south lagoon.

Improve vegetation condition in areas of high habitat and conservation value

A 'very dry' RAS limits opportunity to provide flows to floodplain and wetland vegetation communities at magnitudes required to improve condition. Across much of the Basin, the management focus for vegetation communities will be on avoiding critical loss such as tree death and changes to community composition. In some areas of the southern Basin, carryover into the 2019–20 water year and limited allocation will enable environmental watering to target improvement outcomes around river channels and low-lying wetlands, such as in mid-Murray wetlands and river red gum and black box woodlands at Hattah Lakes.

Where possible, follow up watering of lignum shrublands that were inundated during 2018-19 will help to generate a growth and condition response in lignum in high value habitat areas.

Waterbirds

Waterbirds depend on rivers and wetlands to provide foraging, breeding, roosting and nesting habitat, as well as protection from predators. Waterbirds are highly mobile and can move from catchment to catchment in search of suitable conditions.

The Basin contains nearly half of all wetlands where colonial nesting waterbirds (birds that nest in large colonies) breed in Australia. The spectacular colonies and high concentrations of waterbirds on many of the Basin's wetlands were the catalyst for their nomination as wetlands of international importance under the Ramsar Convention.

Many colonial nesting waterbirds require wetlands to be flooded to initiate and complete breeding. Managers can use small volumes of environmental water to maintain the distribution, structure and health of wetland vegetation; thus ensuring that the wetland is in 'event ready' condition when larger flows arrive. As a result of river regulation, floods have become smaller and less frequent, with wetlands experiencing longer dry spells as much of the water is used for other purposes and captured in dams. Long-term surveys have shown a decline of more than 70% in the total population of waterbirds since 1983. Surveys conducted in 2016 recorded the second lowest numbers on record. Since 2016 total abundance have improved slightly but still have a long way to go, with the last six years being similar to those seen during the millennium drought.

Shorebird numbers fluctuate from year to year. These species rely on multiple international 'staging' sites during their annual migration and are highly specialised foragers, requiring exposed tidal flats for feeding opportunities. Observed long-term declines in these species' abundance could be a result of river regulation locally, but could also be due to degradation at these international 'staging' sites.

For more information about the current condition of the Basin's waterbirds, see the Basin environmental watering outlook for 2019–20.

Rolling multi-year priorities for waterbirds

The rolling, multi-year priorities for waterbirds are to:

- *Improve the abundance and maintain the diversity of the Basin's waterbird population.*
- *Maintain the abundance of key shorebird species in the Lower Lakes and Coorong.*

These priorities address the expected environmental outcomes for waterbirds in the Basin-wide environmental watering strategy.

Improve the abundance and maintain the diversity of the Basin's waterbird population

Environmental water managers should have regard to the annual priorities at Basin-significant sites identified in Table 7. Since it is difficult to predict where waterbirds will accumulate each year, how the priorities are implemented at each site will depend on how waterbirds respond to conditions. Water managers should also have regard to the 'Guidance to achieve waterbird priorities in 2019–20' section below for additional guidance to achieving these Basin annual environmental watering priorities.

Table 7 Rolling, multi-year priority framework for waterbirds

Rolling, multi-year priority	***Improve the abundance and maintain the diversity of the Basin's waterbird population***				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
Basin annual environmental watering priorities	Avoid loss of foraging and roosting habitat at refuge locations.	Maintain foraging and roosting habitat at refuge locations. Support breeding where naturally triggered.	Maintain waterbird breeding habitat in 'event ready' condition. Trigger and provide on-going support for small-scale breeding across functional groups. Support breeding where naturally triggered. Create mosaic of wetland habitats suitable for functional feeding groups.	Support breeding where naturally triggered. Create mosaic of wetland habitats suitable for functional feeding groups. Trigger and provide on-going support for small to moderate-scale breeding across functional groups.	Support breeding where naturally triggered. Create mosaic of wetland habitats suitable for functional feeding groups. Improve the opportunities for large-scale breeding for colonial nesting waterbird species.
Basin significant sites	Corop wetlands Fivebough Swamp* Lowbidgee floodplain Pyap Lagoon River Murray & Euston Lakes Upper Darling River	Barmah-Millewa* Booligal wetlands Lower Lakes, Coorong & Murray Mouth* Corop wetlands (refuge) Fivebough Swamp* (refuge) Great Cumbung Swamp	Barmah-Millewa* Booligal wetlands Lower Lakes, Coorong & Murray Mouth* Corop wetlands Great Cumbung Swamp Gunbower–-Koondrook–Perricoota* Gwydir wetlands*	Barmah-Millewa* Booligal wetlands Lower Lakes, Coorong & Murray Mouth* Corop wetlands Darling Anabranch Fivebough Swamp* Great Cumbung Swamp	Barmah-Millewa* Booligal wetlands Lower Lakes, Coorong & Murray Mouth* Corop wetlands Darling Anabranch Fivebough Swamp* Great Cumbung Swamp

Rolling, multi-year priority	***Improve the abundance and maintain the diversity of the Basin's waterbird population***				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
		Gunbower-Koondrook–Perricoota* Gwydir wetlands* Hattah Lakes* Kerang wetlands* Lake Brewster Lowbidgee floodplain (refuge) Macquarie Marshes* Narran Lakes* Pyap Lagoon (refuge) River Murray & Euston Lakes (refuge) Upper Darling River (refuge)	Hattah Lakes* Kerang wetlands* Lake Brewster Lowbidgee floodplain Macquarie Marshes* Narran Lakes* Pyap Lagoon	Gunbower–Koondrook–Perricoota* Gwydir wetlands* Hattah Lakes* Kerang wetlands* Lake Brewster Lake Buloke Lindsay–Walpolla–Chowilla* Lowbidgee floodplain Macquarie Marshes* Narran Lakes* Pyap Lagoon River Murray & Euston Lakes	Gunbower–Koondrook–Perricoota* Gwydir wetlands* Hattah Lakes* Kerang wetlands* Lake Brewster Lake Buloke Lindsay–Walpolla–Chowilla* Lowbidgee floodplain Macquarie Marshes* Narran Lakes* Pyap Lagoon River Murray & Euston Lakes

*Denotes Basin significant waterbird sites that can be managed for environmental outcomes which are also classified as Ramsar sites.

Maintain the abundance of key shorebird species in the Lower Lakes and Coorong

This rolling, multi-year priority aims to address the expected environmental outcome for migratory shorebirds in the Basin-wide environmental watering strategy as follows:

By 2019, at a minimum, to maintain populations of the following four key species: curlew sandpiper, greenshank, red-necked stint and sharp-tailed sandpiper, at levels recorded between 2000 and 2014.

Initial analysis of data for the four key shorebird species indicates that the long-term average (2000 to 2019) of the four species is largely maintained at levels seen between 2000 and 2014. However, since 2014 the average abundance of curlew sandpipers and common greenshank have dropped while abundance of red-necked stint and sharp-tailed sandpiper have largely been maintained. Interestingly, while, on average, abundance of red-necked stint and sharp-tailed sandpiper has been maintained since 2014, both species also recorded their lowest numbers during this period (Figure 6).

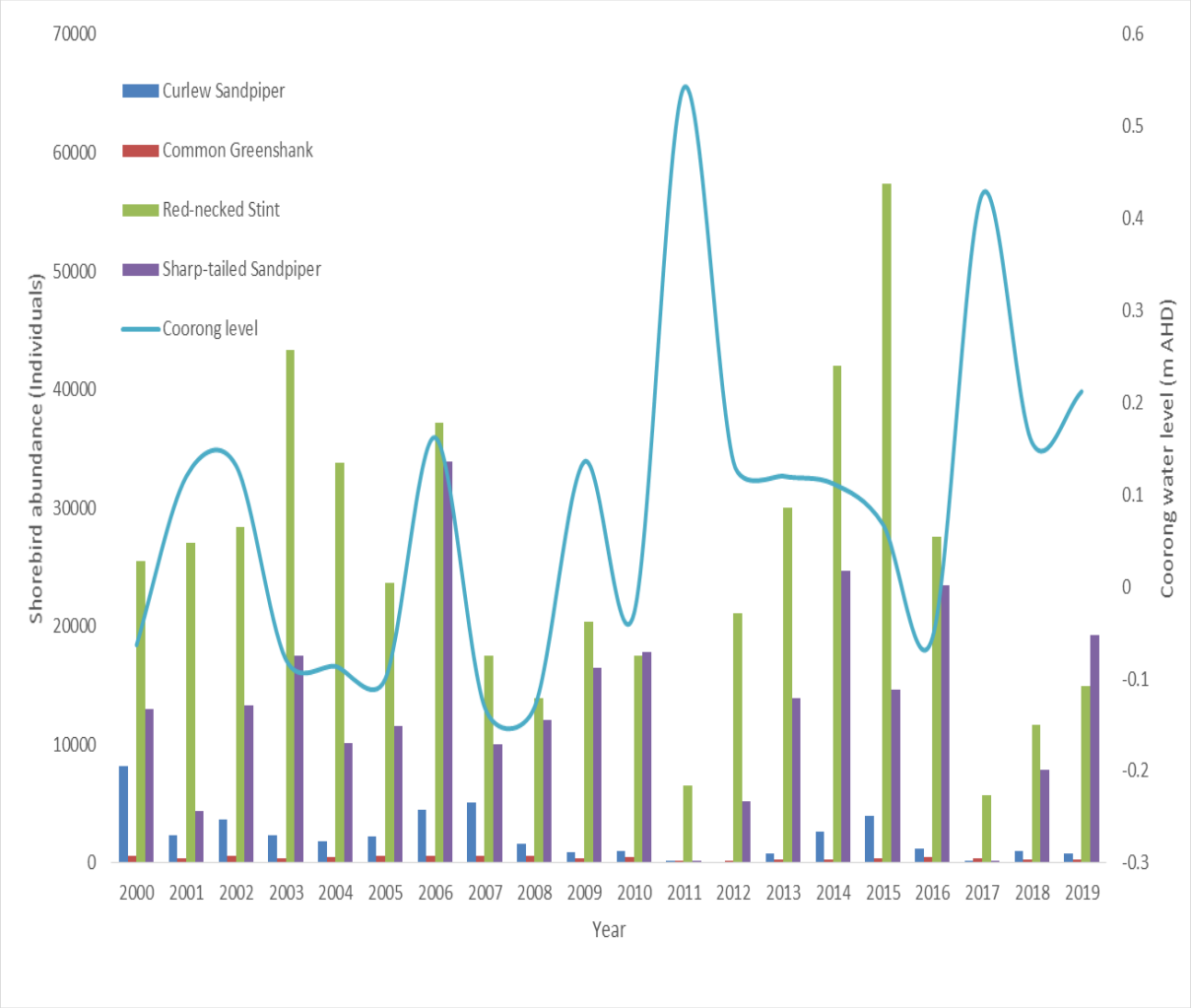

Figure 6: Abundance of four shorebird species (Curlew sandpiper, Common Greenshank, Red-necked stint and Sharp-tailed sandpiper) and Coorong water level at Coorong over the period of 2000 to 2019.

Environmental water managers should continue to work towards this target by having regard to the annual priorities for the Lower Lakes and Coorong identified in Table 8. Water managers should also have regard to the 'Guidance to achieve waterbird priorities in 2019–20' section below for additional guidance to achieving these Basin annual watering priorities for migratory shorebirds, as well as the multi-theme guidance for the Coorong, Lower Lakes and Murray Mouth.

Table 8 Rolling, multi-year priority framework for key shorebird species in the Lower Lakes and Coorong

Rolling, multi-year priority	***Maintain the abundance of key shorebird species in the Lower Lakes and Coorong***				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
Basin annual environmental watering priorities	Avoid loss of foraging and roosting habitat at key refuge locations. Where possible manage algal blooms and water quality at key foraging sites.	Maintain foraging and roosting habitat at refuge locations. Support breeding of resident shorebirds where naturally triggered (i.e. maintain isolation from predators). Manage algal blooms and water quality at key foraging sites.	Build productivity of foraging habitat for summer. Support breeding of resident shorebirds where naturally triggered (i.e. maintain isolation from predators). Manage algal blooms and water quality at key foraging sites.	Build productivity of foraging habitat for summer. Actively maximise shorebird access to foraging habitat during summer. Support breeding of resident shorebirds where naturally triggered (i.e. maintain isolation from predators). Create mosaic of wetland habitats suitable for shorebirds.	Where possible actively maximise shorebird access to foraging habitat during summer. Support breeding of resident shorebirds where naturally triggered (i.e. maintain isolation from predators). Create a mosaic of wetland habitats suitable for shorebirds.

Guidance to achieve waterbird priorities in 2019–20

The MDBA provides the following guidance to achieve the priorities for waterbirds in 2019–20.

Provide flows to maintain and where possible improve habitat and support waterbird breeding where naturally triggered

In addition to the priorities set out in Table 7, water managers should be aware that two of the Basin-significant sites listed in Table 7 have been identified as being in urgent need of environmental water for the 2019–20 water year based on the environmental watering requirements to support waterbirds. Those sites are:

- Narran Lakes
- Koondrook–Perricoota Forest

The Coorong and Lower Lakes has also been identified as important for waterbirds in 2019 given waterbird breeding occurred in 2018. Watering to provide foraging and roosting habitat to support recruitment should be considered. For Narran Lakes this will be difficult, as environmental water cannot be ordered from storage, but relies on a natural event to trigger access arrangements.

These sites have also been identified as priorities for other themes. For further detail, refer to 'Guidance to achieve priorities for sites with multiple ecological needs in 2019–20'.

Maximise availability of productive foraging habitat for shorebirds

To help achieve the Basin annual watering priorities for shorebirds outlined in Table 8, water managers should aim to maximise the availability of productive foraging habitat for shorebirds at key refuge sites across the Basin and at the Lower Lakes and Coorong. To achieve outcomes in the Lower Lakes and Coorong, watering actions need to take into account other Basin annual environmental watering priorities. Refer to the guidance for the Coorong, Lower Lakes and Murray Mouth for further detail.

Native fish

The Basin has more than 60 species of native fish, including freshwater, estuarine, and those that move between the river and the sea. Many of these species are unique to the Basin. Native fish are a key part of river and wetland ecosystems and can be an important part of the ecological character of Basin Ramsar sites.

The condition of native fish in the Basin remains poor. Basin-wide populations of native fish were estimated to be around 10% of pre-European settlement in 2003. Since that time, some localised improvements have been made, however there is little evidence to suggest that Basin-wide populations have improved.

Many of the short-lived species listed in the Basin-wide environmental watering strategy have not been regularly found in annual Basin-wide surveys, and are not widespread. Many of the local populations of short-lived native fish species are under pressure in the northern Basin, for example olive perchlet and purple-spotted gudgeon in catchments experiencing extreme drought and very low flows. In the southern Basin, extensive surveys in the Lower Lakes in South Australia have failed to detect Yarra pygmy perch. However, it is also recognised that where water has been delivered in the past, key species, both small and large-bodied, have benefitted from improved flows and greater access to habitat.

The fish deaths that have recently occurred at a number of locations throughout the Basin highlight the challenging conditions currently influencing native fish. Watering actions that have regard to the Basin annual environmental watering priorities will contribute to the long-term protection and restoration of native fish populations in affected areas.

For more information about the current condition of the Basin's native fish, see the Basin environmental watering outlook for 2019–20.

Rolling multi-year priorities for native fish

To achieve the expected environmental outcomes for key native fish species in the Basin-wide environmental watering strategy, a variety of flow regimes that improve fish habitats and allow fish to complete their life cycles are needed.

The rolling, multi-year priorities for native fish identify flow needs based on current understanding of fish habitat, recruitment and movement needs. Outcomes can be achieved using consumptive and operational water as well as environmental water.

Coordinated management actions can help to address the needs of native fish across catchment boundaries. For example, the Northern Connectivity Event of 2018 showed how coordinated management can help to address some of the needs of native fish. Coordinated actions in the River Murray system in 2018 supported lamprey migration and black bream recruitment. More recently the CEWH in partnership with the NSW Office of Environment and Heritage and other NSW agencies is releasing water for the environment from April to June 2019 to replenish critical waterholes and provide significant support for five endangered native fish in the northern river systems. Governments, local councils, irrigators, Aboriginal communities and landholders have worked together to allow these flows to occur. The rolling, multi-year priorities for native fish are to:

- *Support Basin-scale population recovery of native fish by reinstating flows that promote key ecological processes across local, regional and system scales in the southern connected Basin.*
- *Improve flow regimes and connectivity in northern Basin rivers to support native fish populations across local, regional and system scales.*
- *Support viable populations of threatened native fish, maximise opportunities for range expansion and establish new* populations*.*

Each rolling, multi-year priority has annual environmental priorities that vary according to the RAS as shown in Tables 10, 11 and 12. Some of these actions are similar across the three multi-year priorities as many species of fish occur in both the northern and southern Basin and are also classified as threatened species. Likewise, many of the actions required by these species are similar, particularly those species that inhabit the main channels and anabranches.

Natural flow events can occur under any RAS and can rapidly change conditions. Opportunities for recruitment and subsequent dispersal of native species that these types of events bring should be capitalised upon under any scenario. These priorities are shown in the tables below as suitable under all scenarios.

Support Basin-scale population recovery of native fish by reinstating flows that promote key ecological processes across local, regional and system scales in the southern connected Basin

This priority focuses on providing a suitable flow regime for species that live, and respond to flows, in river channels and anabranches in the southern connected Basin. By coordinating and linking flows in different rivers, and providing connectivity through the system to the estuary, recruitment processes that have been interrupted by historical river management can be improved. Flows that support recruitment processes can also provide food, habitat, and connectivity between habitats. This will promote population recovery of native fish, including the target species of silver perch (listed as Critically Endangered under the *Environment Protection and Biodiversity Conservation (EPBC) Act*, golden perch, Murray cod (listed as Vulnerable under the EPBC Act) and lamprey over the long term.

The following flow components are the focus of this priority:

- end-of-system flows through the barrage fishways and the barrages
- winter flows for habitat, and connectivity between habitats within channels
- flows that support breeding activity in spring
- flows that support dispersal movements in spring, summer and autumn.

To achieve population recovery, each of the target fish species has specific recruitment and flow needs, as outlined in Table 9 and in further detail in *Towards a southern connected Basin flow plan: connecting rivers to recover native fish communities* . For information on the specific flow needs for 2019–20, refer to the annual guidance below.

Table 9 Species-specific objectives and flow needs to achieve the multi-year priority for the southern connected Basin

Species	Recruitment Objectives	Flow needs
Murray cod	Support local recruitment in the main channel of the River Murray and lower Darling River, and regulated anabranches and tributaries.	Perennial base flows in anabranches and tributaries Spring rise in anabranches and tributaries Reduced unnatural variability and maintaining levels in anabranches and tributaries
Silver perch and golden perch	Support annual system-scale recruitment in the mid-Murray. Support local recruitment in the lower River Murray, lower Darling River, tributaries and anabranches. Promote movement and dispersal, particularly of juveniles, into tributaries and anabranches.	Perennial base flows in anabranches and tributaries Spring rise in main river channels Variable flow in main river channels Transmission of flow pulses through the system to allow for egg and larvae drift in spring and summer Flows that provide connectivity to off stream nursery habitat In-channel dispersal flows in spring, summer and autumn throughout the system
Golden perch	Capitalise on episodic system-scale recruitment from the Darling River.	Connectivity between systems for egg and larvae drift Transmission of flow through the system for egg and larvae drift in the Barwon–Darling system Following recruitment events in the Menindee Lakes, provide in-channel dispersal flows from Menindee Lakes into the lower Darling and River Murray system
Short-headed and pouched lamprey	Support system-scale migrations of lamprey from the ocean, through the estuary and into the River Murray to upstream breeding grounds.	End-of-system flows to the Murray River estuary Flow integrity in the lower Murray In-channel dispersal flows throughout the system

Table 10 Rolling, multi-year prioritiy framework for population recovery of native fish in the southern connected Basin

Rolling, multi-year priority	**Support Basin-scale population recovery of native fish by reinstating flows that promote key ecological processes across local, regional and system scales in the southern connected Basin**				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
Basin annual environmental watering priorities	Provide base flows, low flows and small freshes. Maintain refuge waterholes to support key populations of native fish. Provide flows through barrage fishways in winter and spring.	Provide base flows, low flows and small freshes; and medium freshes with peak. Provide flows through barrage fishways all year round. Provide flows through barrages when possible.	Provide medium freshes with peak; large freshes; and hydrological connectivity between systems. Provide flows through barrage fishways all year round. Provide flows through barrages during spring.	Provide medium freshes with peak; large freshes; and hydrological connectivity between systems. Provide flows through barrage fishways all year round. Provide flows through barrages through spring to autumn.	Provide overbank flows (expected rather than targeted); and hydrological connection between systems. Provide flows through barrages year round.
	Support system-scale migrations of golden perch, silver perch and lamprey Maintain the integrity of spawning flow pulses through the system to allow eggs and larvae to drift uninterrupted Provide opportunities for young golden perch and silver perch to disperse following episodic system-scale recruitment events Increase flow connections between major rivers and their tributaries and anabranches to promote movement and dispersal Provide flows that protect ecologically important populations of native fish				

Improve flow regimes and connectivity in northern Basin rivers to support native fish populations across local, regional and system scales

This priority aims to improve native fish populations in the northern Basin by providing suitable flow regimes and increasing connectivity within and between river systems. This will improve recruitment and spawning of native fish within individual catchments and dispersal into the connected northern and southern catchments.

The flow regime of the northern Basin rivers is variable. Recently, the flow regime has considerably changed, with an increasing number of cease-to-flow events and corresponding shorter periods when flows do occur.

Recent analysis of historical flows found a high number of cease-to-flow events in recent years. In addition, flow events that break cease-to-flow conditions historically had multiple flow peaks (typically a small fresh followed closely by a large fresh). More recently, events that break cease-to-flow conditions have had lower total volume and continue to reduce in volume further downstream as water is adsorbed by the dry river bed which, while achieving ecological outcomes, making these events less effective for the environment.

The changes to the historic flow regime are a contributing factor in the decline of the ecological health of the Barwon–Darling and resulting degradation of native fish communities. The northern Basin contains a number of large unregulated systems, limiting the ability to actively manage and deliver water. This makes protecting environmental flows an important management tool.

This priority has three key focus areas, outlined below.

Increase the frequency of flow types necessary to support native fish

The flow regime is comprised of a range 'flow types' that include cease to flows, base flows, freshes, bankfull and overbank flows each of which have the capacity to influence native fish populations.

Each flow type provides a range of functions and benefits for native fish communities. These different flows can maintain water quality, increase movement opportunities and improve access to in-channel habitats like snags. Freshes that inundate river benches and backwaters enable regular inputs of nutrients, supporting productivity and food webs. Higher flows provide energy boosts that drive the ecology of the Barwon–Darling.

Ideally, base flows and low flows would occur in almost all years, preferably between spring and autumn. These flows maintain in-channel habitat, provide drought refuges and maintain water quality. Low flows also allow fish to move between refuge habitats and can inundate snags and benches, providing habitat and food resources, as well as nesting habitat for some species including Murray cod. Small and medium freshes can support recruitment of some species and increase available habitat and productivity, improving recruitment outcomes. Small and medium freshes would ideally occur at least once a year in most years, although the past decade has seen very few of these flows in many northern Basin systems.

Management of held environmental water, stock and domestic flows, and protection of natural flows are all options that can be explored to deliver these flow types at appropriate times.

The larger freshes and overbank flows tend to be natural events that require protection, rather than delivered from storages. These flows have major recruitment outcomes and trigger system-scale fish movements. The frequency of these events is quite low, but their ecological significance is high.

Protect natural recruitment flows to boost native fish populations

Flow events that occur in the northern Basin are crucial for native fish in the Barwon–Darling and connected tributaries. These flows can originate in the upper parts of the system, for example the Border Rivers, and then flow through the Barwon–Darling River. These types of flow events inundate suitable spawning and recruitment habitat, allow for connectivity, with some of the larger fresh events over-topping weirs and providing greater opportunities for fish to move, and can lead to large recruitment events, either localised within the valley or across a northern connected system.

The integrity of these larger flows should be maintained. For some species (e.g. golden perch) this would promote uninterrupted development of eggs, larvae and juvenile fish down the Barwon–Darling and dispersal into nursery habitat in the lower Darling and Menindee Lakes system.

Ensuring Barwon–Darling River flows are sufficient to maintain adequate water quality and water levels, particularly in the lower Darling River and Menindee Lakes, will also boost young fish survival and growth. Once developed, dispersal of young fish from this region into the southern connected Basin and northern catchments can occur under the right conditions.

Increase flow connections between the Barwon–Darling and its tributaries

There are benefits for native fish by connecting the Barwon–Darling and its tributaries on a smaller scale. Connected river flows promote the exchange of fish, other biota and nutrients between systems. Connecting tributaries promotes the movement of native fish, particularly of juvenile and sub-adult golden perch, Murray cod and silver perch into tributary habitats, boosting resident populations.

For more information on the specific flow needs for 2019–20, refer to the annual guidance below.

Table 11 Rolling, multi-year prioritiy framework for flow regimes and connectivity in northern Basin rivers to support native fish populations

Rolling, multi-year priorities	**Improve flow regimes and connectivity in northern Basin rivers to support native fish populations across local, regional and system scales**				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
Basin annual environmental watering priorities	Maintain refuge waterholes to support key populations of native fish. Provide base flows which support hydrological connectivity within systems and minimise cease to flow events.	Provide flows that maintain existing populations. Provide base flows, low flows and small freshes which support hydrological connectivity within and between systems.	Provide flows that support connectivity among populations and chances for fish to disperse. Provide small freshes and medium freshes, and support hydrological connectivity within and between systems.	Provide flows that assist in the broad-scale dispersal of fish across all life history stages into new habitats. Provide medium and large freshes and support hydrological connectivity within systems, between systems, and along the length of the Barwon–Darling and into the Menindee Lakes.	Provide flows that assist in the broad-scale dispersal of fish across all life history stages into new habitats. Protect overbank flows and support hydrological connection within and between systems, especially into the Menindee Lakes (to support the needs of the Lower Darling).
	Support system-scale migrations of golden perch and silver perch Maintain the integrity of spawning flow pulses through the system to allow eggs and larvae to drift uninterrupted Provide opportunities for young golden perch and silver perch to disperse following episodic system-scale recruitment events Increase flow connections between major rivers and their tributaries and anabranches to promote movement and dispersal				

Support viable populations of threatened native fish, maximise opportunities for range expansion and establish new populations

This priority seeks to improve the long-term viability of threatened native fish in the Basin. Actions will be needed over several years, complemented by non-flow measures, to maximise opportunities for threatened species. Achieving this priority will help to meet the long-term outcome sought for threatened fish in the Basin-wide environmental watering strategy.

The focus for managing threatened species is to first protect remaining populations and then increase the areas they occupy. This will reduce the risk of populations going extinct. Boosting threatened fish numbers and increasing the number of locations in which they occur during moderate to wet times builds resilience against potential losses in dry or very dry conditions.

The long-term goal for many threatened fish is to reinstate a network of populations that can connect with each other through flows, and disperse and colonise habitat more regularly. Over time, increased ranges will allow river flows to reconnect populations in the Basin more regularly, building more resilient populations.

To increase the area that threatened species occupy and to build fish populations, a number of steps can be taken in a process that spans multiple years:

- Protect and boost key source populations.
- Support surrogate sites and populations that can start new permanent populations.
- Identify and prepare sites to establish permanent populations.
- Support fish stocked into reintroduction sites and secure their long-term future.

In dry or very dry conditions, the main focus should be on actions that protect refuges, maintain river connectivity and secure water supply to key populations isolated from river channels. Flows can be provided to ensure that essential functions, such as food production and recruitment cues, can be met as well as allowing localised movements to occur.

Some breeding opportunities can also be supported under drier conditions. Short-lived species are particularly vulnerable because of their short lifespans and need for regular (in some cases annual) spawning and recruitment. They are a high priority, particularly under very dry or dry conditions. Opportunities to expand populations or establish new populations are less likely under drier conditions but some opportunities may arise. Establishing and maintaining surrogate populations will also be necessary under very dry conditions.

Moderate and wet to very wet conditions enable more actions to be taken for a greater range of species and sites. This includes more opportunities to provide and protect suitable flow conditions for expanding species' range and establishing new populations. Greater movement opportunities arise under these conditions including promoting long-distance movements for some species, migration and dispersal. Lateral connectivity, including follow-up connections to allow fish to exit off-channel habitats and for dispersal of offspring, is also a key action under these scenarios.

Table 12 Rolling, multi-year priority framework for threatened native fish.

Rolling, multi-year priorities	**Support viable populations of threatened native fish, maximise opportunities for range expansion and establish new populations**				
Resource availability scenario	Very dry	Dry	Moderate	Wet	Very wet
Basin annual environmental watering priorities	Provide flows to protect critical populations of threatened small-bodied fish. Maintain refuge waterholes to support key populations of native fish. Provide base flows which support hydrological connectivity within systems and minimise cease to flow events.	Provide flows that protect existing populations of threatened small-bodied fish. Provide base flows, low flows and small freshes which support hydrological connectivity within and between systems.	Provide flows that expand existing populations of threatened small-bodied fish; and prepare new reintroduction sites. Provide medium freshes with peak; large freshes; and hydrological connectivity within and between systems.	Provide flows that expand existing populations of threatened small-bodied fish; and create new reintroduction sites. Provide medium freshes with peak; large freshes; and hydrological connectivity within and between systems.	Provide flows that assist in the dispersal of threatened small-bodied fish into new habitats. Provide overbank flows (expected rather than targeted); and hydrological connection within and between systems.
	Maintain the integrity of spawning flow pulses through the system to allow eggs and larvae to drift uninterrupted Provide opportunities for young fish to disperse following recruitment events Increase flow connections between major rivers and their tributaries and anabranches to promote movement and dispersal Provide flows that protect ecologically important populations of native fish				

Guidance to achieve native fish priorities in 2019–20

The MDBA provides the following guidance to achieve the priorities for native fish in 2019–20.

Support, and where possible, build upon populations of large-bodied native fish species in the southern connected Basin

The regulated conditions in the southern connected Basin provide reasonable, but not ideal, habitat for most of the large-bodied species that live in the main river channels. Native fish in the southern connected Basin may be under less pressure due to dry conditions than those in the northern Basin. However, the highly regulated conditions in the southern Basin are not suitable for regular recruitment, meaning that southern Basin populations are struggling over the long-term.

The availability of held environmental water in the southern connected Basin presents a number of opportunities to support, and in some cases build upon, the populations of large-bodied species targeted by this priority. In some cases flow cues can be provided by regular operations, for example spawning cues for silver perch in the mid-Murray, while some other actions may require only small amounts of environmental water in-channel. In the southern connected Basin there will be opportunities upon which to build, regardless of the RAS.

To support survival and recruitment of these important species in 2019–20, the following actions should be considered:

- Provide base flows in anabranches and tributaries over winter and early spring to create sufficient habitat for adult and young Murray cod, golden perch, silver perch and trout cod (where they occur) to co-exist.
- Provide in-channel pulses to cue spawning and flow integrity to allow eggs and larvae to be transported downstream.
- Support system-scale migrations of golden perch and silver perch.
- Provide opportunities for young golden perch and silver perch to disperse.
- Support upstream migrations of lamprey by providing flows through barrage fishways during winter and early spring.
- Provide flows that protect ecologically-important populations (for example, the lower Darling River).

Further information on the delivery of flows for fish in the southern connected basin can be found in *Towards a southern connected Basin flow plan: connecting rivers to recover native fish communities*.

Protect critical populations and habitats and improve connectivity in northern Basin rivers to support native fish populations

No-flow conditions in some parts of the northern Basin were temporarily alleviated during late April to June 2019. Initially, these flows were the result of rainfall events, providing short periods of high flow in the Border Rivers, Namoi, Macquarie–Castlereagh, and Warrego catchments. These flows were sufficient to provide brief periods of connection to the Barwon–Darling River.

Environmental flows were also released in mid-April from regulated tributaries – the Border Rivers and the Gwydir River. Over 1,000 km of river habitat will benefit from these flows along the Dumaresq, Macintyre, Gwydir, Mehi and Barwon rivers.

The natural flows have replenished waterholes and provided movement opportunities for native fish species. While these movements are likely to be localised in the Namoi system, the larger flows in the Macquarie–Castlereagh and the Warrego have the potential to result in recruitment of some species, particularly golden perch and Murray cod.

The environmental flows replenished key waterhole refuges for native fish along the Barwon River to the junction of the Barwon and Macquarie rivers, providing significant support for native fish, including Murray cod, silver perch and eel-tailed catfish, which are struggling in the dry conditions.

Key outcomes being sought in 2019–20 in the northern Basin include:

- protecting critical populations in systems where natural and managed flows have not been delivered
- base flows or low flows to restore and replenish waterhole refuges in all northern systems
- whole-of-river flow connectivity for the Barwon–Darling, building upon the current flows in the northern Basin and protecting any further events that may provide flows through to the Menindee Lakes
- follow up flows that provide connectivity between the Warrego and the Barwon–Darling rivers to disperse new recruits, thereby supporting system-scale recruitment of species such as golden perch.

Managed environmental flows may again be required (subject to water availability) if the length of cease-to-flow periods return to the critical levels observed in the recent past. Particularly if current flows are insufficient to break the extended cease-to-flow event below Brewarrina.

Natural flow events in the Barwon–Darling system, including the tributaries, can rapidly change conditions. Flow planning and management should look to build upon opportunities for recruitment and subsequent dispersal of native species as outlined above.

Maintain and improve existing populations of threatened native fish

Almost half of the native fish species in the Murray–Darling Basin are of conservation concern (for a comprehensive list, refer to Appendix 6 of the Basin-wide Environmental Watering Strategy). Several of these threatened fish species have either not been detected or have been detected in low numbers over the past few years. This includes (status in parentheses): purple-spotted gudgeon (Vulnerable under EPBC Act); flathead galaxias (Critically Endangered under EPBC Act); Yarra pygmy perch (Vulnerable under EPBC Act); olive perchlet (Endangered population (western NSW) under NSW Fisheries Management Act); and Rendahl's tandan. Environmental watering, alongside other measures, is a key action to improve outcomes for threatened fish as has been demonstrated by reintroductions of Murray hardyhead into selected wetlands in north-west Victoria, SA and NSW.

In the Lower Lakes, intensive sampling has been undertaken in known Yarra pygmy perch habitat and likely suitable habitat. Despite this effort, no Yarra pygmy perch have been detected, leading to serious concerns about its conservation status in the Basin.

The anticipated RAS across the majority of catchments means that the highest priority for water managers is to focus on protecting existing populations.

Water managers can support a range of actions, alongside non-flow measures, to maintain and improve existing populations of threatened fish. This can be done by protecting or providing flows that:

- drive ecosystem processes that underpin populations, such as food production and maintain suitable water quality
- maintain and enhance instream habitats and refuges
- create connectivity between key areas to protect existing populations
- rovide conditions for successful recruitment of annual species where they occur
- protect populations and support successful recruitment of threatened fish in unregulated systems.

Appendix 1: Seasonal conditions

One of the key steps in developing the environmental watering priorities is determining the water resource availability scenario (RAS). The MDBA calculates the RAS using the *Guidelines for the method to determine priorities for applying environmental water.* The calculation is based on indicators of antecedent climate conditions over the previous year (rainfall, runoff and soil moisture) and surface water availability in public dams of regulated systems. Table 13 Antecedent climate conditions and water storage levels for the catchments of the Murray–Darling Basin for the year to 1 April 2019

Catchment[2] (Regulated = R; Unregulated = Unreg[3])	Precipitation	Root zone soil moisture	Runoff	Antecedent %ile range	Surface water %ile	Resource Availability Scenario
Border Rivers (R)	0–15%	0–15%	0–15%	0–15%	0–15%	Very dry
Gwydir (R)	0–15%	0–15%	0–15%	0–15%	16–45%	Very dry
Namoi (R)	0–15%	0–15%	0–15%	0–15%	0–15%	Very dry
Macquarie–Castlereagh (R)	16–45%	0–15%	16–45%	0–15% to 16–45%	16–45%	Very dry
Lachlan (R)	16–45%	0–15%	16–45%	0–15% to 16–45%	16–45%	Very dry
Murrumbidgee (R)	0–15%	0–15%	0–15%	0–15%	16–45%	Very dry
Lower Darling (R)	0–15%	0–15%	16–45%	0–15% to 16–45%	0–15%	Very dry
Murray (R)	0–15%	0–15%	0–15%	0–15%	16–45%	Very dry
Loddon (R)	16–45%	16–45%	16–45%	16–45%	16–45%	Dry
Campaspe (R)	16–45%	16–45%	0–15%	0–15% to 16–45%	16–45%	Very dry
Goulburn–Broken (R)	0–15%	0–15%	0–15%	0–15%	16–45%	Very dry
Wimmera–Avoca (UnReg)	16–45%	16–45%	46–60%	16–45% to 46–60%	N/A	Dry
Moonie (UnReg)	0–15%	0–15%	16–45%	0–15% to 16–45%	N/A	Very dry

Catchment[2] (Regulated = R; Unregulated = Unreg[3])	Precipitation	Root zone soil moisture	Runoff	Antecedent %ile range	Surface water %ile	Resource Availability Scenario
Barwon–Darling[4] (UnReg)	0–15%	0–15%	16–45%	0–15% to 16–45%	N/A	Very dry
Condamine–Balonne (UnReg)	0–15%	0–15%	0–15%	0–15%	N/A	Very dry
Paroo (UnReg)	0–15%	0–15%	0–15%	0–15%	N/A	Very dry
Warrego (UnReg)	0–15%	0–15%	16–45%	0–15% to 16–45%	N/A	Very dry
Ovens (UnReg)	16–45%	0–15%	16–45%	0–15% to 16–45%	N/A	Very dry
Eastern Mt Lofty Ranges (UnReg)	0–15%	0–15%	16–45%	0–15% to 16–45%	N/A	Very dry

[1] The method for calculating the water resource availability scenario (RAS) is set out in the *Guidelines for the method to determine priorities for applying environmental water* (MDBA 2012): https://www.legislation.gov.au/Details/F2012L02240/4fdd68b4-f6f1-4fed-978d-29e06bb8b525

[2] Based on the best quality data available at the time of writing for public water storages in the Basin. Private water storages have not been included in calculation of the RAS.

[3] For unregulated catchments only antecedent climate conditions can be applied to determine the RAS given these catchments either do not have public water storages or have only small water storages that are unlikely to play a role in environmental watering.

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