Achievement of environmental outcomes in northern Victoria's waterways

Report to meet Murray-Darling Basin Plan Schedule 12 Matter 8 obligations

October 2020

VICTORIA State Government | Environment, Land, Water and Planning

Photo credit
Campaspe River, DELWP.

Acknowledgment

We acknowledge and respect Victorian Traditional Owners as the original custodians of Victoria's land and waters, their unique ability to care for Country and deep spiritual connection to it. We honour Elders past and present whose knowledge and wisdom has ensured the continuation of culture and traditional practices.

We are committed to genuinely partner, and meaningfully engage, with Victoria's Traditional Owners and Aboriginal communities to support the protection of Country, the maintenance of spiritual and cultural practices and their broader aspirations in the 21st century and beyond.

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1. Introduction

The Murray-Darling Basin ('the Basin' or MDB) is of significant environmental, social, cultural and economic value. The environmental values of the Murray-Darling Basin have suffered due to increasing amounts of water being extracted for consumptive uses. In 2012, the Commonwealth Government established the Murray-Darling Basin Plan ('Basin Plan', Commonwealth of Australia 2012) to improve the health of the Basin, while balancing social and economic needs. A key part of the Basin Plan is the recovery of 2,750 gigalitres (GL) of water (long term annual average) to benefit the environment, including native fish, birds and vegetation, and support ecological functions.

The additional water made available for the environment under the Basin Plan has started to provide new opportunities to preserve, restore and maintain high value ecosystems throughout northern Victoria. This water for the environment (referred to as 'environmental water' hereafter) aims to restore and improve the resilience of rivers, wetlands and floodplains; connect rivers to their floodplains and the sea; improve the health of fish, birds and vegetation populations; and keep water quality fit for environmental use.

As part of the obligations under the Basin Plan, Basin States (South Australia, Victoria, New South Wales and Queensland) must report on "*the achievement of environmental outcomes at an asset scale*" (i.e. at rivers, wetlands, floodplains) beginning in 2020 and every five years thereafter (Schedule 12, Matter 8). To demonstrate these outcomes, the results of Victoria's environmental water monitoring programs at priority assets have been considered in the context of Basin Plan Chapter 8 objectives in this report. These objectives can be grouped into protection and restoration of:

- water dependent ecosystems, including their biodiversity, native species and communities and to support their life cycles;
- ecosystem functions, including connectivity within and between water dependent ecosystems, and flow components to maintain populations (for example recruitment, regeneration and movement); and
- ecosystem resilience to climate change, including mitigation of impacts from change to water regimes, and other risks and threats.

Victoria's monitoring program themes are aligned with those of the Basin-wide environmental watering strategy (MDBA 2014 and 2019) and include:

- connectivity (through flows);
- vegetation condition and extent;
- waterbird breeding and diversity; and
- fish distribution, breeding, abundance and movement.

The purpose of this report is to:

- provide an overview of the achievement of environmental outcomes at the asset scale in the Victorian MDB since Basin Plan implementation (2012);
- describe ecological responses and outcomes, for fish, waterbirds, vegetation, frogs and connectivity, that contribute to achieving Basin Plan objectives; and
- highlight the different contexts in which environmental water is delivered in Victoria's MDB waterways and demonstrate learnings and successes from these efforts through case studies.

2. Victorian approach and context to Matter 8

Victoria has made good progress on water recovery, having recovered over 800 GL of the 1,075 GL target to date. For several years, Victoria has regulated and monitored water diversions through its compliance systems and under the cap on diversions. The cap system was replaced in 2019 when the Basin Plan's new system of sustainable diversion limits (SDLs) came into effect. These SDLs establish the average annual amount of water that can be taken from the rivers for towns, industries and farmers in the Murray–Darling Basin.

It will take time to realise the full environmental benefits from water recovery efforts. Nevertheless, early responses from the use of this water are evident. In Victoria, environmental water recovery, planning and delivery is part of a broader, long-term effort to improve waterway health which includes an ongoing investment in environmental works and complementary measures. These works are critical to optimise the benefits from environmental water and improve waterway health.

Environmental works include infrastructure, such as channels, regulators, levee banks and pumps, that are used to deliver water to wetlands and floodplains to provide the right timing, frequency and duration of inundation needed by water-dependent native plants and wildlife. Complementary measures do not deliver water but address other issues to make sure that the environmental benefits can be achieved. These include fishways to help fish move past barriers such as weirs; habitat restoration such as returning woody debris (snags) to rivers to improve instream habitat; revegetation along waterways and fencing to exclude livestock; pest plant and animal control; native fish stocking, and sustainable irrigation programs help maintain healthy catchments.

2.1 Victorian assets (waterways)

The Victorian Murray-Darling Basin has a large diversity of environmental assets, ranging from open water lakes, to river red gum forests, wetlands and lignum shrublands. These assets provide habitat for a range of native species, including many protected under international treaties[1] and listed as threatened under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or Victoria's *Flora and Fauna Guarantee Act 1988* (FFG Act). Important ecosystem functions (e.g. feeding, nesting, reproduction, roosting) are also supported.

This report focuses on 47 priority environmental assets (waterways, including rivers and creeks, floodplains and wetlands) where environmental water can be delivered, and monitoring data is available. These sites are monitored due to their ecological importance, their role in maintaining biological diversity and, for some sites, recognition under the International Convention on Wetlands (Ramsar, 1971).

2.2 Victorian approach, data and analysis

The Basin Plan requires outcomes at the asset scale to be reported every five years. As 2020 is the first time Matter 8 reporting has been undertaken, this report aims to demonstrate achievement of environmental outcomes since the start of the Basin Plan in 2012 (i.e. over an eight-year period), noting that the new SDLs have only been in effect since 1 July 2019.

The report uses data and information from four ecological monitoring programs at priority assets, including:

- the Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP), which focuses on rivers;
- the Victorian Wetland Monitoring and Assessment Program (WetMAP), which focuses on wetlands;
- The Living Murray's (TLM) condition monitoring program, which focuses on TLM icon sites (in Victoria, these are Barmah Forest, Gunbower Forest, Hattah Lakes and Lindsay-Mulcra-Wallpolla Islands; and
- the Commonwealth Environmental Water Office's Long-Term Intervention Monitoring (LTIM) Project, which focuses in Victoria on the Goulburn River.

The report also draws on additional datasets or observations from Victorian catchment management authorities (CMAs) that demonstrate environmental outcomes at the asset scale.

As noted above, it takes time to realise the benefits from environmental water management. Investment in ecological monitoring has grown in line with the investment in environmental water recovery, environmental

[1] Including those listed under international treaties such as the Japan-Australia Migratory Bird Agreement (JAMBA), the China-Australia Migratory Bird Agreement (CAMBA) and under the Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

works, management effort and community expectations. However, detecting outcomes over a five-year period (or even eight years, in this case) can be difficult as many ecological indicators may be highly variable from year to year or change only gradually over time. In addition, this assessment draws on data from a range of programs that monitor different indicators at different assets, commencing at different times (e.g. TLM monitoring and VEFMAP began in 2006, LTIM began in 2014, WetMAP began in 2017). These programs are focused on answering key evaluation questions (KEQs) (VEFMAP, WetMAP and LTIM) or assessing progress towards ecological targets (TLM). This means that the same information is not available for every priority environmental asset. The additional funding required to monitor the same indicators at each of the 47 priority environmental assets would be significant, considering that more than $3 million is invested annually across the above monitoring programs already.

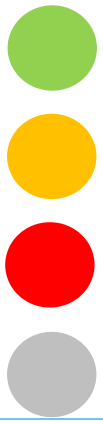
Victoria developed a Matter 8 reporting framework to make the best use of available data by aligning monitoring program KEQs (or targets for TLM) to relevant Basin Plan objectives and targets. This alignment is shown in Table 1 and enables reporting on the achievement of Basin Plan objectives and targets at each asset. Environmental outcomes for each asset are described in Section 3 and achievement of targets (i.e. improvement) is reported in Section 4.

The identification of outcomes at the asset scale was carried out by scientists involved in delivery of the monitoring programs and environmental water managers for each priority environmental asset. Scientists first:

- assessed the status of each objective at relevant assets (i.e. whether available data from KEQs or targets indicated that condition of the broader objective had improved, declined or been maintained);
- assessed the quality of the available data; and
- provided additional information to support their assessment, including links to further technical information.

These entries were then reviewed by relevant environmental water managers.

Status of objectives is represented by four categories:



Improved– there is evidence that condition has been improved (protected or restored) at this asset through environmental water management.

Maintained – there is evidence that condition has been maintained (no indication of improvement or decline) at this asset through environmental water management, and responses may have been variable.

Declined – there is evidence that condition has declined, and the ecosystem remains under stress.

Unknown – there is insufficient data to make an assessment.

Data quality reflects the type and adequacy of available data, in four categories:

1. not enough data available to make an assessment
2. limited evidence and expert opinion-based assessments
3. adequate data to make a qualitative assessment
4. high-quality data able to make a quantitative assessment.

Inclusion of an additional tier of site-specific objectives was also tested. These objectives were developed by CMAs in consultation with local communities. However, there were fewer alignments at this level and this approach would have resulted, overall, in reporting of fewer environmental outcomes. A focus of the update and refinement of long-term watering plans is improving this multi-tier alignment to enable reporting of outcomes against both long-term watering plan and Basin Plan objectives. These updates will occur from 2020 onwards.

Table 1: Rules and assumptions for aligning monitoring with Basin Plan objectives and targets

Basin Plan Objectives	Detailed BP Objectives	BP Targets[2]	Relevant monitoring indicators	Comments
Protection and restoration of water-dependent ecosystems (S 8.05)	Ecological character of Ramsar wetlands.	2c	Any monitoring related to critical components, process and services at Ramsar Sites.	Critical components, process and services are identified in the ecological character descriptions for each Ramsar site. They do not necessarily cover all biota or functions at a site.
	Species listed under JAMBA, CAMBA, ROKAMBA, Bonn Convention.	2g	Abundance, diversity or condition of International migratory waterbirds (these are all shorebirds).	These birds do not breed in Australia so only non-breeding indicators should be considered. Several species listed under these agreements are also resident entirely within Australia (e.g. Caspian tern, eastern great egret) and are not considered relevant for this objective.
	High productive ecosystems.	2c	Metabolism, food webs.	Applied when monitoring of high productivity events (e.g. floodplain inundation) occurs and is monitored.
	Biodiversity – threatened species and communities, representative populations and communities of native biota	2e, g	Abundance, species richness, diversity, community composition, extent (of vegetation communities)	
Protection and restoration of ecosystem functions of water-dependent ecosystems (S8.06)	Connectivity – longitudinal, lateral, vertical	2a, b	Movement of biota (mostly fish) Lateral or longitudinal hydrological connectivity	
	Processes – landforms, habitat diversity, recruitment, regeneration, dispersal, immigration and emigration, food webs	2c, e, f, g	Habitat, breeding (e.g. nesting, fledgling, larvae, etc), recruitment, regeneration, germination, dispersal, movement of biota (mostly fish), metabolism, productivity.	
Ensuring water-dependent ecosystems are resilient to climate change and other risks and threats (S. 8.07)	Refugia, wetting and drying regimes for resilience	2c, e	Refugia, condition of biota, appropriate water regimes.	Following the example of the CEWO outcomes framework (CEWO 2013), condition is considered an indicator of resilience, i.e. improved condition makes an individual or population more resilient to threats.
	Mitigate human threats – impact of alien species, water management activities and water quality	2a	Use of environmental water to mitigate extraction, degraded water quality (salinity, nutrients, pH, etc.), or threats such as weeds, carp, grazing.	Note this objective is met at all assets where environmental water is delivered or actively managed to mitigate the threat of hydrological change.

[2] As per Schedule 7 of the Basin Plan: "*Long Term Targets from July 1, 2019: (2) There are improvements in the following: (a) flow regimes which include relevant flow components set out in paragraph 8.51(1)(b); (b) hydrologic connectivity between the river and floodplain and between hydrologically connected valleys; (c) river, floodplain and wetland types including the condition of priority environmental assets and priority ecosystem functions; (d) condition of the Coorong and Lower Lakes ecosystems and Murray Mouth opening regime; (e) condition, diversity, extent and contiguousness of native water-dependent vegetation; (f) recruitment and populations of native water-dependent species, including vegetation, birds, fish and macroinvertebrates; (g) the community structure of water-dependent ecosystems.*"

Section 3 is divided into Victoria's surface Water Resource Plan Areas (WRPAs) of Northern Victoria, Victorian Murray and Wimmera-Mallee (Figure 1). Additional information for each asset is provided in 0. Case studies for a subset of these assets are provided in Section 5. These provide additional context and information regarding site specific waterway management, lessons learned and environmental outcomes.

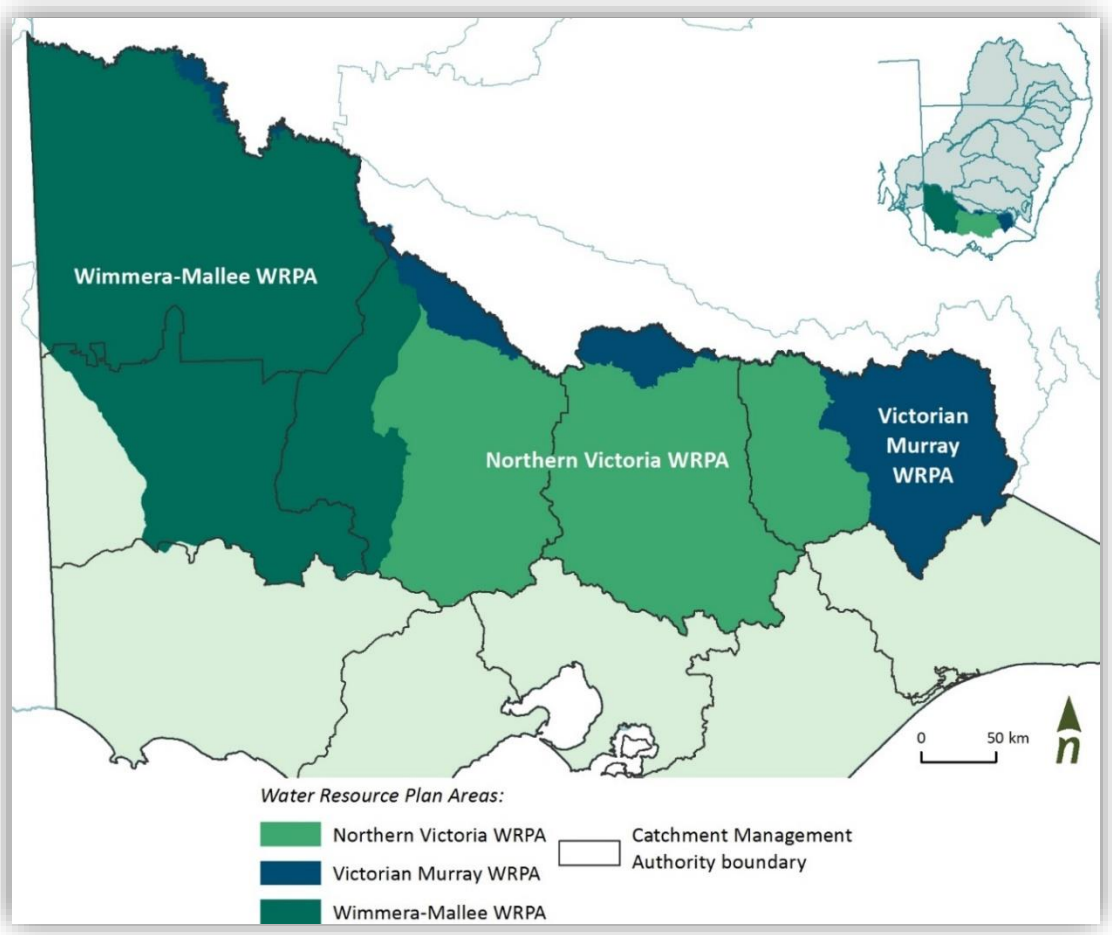


Figure 1: Victoria's three surface water resource plan areas (WRPAs) and their location within the broader Murray-Darling Basin (inset).

3. Results

3.1 Northern Victoria

The Northern Victoria WRPA (see Figure 2) is dominated by northerly flowing river systems connected to the Murray River downstream of the junction with the Kiewa River. It includes the Ovens, Goulburn, Broken, Campaspe and Loddon Rivers, and associated wetlands. Note that nearby wetlands associated with the Murray River (e.g. Barmah Forest) lie in the Victorian Murray WRPA immediately to the north of this WRPA. The amount of environmental water delivered in these systems from 2013-14 to 2019-20 is shown in Table 2. The environmental outcomes at each of the assets listed in Table 2 are described below.

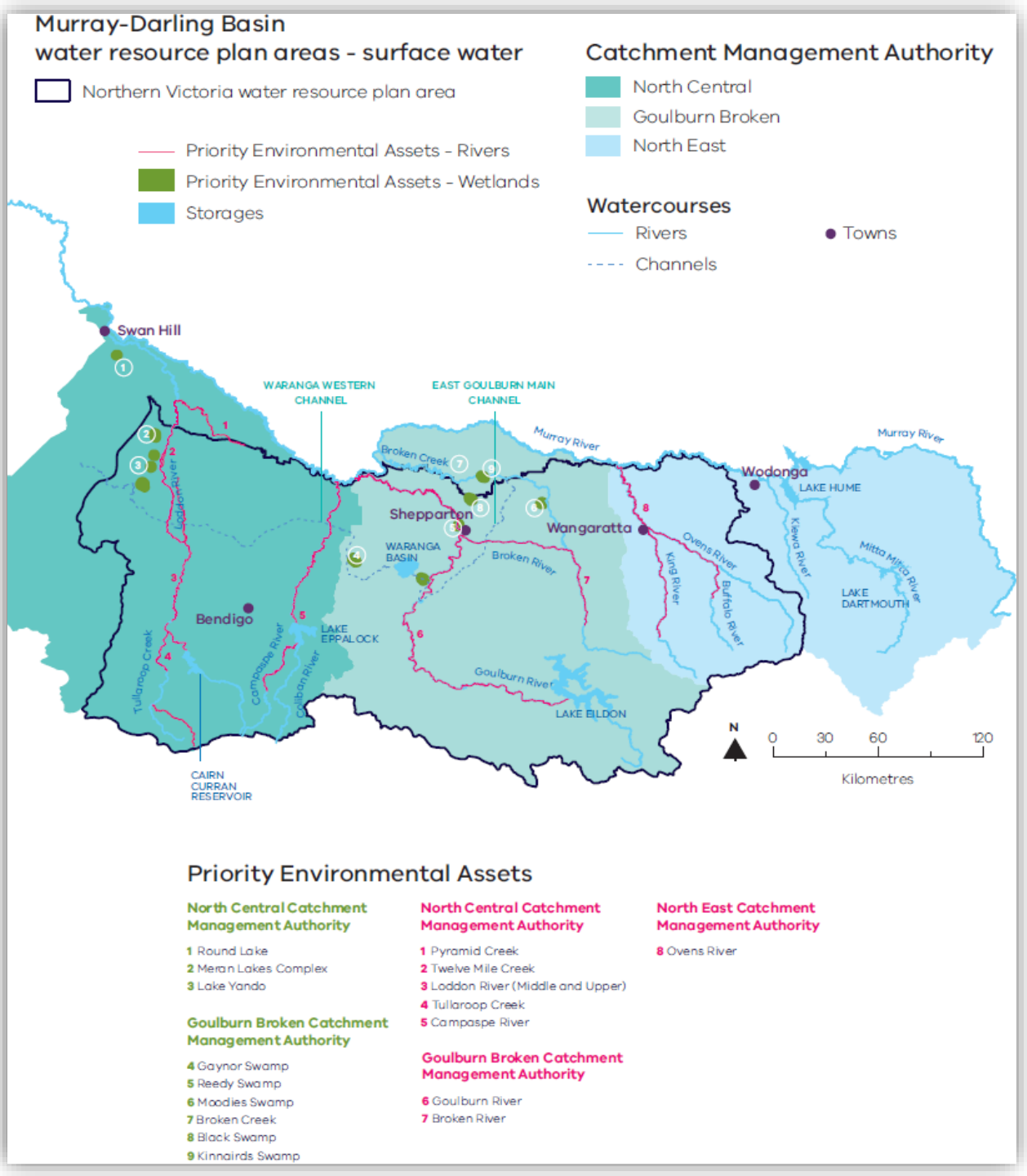


Figure 2: Priority environmental assets within the Northern Victoria WRPA.

Table 2: Volumes of environmental water (megalitres, ML) delivered to assets within the Northern Victoria WRPA since 2013.

Assets	2019-20	2018-19	2017-18	2016-17	2015-16	2014-15	2013-14
Black Swamp	65	80	-	-	80	-	50
Broken Creek	36,350	33,847	41,408	36,364	30,320	34,306	38,594
Broken River	-	250.0	1,000	-	-	-	-
Campaspe River	20,438	23,356	17,940	5,551	13,658	30,729	14,565
Gaynor Swamp	-	601	500	-	-	-	-
Goulburn River	401,881	225,580	354,832	229,753	228,243	309,371	312,349
Kinnaird Wetland	259	384	-	-	689	-	180
Meran Lakes Complex including Lake Little Meran	1,612	510	498	-	2,000	2,000	1,849
Lake Yando	-	-	-	-	-	558	151
Loddon River including Tullaroop Creek & Twelve Mile Creek	13,702	17,150	10,957	11,789	6,712	11,870	9,368
Moodies Swamp	-	-	500	-	500	500	121
Ovens River*	142	162	123	70	70	70	70
Pyramid Creek	123	1,042	861	924	-	-	-
Reedy Swamp	500	500	-	-	356	-	-
Richardson's Lagoon	-	-	458	568	1,309	-	-
Round Lake	300	461	422	350	576	556	509

* Environmental water delivered to the Ovens system through King River and Buffalo River.

3.1.1 Broken System

Black Swamp

Black Swamp is a small intermittent river red gum swamp located on the floodplain of Nine Mile Creek east of Wunghnu and 27 kilometres (km) north of Shepparton. Historical water management resulted in prolonged inundation and the death of many of the mature river red gums. These standing dead trees along with the emergent wetland vegetation provide habitat for foraging and roosting waterbirds. The wetland also contains a significant population of the EPBC-listed vulnerable river swamp wallaby-grass.

WetMAP shows some evidence of contributions to Basin Plan objectives at Black Swamp with maintenance of frog abundance and diversity, of vegetation diversity and cover, and improvements in tree survival and recruitment (Table 3). There was also a high abundance and diversity of native fish.

Table 3: Contributions to Basin Plan objectives for Black Swamp.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Waterbird abundance, diversity, breeding  Data quality = 1	Frog abundance and diversity  Data quality = 2	Frog breeding  Data quality = 1	Insufficient data to assess waterbirds at this site. Five species of frog recorded (out of potentially seven species at this site), with two present in high abundances.
	Vegetation diversity  Data quality = 2	Vegetation cover  Data quality = 2	Fish diversity  Data quality = 2	Minor improvements in wetland vegetation species richness, no change in wetland vegetation cover. Relatively high native fish species richness
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Frog abundance, diversity and breeding  Data quality = 1	Tree condition  Data quality = 2	Native fish  Data quality = 2	Insufficient data to assess the refuge value of site for frogs. Little change in tree condition, which remains poor. Native fish density was high.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Tree survival and recruitment  Data quality = 2			Improvements in the presence of tree recruits and survival of mature trees. Trees at this site remain in poor condition.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Cover of terrestrial and introduced vegetation species  Data quality = 3	Management of flow regime  Data quality = 4		Slight decrease in the cover of terrestrial and introduced plant species during the 2017-2020 monitoring period. Impacts of water management threats have been mitigated by delivery of environmental water in four of the last seven years.

Broken River

The Broken River is a tributary of the Goulburn River rising in the highlands and flowing in a north-easterly direction to join the Goulburn River near Shepparton. Broken River is listed as a wetland of national importance (Cottingham, et al., 2013) and retains healthy in-stream vegetation, with a diversity of submerged and aquatic plant species. This vegetation provides habitat for a range of native fish species including Murray cod (EPBC-listed, vulnerable), silver perch, mountain galaxias and Murray-Darling rainbowfish.

Environmental water management has led to improvements in native fish abundance and recruitment in the Broken River, but movement and dispersal of native fish has not been improved. Although data availability for this asset is low, there is some evidence of contributions to Basin Plan objectives related to biodiversity and protection of in-stream processes (Table 4). Vegetation monitoring was due to start at this waterway in 2019-20 but has been delayed by COVID-19 restrictions.

Table 4: Contributions to Basin Plan objectives for the Broken River.

Basin Plan objective	Indicators and status	Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Fish abundance  Data quality = 1	Increase in abundance and distribution of key species such as Murray cod and Murray-Darling rainbowfish.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Fish recruitment  Data quality = 2	Consistent recruitment of Murray cod and Murray-Darling rainbowfish.
To protect and restore connectivity within and between water-dependent ecosystems – longitudinally along watercourses, laterally between watercourses, floodplains and wetlands, and vertically between surface and subsurface.	Fish dispersal  Data quality = 2	Limited movement and dispersal of silver perch and trout cod, due to instream barriers.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4	Impacts of water management threats have been mitigated by delivery of environmental water in two of the last seven years.

Broken Creek

Broken Creek is a distributary channel of the Broken River, which flows from the river near Winton and discharges to the Murray River near Barmah Forest. The upper reaches are dominated by unique box riparian vegetation and the waterway provides habitat for platypus and eastern long-necked turtles.

Broken Creek supports a diverse and abundant native fish community including the Murray cod and critically endangered silver perch as well small bodied species such as FFG-listed Murray-Darling rainbowfish. VEFMAP fish monitoring shows that native fish populations are being maintained with environmental water (Table 5). Vegetation monitoring is due to start at this waterway in 2019-20 but has been delayed by COVID-19 restrictions.

Table 5: Contributions to Basin Plan objectives for Broken Creek.

Basin Plan objective	Indicators and status	Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Fish abundance and diversity  Data quality = 3	No evidence of improvement or decline in native fish diversity at this asset.

Basin Plan objective	Indicators and status	Rationale
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Fish recruitment and habitat  Data quality = 3	Some evidence of recruitment (e.g. Murray cod) but declining trends in small-bodied native fish. Flows delivered to maintain suitable water quality (and prevent fish death events)
To protect and restore connectivity within and between water-dependent ecosystems – longitudinally along watercourses, laterally between watercourses, floodplains and wetlands, and vertically between surface and subsurface.	Fish dispersal  Data quality = 3	Fishway and telemetry studies that indicate upstream dispersal of fish facilitated by flow pulses and fishway operation.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4	Impacts of water management threats have been mitigated by delivery of significant volumes of environmental water every year since 2013.

Kinnairds Swamp

Kinnairds Swamp occurs in a natural depression near the Broken Creek. Vegetation is dominated by a mosaic of river red gum swamp and plains grassy wetland communities with small areas of emergent marsh and open water. It supports a diversity of wetland fauna including breeding colonies of royal spoonbill. Frog monitoring under WetMAP has recently begun at this asset and preliminary results indicate that the system supports a diversity and abundance of common frog species. Longer-term monitoring is required to detect rarer species and to assess the importance of this wetland as a refuge for frogs (Table 6). Note the CMA has some additional site-specific data that may be able to be integrated with the WetMAP data for future reporting.

Table 6: Contributions to Basin Plan objectives for Kinnairds Swamp.

Basin Plan objective	Indicators and status		Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Frog diversity and abundance  Data quality = 2	Frog breeding  Data quality = 1	Six common frog species recorded in high abundances.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Frog diversity and abundance  Data quality = 1	Frog breeding  Data quality = 1	Frog monitoring is currently inadequate to assess the value of this wetland as a refuge for the long-term survival and resilience of frogs.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4		Impacts of water management threats have been mitigated by delivery of environmental water in four of the last seven years.

Moodies Swamp

Moodies Swamp has three vegetation types, dominated by cane grass, in association with either river red gum, lignum or aquatic herbs. It is listed as a wetland of national importance and supports two species of threatened aquatic flora, the EPBC-listed vulnerable rigid watermilfoil and the FFG-listed slender watermilfoil. The wetland provides important breeding habitat for a range of waterbirds but is particularly significant for brolga.

Although WetMAP monitoring did not detect improvement in vegetation indicators in the short term (Table 7), Goulburn-Broken CMA notes that wetland vegetation composition has changed significantly since a more natural wetting and drying regime was implemented in 2008. This has seen a shift from a cane grass dominated community to the more diverse Cane Grass/Aquatic Herbland Ecological Vegetation Class (EVC). CMA staff have observed good waterbird breeding at the site, including brolga, black swans, grebes, ducks, pied cormorants, and potentially Nankeen night-herons.

Table 7: Contributions to Basin Plan objectives for Moodies Swamp.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Frog diversity, abundance and breeding  Data quality = 1	Waterbird habitat  Data quality = 2	Woodland birds  Data quality = 2	Insufficient data to assess trends in frog indicators. Suitable habitat for large-bodied waders, but not for most waterfowl and shorebirds.
	Vegetation diversity  Data quality = 2	Vegetation cover  Data quality = 2	Lignum condition  Data quality = 2	Moderate cover, diversity and condition of wetland vegetation, including lignum.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Frog diversity, abundance and breeding  Data quality = 1	Tree condition  Data quality = 2	Lignum condition  Data quality = 2	Insufficient data to assess trends in frog indicators. Tree condition did not change, but the condition of lignum was maintained, indicating moderate resilience to future threats.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Tree condition  Data quality = 2	Tree survival and recruitment  Data quality = 2		Little response with respect to flowering of wetland trees and no change in recruitment indicators for trees.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Cover of terrestrial and introduced vegetation species  Data quality = 2	Management of flow regime  Data quality = 4		Slight decrease in the cover of terrestrial and introduced plant species. Impacts of water management threats have been mitigated by delivery of environmental water in four of the last seven years.

3.1.2 Campaspe System

Campaspe River

The Campaspe River rises in the central highlands of the Great Dividing Range, before flowing into the major storage at Lake Eppalock. The river then continues from Lake Eppalock in a northerly direction to discharge into the Murray River downstream of Echuca. The river has a narrow riparian zone dominated by large river red gums. It supports several large-bodied native fish such as Murray cod, Macquarie perch, trout cod and golden perch, as well as platypus, rakali, turtles and frogs.

Environmental water has contributed to substantive improvements in vegetation diversity, extent and recruitment increasing resilience to drought. Native fish abundance and recruitment has improved, but dispersal of native fish is still limited by artificial instream barriers. The North Central CMA is working to address these through construction of fishways (e.g. at Echuca Weir in 2014, delivered in partnership with Goulburn-Murray Water) and delivery of the CMA's Native Fish Recovery Plan. There is good evidence of contribution to several Basin Plan objectives as indicated in Table 8. Further information regarding the environmental outcomes for the Campaspe River is captured in the case study in section 5.

Table 8: Contributions to Basin Plan objectives for Campaspe River.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Instream vegetation  Data quality = 4	Fringing emergent and herbaceous vegetation  Data quality = 4	Fish abundance  Data quality = 3	Minor benefits to instream vegetation through baseflows. Baseflows and spring freshes improving diversity and extent of fringing herbaceous and emergent vegetation. Measured increase in abundance and distribution of native fish since 2007.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Instream vegetation  Data quality = 4	Fringing emergent and herbaceous vegetation  Data quality = 4		Benefits to instream vegetation improving recruitment and populations. Fringing herbaceous and emergent vegetation supported by environmental flows increasing resilience to drought.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Vegetation recruitment  Data quality = 3	Fish recruitment  Data quality = 4	Fish dispersal  Data quality = 3	Good vegetation recruitment (emergent, herbaceous and woody). High survival of juvenile fish (stocked and naturally spawned). Little improvement in dispersal and movement of native fish.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Vegetation growth and survival  Data quality = 4		Management of flow regime  Data quality = 4	Environmental flows are reducing the encroachment of exotic terrestrial species within this waterway. Impacts of water management threats have been mitigated by delivery of environmental water every year since 2013.

Basin Plan objective	Indicators and status	Rationale
To protect and restore connectivity within and between water-dependent ecosystems – longitudinally along watercourses, laterally between watercourses, floodplains and wetlands, and vertically between surface and subsurface.	Fish dispersal  Data quality = 3	Little improvement in dispersal and movement of native fish due to instream barriers.

3.1.3 Central Murray Wetlands

Richardson's Lagoon

Richardson's Lagoon (also known as Baillieu's Lagoon) is a 120 hectare (ha) wetland located on the Murray River floodplain near Echuca. It provides a range of habitats, including open water and reed beds through the channel of the wetland and Intermittent Swampy Woodland EVC on the floodplain. Richardson's Lagoon provides significant waterbird habitat, with abundant breeding and roosting sites (Table 9).

Table 9: Contributions to Basin Plan objectives for Richardson's Lagoon.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Woodland birds  Data quality = 1	Waterbird habitat  Data quality = 2	Waterbird diversity  Data quality = 2	Moderate responses of waterbirds to environmental water, but habitat limited to open water species.
	Frog breeding  Data quality = 1	Frog abundance  Data quality = 2	Frog diversity  Data quality = 1	Low level of frog data, but species richness was low, and wetland is in poor condition for frogs.
	Vegetation diversity  Data quality = 2	Lignum condition  Data quality = 2	Vegetation cover  Data quality = 3	Increase in wetland vegetation species richness, lignum in moderate condition and little improvement in native vegetation cover.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Frog diversity, abundance and breeding  Data quality = 1	Tree condition  Data quality = 2	Lignum condition  Data quality = 3	Limited frog data but species richness was low. Insufficient data to assess the refuge value of site for frogs. Note the section of wetland where tree condition was calculated did not receive environmental water during the monitoring period.

Basin Plan objective	Indicators and status		Rationale
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Tree survival and recruitment  Data quality = 2	Tree condition  Data quality = 2	Improvements in the presence of tree recruits and survival of mature trees. Note the section of wetland where tree condition was calculated did not receive environmental water during the monitoring period.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Cover of terrestrial and introduced vegetation species  Data quality = 3	Management of flow regime  Data quality = 4	Slight decrease in the cover of terrestrial and introduced plant species. Impacts of water management threats have been mitigated by delivery of environmental water in three of the last seven years.

Round Lake

Round Lake is a saline wetland on the outskirts of the town of Boga, on the floodplain of the Avoca River. The system supports submerged large-fruit sea tassel and a variety of charophytes, which are important habitat for the EPBC-listed endangered Murray hardyhead. The wetland is also important for supporting a diversity of waterbirds, particularly small wading species, including international migrants.

Fish and bird data provide measured evidence of contributions to Basin Plan objectives (Table 10). Allowing salinity to increase to >40,000 µS cm^{-1} outside of the Murray hardyhead spawning season provides a competitive advantage for adult hardyheads, as other native species and the introduced eastern gambusia cannot tolerate such high salinity levels (Papas et al., 2020).

Table 10: Contributions to Basin Plan objectives for Round Lake.

Basin Plan objective	Indicators and status		Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Waterbird diversity  Data quality = 2	Waterbird habitat  Data quality = 2	There is clear evidence from this site that water inflows are followed by influxes of waterbirds and there is good quality habitat for foraging birds. Large numbers of woodland birds supported in the surrounding black box vegetation.
	Waterbird breeding  Data quality = 2	Woodland birds  Data quality = 3	
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Fish  Data quality = 3		Environmental water is maintaining habitat for Murray hardyhead.

To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Fish  Data quality = 3	Management of flow regime  Data quality = 4	Round Lake receives environmental water to decrease salinity concentrations and maintain lake levels for the successful spawning and recruitment of Murray hardyhead. Impacts of water management threats have been mitigated by delivery of environmental water every year since 2013.
To protect and restore water-dependent ecosystems that support species listed under JAMBA, CAMBA, ROKAMBA, Bonn Convention.	Migratory shorebirds  Data quality = 2		Clear evidence that water inflows are followed by influxes of waterbirds, as water levels dropped the site was used by several species of migratory shorebird.

3.1.4 Goulburn System

Gaynor Swamp

Gaynor Swamp is a cane grass marsh that supports large numbers of waterbirds when inundated. It is an important breeding site for brolga. When water levels recede large numbers of shorebirds such as red-necked avocet forage in the shallow waters. It provides habitat for a wide variety of water dependent and terrestrial fauna species, with over 110 species recorded within the wetland.

This asset was watered for the first time in 2017-18, when monitoring also commenced. There have been some improvements in the condition of Gaynor Swamp from the use of environmental water, particularly with respect to waterbird abundance, vegetation cover and the condition of lignum. There is, therefore, limited data for this site and results must be considered in this context (Table 11).

Table 11: Contributions to Basin Plan objectives for Gaynor Swamp.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Waterbird abundance  Data quality = 2	Waterbird habitat  Data quality = 2	Waterbird breeding  Data quality = 2	Improvements in waterbird habitat. Expected waterbird breeding response not realised; but large numbers of waterbirds observed. No response of woodland birds to environmental watering. High abundance of one species of frog and low numbers of four additional species. Improvement in vegetation cover and lignum condition. No change in vegetation species diversity.
	Woodland birds  Data quality = 1	Frog abundance and diversity  Data quality = 2	Frog breeding  Data quality = 1	
	Vegetation cover  Data quality = 2	Lignum condition  Data quality = 2	Vegetation diversity  Data quality = 2	
To protect refugia in order to support the long-term survival and resilience of water-dependent	Lignum condition  Data quality = 2	Frog abundance, diversity, breeding  Data quality = 1		Improvement in lignum condition, which would increase resilience to future drought or other threats. Frog data is

populations of native flora and fauna.			currently too limited to assess the site's value as a refuge.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).		Tree survival and recruitment  Data quality = 2	No change in the presence of tree recruits or survival of mature trees. Trees at this site remain in poor condition. This is a legacy from sustained inundation and replanting would be required to re-establish trees.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Cover of terrestrial and introduced vegetation species  Data quality = 2	Management of flow regime  Data quality = 4	Slight decrease in the cover of terrestrial and introduced plant species. Impacts of water management threats have been mitigated by delivery of environmental water in two of the last seven years.

Goulburn River

The Goulburn River rises in the Great Dividing Range upstream of Woods Point and meets the Murray River east of Echuca. Downstream of Lake Eildon, the Goulburn is a declared Victorian Heritage River in recognition of its important ecological and social values. The waterway is lined with river red gums and supports a variety of large and small bodied native fish species including Murray cod, golden perch, trout cod, and silver perch.

The Lower Goulburn River comprises the reaches downstream of Goulburn Weir and is characterised by the Lower Goulburn National Park, which includes the riparian and floodplain forests from Shepparton to the confluence with the Murray River. There have been improvements in native fish abundance, diversity and dispersal, which have contributed to Basin Plan objectives (Table 12). Since 2017-18, significant increases inter-valley transfers (IVT) of water have led to sustained high flows over summer and autumn. This has resulted in inundation of lower bank vegetation beyond tolerance limits and subsequent vegetation loss and bank erosion (Sutton et al., 2020).

Table 12: Contributions to Basin Plan objectives for the Goulburn River.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Fish diversity  Data quality = 4	Fish abundance  Data quality = 3	Riparian vegetation  Data quality = 3	The abundance and distribution of self-sustaining populations of key native fish species including Murray cod, golden perch, silver perch, Murray-Darling rainbowfish and trout cod has been maintained or improved in the long term. No improvement in water dependent vegetation due to impacts of IVT delivery

Basin Plan objective	Indicators and status		Rationale
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Fish spawning and recruitment  Data quality = 3	Macro-invertebrates  Data quality = 3	Golden and silver perch spawning, and movement responded to environmental water delivery and conditions were favourable for natural spawning and recruitment of Murray cod, trout cod and Murray-Darling rainbowfish. Increased flows have been associated with an increase in the abundance and biomass of some macroinvertebrate taxa, particularly crustaceans, and may sustain other taxa during dry periods. Environmental flows were the primary contributor of sediment and seeds to riverbanks, providing three-quarters of sediment and seed deposition on banks. Environmental water produced about a quarter of the organic carbon created by gross primary productivity over the five-year period.
	Riparian seed dispersal  Data quality = 3	Carbon cycling  Data quality = 3	
To protect and restore connectivity within and between water-dependent ecosystems – longitudinally along watercourses, laterally between watercourses, floodplains and wetlands, and vertically between surface and subsurface.	Fish dispersal  Data quality = 3		Golden and silver perch spawn and golden perch migrate in response to spring flow pulses or bank full flows, including from environmental water delivery.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4		Impacts of water management threats have been mitigated by delivery of environmental water every year since 2013.

Reedy Swamp

Reedy Swamp is a 130 ha wetland on the outskirts of Shepparton, on the floodplain of the Goulburn River. The site supports areas of open water and emergent marsh, dominated by giant rush. It provides important foraging and breeding habitat for waterbirds, regularly supporting breeding colonies of spoonbills and ibis. Birds have been monitored at this site since 2017 and results indicate that diversity is increasing in response to environmental water management (Table 13). Frog monitoring commenced in 2019. While this dataset is not yet large enough for conclusive assessment, the Goulburn Broken CMA has additional data and observations that suggest Reedy Swamp is an important frog refuge. It is anticipated that on-going data collection through WetMAP will confirm that the condition of this indicator is improving, and relevant objectives met.

Table 13: Contributions to Basin Plan objectives for Reedy Swamp.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Waterbird diversity  Data quality = 3	Waterbird habitat  Data quality = 2	Woodland birds  Data quality = 2	Assessments indicate good habitat for waterbirds that is controlled by the managed water regime. Waterbird influx observed in response to inundation.
	Waterbird breeding  Data quality = 1	Frog diversity and abundance  Data quality = 2	Frog breeding  Data quality = 1	Three common frog species were recorded in low numbers during 2019-20 audio-visual surveys of the watered wetland. When inundated for a suitable duration Reedy Swamp should provide habitat for multiple frog species.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Frog breeding, abundance and diversity  Data quality = 1			The WetMAP frog monitoring data are currently inadequate to assess the value of Reedy Swamp as a refuge for the long-term survival and resilience of frogs.
To protect and restore water-dependent ecosystems that support species listed under JAMBA, CAMBA, ROKAMBA, Bonn Convention.	Migratory shorebirds  Data quality = 2			Clear evidence that water inflows are followed by influxes of waterbirds, including small numbers of migratory species Latham's snipe was recorded in small numbers on multiple surveys and the habitat at the site is suitable for this species.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4			Impacts of water management threats have been mitigated by delivery of environmental water in three of the last seven years.

3.1.5 Loddon System

Loddon River

The Loddon River is Victoria's second longest river flowing north for approximately 430 km from its headwaters in Wombat State Forest in the Great Dividing Range, near Daylesford, towards the Murray. It has high ecological value due to its wide variety of water dependent flora and fauna including twenty-six waterbird species and the EPBC-listed critically endangered silver perch and vulnerable growling grass frog. The local communities particularly value the native fish and platypus populations, as well as the aesthetic and recreational values of the river. There is evidence from VEFMAP that environmental flows are maintaining vegetation and fish communities along the Loddon River. Improvements, however, are limited by a lack of flow variability and low summer flows, including periods of cease to flow (Table 14).

Table 14: Contributions to Basin Plan objectives for the Loddon River.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Fish diversity  Data quality = 2	Emergent vegetation  Data quality = 4		No evidence of change in fish abundance and diversity. Emergent vegetation cover is high at some sites, but a lack of flow variability has limited the cover of riparian herbaceous vegetation and high turbidity limits in-stream vegetation.
	Herbaceous vegetation  Data quality = 4	Instream vegetation  Data quality = 4		
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Emergent vegetation  Data quality = 4	Herbaceous vegetation  Data quality = 4	Instream vegetation  Data quality = 4	Deep-rooted emergent vegetation likely to be resilient to dry conditions. Narrow band of riparian herbaceous vegetation highly susceptible to changes in flow level. Environmental flows are likely to be supporting existing in-stream plants, but limited potential to increase diversity and extent.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Vegetation recruitment  Data quality = 4	Fish dispersal  Data quality = 3	Fish recruitment  Data quality = 2	Limited recruitment for vegetation, due to lack of flow variability. Positive responses for fish dispersal. Limited outcomes for native fish recruitment.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Vegetation growth and survival  Data quality = 4		Management of flow regime  Data quality = 4	Environmental flows are likely to be reducing the encroachment of exotic terrestrial species within this waterway but over a very narrow range in bank elevation. Impacts of water management threats have been mitigated by delivery of environmental water every year since 2013.

Lake Little Meran (Lake Little Meering)

Lake Little Meran is part of the Meran Lakes Complex. This temporary freshwater lake provides open water habitat during its wet phase, which supports deep water foraging waterbirds. As the wetland dries, the deepest sections of the wetland bed provide mudflat habitat for wading birds, including many threatened and migratory species. It supports a mix aged canopy of black box woodland higher on the wetland margins, and river red

gum woodland along the lake edge. There is some evidence to suggest that environmental water has contributed to the diversity and abundance of waterbirds and woodland birds and frog diversity. Data for this site is, however, limited and results should be considered in this context (Table 15).

Table 15: Contributions to Basin Plan objectives for Lake Little Meran.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Waterbird breeding  Data quality = 2	Waterbird abundance  Data quality = 2	Woodland birds  Data quality = 2	Positive response with respect to waterbird abundance and breeding to environmental water. An abundance of woodland birds, with habitat supported by environmental water. Four common frog species recorded. The site is expected to provide habitat for frogs when suitably inundated.
	Frog diversity  Data quality = 2	Frog abundance  Data quality = 2	Frog breeding  Data quality = 1	
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Frog diversity  Data quality = 1	Frog abundance  Data quality = 1	Frog breeding  Data quality = 1	Frog monitoring is currently inadequate to assess the value of this wetland as a refuge for the long-term survival and resilience of frogs.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4			Impacts of water management threats have been mitigated by delivery of environmental water to the complex in six of the last seven years.

Lake Yando

Lake Yando is an intermittent wetland on the floodplain of the Loddon River. It is surrounded by river red gum woodland and when inundated supports emergent reed beds and a number of rare or threatened wetland plant species including the EPBC-listed vulnerable rigid water-milfoil and river swamp wallaby-grass. The site supports a diversity of waterbirds and frogs in the wet phase.

There is some evidence from vegetation monitoring of contributions to Basin Plan objectives at this site with improvements in wetland vegetation diversity and lignum condition (Table 16). However, historical water management and prolonged inundation has resulted in the death of mature river red gums at this wetland; revegetation and other management interventions may be required to restore this site.

Table 16: Contributions to Basin Plan objectives for Lake Yando.

Basin Plan objective	Indicators and status		Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Vegetation diversity  Data quality = 2	Lignum condition  Data quality = 2	Positive response with respect to vegetation diversity and the condition of lignum in response to environmental water. Native vegetation cover, however remained poor. Insufficient data to assess the effects on environmental water on waterbirds at this site.
	Waterbirds  Data quality = 1	Vegetation cover  Data quality = 2	

Basin Plan objective	Indicators and status		Rationale
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Tree condition  Data quality = 2	Lignum condition  Data quality = 2	Tree condition did not change, but the condition of lignum improved, indicating increased resilience to future threats.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Tree condition  Data quality = 2	Tree survival and recruitment  Data quality = 2	Little response with respect to flowering of wetland trees, but evidence of recruitment.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Cover of terrestrial and introduced vegetation species  Data quality = 2	Management of flow regime  Data quality = 4	Slight decrease in the cover of terrestrial and introduced plant species. Impacts of water management threats have been mitigated by delivery of environmental water in two of the last seven years.

Tullaroop Creek

Tullaroop Creek is the main tributary of the Loddon River rising in the Great Dividing Range and flowing through the upper catchment to join the Loddon at Laanecoorie Reservoir. The creek is characterised by several deep in-channel pools and supports a native fish community including the river blackfish. VEFMAP monitoring has provided a high-quality vegetation data set that demonstrates consistent achievement of Basin Plan objectives at this asset, with all indicators showing objectives are being maintained or improved. The evidence of improvements in emergent fringing vegetation is particularly convincing (Table 17).

Table 17: Contributions to Basin Plan objectives for Tullaroop Creek.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Emergent vegetation  Data quality = 4	Herbaceous vegetation  Data quality = 4	Instream vegetation  Data quality = 4	High cover, but low diversity of emergent vegetation supported by environmental flows. No change in fringing herbaceous vegetation. Only one common species of instream aquatic vegetation recorded
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Emergent vegetation  Data quality = 4	Herbaceous vegetation  Data quality = 4	Instream vegetation  Data quality = 4	Emergent vegetation tolerant of extended dry conditions. Short term resilience in instream aquatic vegetation. No change in fringing herbaceous vegetation.

Basin Plan objective	Indicators and status		Rationale
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Vegetation recruitment  Data quality = 4		Recruitment of emergent species at the Tullaroop Creek sites is improving, supported by environmental flows
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Vegetation growth and survival  Data quality = 4	Management of flow regime  Data quality = 4	Environmental flows are likely to be reducing the encroachment of exotic terrestrial vegetation species on the waterway banks, but high pressure from grazing livestock is preventing improvement in native riparian vegetation species. Impacts of water management threats have been mitigated by delivery of environmental water to the Loddon system including Tullaroop Creek every year since 2013

Pyramid Creek

Pyramid Creek is a single channel tributary stream of the Loddon River that flows along the border of the Victorian Riverina and the Murray Fans bioregions. The creek is now an artificially deep and narrow channel that lacks typical creek geomorphological components, such as run/riffle and pool structure. Twenty-six species of waterbirds have been recorded in the Loddon River system; most of these records are for Pyramid Creek. VEFMAP data shows that environmental water is maintaining fish populations at this asset (Table 18).

Table 18: Contributions to Basin Plan objectives for Pyramid Creek.

Basin Plan objective	Indicators and status		Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Fish abundance and diversity  Data quality = 2		Positive responses of fish dispersal, retention and survival of some species due to environmental flows, although long term data to assess population trends are still limited.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Fish survival  Data quality = 3	Fish habitat  Data quality = 3	Score based on positive responses of fish dispersal, retention and survival of some species to environmental flow freshes and baseflow periods. While environmental water is achieving its objectives at an event-based level for some species, overall habitat diversity remains low, a legacy of historic channel dredging.

Basin Plan objective	Indicators and status	Rationale
To protect and restore connectivity within and between water-dependent ecosystems – longitudinally along watercourses, laterally between watercourses, floodplains and wetlands, and vertically between surface and subsurface.	Fish dispersal  Data quality = 3	Positive responses of fish dispersal, retention and survival of some species to environmental flow freshes and baseflow periods where water quality and connectivity is maintained.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4	Impacts of water management threats have been mitigated by delivery of environmental water in four of the last seven years.

Twelve Mile Creek

Twelve Mile Creek is a northerly flowing anabranch of the Loddon River that forms the eastern boundary of Canary Island. The banks of Twelve Mile Creek support the Grassy Riverine Forest/Riverine Swamp Forest Complex EVC and the waterway is likely to support quality habitat for a range of aquatic biota including native fish and platypus.

Overall, vegetation condition at Twelve Mile Creek has improved as a result of multiple management actions including the delivery of environmental water. However, riparian vegetation condition has been severely impacted by livestock access at some sites, which limits the benefits that can be achieved by environmental water at these sites. Improved vegetation condition has contributed to Basin Plan objectives as summarised in Table 19.

Table 19: Contributions to Basin Plan objectives for Twelve Mile Creek.

Basin Plan objective	Indicators and status		Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Emergent and fringing herbaceous vegetation  Data quality = 4	Instream vegetation  Data quality = 3	Species diversity, distribution and cover of riparian vegetation (emergent and herbaceous) is high. Patchy distribution and abundance of instream vegetation.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Emergent and fringing herbaceous vegetation  Data quality = 4	Instream vegetation  Data quality = 3	Riparian vegetation (emergent and herbaceous) supported by environmental flows increasing resilience to drought where not impacted by stock access. Environmental flows are likely to be supporting existing instream vegetation.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Fringing vegetation recruitment  Data quality = 4		Good recruitment of fringing vegetation facilitated by environmental flows.

Basin Plan objective	Indicators and status		Rationale
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Vegetation growth and survival  Data quality = 3	Management of flow regime  Data quality = 4	Environmental flows reduce encroachment of exotic terrestrial species. Stock impact limit the benefit of this to native flora. Impacts of water management threats are mitigated by delivery of environmental water to the Loddon system including Twelve Mile Creek every year since 2013.

3.1.6 Ovens System

Ovens River

The Ovens River rises in the Great Dividing Range near Mt Hotham and discharges to the Murray River at Lake Mulwala. The Ovens River from Killawarra to Lake Mulwala is a declared Victorian Heritage River in recognition of its outstanding ecological and cultural values. The river red gum dominated riparian vegetation is of outstanding quality and the waterway supports a wide range of fish species including Murray cod, trout cod and fly-specked hardyhead. Frogs are abundant in the lower reaches and include threatened species such as the growling grass frog. Management of environmental water, both held and unregulated, has resulted in positive outcomes for native fish at this asset (Table 20).

Table 20: Contributions to Basin Plan objectives for the Ovens River.

Basin Plan objective	Indicators and status	Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Fish diversity  Data quality = 3	Score based on presence of self-sustaining populations of native fish, including reestablishment of two threatened fish species (trout cod and Macquarie perch). Murray cod population increased in recent years.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Fish reproduction  Data quality = 3	Score based on presence of self-sustaining populations of native fish, including reestablishment of two threatened fish species, habitat values supported by natural flow regime and instream habitat values.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4	Impacts of water management threats have been mitigated by delivery of environmental water to the Ovens River system (via King and Buffalo Rivers) every year since 2013.

3.2 Victorian Murray

The extent of the Victorian Murray WRPA is shown in Figure 3. The WRPA area extends from Omeo in the far east of Victoria to the South Australian border in the north west of the state. The WRPA can be characterised by two distinct regions. The first of these regions comprises the Victorian tributaries of the Murray River, upstream of Albury, including the Kiewa and Mitta Mitta Rivers. The second region comprises the lower reaches of tributaries from the Northern Victoria WRPA and the anabranches and floodplain wetlands along the length of the Murray River. The amount of environmental water delivered in these assets from 2013-14 to 2019-20 is shown in Table 21. The environmental outcomes at each of the assets listed in Table 21 are described below.

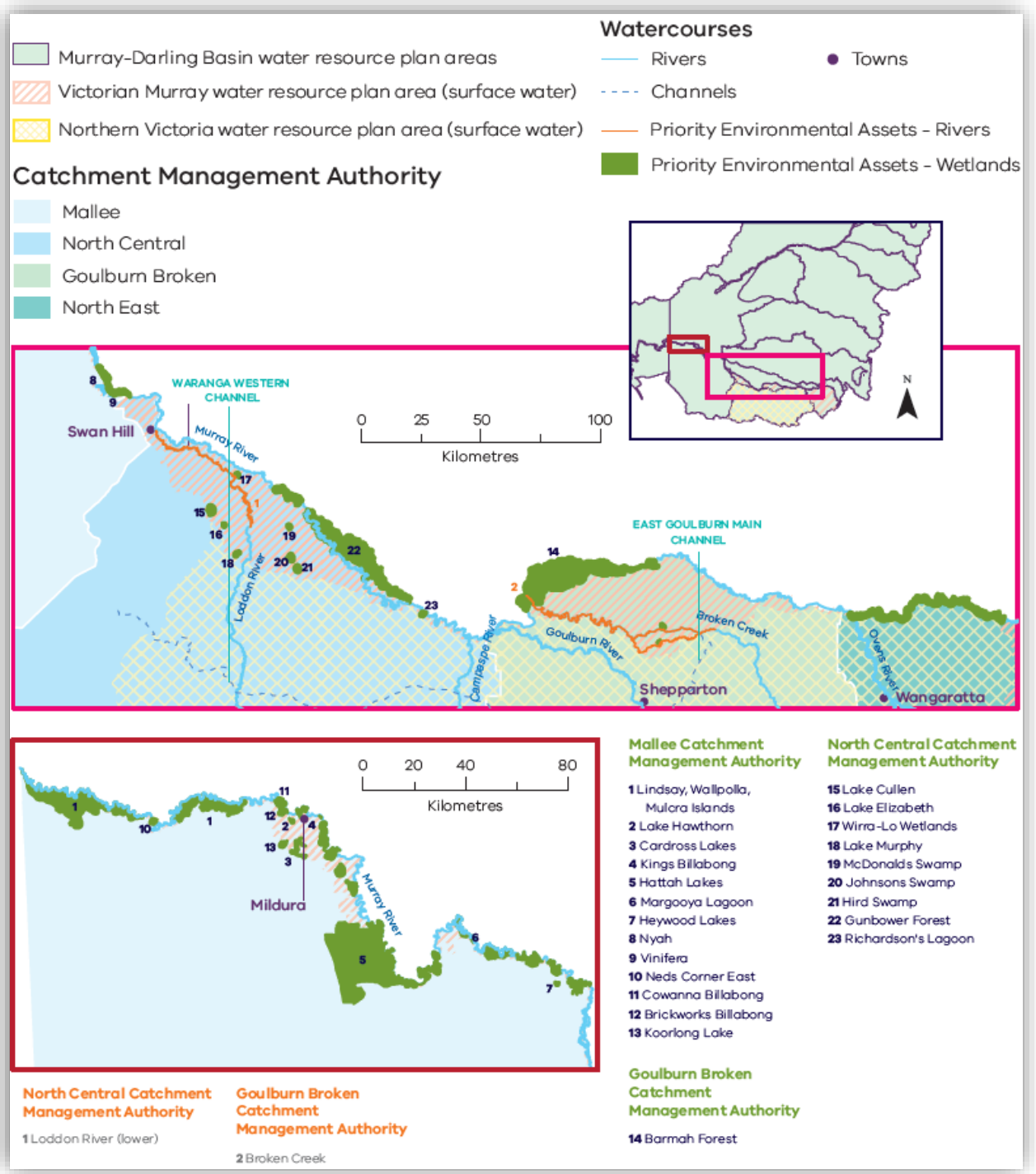


Figure 3: Priority environmental assets in the Victorian Murray WRPA.

Table 21: Environment water delivered to assets within the Victorian Murray WRPA since 2013 (ML).

Assets	2019-20	2018-19	2017-18	2016-17	2015-16	2014-15	2013-14
Barmah Forest	230,668	74,636	21,701	111,505	403,294	-	355,400
Brickworks Billabong	320	251	250	-	400	200	348
Cardross Lake	-	-	506	-	953	577	-
Cowanna Billabong	-	-	-	-	250	-	-
Gunbower Forest	2,758	41,811	9,579	26,653	28,692	37,394	19,257
Hattah Lakes	7,164	281	111,932	31,847	6,840	76,196	97,288
Hird Swamp	-	-	2,220	1,370	-	945	-
Heywood Lake including Little Heywood Lake	-	-	512	3,000	-	-	-
Johnson Swamp	3,240	1,500	-	-	2,890	1,500	-
Kings Billabong, including Ducksfoot Lagoon*	-	-	-	-	-	-	-
Lake Cullen	6,385	7,790	-	17,180	-	-	-
Lake Elizabeth	960	1,080	530	750	1,070	675	1,455
Lake Hawthorn	1,460	1498	447	-	459	-	-
Lake Murphy	-	-	580	-		2,983	-
Lake Koorlong	148	57	-	-	-	-	-
Lindsay, Mulcra and Wallpolla Islands including Horseshoe Lagoon	-	-	8,001	457	11,339		3,745
Margooya Lagoon*	-	-	-	-	-	-	-
McDonalds Swamp	293	230	350	750	-	904	1,240
Ned's Corner East	98	-	104	250	88	-	-
Nyah Floodplain	-	1,000	1,877	-	790	1,266	-
Vinifera Floodplain	-	665	925	-	400	500	-
Wirra-Lo Wetland Complex	245	92	80	165	369	140	-

* Although environmental water has not been delivered to these sites to date, infrastructure enables the water regime to be managed for environmental outcomes.

3.2.1 Central Murray Wetlands

Barmah Forest

Barmah Forest is designated a wetland of international importance under the Ramsar Convention and, together with the Millewa Forest in NSW, is the largest river red gum forest in Australia. In addition to the extensive forests and woodlands, Barmah Forest supports important open marsh vegetation, including the iconic Moira grass plains. The site is important for colonial nesting waterbirds, native fish and supports a significant proportion (>10%) of the south eastern Australian population of the endangered Australasian bittern.

Environmental water has been delivered to Barmah Forest in six of the seven years since the Basin Plan commenced in 2012. There is a wide body of evidence indicating that this, combined with natural flooding, has

contributed to improved waterbird, fish, frog and turtle indicators (Table 22). The extent of Moira grass, however, has continued to decline due to other changes to flow patterns including unseasonal inundation, as well as non-flow factors (grazing). For more detail and context to this asset, please see the case study in section 5.1

Table 22: Contributions to Basin Plan objectives for Barmah Forest.

Basin Plan objective	Indicators and status	Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Floodplain vegetation  Data quality = 4 Habitat for waterbirds  Data quality = 4 Understorey vegetation  Data quality = 3	Maintenance of the extent of river red gum and giant rush but decline in Moira grass extent. Insufficient inundation of floodplain marshes has decreased habitat for waterbirds such as bitterns.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Waterbirds  Data quality = 3 Fish recruitment  Data quality = 3	Breeding of waterbirds (cormorants). Recent improvement in native fish recruitment
To ensure that declared Ramsar wetlands that depend on Basin water resources maintain their ecological character.	Vegetation  Data quality = 4 Native fish  Data quality = 3 Waterbirds  Data quality = 3 Habitat for waterbirds  Data quality = 4	Exceedance of Limit of Acceptable Change for Moira grass, with extent now reduced to less than 10% of its extent at the time of listing as a Ramsar site. Native fish and waterbird diversity and abundance has been maintained. Decreased inundation of floodplain marshes has decreased habitat for waterbirds such as bitterns
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Frog breeding  Data quality = 3 Habitat for frogs, turtles  Data quality = 2 Turtle breeding  Data quality = 2 Fish recruitment (rivers)  Data quality = 3 Fish recruitment (wetlands)  Data quality = 1 Habitat for waterbirds  Data quality = 4	Breeding of frogs stimulated by environmental water. Habitat for frogs and turtles good to fair. Improved recruitment in river and wetland fish.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Presence and extent of invasive plant species  Data quality = 4	While there is some evidence of localised invasive native species (river red gum and giant rush) expanding in Barmah Forest, with potential to impact Moira grass and swamp wallaby-grass; there

Basin Plan objective	Indicators and status	Rationale
		are few non-native plant species.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4	Although unseasonal inundation continues to be a problem, some of the impact from water management threats have been mitigated by delivery of environmental water to the Barmah Forest in six of the last seven years.

Gunbower Forest

Gunbower Forest comprises approximately 20,000 ha of floodplain between the Murray River and Gunbower Creek and is designated a wetland of international importance under the Ramsar Convention. It is predominantly river red gum forest and woodland, with smaller areas of black box woodland. The forest also features a variety of permanent and temporary wetlands, including lakes, swamps and lagoons. These support wetland vegetation communities and provide habitat for several bird species, many of which breed within the site. The site includes Gunbower National Park, Gunbower State Forest and a portion of the Murray River Park.

There is a wide body of evidence indicating that environmental water management, supported by construction of works under TLM that allow targeted watering of 4,800 ha of the forest, has contributed to improved condition and achievement of Basin Plan objectives (Table 23). While the ecological character of the Ramsar site has been maintained, there is some evidence of a decline in waterbird habitat quality outside the watering footprint. For more information, please see the case study in section 5.1.

Table 23: Contributions to Basin Plan objectives for Gunbower Forest.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Threatened flora  Data quality = 4	Habitat  Data quality = 4	Native fish  Data quality = 4	Threatened flora species have been sustained, but not increased. Habitat for fauna has improved with environmental water as has tree recruitment. Frog and fish diversity have been maintained.
	Floodplain vegetation  Data quality = 3	Frog populations  Data quality = 3		
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Floodplain ecosystems  Data quality = 2	Waterbird habitat  Data quality = 3		Maintenance of floodplain and wetland habitats within the environmental watering footprint, which is likely to serve as a refuge and support recovery of the broader site during wetter times.

Basin Plan objective	Indicators and status			Rationale
To ensure that declared Ramsar wetlands that depend on Basin water resources maintain their ecological character.	Threatened waterbirds  Data quality = 3	Fish dispersal  Data quality = 4	Threatened flora  Data quality = 4	All measures are within Limits of Acceptable Change. Threatened waterbirds, flora and fish dispersal have all improved.
	Waterbird refuge  Data quality = 3	Waterbird habitat  Data quality = 4	Native fish  Data quality = 4	Native fish abundance has been maintained. The limited watering footprint means that the value of the overall site for waterbird refuge and breeding has been maintained, rather than improved.
	Waterbird breeding  Data quality = 4	Tree recruitment  Data quality = 4		
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Threatened waterbirds  Data quality = 4	Fish dispersal  Data quality = 4		Maintenance of waterbird habitat and breeding as well as native fish and frog lifecycle processes. No evidence of improvement in these indicators.
	Waterbird breeding  Data quality = 4	Frogs  Data quality = 3		
To protect and restore connectivity within and between water-dependent ecosystems – longitudinally along watercourses, laterally between watercourses, floodplains and wetlands, and vertically between surface and subsurface.	Fish dispersal  Data quality = 4			With more regular provision of environmental water to the floodplain, more opportunities have been provided to native fish to move on and off the floodplain.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4			Impacts of water management threats have been mitigated by delivery of environmental water to the Gunbower Forest every year since 2013.

Hird Swamp

Hird Swamp is a 344 ha deep freshwater marsh located within the Kerang Wetlands Ramsar Site. The wetland provides a variety of habitats including emergent marshes dominated by cumbungi and common reed, large areas of dense tangled lignum, with a sparse overstorey including patches of river red gums. The site supports a diversity and abundance of waterbirds including the EPBC-listed endangered Australasian bittern and the FFG-listed freckled duck and hardhead.

Contributions to Basin Plan objectives at Hird Swamp are summarised in Table 24 and include positive responses from waterbirds and vegetation as well as maintenance of the ecological character within this portion of the Kerang Wetlands Ramsar Site.

Table 24: Contributions to Basin Plan objectives for Hird Swamp.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Waterbird diversity  Data quality = 2	Waterbird habitat  Data quality = 2	Waterbird breeding  Data quality = 2	Hird Swamp supports a diversity and abundance of waterbirds that has been supported by environmental water.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Vegetation diversity  Data quality = 2	Tree condition  Data quality = 2	Lignum condition  Data quality = 2	Moderate improvement in lignum condition; some improvements in cover and species richness of wetland vegetation. Little improvement in tree condition.
To ensure that declared Ramsar wetlands that depend on Basin water resources maintain their ecological character.	Waterbirds  Data quality = 3	Lignum condition  Data quality = 2	Vegetation diversity  Data quality = 4	All measures are within Limits of Acceptable Change.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Tree survival and recruitment  Data quality = 2	Waterbird breeding  Data quality = 2		Tree cover is naturally sparse in the aquatic herb dominated wetland, and there has been no change in tree survival and recruitment has not yet been detected, longer term monitoring is required. Waterbird breeding has been maintained.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Cover of terrestrial and introduced vegetation species  Data quality = 2			Slight decrease in the cover of terrestrial and introduced plant species.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4			Impacts of water management threats have been mitigated by delivery of environmental water to Hird Swamp in three of the last seven years.

Johnsons Swamp

Johnson Swamp is a 340 ha deep freshwater marsh located within the Kerang Wetlands Ramsar Site. The wetland provides high quality habitat for waterbirds including emergent marsh, dense tangled lignum and chenopod shrublands. The site supports a diversity and abundance of waterbirds including the EPBC-listed endangered Australasian bittern and as well as large numbers of ibis and waterfowl. Note that the CMA has some additional site-specific data that may be able to be integrated with the WetMAP data for future reporting.

Monitoring of frogs under WetMAP has only recently begun at this asset and it is too early to report against environmental outcomes (Table 25).

Table 25: Contributions to Basin Plan objectives for Johnsons Swamp.

Basin Plan objective	Indicators and status	Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Frog diversity, abundance and breeding  Data quality = 1	Six frog species were recorded during audio-visual surveys of the watered wetland in 2019-20. Results of 2019-20 AudioMoth acoustic logger surveys are yet to be analysed and may provide additional frog species at some localities around the wetland.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Frog diversity, abundance and breeding  Data quality = 1	Frog monitoring is currently inadequate to assess the value of this wetland as a refuge for the long-term survival and resilience of frogs.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4	Impacts of water management threats have been mitigated by delivery of environmental water to Johnsons Swamp in four of the last seven years.

Lake Cullen

Lake Cullen is a large saline wetland in the Kerang Wetlands Ramsar site, covering approximately 630 ha. Although providing predominantly open water and mudflat habitat, it also supports low saltmarsh shrublands dominated by glasswort as well as some areas of emergent marsh comprising cumbungi and common reed. The wetland supports very large numbers of waterbirds with > 20,000 individuals recorded on occasions. The diverse habitat types, in turn, support a diversity of waterbird species including ducks, fish-eating species and waders, some of which are listed under international migratory bird agreements.

Lake Cullen has been monitored under WetMAP since 2017, with some evidence of contributions to Basin Plan objectives with respect to waterbirds (Table 26). The North Central CMA, however, has additional knowledge and information that illustrates the value of the site for migratory waterbirds, particularly under rare inundation events such as that provided in 2017 (see case study 5.1.3).

Table 26: Contributions to Basin Plan objectives for Lake Cullen.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Waterbird diversity  Data quality = 3	Waterbird habitat  Data quality = 2	Woodland birds  Data quality = 1	Large numbers and high diversity of waterbirds following environmental watering.

Basin Plan objective	Indicators and status	Rationale
To ensure that declared Ramsar wetlands that depend on Basin water resources maintain their ecological character.	Waterbird diversity and abundance  Data quality = 3	Limits of Acceptable Change are met for waterbirds at the site, with evidence of improved abundance and diversity from environmental water management.
To protect and restore water-dependent ecosystems that support species listed under JAMBA, CAMBA, ROKAMBA, Bonn Convention.	Waterbird diversity  Data quality = 2	Bird diversity maintained.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4	Impacts of water management threats have been mitigated by delivery of environmental water to Lake Cullen every year since 2016.

Lake Elizabeth

Lake Elizabeth is a 94 ha deep permanent saline lake located within the Wandella Creek sub catchment of the Loddon River basin. The wetland is fringed by low saltmarsh shrubland dominated by glasswort and supports submerged vegetation comprising sea tassel and fox-tail stonewort. The site supports a population of the EPBC-listed endangered Murray hardyhead as well as a diversity and abundance of waterbirds. WetMAP provides evidence of the contribution to Basin Plan objectives relating to biodiversity, refugia and supporting migratory waterbirds at this asset (Table 27). Water management at this site has supported Murray hardyhead, by allowing salinity to exceed 40,000 µS cm^{-1} outside of the spawning season, exceeding the tolerance range of other native species eastern gambusia, providing a competitive advantage for the saline-adapted adult Murray hardyhead (Papas et al., 2020).

Table 27: Contributions to Basin Plan objectives for Lake Elizabeth.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Waterbird diversity  Data quality = 3	Waterbird breeding  Data quality = 2	Woodland birds  Data quality = 1	Large numbers and high diversity of waterbirds following environmental watering, but no evidence of breeding. Abundant woodland birds in adjacent terrestrial vegetation.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna	Fish  Data quality = 3			Based on catch results (number of fish and sizes), recruitment and survival of Murray hardhead was good.

Basin Plan objective	Indicators and status	Rationale
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Fish  Data quality = 3	Based on catch results (numbers and sizes), recruitment and survival of Murray hardhead was good.
To protect and restore water-dependent ecosystems that support species listed under JAMBA, CAMBA, ROKAMBA, Bonn Convention.	Waterbird diversity  Data quality = 2	Moderate numbers of sharp-tailed sandpipers, habitat for migratory shorebirds maintained.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4	Impacts of water management threats have been mitigated by delivery of environmental water to Lake Elizabeth every year since 2013.

Lake Murphy

Lake Murphy is a 172 ha intermittent and variably saline wetland situated approximately 8 km south-west of Kerang. It is surrounded by an open woodland of black box with patches of dense tangled lignum and periodically supports a diversity and abundance of waterbirds. This was particularly evident after a large watering event in spring 2014; more than 1,000 waterbirds of at least 25 species were observed in the subsequent months. Lake Murphy retained water from this event until January 2016. There is some evidence of contributions to Basin Plan objectives at this asset with respect to waterbirds and lignum condition.

Table 28: Contributions to Basin Plan objectives for Lake Murphy.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Waterbird diversity  Data quality = 2	Waterbird habitat  Data quality = 2	Woodland birds  Data quality = 1	Large numbers and a high diversity of waterbirds moved into the site after environmental water was delivered. Surrounding habitat is not good for woodland birds. Improvements in wetland vegetation diversity, but little change in cover. Improvements in lignum condition.
	Frog diversity, abundance and breeding  Data quality = 2		Lignum condition  Data quality = 2	
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Frog diversity, abundance and breeding  Data quality = 1	Tree condition  Data quality = 2	Lignum condition  Data quality = 2	Insufficient data to assess the refuge value of site for frogs. Tree condition maintained but not improved. Improvements in lignum condition.

Basin Plan objective	Indicators and status		Rationale
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Tree condition  Data quality = 2	Tree survival and recruitment  Data quality = 2	Improvements in the presence of tree recruits and survival of mature trees. Tree condition maintained but not improved.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Cover of terrestrial and introduced vegetation species  Data quality = 2		Slight decrease in the cover of terrestrial and introduced plant species.
To protect and restore water-dependent ecosystems that support species listed under JAMBA, CAMBA, ROKAMBA, Bonn Convention.	Waterbird diversity  Data quality = 2		Several migratory shorebirds were recorded as water levels receded.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4		Impacts of water management threats have been mitigated by delivery of environmental water to Lake Murphy in two of the last seven years.

McDonalds Swamp

McDonalds Swamp is a 164 ha wetland on the floodplain between the Loddon and the Murray Rivers. This former river red gum swamp is now dominated by open water, emergent reeds and standing dead trees as a result of historical water management. The site supports a diversity of waterbirds including ducks, large-bodied waders and as water levels recede, small waders. The wetland also supports waterfowl breeding including black swan and pink-eared ducks.

While there was some evidence of contributions to Basin Plan objectives with respect to waterbird diversity and lignum condition (Table 29), concerns over expanding cumbungi impacting on vegetation diversity and waterbird habitat have been raised. In addition, historical water management at this site resulted in prolonged inundation and the death of mature native trees, which may require additional interventions such as planting of river red gum to restore values (Papas et al., 2020).

Table 29: Contributions to Basin Plan objectives for McDonalds Swamp.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or	Waterbird diversity  Data quality = 2	Waterbird habitat  Data quality = 3	Woodland birds  Data quality = 1	High diversity and abundance of waterbirds. There is evidence that increasing cover of tall marsh may be decreasing the variety of

Basin Plan objective	Indicators and status			Rationale
communities, their life cycles, and representative populations and communities of native biota.	Frog breeding  Data quality = 1	Frog abundance  Data quality = 2	Frog diversity  Data quality = 2	habitat found in the wetland. Five common species of frog recorded, but insufficient evidence to link breeding success to environmental water. Wetland vegetation remains in poor condition, but there is evidence of improvements in lignum.
	Vegetation diversity  Data quality = 2	Lignum condition  Data quality = 2	Vegetation cover  Data quality = 2	
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Frog diversity, abundance and breeding  Data quality = 1	Lignum condition  Data quality = 3		Positive response in lignum condition. Insufficient data to assess the refuge value of site for frogs.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Tree survival and recruitment  Data quality = 2			Historical water management at this site resulted in prolonged inundation and the death of mature native trees. The surviving trees remain in poor condition.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Cover of terrestrial and introduced vegetation species  Data quality = 3			Slight decrease in the cover of terrestrial and introduced plant species.
To protect and restore water-dependent ecosystems that support species listed under JAMBA, CAMBA, ROKAMBA, Bonn Convention.	Migratory shorebirds  Data quality = 1			Several migratory shorebirds observed in moderate numbers
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4			Impacts of water management threats have been mitigated by delivery of environmental water to McDonalds Swamp in six of the last seven years.

Wirra-Lo Wetland Complex

The Wirra-Lo Wetland Complex covers 66 ha and is comprised of a series of swamps, creeks and depressions located at the junction of Barr Creek and the Loddon River. The complex is ecologically significant due to the variety of habitat types that can support a high diversity of waterbirds, frogs (including the threatened growling grass frog), mammals, reptiles and macroinvertebrates. WetMAP frog and waterbird monitoring indicates moderate contributions to Basin Plan objectives related to biodiversity (Table 30).

Table 30: Contributions to Basin Plan objectives for Wirra-Lo Wetland Complex.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Woodland birds  Data quality = 1	Waterbird habitat  Data quality = 2	Waterbird diversity  Data quality = 2	Moderate diversity and abundance of waterbirds, but an improvement observed with environmental water. Seven species of frog recorded, including the threatened growling grass frog. When inundated for a suitable duration the wetland complex will provide habitat and breeding opportunities for multiple frog species.
	Frog diversity and abundance  Data quality = 2		Frog breeding  Data quality = 2	
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Frog diversity, breeding and abundance  Data quality = 1			The WetMAP frog monitoring data are currently inadequate to assess the value of Wirra-Lo Wetland Complex as a refuge for the long-term survival and resilience of frogs.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4			Impacts of water management threats have been mitigated by delivery of environmental water to the Wirra-Lo Wetland Complex every year since 2014.

3.2.2 Lindsay, Mulcra and Wallpolla Islands

Lindsay, Mulcra and Wallpolla Islands are part of the cross-border Chowilla–Lindsay–Wallpolla TLM icon site, which has components in South Australia, New South Wales and Victoria. The islands are formed by a series of anabranches of the Murray River, covering 26,156 ha. The waterways, wetlands and broader floodplain have high ecological significance. When inundated, these areas provide refuges and resources for a range of flora and fauna, including threatened species; they also provide important waterbird breeding habitat. As at other TLM sites, works under this program have increased the ability to manage and deliver water. However, only 1,500 ha can be watered with existing works, although there is also greatly increased control over frequency and duration of wetland and floodplain inundation in these areas. The relatively small area of influence means that environmental watering is insufficient to maintain condition and diversity across the broader site (Table 31).

Horseshoe Lagoon on Wallpolla Island provides an example of the positive outcomes at a site scale, where construction of a regulator through TLM in 2006 has enabled active management of the water regime. Previously permanently inundated by the Lock 9 weir pool, the wetland is surrounded by mature river red gum communities and is an important nursery for large-bodied native fish such as gold and silver perch. The site supports a diverse frog community and several waterbird species. Monitoring of frogs shows contributions to Basin Plan biodiversity within the lagoon (Table 32).

Table 31: Contributions to Basin Plan objectives for Lindsay, Mulcra and Wallpolla Islands.

Basin Plan objective	Indicators and status		Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Waterbird diversity  Data quality = 3	Fish diversity  Data quality = 2	Waterbird diversity and abundance over the past decade has remained stable. Maintenance of fish diversity and increase in abundances of some species. Decline in water dependent flora species in both wetland and floodplain habitats due to dry conditions and infrequent inundation, particularly outside of the limited area that is able to be watered.
	Wetland vegetation  Data quality = 4	Floodplain vegetation  Data quality = 4	
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Black box condition  Data quality = 2		Ongoing decline in black box canopy condition and insufficient germination and recruitment.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Waterbird diversity  Data quality = 1		Waterbird diversity and abundance over the past decade has remained stable.
To protect and restore water-dependent ecosystems that support species listed under JAMBA, CAMBA, ROKAMBA, Bonn Convention.	Waterbird diversity  Data quality = 3		Number of migratory shorebird species at the site is declining as habitat is reduced by infrequent inundation.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4		Impacts of water management threats have been mitigated by delivery of environmental water to Lindsay, Mulcra and Wallpolla Islands in four of the last seven years. As noted above this hydrological improvement may be insufficient.

Table 32: Contributions to Basin Plan objectives for Horseshoe Lagoon.

Basin Plan objective	Indicators and status	Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Frog diversity  Data quality = 2 Frog abundance  Data quality = 3 Frog breeding  Data quality = 1	Seven frog species recorded. Generally, water-levels in Horseshoe Lagoon are maintained by the Lock 9 weir pool, providing habitat for multiple frog species.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Frog diversity, abundance and breeding  Data quality = 1	The WetMAP frog monitoring data are currently inadequate to assess the value of this asset as a refuge for frogs
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4	Impacts of water management threats have been mitigated by management of the water regime in Horseshoe Lagoon.

3.2.3 Lower Murray Wetlands

Brickworks Billabong

Brickworks Billabong is a permanent saline wetland within Merbein Common on the Murray River Floodplain north of Mildura. It contains small areas of emergent macrophytes (common reed and cumbungi) and dense submerged beds of sea tassel. The wetland supports a translocated population of the EPBC-listed Murray hardyhead. Delivery of environmental water to this site has supported persistence of this population since 2014 (Table 33).

Table 33: Contributions to Basin Plan objectives for Brickworks Billabong.

Basin Plan objective	Indicators and status	Rationale
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Fish  Data quality = 2	Murray hardyhead captured in 2019 indicate their persistence at this site.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Fish  Data quality = 2	Salinity concentrations are not high enough in Brickworks Billabong to limit spawning and recruitment of Murray hardyhead, nor to eliminate alien species. Alien species may be limiting recovery at this site.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4	Impacts of water management threats have been mitigated by delivery of environmental water to Brickworks Billabong in six years of the last seven years.

Cowanna Billabong

Cowanna Billabong is located within the Merbein Common on the floodplain of the Murray River downstream of Mildura. This freshwater billabong provides habitat for a diversity of waterbirds including several fish-eating species, it also provides off river habitat for native fish. There is limited data available for this asset, with monitoring to date represented by a small number of frog surveys (Table 34).

Table 34: Contributions to Basin Plan objectives for Cowanna Billabong.

Basin Plan objective	Indicators and status	Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Frog diversity and abundance  Data quality = 3	Wetland condition provides habitat for multiple frog species, five species recorded in 2018–19.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Frog diversity, abundance and breeding  Data quality = 1	The WetMAP frog monitoring data are currently inadequate to assess the value of Cowanna Billabong as a refuge for the long-term survival and resilience of frogs. Longitudinal data are needed.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4	Impacts of water management threats have been mitigated by delivery of environmental water to Cowanna Billabong in 2015.

Cardross Lake

Cardross Lake is the main waterbody in the Cardross Lakes complex of interconnected irrigation drainage basins. While not a natural wetland, it has received irrigation drainage since the 1930s and provides approximately 80 ha of predominantly open water habitat. The saline system contains beds of the submerged aquatic plant sea tassel and populations of the EPBC-listed endangered Murray hardyhead and the FFG-listed southern purple spotted gudgeon (last recorded in the 1990s) previously colonised this lake. As a result, it was listed as a wetland of national importance. While the Murray hardyhead population survived the Millennium drought at this site, none were detected during sampling in 2017 and 2018. Environmental water has not been delivered to the lake since 2017-18.

Table 35: Contributions to Basin Plan objectives for Cardross Lake.

Basin Plan objective	Indicators and status	Rationale
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Fish  Data quality = 2	No Murray hardyhead detected during sampling in 2017 and 2018.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Fish  Data quality = 2	Cardross Lake previously contained a Murray hardyhead population. The population survived the Millennium drought, but none were captured during sampling in 2017 and 2018.

Basin Plan objective	Indicators and status	Rationale
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4	Impacts of water management threats have been mitigated by delivery of environmental water to Cardross Lake in three of the last seven years.

Kings Billabong, including Ducksfoot Lagoon

Kings Billabong is a 1,867 ha floodplain-wetland complex located in the Kings Billabong Park approximately 10 km south east of Mildura. It is an important conservation area due to its environmental and recreation value. The area contains several depleted and vulnerable ecological vegetation classes and regionally important wetlands, and it supports a high number of native flora and fauna species. Limited data suggests moderate contributions to Basin Plan objectives by the maintenance of frog populations at the site (Table 36).

Ducksfoot Lagoon is a small wetland within the Kings Billabong Park, located adjacent to the Murray River. It was permanently inundated by the influence of the Lock 11 weir pool until a regulator was built in 2010 to enable management of its water regime.

While neither wetland has received held environmental water to date, the wetting and drying of Ducksfoot Lagoon is actively managed for environmental outcomes using the connected regulator. The site supports foraging habitat for a diversity of waterbirds and frog species, including the EPBC-listed growling grass frog. WetMAP monitoring of frogs and fish has demonstrated contributions to Basin Plan objectives related to biodiversity, refugia and connectivity at this asset (Table 37).

Table 36: Contributions to Basin Plan objectives for Kings Billabong.

Basin Plan objective	Indicators and status		Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Frog abundance  Data quality = 3	Frog breeding  Data quality = 1	Six species of frog recorded, including the threatened growling grass frog.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Frog diversity, abundance and breeding  Data quality = 1		The WetMAP frog monitoring data are currently inadequate to assess the value of this asset as a refuge for frogs.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4		Impacts of water management threats have been mitigated by active management of the water regime in Kings Billabong.

Table 37: Contributions to Basin Plan objectives for Ducksfoot Lagoon.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Frog diversity and abundance  Data quality = 2	Fish diversity  Data quality = 3	Fish abundance  Data quality = 3	Five species of frog recorded, with two in large abundances. Relatively high native fish species richness. Demonstrated relationship between inundation and production of fish.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Frog breeding  Data quality = 1	Fish biomass  Data quality = 2		The WetMAP frog monitoring data are currently inadequate to assess the value of this asset as a refuge for frogs. Asset continues to maintain a moderate level of fish biomass and rapid recolonization after drawdown.
To protect and restore connectivity within and between water-dependent ecosystems – longitudinally along watercourses, laterally between watercourses, floodplains and wetlands, and vertically between surface and subsurface.	Fish dispersal  Data quality = 3			Native fish movement into and out of Ducksfoot Lagoon has been demonstrated.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4			Impacts of water management threats have been mitigated by active management of the water regime in Ducksfoot Lagoon.

Lake Hawthorn

Lake Hawthorn is a saline wetland on the Murray River floodplain, approximately 3 km from Mildura. The site periodically supports migratory shorebirds. The lake also supports submerged sea tassel, which provided important habitat for the EPBC-listed Murray hardyhead prior to and during the Millennium Drought. However, this species has not been detected in recent years and a reintroduction attempt in 2018 was unsuccessful, most likely due to the high salinity levels. Environmental water delivery has not been able to reduce salinity to tolerable levels that would support spawning and recruitment of Murray hardyhead in the future (Table 38). As such, supporting this species may no longer be an appropriate management objective and its absence is unlikely to be representative of the broader health of this asset.

Table 38: Contributions to Basin Plan objectives for Lake Hawthorn.

Basin Plan objective	Indicators and status	Rationale
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Fish  Data quality = 2	Environmental water delivery was unable to reduce salinity levels within the range suitable to support Murray hardyhead spawning and recruitment. The species is no longer present at this site.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Fish  Data quality = 1	Environmental water delivery was unable to reduce salinity levels within the range suitable to support Murray hardyhead spawning and recruitment. The species is no longer present at this site.

Basin Plan objective	Indicators and status	Rationale
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4	Environmental water has been delivered to Lake Hawthorn, in four of the last five years. While Murray hardyhead are no longer present, the site continues to provide periodic habitat for migratory shorebirds.

Heywood Lakes (including Little Heywood Lake)

Heywood Lakes are situated on the River Murray floodplain between Swan Hill and Robinvale, southeast of Boundary Bend. The site includes three wetlands, covering approximately 1600 ha: Heywood's Lake and Little Lake Heywood, located to the south of the Murray Valley Highway, and one small unnamed wetland to the north of the highway. Heywood's Lake and Little Lake Heywood are ephemeral deflation basins that fluctuate between terrestrial and aquatic states. The wetlands fill naturally during very high floods of the Murray River and, after filling, Heywood's Lake would retain water for several years. The site supports a diversity of wetland flora and fauna when inundated, including more than 30 waterbird species, some of which are listed as under the FFG Act (Australian bustard, blue-billed duck, eastern great egret, freckled duck, little egret, white-bellied sea eagle). The EPBC-listed growling grass frog and regent parrot have also been recorded at this site.

While there is some evidence that environmental water has improved wetland vegetation diversity and decreased encroachment of terrestrial vegetation onto the wetland bed at this asset, prolonged inundation has resulted in a decline in the condition of mature black box trees (Table 39).

Table 39: Contributions to Basin Plan objectives for Heywood Lakes.

Basin Plan objective	Indicators and status	Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Vegetation diversity  Data quality = 2 Vegetation Cover  Data quality = 2	Moderate improvements in wetland vegetation cover and diversity.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Tree condition  Data quality = 2	Trees at this site remain in poor condition.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Tree survival and recruitment  Data quality = 2 Tree condition  Data quality = 2	Little improvement in the presence of tree recruits and survival of mature trees. Trees at this site remain in poor condition.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Cover of terrestrial and introduced vegetation species  Data quality = 2	Slight decrease in the cover of terrestrial and introduced plant species.

Basin Plan objective	Indicators and status	Rationale
	Management of flow regime  Data quality = 4	Impacts of water management threats have been mitigated by delivery of environmental water to Heywood Lakes in two of the last four years.

Lake Koorlong

Lake Koorlong is located near Lake Cardross on the Murray River floodplain south-west of Mildura. Like Cardross Lake, it is an artificial evaporation basin that has received irrigation drainage since the 1930s. The lake provides predominantly open water habitat and contains beds of the submerged aquatic plant sea tassel. A population of the EPBC-listed Murray hardyhead has been established in Lake Koorlong through a series of translocations from 2009 to 2013. Environmental water has been delivered to the lake to manage lake levels and salinity, to ensure suitable habitat is maintained (Table 40). Sampling in 2018 detected large numbers of Murray hardyhead, indicating successful multi-generational breeding. For more information, please see the case study in section 5.1.

Table 40: Contributions to Basin Plan objectives for Lake Koorlong.

Basin Plan objective	Indicators and status	Rationale
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Fish  Data quality = 2	Lake Koorlong is actively managed to maintain suitable habitat for Murray hardyhead. Sampling in 2018 detected large numbers of this species.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Fish  Data quality = 2	Salinity in Lake Koorlong is not high enough to impact Murray hardyhead spawning success (nor does it eliminate other species of fish). Dense aquatic vegetation provides ample resources for all fish present, reducing competitive interactions, or may have mediated inter-specific aggression through the provision of structurally complex habitat.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4	Delivery of environmental water to Lake Koorlong for the last two years has maintained suitable habitat for Murray hardyhead.

Margooya Lagoon

Margooya Lagoon is a 44 ha wetland on the floodplain of the Murray River, 10 km south-east of Robinvale. Although held environmental water has not been delivered to this site to date, construction of a regulator in 2009 has enabled the water regime to be managed for environmental outcomes. Prior to this, the wetland was permanently inundated by the Lock 15 weir pool. The littoral zone of the lagoon supports the Tall Marsh EVC, surrounded by fringing river red gum woodland. The wetland provides habitat for a large range of species, including the EPBC-listed growling grass frog, regent parrot and the FFG-listed white-bellied sea-eagle. The lagoon also provides nursery habitat for native fish species such as golden and silver perch. Fish monitoring carried out under WetMAP demonstrates contributions to Basin Plan objectives related to diversity, refugia and connectivity (Table 41).

Table 41: Contributions to Basin Plan objectives for Margooya Lagoon.

Basin Plan objective	Indicators and status		Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Fish diversity  Data quality = 2	Fish biomass  Data quality = 2	Asset supports a relatively high number of native fish species. Some evidence of increased fish production with inundation.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Fish biomass  Data quality = 2		Environmental water is used to regularly top up the lagoon and prevent it drying out and reducing fish biomass to zero. The site provides a refuge in the wider wetland.
To protect and restore connectivity within and between water-dependent ecosystems – longitudinally along watercourses, laterally between watercourses, floodplains and wetlands, and vertically between surface and subsurface.	Fish dispersal  Data quality = 3		The movement of native fish into and out of Margooya Lagoon has been demonstrated.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4		Impacts of water management threats have been mitigated by actively managing the water regime in Margooya Lagoon.

Nyah Floodplain

The Nyah floodplain comprises around 900 ha of wetland, river red gum forest and black box woodland, located 30 km north of Swan Hill. The diversity of habitat at the site supports a range of species, including a number listed as threatened under the EPBC Act (growling grass frog, Murray cod, silver perch and regent parrot) and FFG Act (broad-shelled turtle, royal spoonbill and Nankeen night-heron). Frog monitoring under WetMAP has only recently commenced at this site, and there is insufficient data to determine contributions to Basin Plan objectives at this stage (Table 42).

Table 42: Contributions to Basin Plan objectives for Nyah Floodplain.

Basin Plan objective	Indicators and status		Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Frog abundance and diversity  Data quality = 1	Frog breeding  Data quality = 1	Three common frog species recorded 2018-19, but monitoring is currently inadequate to assess the value of this wetland for biodiversity and breeding.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Frog abundance and diversity  Data quality = 1	Frog breeding  Data quality = 1	Frog monitoring is currently inadequate to assess the value of this wetland as a refuge for the long-term survival and resilience of frogs.

Basin Plan objective	Indicators and status	Rationale
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4	Impacts of water management threats have been mitigated by delivery of environmental water to the Nyah Floodplain in four of the last seven years.

Ned's Corner East

Ned's Corner East is a Murray River floodplain wetland within Ned's Corner Station, a property owned and managed by Trust for Nature. Ned's Corner is the largest freehold property in Victoria and the biggest private conservation reserve in the state, located around 60 km west of Mildura. The wetland is surrounded by river red gum and black box woodland and supports a diversity of frogs and waterbirds. While there is some evidence that environmental watering has maintained frogs, trees and lignum at this location (Table 43), high temperatures during and after watering in 2018 and 2019 led to the widespread mortality of wetland vegetation before flowering and seed set could occur (Papas et al., 2020).

Table 43: Contributions to Basin Plan objectives for Ned's Corner East.

Basin Plan objective	Indicators and status		Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Frog breeding  Data quality = 1	Frog abundance and diversity  Data quality = 2	Six common frog species recorded. Insufficient data to assess trends in abundance or diversity of waterbirds.
	Vegetation cover and diversity  Data quality = 2	Bird abundance and diversity  Data quality = 1	Little improvement in vegetation cover or diversity following environmental water.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Frogs  Data quality = 1	Tree condition  Data quality = 2	Lignum condition  Data quality = 2	Moderate improvement in lignum, no change in tree condition. Insufficient data to assess the refuge value of site for frogs.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Tree survival and recruitment  Data quality = 2	Tree condition  Data quality = 2	Little improvement in the presence of tree recruits and survival of mature trees. No change in tree condition.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Cover of terrestrial and introduced vegetation species  Data quality = 2		Slight decrease in the cover of terrestrial and introduced plant species.

Basin Plan objective	Indicators and status	Rationale
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4	Impacts of water management threats have been mitigated by delivery of environmental water to Ned's Corner East in four of the last seven years.

Vinifera Floodplain

The Vinifera Floodplain comprises around 640 ha of wetland, creek, river red gum forest and black box woodland, on the Murray River in northern Victoria. When inundated, the site supports a diversity of species, including several EPBC-listed species including growling grass frog, Murray cod, silver perch and FFG-listed bird species including hardhead, royal spoonbill and Nankeen night-heron.

There is some evidence that environmental water has contributed to Basin Plan objectives through maintenance of vegetation diversity and condition (Table 44). Waterbirds, frogs and fish are not monitored at this site.

Table 44: Contributions to Basin Plan objectives for Vinifera Floodplain.

Basin Plan objective	Indicators and status	Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Vegetation diversity  Data quality = 3 Vegetation cover  Data quality = 3	Maintenance of wetland vegetation cover and diversity in response to environmental water.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Tree condition  Data quality = 2	No change in tree condition at this site.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Tree condition  Data quality = 2 Tree survival and recruitment  Data quality = 2	Improvements in the presence of tree recruits and survival of mature trees. Trees at this site remain in poor condition.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Cover of terrestrial and introduced vegetation species  Data quality = 2	Slight decrease in the cover of terrestrial and introduced plant species.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4	Impacts of water management threats have been mitigated by delivery of environmental water to the Vinifera Floodplain in four of the last seven years.

3.2.4 Hattah Lakes

The Hattah Lakes is an extensive complex of lakes and floodplain set within the Hattah–Kulkyne National Park and the Murray–Kulkyne Regional Park. Twelve of the lakes are part of the Hattah–Kulkyne Lakes Ramsar Site, listed primarily for their value as waterbird habitat and importance in maintaining regional biodiversity. The area is also one of TLM's six icon sites.

The lakes support breeding of colonial nesting waterbirds, primarily fish-eating species such as cormorants, and provide occasional nursery habitat for native fish. There are extensive areas of river red gum and black box woodland on the floodplain surrounding the lakes, which support a diversity of waterbirds and woodland birds including the EPBC-listed regent parrot. Through TLM, environmental watering infrastructure was completed in 2014 that enables watering of 6,000 ha of lakes and floodplain, including all 12 Ramsar-listed lakes. This has improved the condition of vegetation, fish and waterbirds and maintained the ecological character of this Ramsar site (Table 45). For more information, please see the case study in section 5.1.

Table 45: Contributions to Basin Plan objectives for Hattah Lakes.

Basin Plan objective	Indicators and status	Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Black box Data quality = 4	Improvements in the condition of black box woodland at the site in response to environmental water.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Floodplain vegetation Data quality = 4 Lignum Data quality = 2 Wetland vegetation Data quality = 4 Black box Data quality = 4	Improvement in the condition of floodplain and wetland vegetation communities. Condition of lignum has been maintained.
To ensure that declared Ramsar wetlands that depend on Basin water resources maintain their ecological character.	Wetland vegetation Data quality = 4 Native fish Data quality = 3 Waterbird breeding Data quality = 3	All measures are within Limits of Acceptable Change. Improvements in wetland vegetation, native fish populations and waterbird breeding have been recorded.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Native fish Data quality = 3 Waterbird breeding Data quality = 3	Improved breeding and recruitment of native fish; nursery habitat provided. Significant cormorant breeding events in response to environmental water delivery.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime Data quality = 4	Impacts of water management threats have been mitigated by delivery of environmental water to Hattah Lakes every year since 2013.

3.3 Wimmera-Mallee

The Wimmera-Mallee WRPA (see Figure 4) is located in north-west Victoria and extends from the Grampians and the Pyrenees Ranges in the South, to Ouyen and Kerang in the North. The WRPA extends west to the South Australian border and east to meet the Northern Victoria WRPA. The area is dominated by the Wimmera, Avon-Richardson and Avoca River systems. The three waterway systems flow inland to the north, terminating in large lake systems. Major wetlands in the WRPA include Lake Albacutya and Lake Hindmarsh, terminal lakes of the Wimmera system, and the Wimmera Mallee Pipeline wetlands, a large collection of wetlands located east of the terminal lakes. Only a few waterways in the region can receive water for the environment (Table 46).

Figure 4: Priority environmental assets in the Wimmera-Mallee WRPA.

Table 46: Environmental water delivered to assets within the Wimmera-Mallee WRPA since 2013 (ML)

Assets	2019-20	2018-19	2017-18	2016-17	2015-16	2014-15	2013-14
Carapugna Wetland	10.3	13.8	14.2	4.8	-	8.6	-
Crow Swamp	5	10.9	11.8	3.1	4.9	9.3	-
MacKenzie River, Burnt Creek and Bungalally Creek	2,178	3,388	6,403	3,429	1,010	-	-
Mount William Creek	139	1,660	764	155	100	-	-

3.3.1 Wimmera System

Burnt Creek

Burnt Creek is a distributary of the MacKenzie River in western Victoria. The riparian zone is lined with river red gum and melaleuca. The waterway is a key location for the breeding of southern pygmy perch and obscure galaxias. Although results of VEFMAP indicate contributions to Basin Plan objectives by improvements in vegetation and fish at this asset (Table 47), it should be noted that this is largely due to conditions in the perennially flowing upper Burnt Creek, whereas the lower reaches are often dry flow for prolonged periods.

Table 47: Contributions to Basin Plan objectives for Burnt Creek.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Fish abundance  Data quality = 3	Emergent vegetation  Data quality = 4		Increase in abundance and distribution of native fish. Increased abundance of emergent and fringing herbaceous plant species in response to flow management. Consistent and abundant in-stream vegetation in upper and middle reaches.
	Herbaceous vegetation  Data quality = 4	Instream vegetation  Data quality = 4		
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Emergent vegetation  Data quality = 4	Herbaceous vegetation  Data quality = 4	Instream vegetation  Data quality = 4	Deep-rooted emergent vegetation likely to be resilient to dry conditions. Flowing upper reaches are a refugia for herbaceous fringing vegetation. Environmental flows support the existing in-stream plants.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal,	Vegetation recruitment  Data quality = 4	Fish dispersal  Data quality = 3	Fish recruitment  Data quality = 1	Environmental flows are enhancing germination and recruitment of vegetation, but in a narrow riparian band. Positive responses for fish dispersal and evidence of fish recruitment.

Basin Plan objective	Indicators and status	Rationale
movement, migration, food webs).		
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Vegetation growth and survival  Data quality = 4	Environmental flows are reducing the encroachment of exotic terrestrial species within this waterway.
To protect and restore connectivity within and between water-dependent ecosystems – longitudinally along watercourses, laterally between watercourses, floodplains and wetlands, and vertically between surface and subsurface.	Fish dispersal  Data quality = 1	Environmental water has enhanced connectivity and water quality to recover and maintain fish species. Lower Burnt Creek receives little environmental water and remains in poor condition.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4	Impacts of water management have been mitigated by delivery of environmental water to Burnt Creek every year since 2015.

MacKenzie River

The MacKenzie River is a tributary of the Wimmera River. It is known for supporting the only confirmed population of platypus in the Wimmera region and is a key location for river blackfish, southern pygmy perch and obscure galaxias. The waterway supports the EPBC-listed Glenelg spiny crayfish and the rare western swamp crayfish.

Similar to Burnt Creek, the upper sections of the MacKenzie River are in better condition than the lower reaches. However, environmental water is helping to maintain refuge pools in the lower sections and contributing to Basin Plan objectives (Table 48). High and increasing abundance and distribution of native fish species, including southern pygmy perch, galaxiids and gudgeons since the Millennium drought when much of the reach dried. As these short-lived species need to recruit almost every year to maintain their populations, increased abundance 2013-2018 show the in-stream and other processes to meet ecological requirements (e.g. for reproduction and recruitment) are being supported. For more information, please see the case study in section 5.2.

Table 48: Contributions to Basin Plan objectives for the MacKenzie River.

Basin Plan objective	Indicators and status		Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Fish abundance and diversity  Data quality = 3	Emergent vegetation  Data quality = 4	Increase in abundance and distribution of native fish. An increase in abundance of emergent and fringing herbaceous plant species in response to flow management. Increases in instream, aquatic vegetation, particularly in the lower reaches, where these species had been absent for many years.
	Herbaceous vegetation  Data quality = 4	Instream vegetation  Data quality = 4	

Basin Plan objective	Indicators and status			Rationale
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Emergent vegetation  Data quality = 4	Herbaceous vegetation  Data quality = 4	Instream vegetation  Data quality = 4	Key drought refugia (pools) and sections between pools are being maintained and restored for fringing vegetation. This includes most of the upper reaches.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Vegetation recruitment  Data quality = 4	Fish abundance and distribution  Data quality = 2	Fish recruitment  Data quality = 2	Environmental flows are enhancing germination and recruitment of vegetation, but in a narrow riparian band. Positive responses for fish distribution and evidence of fish recruitment.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Vegetation growth and survival  Data quality = 4			Most exotic plant species at this site are terrestrial; providing environmental flows suppresses encroachment.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4			Impacts of water management have been mitigated by delivery of environmental water every year since 2015.

Mt William Creek

The Mt William Creek is a major tributary of the Wimmera River, rising on the slopes of Mt William in the Grampians and discharging to the Wimmera River near Taylor's Lake. Mount William Creek supports regionally important populations of river blackfish, southern pygmy perch and the western swamp crayfish. Environmental water is helping to maintain refugia in this asset and contributing to Basin Plan objectives with respect to fish and vegetation (**Table 49**).

Table 49: Contributions to Basin Plan objectives for Mt William Creek.

Basin Plan objective	Indicators and status		Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Fish diversity  Data quality = 3	Emergent vegetation  Data quality = 4	Maintaining abundance and distribution of native fish. A slow expansion of emergent and fringing herbaceous plant species and instream vegetation in response to flow management.
	Herbaceous vegetation  Data quality = 4	Instream vegetation  Data quality = 4	

Basin Plan objective	Indicators and status			Rationale
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Emergent vegetation  Data quality = 4	Herbaceous vegetation  Data quality = 4	Instream vegetation  Data quality = 4	Key drought refugia (pools) and sections between pools are being maintained and restored for fringing vegetation.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Vegetation recruitment  Data quality = 4	Fish dispersal  Data quality = 3	Fish recruitment  Data quality = 1	Environmental flows are enhancing germination and recruitment of vegetation, but in a narrow riparian band. Spatial distribution indicates protection of fish dispersal, and there is improved fish recruitment, but lower reach remains in poor condition
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Vegetation growth and survival  Data quality = 4			Environmental flows prevent encroachment of exotic terrestrial species within this waterway.
To protect and restore connectivity within and between water-dependent ecosystems – longitudinally along watercourses, laterally between watercourses, floodplains and wetlands, and vertically between surface and subsurface.	Fish dispersal  Data quality = 1			Environmental water post 2011 has enhanced connectivity and water quality to recover and maintain fish species. Lower reach remains in poor condition.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4			Impacts of water management have been mitigated by delivery of environmental water to Mt William Creek every year since 2015.

3.3.2 Wimmera-Mallee Pipeline Wetlands

Carapugna Wetland

Carapugna Wetland is an intermittent wetland comprising black box open woodland and areas of freshwater meadow. When inundated it supports a diversity of aquatic wetland species including the EPBC-listed ridged water-milfoil. The wetland supports a variety of waterbird species including ducks and large-bodied waders, with breeding observed for Australasian grebes.

While there is evidence of contribution to Basin Plan objectives from improvements in vegetation diversity and lignum condition and the maintenance of waterbird abundance and breeding (Table 50), inundation was of insufficient duration to support large numbers or a diversity of frogs, although this is based on only two years of monitoring.

Table 50: Contributions to Basin Plan objectives for Carapugna Wetland.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Woodland birds Data quality = 1	Waterbird breeding Data quality = 1	Waterbird diversity Data quality = 1	Insufficient duration of inundation to support large numbers of birds or waterbird breeding. Very low abundance and diversity of frogs due to short durations of inundation over 2018-2020 monitoring period. Increase in wetland species richness, lignum in good condition and little improvement in native vegetation cover.
	Frog breeding Data quality = 1	Frog abundance Data quality = 2	Frog diversity Data quality = 2	
	Vegetation diversity Data quality = 2	Lignum condition Data quality = 2	Vegetation cover Data quality = 2	
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Frogs Data quality = 1	Tree condition Data quality = 2	Lignum condition Data quality = 2	Moderate improvement in tree condition, lignum in good condition. Insufficient data to assess the refuge value of site for frogs.
To protect and restore in-stream and floodplain processes including flow components and inundation and recession events that meet ecological requirements (e.g. habitat diversity, recruitment, regeneration, dispersal, movement, migration, food webs).	Tree survival and recruitment Data quality = 2	Tree condition Data quality = 2		Improvements in the presence of tree recruits and survival of mature trees. Trees at this site remain in moderate condition.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Cover of terrestrial and introduced vegetation species Data quality = 2			Slight decrease in the cover of terrestrial and introduced plant species.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime Data quality = 4			Impacts of water management have been mitigated by delivery of environmental water to Carapugna Wetland for five of the last six years.

Crow Swamp

Crow Swamp is a shallow freshwater marsh comprising river red gum woodland and areas of freshwater meadow. The wetland supports a community of the rare spiny lignum and when inundated a variety of

waterbirds and frog species. There is some evidence that improved vegetation diversity is contributing to the relevant Basin Plan objective (Table 51).

Table 51: Contributions to Basin Plan objectives for Crow Swamp.

Basin Plan objective	Indicators and status			Rationale
To protect and restore biodiversity dependent on Basin water resources, including ecosystems supporting threatened species or communities, their life cycles, and representative populations and communities of native biota.	Frog diversity, abundance and breeding  Data quality = 1	Vegetation diversity  Data quality = 2	Vegetation Cover  Data quality = 2	Insufficient data to assess the site for frogs. Moderate improvements in wetland vegetation diversity and abundance.
To protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna.	Frog diversity, abundance and breeding  Data quality = 1			Insufficient data to assess the refuge value of site for frogs.
To mitigate human-induced threats such as impacts of alien species, water management activities and degraded water quality.	Management of flow regime  Data quality = 4			Impacts of water management threats have been mitigated by delivery of environmental water to Crow Swamp every year since 2014.

4. Basin Plan Targets

Table 52 summarises where Victoria has met Basin Plan targets at each asset, as set out in Schedule 7:

"*Long Term Targets from July 1, 2019: (2) There are improvements in the following:*

(a) flow regimes which include relevant flow components set out in paragraph 8.51(1)(b);

(b) hydrologic connectivity between the river and floodplain and between hydrologically connected valleys;

(c) river, floodplain and wetland types including the condition of priority environmental assets and priority ecosystem functions;

(d) condition of the Coorong and Lower Lakes ecosystems and Murray Mouth opening regime;

(e) condition, diversity, extent and contiguousness of native water-dependent vegetation;

(f) recruitment and populations of native water-dependent species, including vegetation, birds, fish and macroinvertebrates;

(g) the community structure of water-dependent ecosystems".

For each asset, indicators which demonstrate that targets are being met are listed in the relevant column for each target. Where cells are blank, this means that the target is not applicable to that asset, relevant indicators are not measured at the asset, or that the target has not been met. For example, by providing environmental water and managing the water regime, Target 2a is achieved at all assets as the flow regime has been improved. Section 3 provides additional information about the indicator measured at each asset and the improvements detected.

Table 52: Achievement of Basin Plan Targets

Asset	Basin Plan Targets					
	2a (hydrology)	2b (connectivity)	2c (wetland types)	2e (vegetation)	2f (fauna)	2g (community structure)
Twelve Mile Creek	Flow regimes		Emergent and fringing herbaceous vegetation	Emergent and fringing herbaceous vegetation		Emergent and fringing herbaceous vegetation
Barmah Forest	Flow regimes		Understorey vegetation	Understorey vegetation	Waterbird diversity and abundance	Waterbird breeding, native fish recruitment; frog breeding
Black Swamp	Flow regimes		Tree survival and recruitment	Tree survival and recruitment	Native fish diversity	Tree survival and recruitment

Asset	Basin Plan Targets					
	2a (hydrology)	2b (connectivity)	2c (wetland types)	2e (vegetation)	2f (fauna)	2g (community structure)
Brickworks Billabong	Flow regimes					
Broken Creek	Flow regimes	Fish dispersal				
Broken River	Flow regimes				Native fish abundance	Native fish recruitment
Burnt Creek	Flow regimes	Fish dispersal	Emergent and fringing herbaceous vegetation; instream vegetation	Emergent and fringing herbaceous vegetation; instream vegetation	Native fish abundance	Native fish recruitment; vegetation growth and survival
Campaspe River	Flow regimes		Emergent and fringing herbaceous vegetation; instream vegetation	Emergent and fringing herbaceous vegetation; instream vegetation	Native fish abundance	Native fish recruitment; vegetation growth and survival
Carapugna Wetland	Flow regimes		Vegetation diversity	Vegetation diversity, lignum condition		
Cardross Lake	Flow regimes					
Cowanna Billabong	Flow regimes					
Crow Swamp	Flow regimes		Vegetation diversity	Vegetation diversity		
Gaynor Swamp	Flow regimes		Waterbird habitat; wetland vegetation cover, lignum condition	Wetland vegetation cover, lignum condition	Waterbird abundance	
Goulburn River	Flow regimes	Riparian seed dispersal; fish dispersal			Native fish diversity and abundance	Fish spawning and recruitment
Gunbower Forest	Flow regimes	Fish dispersal	Habitat for fauna; floodplain vegetation	Floodplain vegetation; threatened flora; tree recruitment	Threatened waterbirds	Tree recruitment

Asset	Basin Plan Targets					
	2a (hydrology)	2b (connectivity)	2c (wetland types)	2e (vegetation)	2f (fauna)	2g (community structure)
Hattah Lakes	Flow regimes		Black box condition; floodplain vegetation, wetland vegetation	Black box condition; floodplain vegetation, wetland vegetation	Native fish diversity and abundance	Waterbird breeding
Hird Swamp	Flow regimes		Waterbird habitat; vegetation diversity	Vegetation diversity	Waterbird diversity	
Johnsons Swamp	Flow regimes					
Kings Billabong including Ducksfoot Lagoon	Flow regimes (managed regulator)	Fish dispersal			Fish diversity and abundance	Fish biomass
Kinnairds Swamp	Flow regimes				Frog diversity and abundance	
Lake Cullen	Flow regimes		Waterbird habitat		Waterbird diversity	
Lake Elizabeth	Flow regimes				Waterbird diversity; native fish condition	Fish spawning and recruitment
Lake Hawthorn	Flow regimes					
Heywood Lakes	Flow regimes		Vegetation diversity	Vegetation cover and diversity		
Lake Koorlong	Flow regimes				Native fish condition	Fish spawning and recruitment
Lake Little Meran	Flow regimes				Waterbird diversity and abundance; woodland birds	Waterbird breeding
Lake Murphy	Flow regimes		Waterbird habitat	Lignum condition	Waterbird diversity	
Lake Yando	Flow regimes		Vegetation diversity	Vegetation diversity, lignum condition; tree survival and recruitment		Tree survival and recruitment
Lindsay, Mulcra and Wallpolla Islands	Flow regimes				Native fish diversity	

Asset	Basin Plan Targets					
	2a (hydrology)	2b (connectivity)	2c (wetland types)	2e (vegetation)	2f (fauna)	2g (community structure)
Loddon River	Flow regimes	Fish dispersal	Emergent vegetation	Emergent vegetation	Fish dispersal	
MacKenzie River	Flow regimes		Emergent and fringing herbaceous vegetation; instream vegetation	Emergent and fringing herbaceous vegetation; instream vegetation	Native fish abundance	Native fish recruitment; vegetation growth and survival
Margooya Lagoon	Flow regimes (managed regulator)	Fish dispersal			Native fish diversity	Fish biomass
McDonalds Swamp	Flow regimes			Lignum condition	Waterbird diversity	
Moodies Swamp	Flow regimes				Woodland birds	
Mt William Creek	Flow regimes		Emergent and fringing herbaceous vegetation; instream vegetation	Emergent and fringing herbaceous vegetation; instream vegetation		Native fish recruitment; vegetation growth and survival
Ned's Corner East	Flow regimes			Lignum condition		
Nyah Floodplain	Flow regimes					
Ovens River	Flow regimes				Fish diversity	Fish reproduction
Pyramid Creek	Flow regimes	Fish dispersal				
Reedy Swamp	Flow regimes				Waterbird diversity; migratory shorebirds	Waterbird breeding
Richardson's Lagoon	Flow regimes		Wetland vegetation diversity		Wetland vegetation diversity	
Round Lake	Flow regimes		Waterbird habitat		Waterbird diversity and abundance; woodland birds; native fish condition	Waterbird breeding; fish spawning and recruitment
Tullaroop Creek	Flow regimes		Emergent vegetation	Emergent vegetation		Vegetation recruitment
Vinifera Floodplain	Flow regimes		Tree survival and recruitment	Tree survival and recruitment		Tree survival and recruitment

Asset	Basin Plan Targets					
	2a (hydrology)	2b (connectivity)	2c (wetland types)	2e (vegetation)	2f (fauna)	2g (community structure)
Wallpolla Horseshoe	Flow regimes				Frog diversity and abundance	
Wirra-Lo Wetland Complex	Flow regimes		Waterbird habitat		Waterbird diversity; frog diversity and abundance	

5. Case studies

Waterway condition is influenced by many factors that cannot be adequately captured in the high-level outcomes assessment documented in the previous sections of this report. Case studies have been developed for a selection of waterways to illustrate the complexities of past management, current condition and future challenges for these sites that will influence the outcomes that can be achieved by environmental watering.

5.1 Wetlands

5.1.1 Multi-year watering strategies: Maintaining the ecological character of the Hattah-Kulkyne Lakes Ramsar Site

The Hattah-Kulkyne Lakes were listed as a wetland of international importance in 1982. The site comprises 12 separate lakes within the Hattah-Kulkyne National Park in the Mallee region of Victoria. The site supports a diversity of native wetland vegetation and waterbirds, waterbird breeding, and acts as a nursery for several species of native fish. The lakes receive water via Chalka Creek, an anabranch of the Murray River.

The site depends on regular flooding and was severely degraded by river regulation and water extraction, which had reduced the frequency, magnitude and duration of high flows. The associated impacts included reductions in the health of river red gum and black box communities (including tree deaths and a demonstrated transition to a more terrestrial understorey), a reduction in the availability of wetland habitat for waterbirds, fish, frogs and turtles, and in the diversity and abundance of wetland flora in the lakes.

Environmental works, funded through TLM, were completed in 2014 to restore a more natural water regime to the lakes and achieve the ecological objectives that had been set for the system. The works included construction of a large pump station and a series of stop banks and flow regulators, as well as lowering sills in Chalka Creek to enable natural inflow to occur more frequently (at Murray River flows of around 23,000 ML/day, rather than 36,000 ML/day). In the absence of high river flows, environmental water can be pumped into the lakes and retained using regulators, until required inundation durations are met. As the pumps can be used at any river level, this provides an effective mechanism to water the lake system during dry times.

The works are operated in conjunction with natural high flows to provide a variable water regime across the lake system, which includes more than 20 perennial and intermittent wetlands, ranging in size from less than 10 ha to around 200 ha. Surrounding vegetation communities range from those that require frequent flooding, such as river red gum woodland, to those that require only periodic inundation, such as black box woodland and lignum shrubland. Watering events of different extents and sizes are needed to meet the water requirements of this diverse landscape.

For example, Lake Kramen is an episodic wetland, located some distance from the rest of the lake system. It would have flooded relatively rarely under natural conditions, only during very high Murray River flows. Environmental water was used in this lake most recently in 2019 when monitoring indicated that vegetation was in poor health and at risk of a permanent decline. Lake Kramen will now be allowed to dry out over several years, until ecological condition again indicates a watering event is needed.

Conversely, other wetlands such as Lake Hattah, a naturally semi-permanent wetland, need much more frequent watering and support a different set of ecological characteristics. Lake Bitterang, a persistent temporary wetland, requires yet another water regime (Figure 5). This strategic multi-year management of variable water regimes across different wetlands supports the diversity of habitat required for the survival of a suite of different types of waterbirds from fish eating species such as pelicans and cormorants that prefer deeper water, to small wading species that forage on mudflats.

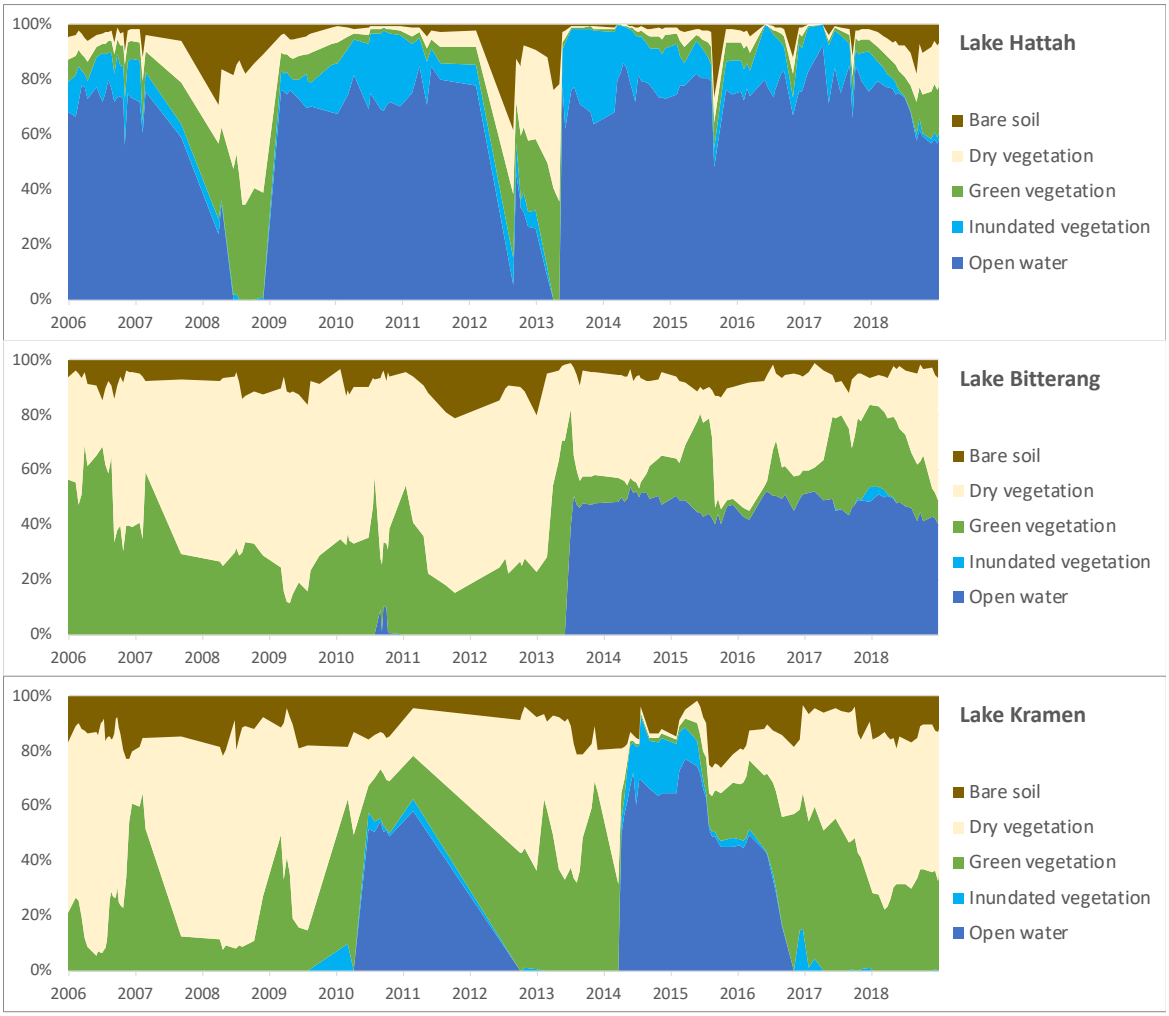


Figure 5: Proportions of open water, inundated vegetation, green vegetation, brown vegetation and bare soils at Lakes Hattah, Bitterang and Kramen in the Hattah-Kulkyne Lakes Ramsar Site.

Note no data for Lake Kramen between September 2011 and March 2013.

Source: GeoScience Australia; WIT

5.1.2 Achieving ecological outcomes requires more than just water: Barmah Forest

Barmah Forest, like many Victorian Ramsar sites, was listed as a wetland of international importance in 1982. Together with Millewa Forest in NSW, it forms the largest remaining expanse of river red gum forest and woodland in Australia. It is considered internationally important for its wetland vegetation communities, supporting threatened species and colonial nesting waterbirds. Barmah Forest was formally gazetted as a national park in 2010 and is jointly managed by Parks Victoria and the Yorta Yorta Nation Aboriginal Corporation (YYNAC).

At the time the site was listed as a Ramsar site, it supported the largest area of Moira grass plains in the state (more than 1,500 ha, or over 5% of the whole forest area). This wetland plant not only has inherent values, it also supports several important ecological functions such as carbon and nutrient cycling, and providing habitat for frogs, fish and waterbirds, including the EPBC-listed endangered Australasian bittern.

Moira grass has declined in extent at Barmah Forest over the past decades and is now estimated to be less than 10% of what it was in the 1970s. Water requirements for Moira grass are important - too much water in summer when conditions would have been naturally dry, and giant rush takes over, too little water over multiple years and river red gum seedlings start to encroach. It takes more than just the right water regime, however, to maintain and improve Moira grass at Barmah Forest. The plant is very palatable and has been severely impacted by grazing, particularly by feral horses.

Site managers have been working to restore water regimes with environmental water in conjunction with other management activities such as fencing to exclude the feral horses, while allowing access to native animals

such as kangaroos and birds. The exclusion fences have been a point of contention with some stakeholder groups.

However, after several years of extensive consultation with government agencies, YYNAC, community members, environmental groups and other stakeholders, detailed plans have been developed based on long-term scientific evidence (including the exclusion plots shown in Figure 6) and implementation of a feral horse management program in Barmah Forest has begun.

Figure 6: The benefit to vegetation of fencing to limit grazing is evident on the left hand side of each photo during both the inundated phases (left) and the dry (right).

Little Rushy Swamp Barmah Forest.

Credit: Keith Ward, Goulburn Broken CMA.

Figure 7: Feral horses grazing on Moira grass at Barmah Forest Ramsar Site

Credit: Alan Flickr.

5.1.3 Protecting threatened and migratory species: Lake Cullen Kerang Wetlands

Lake Cullen is one of the 23 wetlands that comprise the Kerang Wetlands Ramsar Site, within the larger Central Murray wetlands system. It is the largest wetland in the Ramsar Site, and its intermittent nature historically made it highly productive, providing habitat for a diversity and abundance of threatened and migratory waterbirds. However, over the decades local hydrology had been altered to such an extent that it was rarely inundated by natural flows. Until recently, it was thought that groundwater movement meant that Lake Cullen would only hold water when the nearby Avoca Marshes were also full. Consistent with this theory, environmental water was not delivered to Lake Cullen until 2017, when natural floods in 2016 provided a rare opportunity to provide an extended duration of inundation.

The environmental water and resulting inundation supported a range of waterbird species. When full, the lake supported large numbers of fish-eating species, including more than 1000 Australian pelicans counted in March 2017. As water levels dropped, lower water levels meant conditions then became suitable for foraging of large wading bird species such as eastern great egret, royal spoonbill and the EPBC-listed endangered Australasian bittern. Then as aquatic vegetation became exposed and insects matured, herbivorous, dabbling and filter feeding bird species arrived in large numbers.

As water levels dropped further there was concern from the community that the habitat for waterbirds would be diminished, particularly as conditions were very dry. At the same time local knowledge suggested that Lake Cullen could hold water without filling the Avoca Marshes and a North Central CMA investigation confirmed this to be true. Lake Cullen received environmental water for another year with another outstanding waterbird response. Over 20,000 waterbirds across 51 species were recorded at the lake in early 2018. This included over 1% of the eastern Australian population of the Australasian bittern, the rare international migratory black-tailed godwit, and 16 other species listed as threatened under Commonwealth or Victorian legislation.

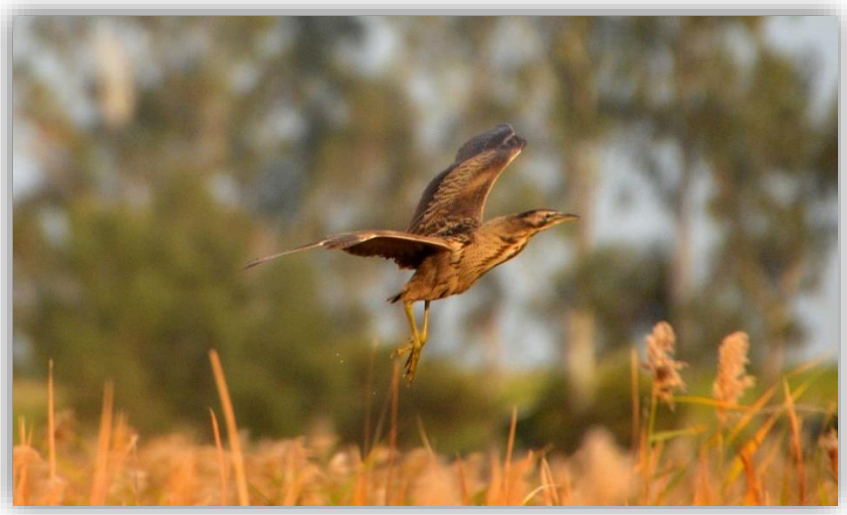


Figure 8: Australasian bittern (top) and bar-tailed godwit with red-necked avocets (bottom) at Lake Cullen.

Credit: Damian Cook; Rakali Consulting.

5.1.4 Making the most of available environmental water: Gunbower Forest

Gunbower Forest is a large floodplain forest on the Murray River, it's an icon site for The Living Murray program, and is another of Victoria's Ramsar Sites. It supports extensive river red gum forests and woodlands, black box woodlands and over 1000 ha of wetlands. During the Millennium Drought the condition of river red gum forests and woodlands in Gunbower Forest declined significantly. This included a decline in canopy condition, with an increase in dead leaves and branches, and a change in population structure (Figure 9). While periodic natural floods and application of environmental water have restored the condition (and improved resilience) of parts of the forest, it has not been sufficient to benefit the entire extent of this vegetation community.

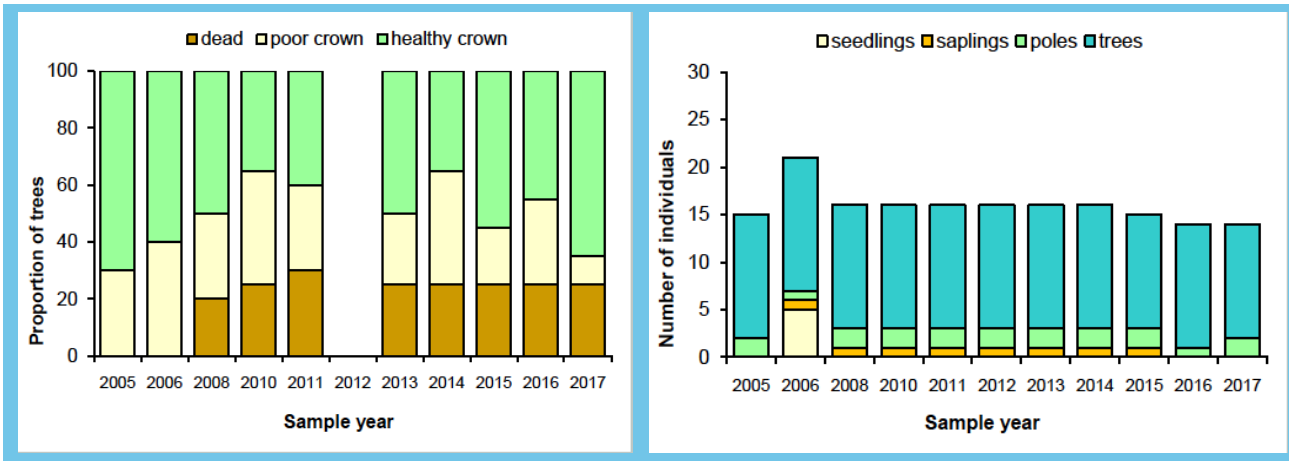


Figure 9: Crown condition (left) and population structure (right) of river red gums at one monitoring location within Gunbower Forest Ramsar Site

Source: Bennetts and Jolly 2017

The Living Murray program commissioned significant works and upgrades to infrastructure at Gunbower Forest in 2014 to allow for more efficient use of environmental water. This allows a greater proportion of the site to be inundated with much smaller volumes of water than would have been required without regulators and other water infrastructure in place. Improvements in collaboration between the states and their management processes have also increased efficient use of this water, optimising reuse of the environmental water that passes through the forest at more sites downstream of the forest for other environmental outcomes. However, the extent of forest that can be effectively inundated is relatively small and represents just a fraction of the total Ramsar site. This area is called "the managed floodplain" and while 87% of the wetlands in the Ramsar site can receive environmental water, just 25% of the total area of river red gum and 2% of the black box woodland are within scope for environmental watering. Within this watered footprint, tree health has measurably improved compared to sites outside that are reliant on periodic natural floods and rainfall to survive.

Figure 10: River red gum woodland, Gunbower Forest.

Credit: Kate Bennetts and Dylan Osler; Fire, Flood & Flora

Source: Bennetts and Jolly 2017

5.1.5 Conserving Murray hardyhead: Lake Koorlong

The Murray hardyhead is a small native fish that is endemic to the lower Murray-Darling Basin and has a short life span of up to just 18 months. Although historically common, over the past 50 years it has become increasingly rare and is listed as nationally endangered under the EPBC Act and considered critically endangered in Victoria. The species was severely impacted by the Millennium Drought with many sub-populations becoming extinct or experiencing substantial declines in abundance. With a short life cycle, loss of a single breeding season can lead to rapid local extinctions.

To conserve this species and ensure its continued survival, Victoria has implemented rescue and captive breeding programs, translocations and reintroductions. Lake Koorlong, located 12 km south of Mildura, was a site identified as suitable for reintroduction of Murray hardyhead. Three hundred individuals were released to Lake Koorlong in 2009 and a further 90 captive bred fish were released in 2013. These fish, supported by a carefully planned and delivered environmental water regime, have thrived and formed a self-sustaining population.

Figure 11: Murray hardyhead (left) founded on Lake Koorlong (right).

Credit: David Wood, Mallee CMA

5.2 Rivers

5.2.1 Supporting fish and vegetation in intermittent streams: Wimmera River

Historically, the science of environmental water has looked at its impact on individual species (e.g. southern pygmy perch) or a group of species (e.g. fish). As our understanding and ability to manage this water has become more sophisticated, we are now interested in building on this knowledge and more efficiently using the limited water available to provide benefits for many species and groups at once. To do this, it's important to understand how one species or group might affect another. A system of creeks and rivers connected to the Wimmera River offered an ideal opportunity to jointly study fish and vegetation responses to flow management. This work is particularly valuable as there are few studies about the impacts of environmental flows on intermittent waterways.

Survey results indicate that the delivery of environmental water since the construction and operation of the Wimmera-Mallee Pipeline has enhanced habitat availability and connectivity in the upper Mackenzie River and Burnt Creek, resulting in a more extensive plant population and an abundant and wide distribution of fish species such as southern pygmy perch.

Environmental flows have also been crucial in maintaining a diverse fish community and a broad extent of aquatic plants in the intermittent reaches of the lower Mackenzie River and Mount William Creek, by providing opportunities for dispersal of fish recruits and plant propagules during fresh events, as well as maintaining soil moisture for aquatic plant survival and critical refuge pools when flow stops.

Correlations between flow, fish numbers and aquatic plants suggested interactions and dependencies between taxa. This was particularly evident for southern pygmy perch and aquatic plant species, which are likely to provide critical habitat for spawning, feeding or refuge from predation for these fish.

Based on these results, the scientists working on VEFMAP constructed a simple conceptual model (Figure 12) to show how taxa respond to managed flows in intermittent rivers and streams. This can be used to guide the management of environmental flows for better ecological outcomes.

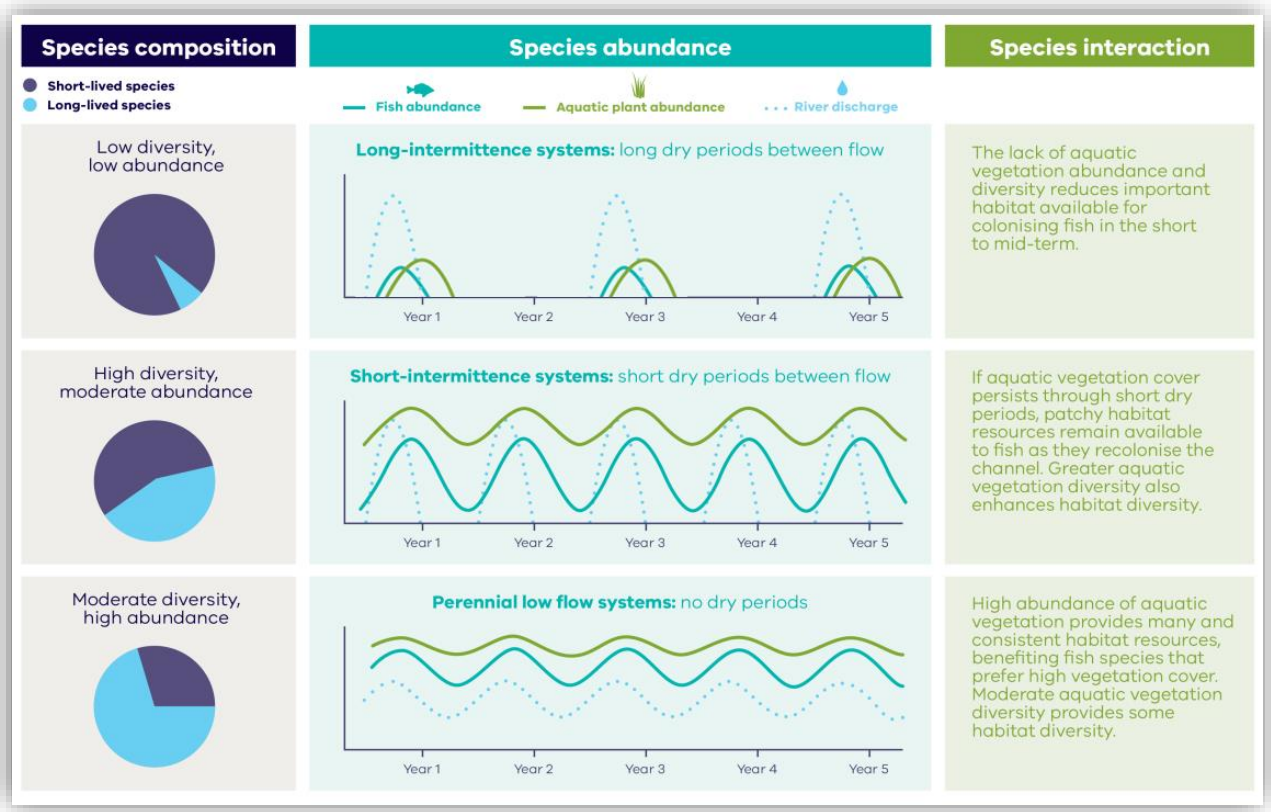


Figure 12: Conceptual model of taxa response to managed flows (Tonkin et al. 2020).

5.2.2 Active and adaptive environmental water delivery: Campaspe River

The Campaspe River in northern Victoria was severely impacted by the Millennium Drought. Lake Eppalock nearly dried and the river contracted to a series of isolated pools. This impacted on the health of fish and riparian vegetation with a decline in the condition of long-lived river red gum trees and growth of reeds across the channel. The 2011 and 2012 floods scoured the channel (removing instream and riparian fringing vegetation) and provided a much-needed drink to the riparian zone. Since 2012, the Campaspe River has received environmental water aimed at restoring the condition of the system.

Monitoring through the VEFMAP has been instrumental in informing adaptative management of environmental water in this system. The lessons learned have been used to better plan and deliver water to meet the objectives of improving habitat for fish and riparian vegetation diversity and abundance, as illustrated by the following two examples.

Riparian seed banks: A study of the soil seedbank from the Campaspe River showed that frequently flooded bars and benches within the river channel had an abundant seedbank dominated by native species like sedges and rushes, while the less frequently inundated floodplain contained a high density of exotic grasses and other terrestrial species (Pereira et al. 2020). Environmental flows in the Campaspe River appear to be successfully limiting the growth of terrestrial exotic species within the river channel and favouring native riparian plant species. Future investigations will support management of the season, frequency, depth and duration of environmental flow releases required to promote germination and recruitment of native riparian plants across all sections of the riparian zone.

Native fish population responses: Monitoring data from the Campaspe has shown substantial increases in the abundance and distribution of species such as Murray cod, golden perch and Murray-Darling rainbowfish (Tonkin et al. 2020a). This data was then used to develop a population model for Murray cod, enabling a comparison of flow scenarios to assess long term population outcomes.

The model predicted that delivering environmental water matched to flow recommendations outperformed several other management flow scenarios in most years, increasing the minimum Murray cod adult population size by over 50% above other scenarios over a 15-year period. These same environmental flows, while improving the survival and distribution of stocked golden perch, will not enhance golden perch recruitment. This information can be used to inform how future environmental water is managed in the system for native fish outcomes.

Figure 13: Golden perch (top) and Murray cod (bottom).

Credit: Zeb Tonkin, Arthur Rylah Institute and Mark Turner Goulburn Broken CMA

5.2.3 The rivers are the veins of the Country: King River

Taungurung Traditional Owners and the North East CMA have worked with the VEWH and Goulburn-Murray Water to release water for the environment. In June 2019, 39 ML of water owned by Taungurung Land and Waters Council was delivered as an environmental flow to the King River.

This water release contributed to healing Country by providing a boost to the health and productivity of the waterway. This flow provided a small variation in the water level of the King River downstream of Lake William Hovell, which inundated new habitat for waterbugs and fish, allowing them to move more freely and find new sources of food. The release coincided with the Taungurung Water Group visiting the King Valley to scope out sites for a future Aboriginal Waterway Assessment of the King River.

Shane Monk, Taungurung man, said “The rivers are the veins of the Country, if you take too much water from them Country would get sick. Taungurung has a responsibility and we are only doing the right thing for Country by bringing water back to the river. We are working with the North East CMA, VEWH and GMW to achieve this. We feel confident we can do more if we continue working together.”

Catherine McInerney, Environmental Water Officer at the North East CMA, explains “The King River catchment has recently been incorporated into the Taungurung Clans Aboriginal Party area. It has been great to start our working relationship with them by providing some positive environmental and cultural outcomes on the ground, or waterway as the case may be!”

“This project shows a great collaboration between Traditional Owners and water agencies, with a positive impact on the environment,” said Catherine.

Figure 14: Taungurung and North East CMA at King River

Credit: North East CMA

5.2.4 Restoring native fish populations: Gunbower Creek

Gunbower Creek in northern Victoria is used to deliver irrigation water in the Torrumbarry Irrigation Area. Until 2013, irrigation use dominated the water regime so that flow in the creek was substantially altered from its natural state. During the summer irrigation season there were constant high flows while in winter there was no flow, and in spring when irrigation demands fluctuate there were rapid decreases in water level.

Unfortunately, spring is also the spawning season for Murray cod, an iconic and EPBC-listed threatened fish species. As a result, the populations of Murray cod in the system declined significantly. In the five years prior to 2013, monitoring detected no young-of-year fish (fish in their first year of life), very low numbers of juvenile fish and low numbers of adult fish.

Even with hundreds of fish being stocked in the system, the population continued to decline with juveniles not surviving to recruit into the adult population. Other factors appeared ideal for Murray cod, for example physical habitat included large amounts of submerged woody debris, which indicated the flow regime was a key factor limiting fish survival and recruitment. North Central CMA worked with fish biologists to design a “fish hydrograph”, a pattern of flows that would meet the needs of Murray cod using environmental water and help to restore populations (Figure 15).

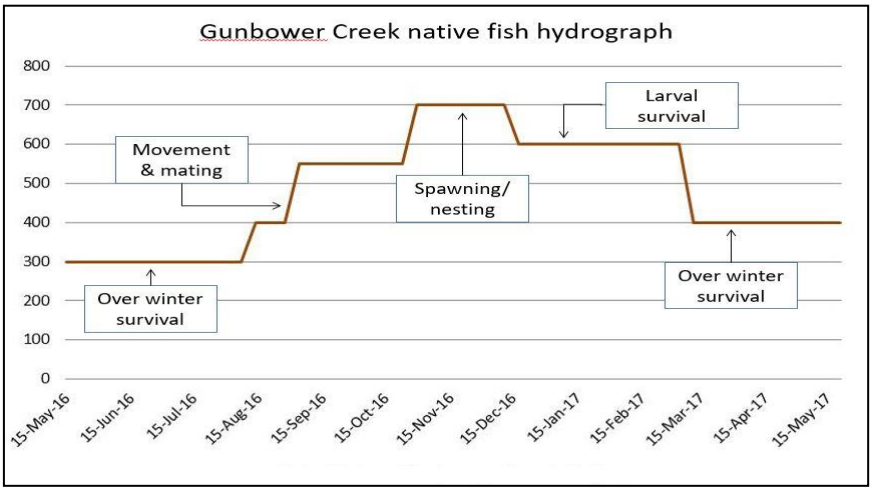


Figure 15: Initial (2013) fish hydrograph for Murray cod in Gunbower Creek.

As the CMA has learned more about the importance of different flow components they have adapted and improved the hydrograph year-on-year, also accounting for creek capacity which can be limited in spring.

Source: Mallen-Cooper and Zampatti 2015

Environmental water has been used since 2013 to deliver a tailored fish hydrograph in Gunbower Creek, building on learnings each year. Since implementation of environmental watering there has been evidence of recruitment in five native species: Australian smelt, carp gudgeon, Murray cod, Murray-Darling rainbow fish and unspecked hardyhead (e.g. Bloink & Robinson 2016). There has been a marked improvement in the population structure of Murray cod in the system and, in 2017–18, the first instances of freshwater catfish recorded in over 15 years.

Figure 16: Post larval Murray cod from Gunbower Creek spawned on a planned hydrograph in spring 2013.

5.2.5 Improving habitat for platypus: Wimmera catchment

Platypus were once widespread throughout the Wimmera River and its tributaries. The species relies on permanent water to feed and reproduce. A combination of land clearing, water extraction and a drying climate has led to a decline in populations in the region. Following the Millennium Drought, the upper MacKenzie River supported the only resident platypus population in the Wimmera system.

The availability of reliable surface water in the upper MacKenzie River has been considered critical to the species' persistence through the drought and its survival through other challenges, such as floods and bushfires. While the species had been restricted to the MacKenzie River upstream of Dad and Dave's Weir, over the past decade, the use of environmental water and other management activities, such as the activation of a fish ladder, has resulted in the platypus distribution expanding into the lower river reaches. There is growing evidence that the population is also slowly increasing.

Regular monitoring of platypus in the region has continued since 2008, with a combination of live trapping and environmental DNA. Environmental DNA is an emerging science, where small traces of platypus DNA are detected in water samples and allow scientists to more easily track the distribution of the species in waterways. It is hoped that with ongoing water management, informed by monitoring, platypus distribution can continue to increase and eventually be restored in the main channel of the Wimmera River.

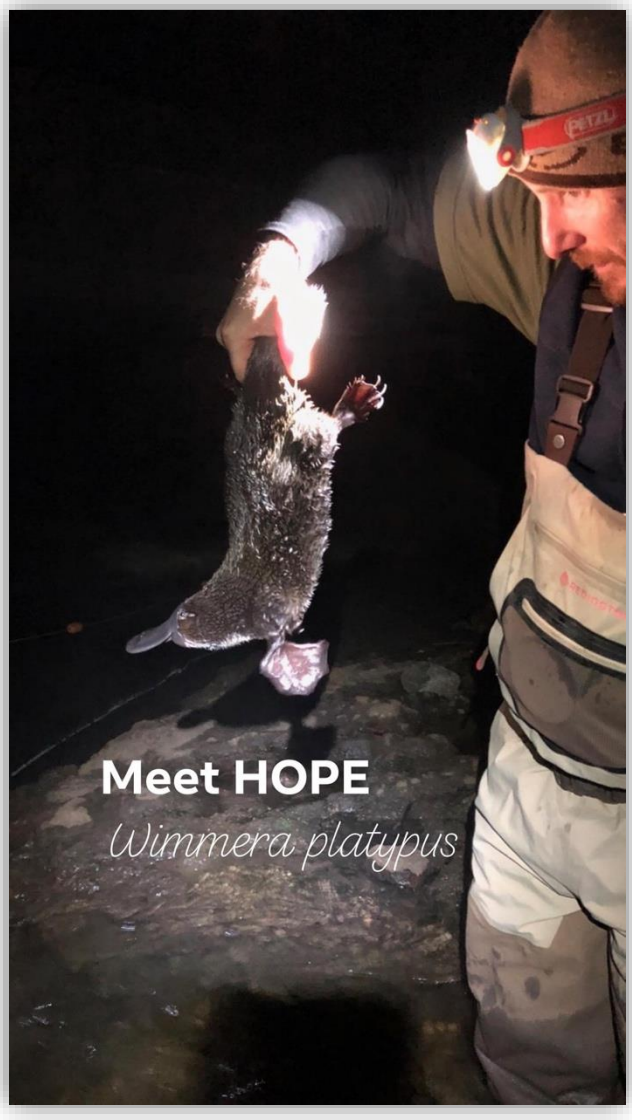


Figure 17: Meet Hope – Wimmera Platypus

Credit: Wimmera CMA

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Appendix A-Spreadsheet

[Please see Appendix A at https://www.water.vic.gov.au/__data/assets/pdf_file/0028/510859/VIC-Basin-Plan-Matter-8-2020-Report-APPENDIX-A.pdf]

Appendix B-Species Scientific Names Glossary

Species Common Name	Species Scientific Name
Australasian bittern *	*Botaurus poiciloptilus*
Australasian grebe	*Tachybaptus novaehollandiae*
Bar-tailed godwit	*Limosa lapponica*
Black box	*Eucalyptus largiflorens*
Black swan	*Cygnus atratus*
Broad-shelled turtle #	*Chelodina expansa*
Brolga	*Grus rubicunda*
Cane grass	*Eragrostis infecunda*
Common reed	*Phragmites australis*
Cumbungi	*Typha* spp.
Eastern gambusia	*Gambusia holbrooki*
Eastern long-necked turtle	*Chelodina longicollis*
Fly-specked hardyhead	*Craterocephalus stercusmuscarum*
Fox-tail stonewort	*Lamprothamneum compactum*
Freckled duck #	*Stictonetta naevosa*
Giant rush	*Juncus ingens*
Glasswort	*Tecticornia* spp.
Glenelg spiny crayfish	*Euastacus bispinosus*
Golden perch	*Macquaria ambigua*
Growling grass frog *	*Litoria raniformis*
Hardhead	*Aythya australis*
Large-fruit sea tassel	*Ruppia megacarpa*
Latham's snipe	*Gallinago hardwickii*
Lignum	*Duma florulenta*
Macquarie perch	*Macquaria australasica*
Moira grass	*Pseudoraphis spinescens*
Mountain galaxias	*Galaxias olidus*
Murray cod *	*Maccullochella peelii*
Murray hardyhead *	*Craterocephalus fluviatilis*
Murray-Darling rainbowfish #	*Melanotaenia fluviatilis*
Nankeen night-heron	*Nycticorax caledonicus*
Obscure galaxias	*Galaxias olidus*
Pied cormorant	*Phalacrocorax varius*

Pink-eared duck	*Malacorhynchus membranaceus*
Platypus	*Ornithorhynchus anatinus*
Rakali	*Hydromys chrysogaster*
Red-necked avocet	*Recurvirostra novaehollandiae*
Regent parrot	*Polytelis anthopeplus*
Ridged water-milfoil	*Myriophyllum porcatum*
River blackfish	*Gadopsis marmoratus*
River red gum	*Eucalyptus camaldulensis* subsp. *camaldulensis*
River swamp wallaby-grass *	*Amphibromus fluitans*
Royal spoonbill	*Platalea regia*
Sea tassel	*Ruppia megacarpa*
Silver perch *	*Bidyanus bidyanus*
Slender water-milfoil	*Myriophyllum gracile* var. *lineare*
Southern pygmy perch	*Nannoperca australis*
Spiny lignum	*Duma horrida* subsp. *horrida*
Trout cod	*Maccullochella macquariensis*
Western swamp crayfish	*Gramastacus insolitus*
White-bellied sea-eagle #	*Haliaeetus leucogaster*

Some of these species are protected either by federal or Victorian Acts:

- * Federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- # Victorian *Flora and Fauna Guarantee Act 1988* (the FFG Act) including 3 Victorian advisory lists:
    - Advisory List of Threatened Invertebrate Fauna in Victoria – 2009
    - Advisory List of Threatened Vertebrate Fauna – 2013
    - Advisory List of Rare or Threatened Plants in Victoria – 2014 as Critically Endangered, Endangered, Vulnerable or Rare

Others are listed under international treaties such as:

- Japan-Australia Migratory Bird Agreement (JAMBA)
- China-Australia Migratory Bird Agreement (CAMBA)
- Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA)