



Australian Government



# Icon site condition

The Living Murray

May 2018

Published by the Murray–Darling Basin Authority  
MDBA publication no: 06/18  
ISBN (online): 978-1-925599-74-9



GPO Box 1801, Canberra ACT 2601  
engagement@mdba.gov.au



1800 230 067  
mdba.gov.au

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### **Acknowledgement of the Traditional Owners of the Murray–Darling Basin**

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

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

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

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# Executive summary

The Living Murray initiative aims to improve the ecological condition of significant forests, wetlands and lakes along the River Murray as part of helping to deliver the Basin Plan objectives and outcomes. It is a joint partnership between the Australian Government and Basin state and territory governments, and the Murray–Darling Basin Authority.

This report draws on over 10 years of ecological monitoring undertaken as part of The Living Murray by local and state agencies at six priority environmental assets, also known as icon sites, on the River Murray in the southern Murray–Darling Basin. This monitoring provides invaluable long term data, tracking the ecological condition of these assets and ecological responses to water delivery for the environment over time. This is from the time of the longest drought in Australia’s recorded history (the millennium drought) when only small amounts of water for the environment were available, through improved conditions, to the first use of environmental works and more water available for the environment across the Basin.

This report is a first attempt at providing a high level qualitative assessment of the performance against icon site objectives from 2006–07 to 2016–17. This information is essential to support adaptive management at the site, system and basin scales and its presentation and utility will be refined over time.

While it is still early days, this monitoring provides a strong evidence base that, where environmental water holders and managers have been able to deliver water for the environment, the health of the southern Murray–Darling Basin rivers, wetlands and floodplains are improving. This monitoring shows the critical role of water for the environment to build on the benefits of natural flooding, maintain and build resilience in dry times and how the operation of environmental works over successive years is helping achieve environmental outcomes.

# Introduction

The Living Murray initiative commenced in 2002 and aims to improve the ecological condition of six priority environmental sites (icon sites) on the River Murray in the southern Murray–Darling Basin (Figure 1):

- Barmah–Millewa Forest
- Koondrook–Perricoota and Gunbower Forest
- Hattah Lakes
- Chowilla and Lindsay–Mulcra–Wallpolla Island
- Lower Lakes, Coorong and Murray Mouth
- River Murray Channel

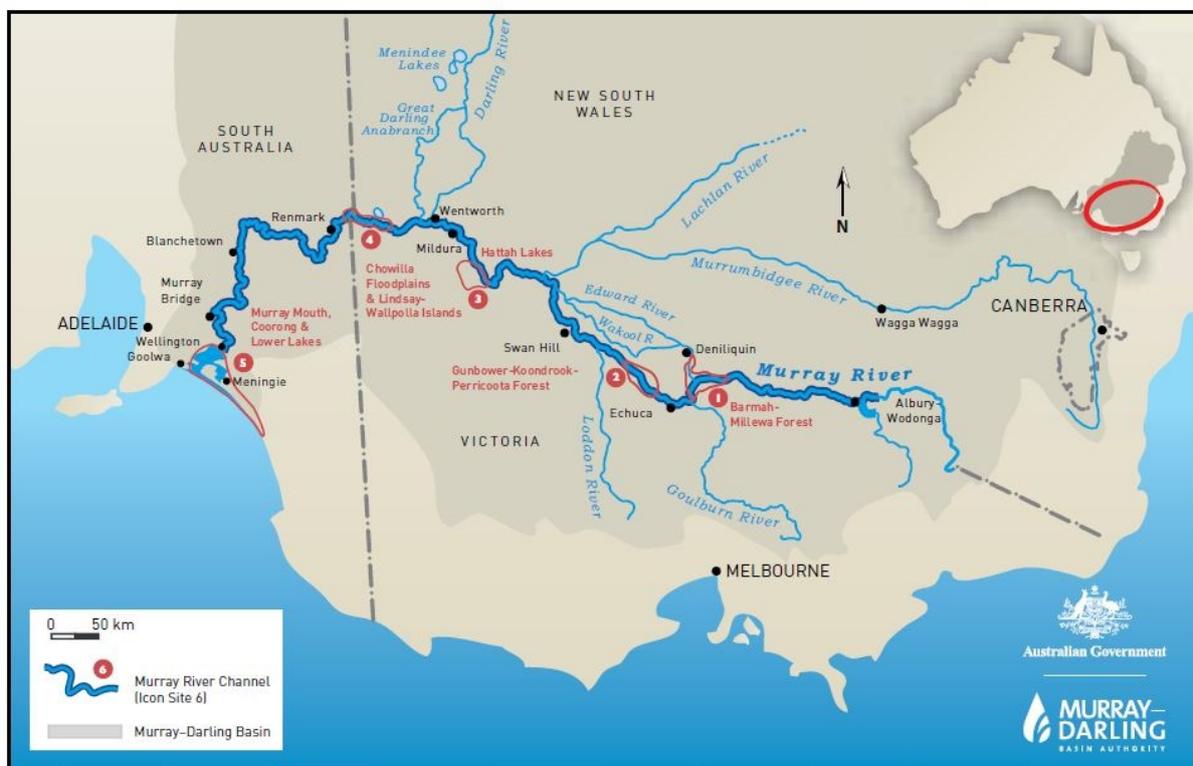


Figure 1: Map of The Living Murray icon sites

It is a partnership between the Australian Government and the New South Wales, Victorian, South Australian and Australian Capital Territory governments and is managed by the Murray–Darling Basin Authority (MDBA). Through a \$650 million investment, it has acquired almost 500 GL of water for the environment, and between 2011 and 2015 built a number of environmental works to help deliver this water more efficiently and effectively to sites along the River Murray.

The Basin Plan was legislated in 2012 with the aim of returning the Basin to a healthy working system and building on existing initiatives like The Living Murray. The aim of the Plan is to improve the Basin’s environment, while balancing social and economic needs in a sustainable way. The Plan sets an environmentally sustainable level of take for consumptive water (sustainable diversion limit) and secures a share of available water for the environment. This ‘environmental water’ allows managers

to restore the critical elements of the flow regime so that plant and animal species can complete their lifecycles and help build resilience in healthy habitats.

Since the Basin Plan came into effect in 2012, The Living Murray has helped deliver the Basin Plan. It is also transitioning to align more effectively with the Plan. This alignment has included the establishment of the Southern Connected Basin Environmental Watering Committee (SCBEWC), which is made up of Basin state and Australian Government environmental water holders, water managers and key river operators.

The Committee was established by the Murray–Darling Basin Ministerial Council in 2015 to coordinate the delivery of all environmental water in the southern Basin to maximise environmental outcomes and give effect to the Basin Plan. Water available for the environment in the southern Basin includes water held by Commonwealth, Victorian, New South Wales (NSW) and South Australian (SA) environmental water holders, planned environmental entitlements (particularly in NSW), Barmah–Millewa Environmental Water Allocation, the Living Murray portfolio and the River Murray Increase Flows (RMIF). SCBEWC also has decision making responsibility for the jointly held water portfolios (The Living Murray and RMIF) and oversees the management and monitoring of The Living Murray icon sites.

As part of its overall Environmental Management Framework, the Basin Plan requires Long-term watering plans (LTWPs) to be developed by Basin state governments to guide the management of environmental water at regional scales over the longer term. Long-term watering plans set objectives, targets and watering requirements for *priority environmental assets and functions* consistent with the Basin Plan requirements and objectives. They are to be developed for each of the 20 surface water resource plan areas in the Basin. To date, Long-term watering plans have been published for the Victorian Murray, Northern Victoria, Wimmera–Mallee, Warrego–Paroo–Nebine, South Australian River Murray and Eastern Mount Lofty Ranges water resource plan areas. For the remaining 14 plans, their timelines are aligned to coincide with the development of state water resource plans in 2019.

The Living Murray sites have been, or are anticipated to be, identified as priority environmental assets in the completed Long-term watering plans. Each of these sites have established ecological objectives based on site environmental water requirements that can be achieved through the delivery of water for the environment and the use of environmental works. Ecological objectives have been refined over time to reflect new data, learnings and knowledge gained from a history of delivering water for the environment and the use of environmental works. It is anticipated that there may be further review of these objectives to ensure full alignment with the Basin Plan.

The condition of the six Living Murray sites have been monitored since 2006–07. The monitoring is used to assess the key indicators of health such as vegetation, fish and waterbirds, and track progress against the site ecological objectives.

This complements other monitoring and evaluation across the Basin including Basin state programs, the Commonwealth Environmental Water Office Long Term Intervention Monitoring, Murray–Darling Basin Joint Venture Monitoring and Evaluation (coordinated by MDBA) and the MDBA’s Basin-wide monitoring and evaluation.

# This report

This report provides a high level qualitative assessment of the performance against icon site objectives from 2006–07 to 2016–17. This is a first attempt to draw together a significant amount of information from 10 years of detailed monitoring reports. It is anticipated that this type of assessment and the approach to reporting will be refined over time.

This information supports adaptive management at the site, system and Basin scale. At the site (or asset) scale this information has informed and helped refine on-ground management and water planning, including:

- management of particular events (i.e. timing, duration, inundation patterns)
- operation of works and measures (including regulator and pump operation)
- mitigation of the impact of pest species at sites e.g. Carp and feral horse and pig populations
- preparation of annual watering proposals for consideration by environmental water holders and
- refinement of site management plans.

At the system scale, the overall performance against objectives both for each site and across the ecological themes helps inform the annual watering priorities by the Basin state governments and the prioritisation of environmental water demands across the River Murray system (or southern Basin) coordinated through SCBEWC annually. Over time this will also include refinement of LTWPs for this region.

At the Basin scale, performance against site (or asset) scale objectives from across the Basin will in future be considered alongside achievement of expected outcomes at the Basin scale to evaluate the overall performance of the Basin Plan from an environmental perspective. The first of the evaluations was published in 2017 (MDBA 2017). These periodical evaluations inform both the refinement of Basin scale environmental water planning (i.e. the [Basin-wide environmental watering strategy](#) and [Basin annual environmental watering priorities](#)) and reviews of the Basin Plan overall.

The data summarised in this report helped inform and complements the findings of the 2017 Basin Plan Evaluation. The report Environmental Assets – 2017 Evaluation (MDBA, 2018) details the steps required to refine reporting against site (asset) scale objectives (including that for The Living Murray icon sites) to better inform evaluations of the Basin Plan.

## Icon sites watering history

A summary of annual River Murray inflows, and the watering history and the use of environmental works by icon site from 2006–07 to 2016–17 is provided at Appendix A. Further information on the watering history at icon sites is also available on the [MDBA website](#).

Between 2000–01 and 2009–10 the Murray–Darling Basin was impacted by severe drought. Conditions started to improve in the River Murray system from late 2010 as the drought broke bringing above average rainfall and river inflows. Natural flooding also occurred across the system in 2011–12, 2012–13 and in 2016–17.

Over time, water available for the environment in the Basin has increased. In 2009–10 there were only small volumes available (approximately 120 GL) that were used at icon sites to provide drought refuges and support critical habitats and ecological processes. Yet in 2014–15, environmental water holders delivered more than 1,000 GL to icon sites, and in 2016–17 around 1,500 GL, as part of larger coordinated multi-site environmental water delivery across the southern Basin.

Environmental works were built at Gunbower Forest, Koondrook–Perricoota Forest, Hattah Lakes, Lindsay and Mulcra Islands, and Chowilla between 2011 and 2015. These works have been identified as supply projects being considered as part of the Sustainable Diversion Limits Adjustment Mechanism. Supply projects are new ways to manage the Basin's rivers to more efficiently deliver water for Basin Plan environmental outcomes, allowing more water for consumptive use.

Environmental works were first used to deliver water at Gunbower Forest, Hattah Lakes and Mulcra Island in 2013–14. In 2014–15, environmental works at Koondrook–Perricoota Forest and Chowilla were operated for the first time. With the exception of Koondrook–Perricoota Forest, all the icon site environmental works have been operated over successive years. To date, Koondrook–Perricoota Forest works have been operated once in 2014–15 — 26GL was delivered to test the works and inundate 4,500 hectares of high value wetlands and creeks in the forest.

While there has been larger volumes of water for the environment delivered in recent years, The Living Murray monitoring shows that the health varies across icon sites. It should be noted that it will take time for ecosystems to respond and some areas will respond faster with less watering than others. Figure 2 provides a schematic of the condition of icon sites in 2016–17 drawn from The Living Murray monitoring reports that track the condition of sites over time (see Appendixes B and C for references). This monitoring shows that the health of some sites are improving, while at other sites condition is mixed with some improvements, and some sites are in poor condition.

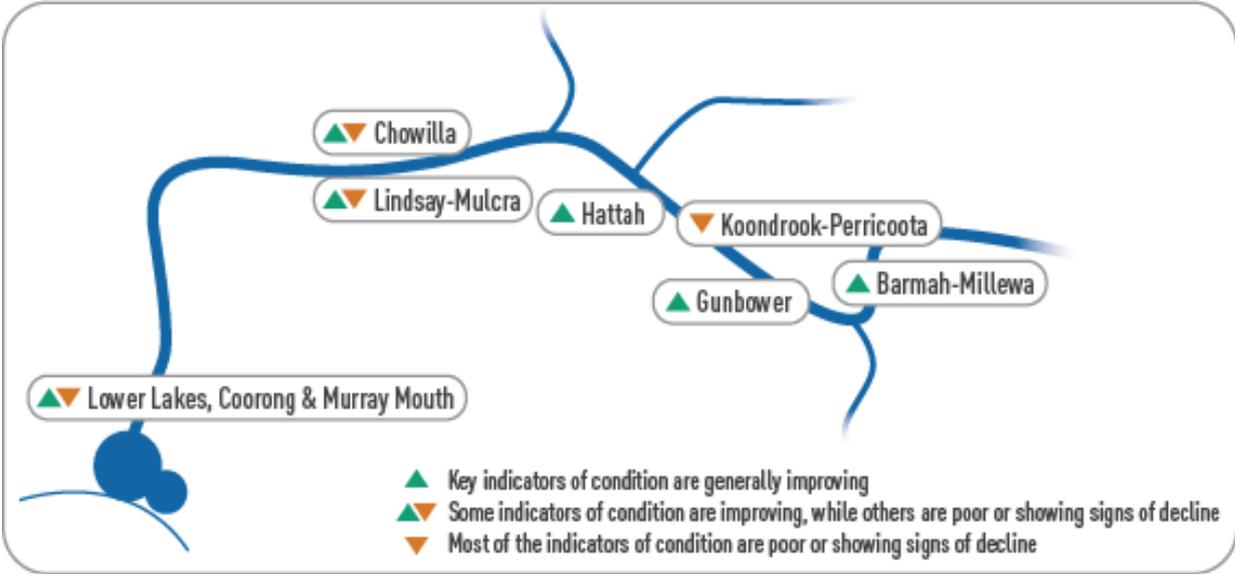


Figure 2: Schematic of icon site condition

# Performance against icon site ecological objectives

Figures 3 to 8 provide a summary of the annual performance against ecological objectives and hence overall condition for each site from 2006–07 to 2016–17. These summaries are based on the information in Appendix B.

The summaries are a high level qualitative assessment of annual performance based on the number of icon site ecological objectives that have been met, partially met or not met each year (see Table 1 for definitions). This assessment has been made by drawing on 10 years of annual monitoring reports. The reports for 2016–17 are referenced in Appendix C. Figures 3 to 8 also include the volumes of environmental water delivered each year, and at sites with works, identify years when works were operated (drawing on information from Appendix A).

Table 1: Icon site ecological objective assessment criteria

Assessment	Definition
Met	All ecological objective targets are met
Partial	One or more ecological objective targets have been met
Not Met	No ecological objective targets have been met
Not monitored	The objective was not monitored in this year

Key observations about performance against site objectives over time include:

- Water for the environment delivered following natural flood events is helping to consolidate the benefits of natural flooding.
- While there is some lag in ecological response, the assessments show that watering is helping to sustain the condition at a number of icon sites such as Barmah–Millewa and Gunbower Forests.
- The only objective not met at Barmah–Millewa Forest is Moira grass growth and extent. Inundation requirements for Moira grass growth in the Forest are difficult to achieve within current operational constraints.
- The absence of larger floodplain watering (natural or environmental water delivery) between 2012 and 2016 in Koondrook–Perricoota Forest has meant the benefits of natural flooding in 2010–11 and 2011–12 haven't been sustained.
- Since 2010–11 the condition of Hattah Lakes has improved due to a combination of natural floods and the use of environmental works between 2013–14 and 2016–17. These works provide connectivity between the river and the floodplain and enable delivery of water to a larger area of the floodplain.

- At Lindsay–Mulcra–Wallpolla Island and Chowilla, the use of environmental works over successive years has helped sustain the condition of creeks and areas of the lower floodplain.
- In the Lower Lakes, Coorong and Murray Mouth, high natural inflows and environmental water delivery has contributed to improving the condition of the site, however, performance against some objectives (waterbirds and some fish species) has declined in recent years.

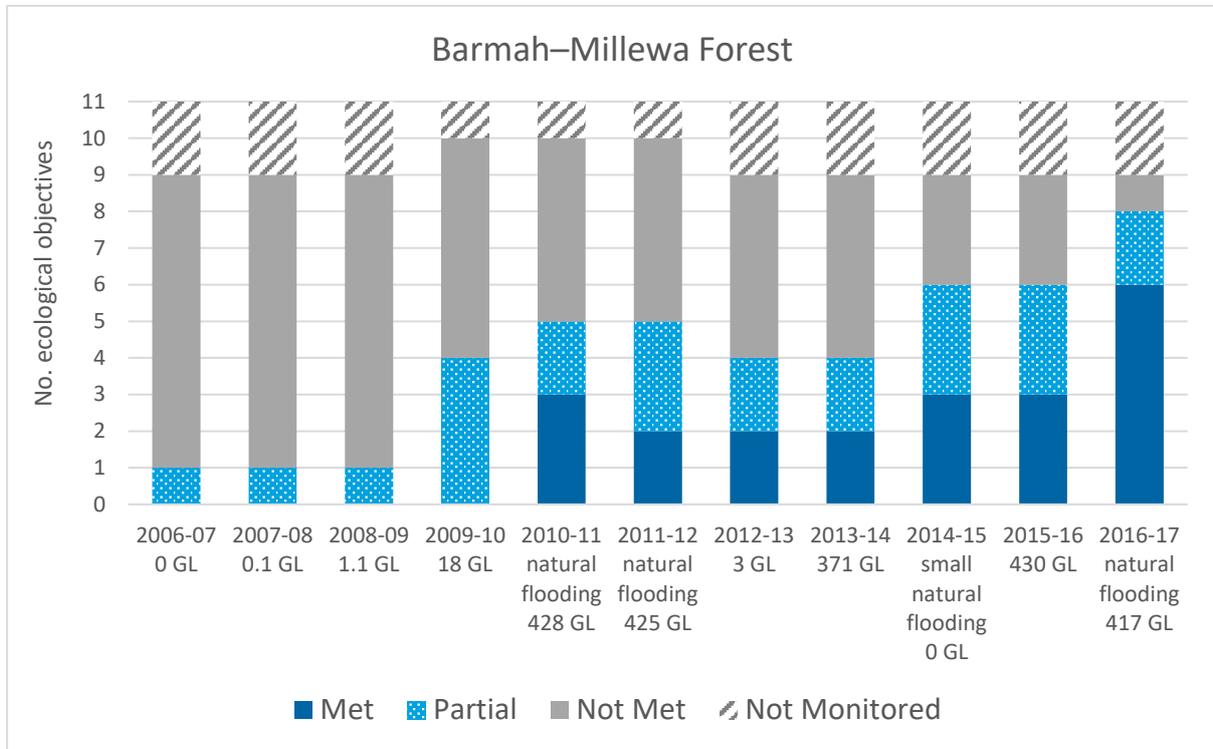


Figure 3: Barmah –Millewa Forest – Performance of ecological objectives 2006–07 and 2016–17

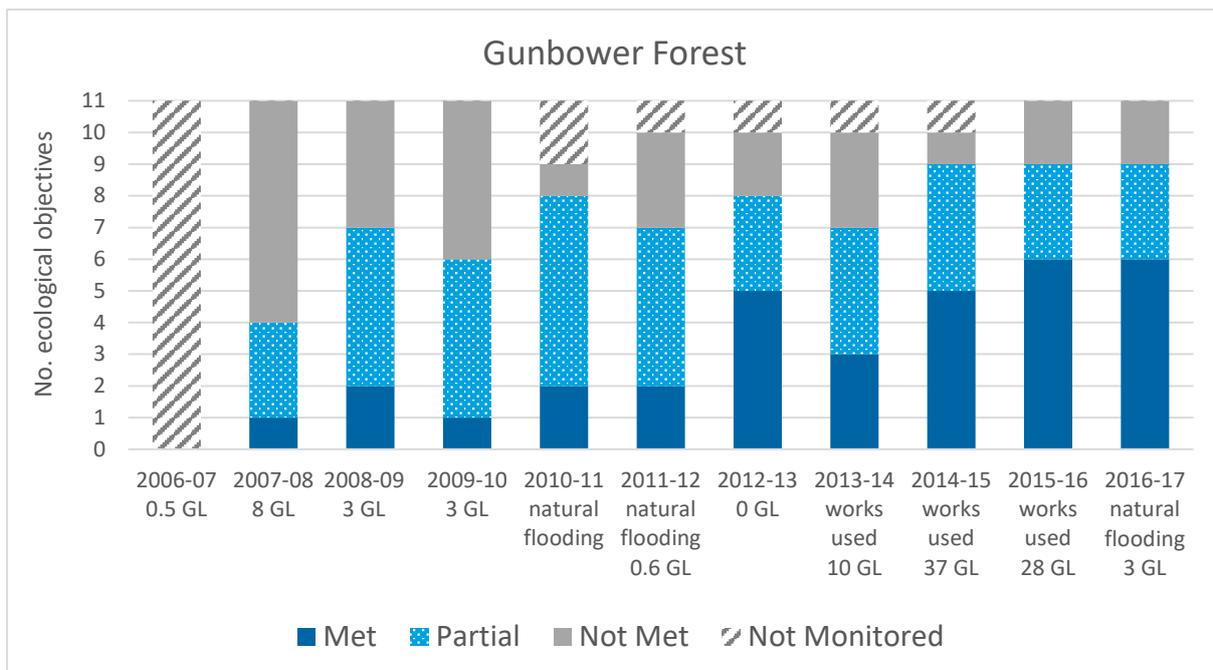


Figure 4: Gunbower Forest – Performance of ecological objectives 2006–07 and 2016–17

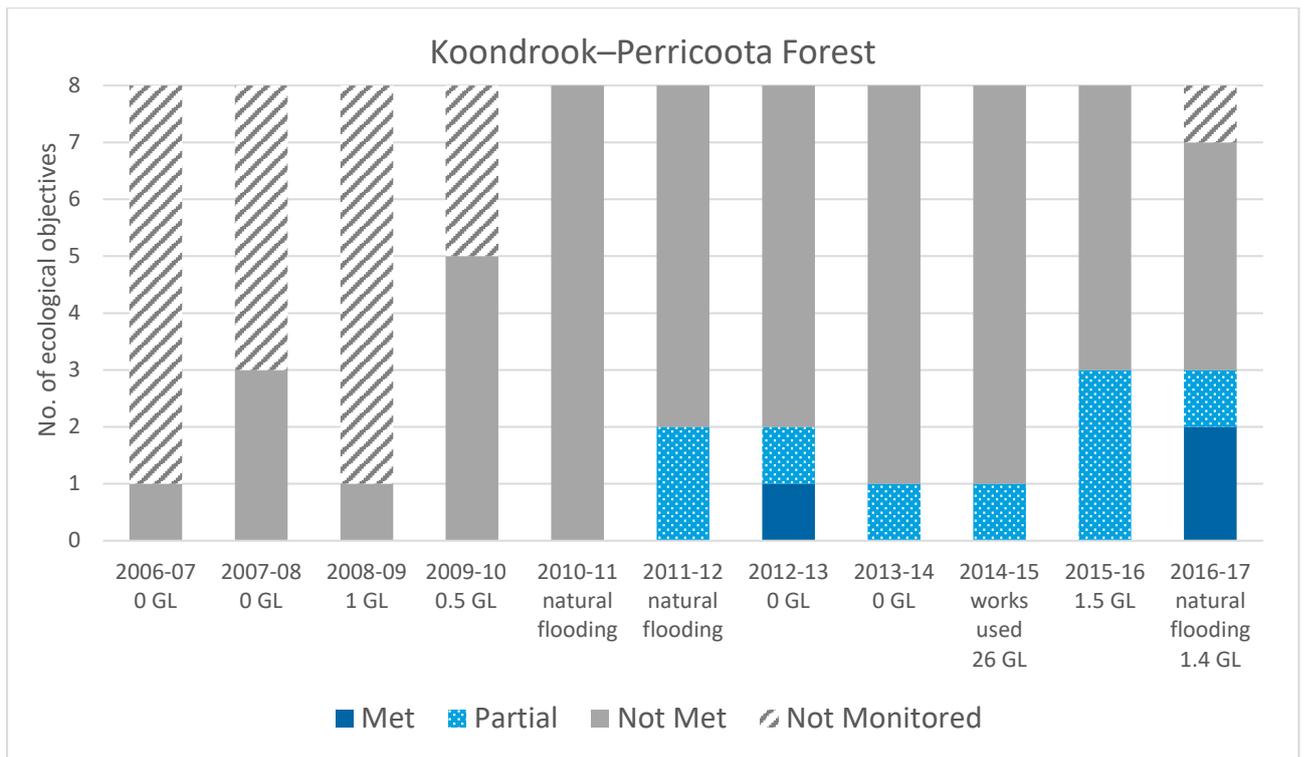


Figure 5: Koondrook–Perricoota Forest – Performance of ecological objectives 2006–07 and 2016–17

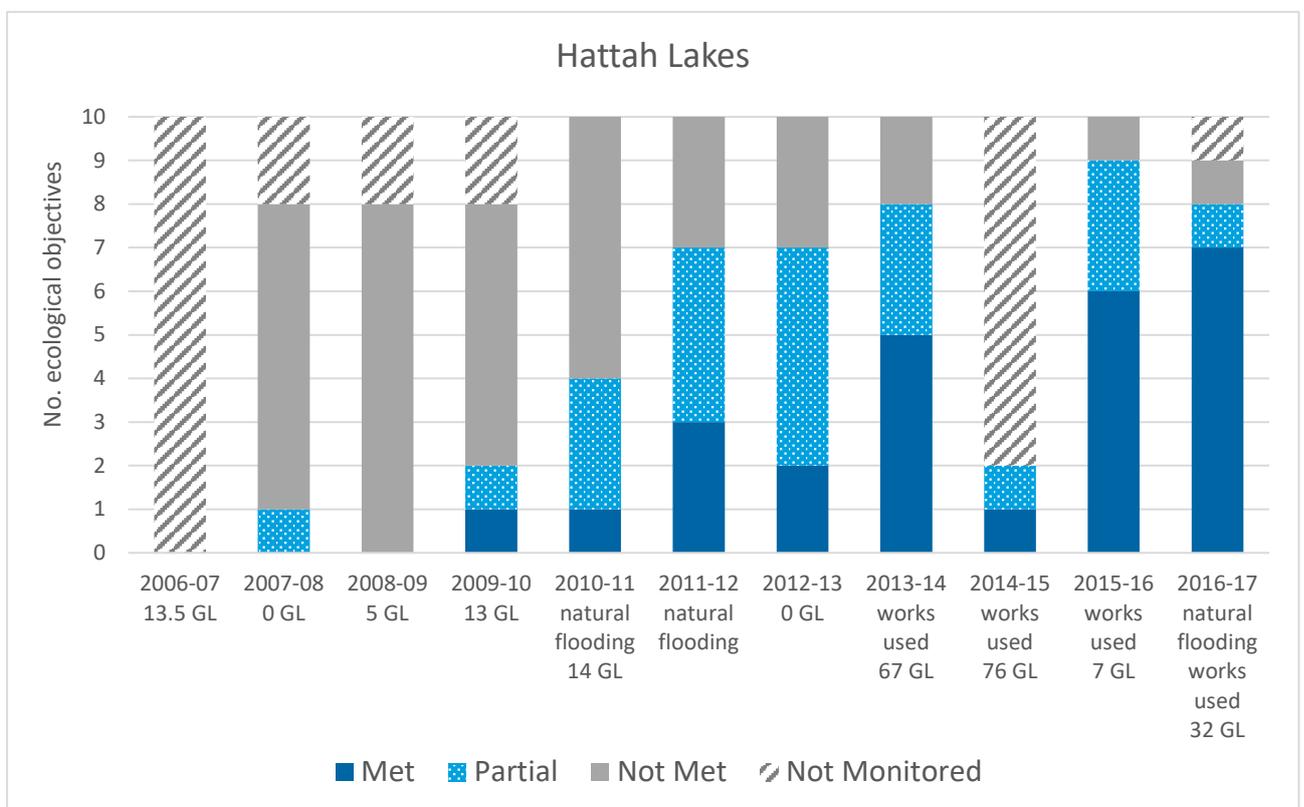


Figure 6: Hattah Lakes – Performance of ecological objectives 2006–07 and 2016–17

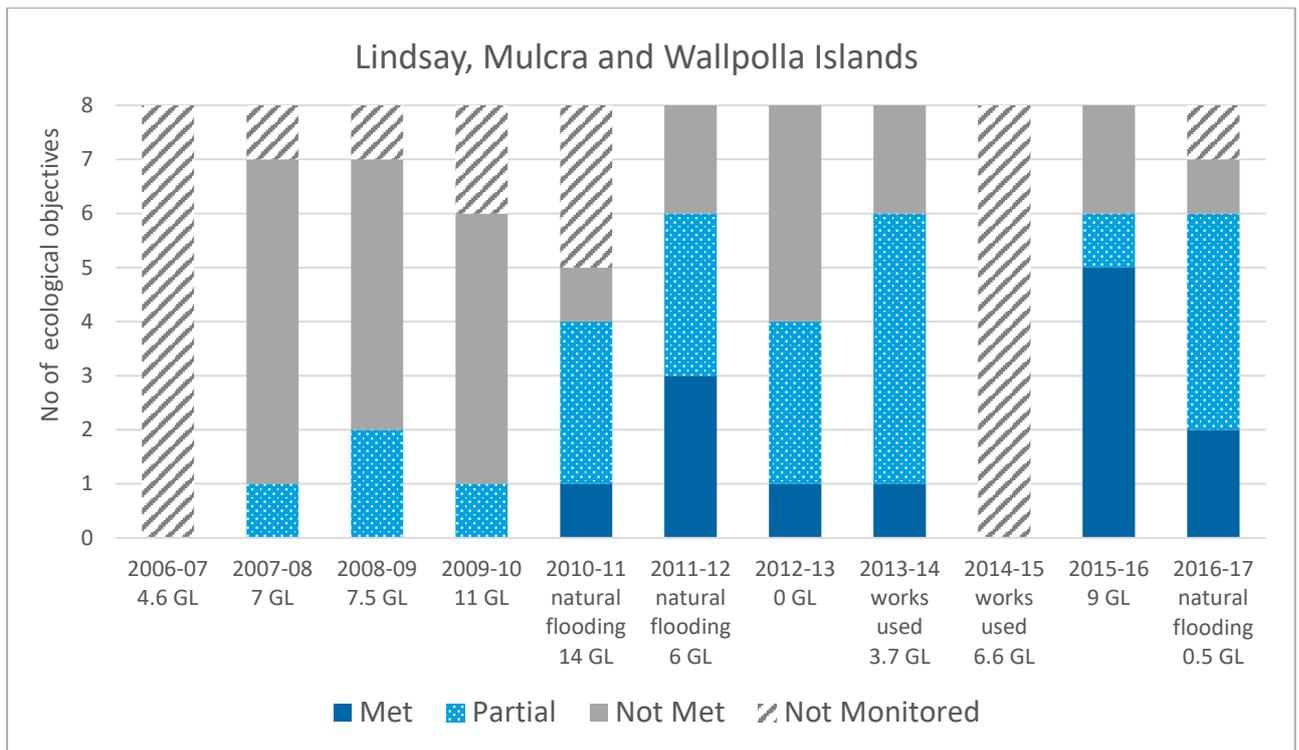


Figure 7: Lindsay, Mulcra and Wallpolla Islands — Performance of ecological objectives 2006–07 and 2016–17

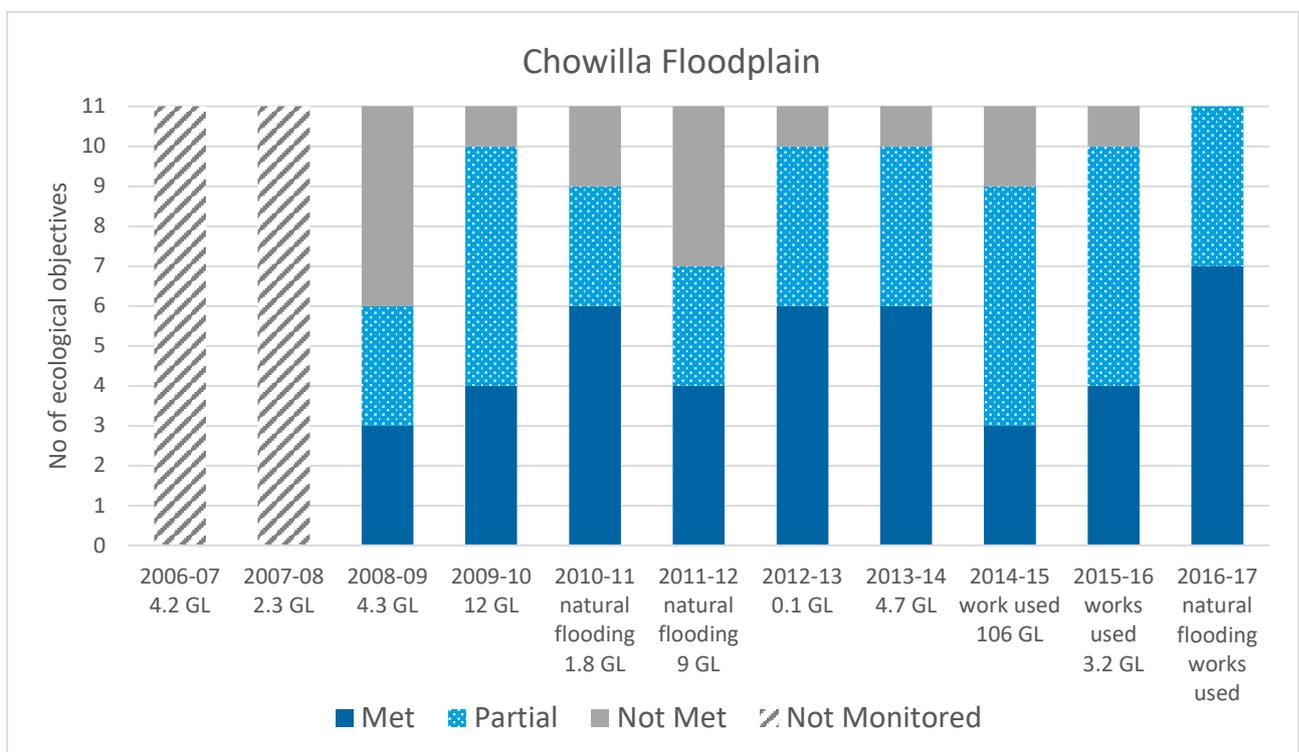


Figure 8: Chowilla Floodplain — Performance of ecological objectives 2006–07 to 2016–17

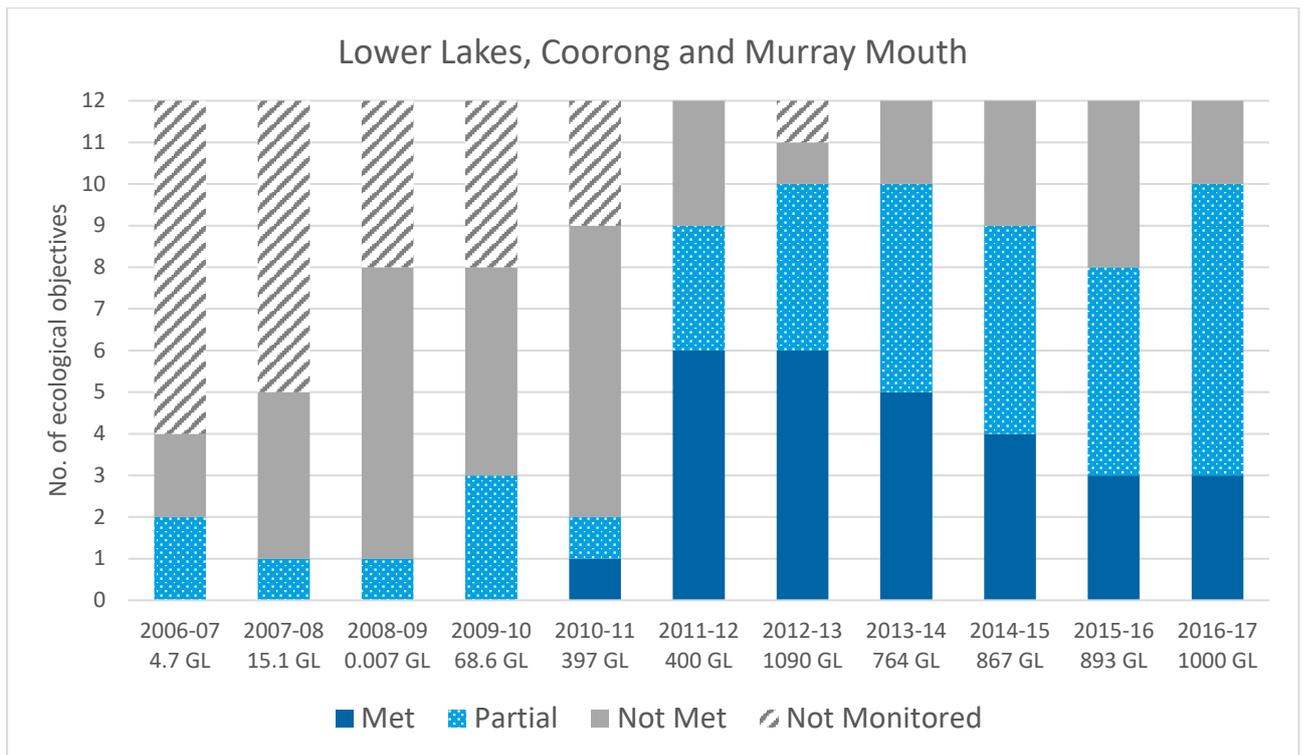


Figure 9: Lower Lakes, Coorong and Murray Mouth — Performance of ecological objectives from 2006–07 to 2016–17

## Progress against ecological themes

Figures 9 to 12 provide the extent to which icon site objectives have been met in 2016–17 across all icon sites by ecological themes. These themes are based on the ecological objectives of vegetation, waterbirds, fish and other ecological objectives and the information provided at Appendixes B and C.

Key observations are:

- More vegetation objectives are being met, or partially met, across icon sites compared to waterbird, fish and other ecological objectives.
- Vegetation outcomes requiring inundation of higher parts of the floodplain (e.g. Blackbox) are only being partially met, often only with natural flooding. Relaxing operational constraints would assist to meet these outcomes.
- Although wet conditions during spring 2016 resulted in a significant improvement in the extent and abundance of *Ruppia tuberosa* (*R. tuberosa*) in the Coorong, reproduction was hampered by the presence of filamentous algae.
- Almost half of the waterbird and fish objectives are being fully met.
- Waterbird outcomes may lag behind improvements to habitats recovery including food sources (e.g. invertebrates and *Ruppia*) and vegetation required for nesting (e.g. lignum).
- The fish ecological objectives not being met are predominantly rare and endangered species across the icon sites.
- Around two thirds of other ecological objectives are either being met or partially met, with a third of the objectives not currently monitored.

Note further commentary for partially met objectives in 2016–17 are provided in Appendix B.



## Vegetation Objectives 2016-17

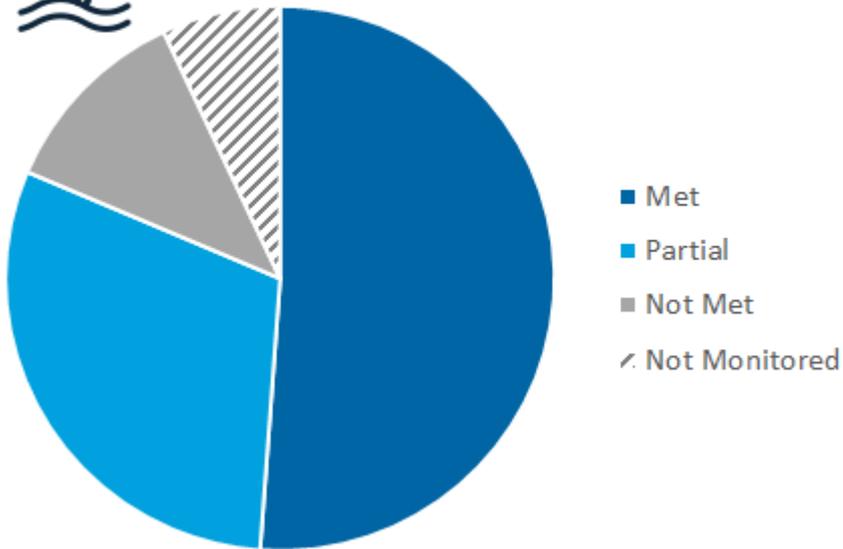


Figure 10: Performance of vegetation objectives across all icon sites in 2016-17



## Waterbird Objectives 2016-17

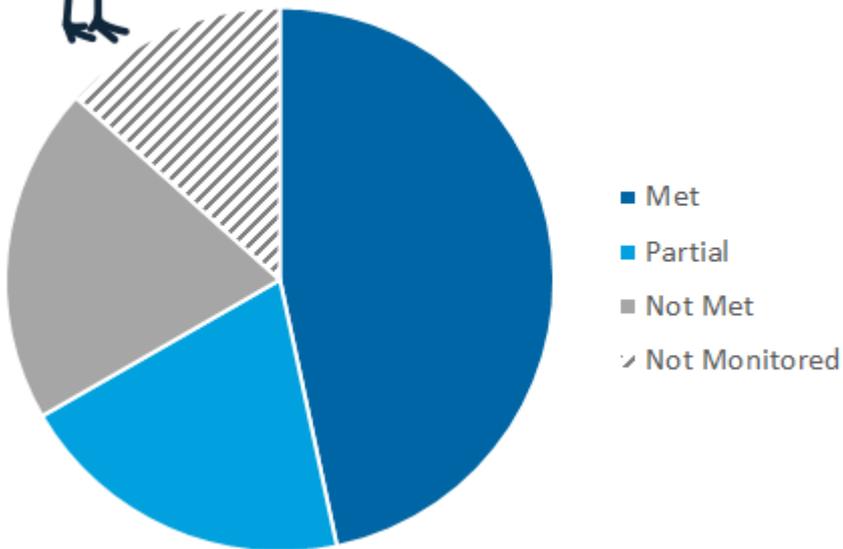


Figure 11: Performance of waterbird objectives across all icon site in 2016-17

## Fish Objectives 2016-17

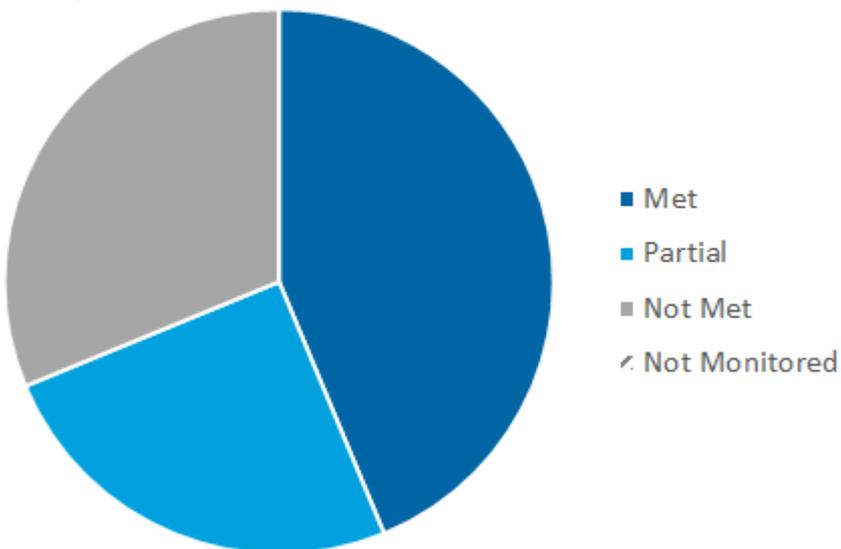


Figure 12: Performance of fish objectives across all icon sites in 2016–17

## Other Objectives 2016-17

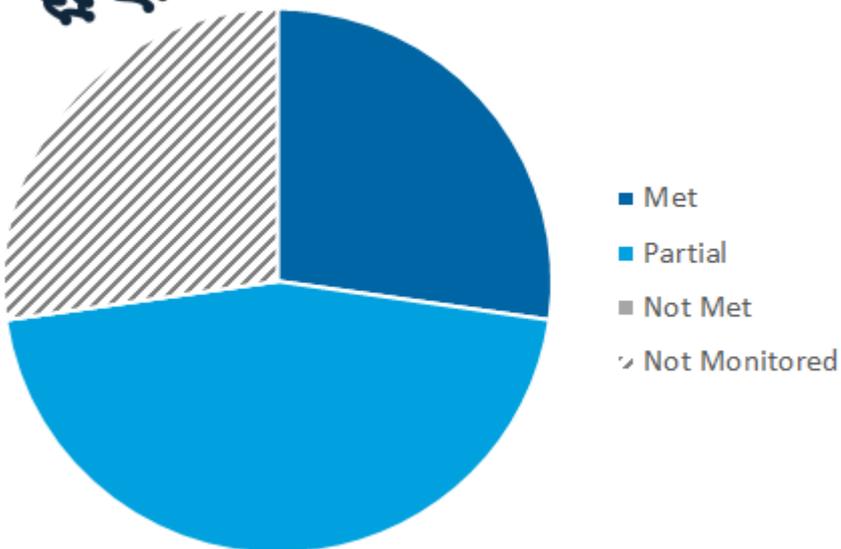


Figure 13 – Performance of other ecological objectives across all icon sites in 2016–17

# Conclusions

The overall conclusions from this initial assessment are:

- The condition of most sites have improved with the delivery of water for the environment and the use of works.
- Sites in the Upper River Murray, with the exception of Koondrook–Perricoota Forest, are meeting or partially meeting a larger number of ecological objectives than sites in the Lower River Murray.
- While natural flooding improves the condition of sites, sites that have received natural flooding and only delivered small scale waterings, are not improving (e.g. Koondrook–Perricoota).
- Of the sites with environmental works, sites that have used works to deliver environmental water over successive years are performing better against their ecological objectives than sites that haven't.
- Addressing operational constraints will support the achievement of ecological objectives in the southern Basin.
- Focusing on fish and waterbird outcomes in coming years should consolidate on the gains from natural flooding and the strong vegetation responses recorded.

## Next steps

**Step 1:** The information in this report will continue to be used to inform the prioritisation of environmental watering activities in the southern Basin for the 2018–19 water year. For example:

- Icon Site Managers using this information to develop their annual watering proposals
- SCBEWC using this information to inform the:
  - identification of opportunities for coordination between environmental holders, and
  - commitments for the use of the jointly held water portfolios.

**Step 2:** Review the annual report cards of site condition to improve utility and support web-based communication of site condition.

**Step 3:** Work with governments during 2018–19 to complete a review of the alignment of The Living Murray monitoring and site objectives with the Basin Plan.

**Step 4:** Work with governments to assist with preparation for the 2020 Basin Plan Evaluation at the asset scale, as required.

While the next steps outlined in this section are specifically for the monitoring and evaluation associated with The Living Murray initiative, they are consistent and seek to further implement the over-arching recommendation 11.2 from the Basin Plan Evaluation 2017 (MDBA, 2017):

- *IR11.2: Basin governments, the MDBA and the Commonwealth Environmental Water Holder should continue to work together to better plan, coordinate and align their monitoring programs to support better evaluation outcomes and clearer reporting.*

In particular, these steps contribute to the implementation of the specific actions in relation to asset-scale monitoring and evaluation under the Basin Plan (MDBA, 2018), namely:

- *Review alignment of existing asset-scale monitoring programs with the Basin-wide Watering Strategy and the Long-term Watering Plans objectives and targets (as they are finalised).*
- *Coordinate monitoring efforts across governments to establish an agreed Basin-wide asset-scale monitoring program using consistent approaches, where appropriate.*
- *The MDBA must work with states and the Australian Government to develop an agreed framework that supports a consistent approach to asset-scale reporting and evaluation and their effective aggregation to inform Basin Plan evaluations.*

## References and further reading

Water for the environment <https://www.mdba.gov.au/managing-water/water-for-environment>

The Living Murray Icon Sites <https://www.mdba.gov.au/managing-water/environmental-water/delivering-environmental-water/living-murray-program>

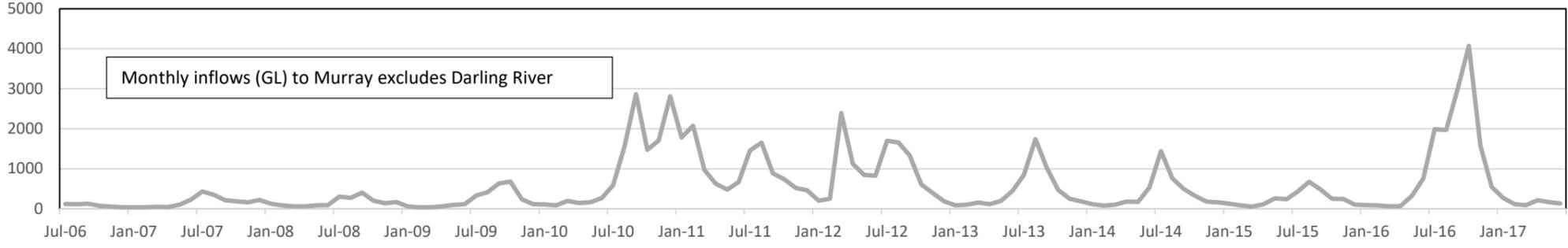
Icon site monitoring reports [https://www.mdba.gov.au/publications/all-publications?field\\_publication\\_category\\_tid=67](https://www.mdba.gov.au/publications/all-publications?field_publication_category_tid=67)

MDBA (2017) 2017 Basin Plan Evaluation <https://www.mdba.gov.au/basin-plan-roll-out/2017-basin-plan-evaluation>, Murray–Darling Basin Authority

Basin Plan Sustainable Diversion Limit Adjustment Mechanism <https://www.mdba.gov.au/basin-plan-roll-out/sustainable-diversion-limits/sdlam>

MDBA (2018) *Environmental assets – 2017 Evaluation*, Murray–Darling Basin Authority

# Appendix A — Summary of watering history and use of environmental works

Icon Site	Climate, E-water delivered to icon sites and use of works	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17								
<b>Scale of watering</b> <table border="1"> <tr> <td>0-10 GL</td> <td></td> <td>50-100 GL</td> <td></td> </tr> <tr> <td>10-50 GL</td> <td></td> <td>100 GL +</td> <td></td> </tr> </table>		0-10 GL		50-100 GL		10-50 GL		100 GL +												
0-10 GL		50-100 GL																		
10-50 GL		100 GL +																		
Barmah-Millewa	E-watering GL	Nil	0.1	1.1	18	428 + natural flooding	425 + natural flooding	3	371	Small natural flooding event	430	417 + natural flooding								
	TLM Works	Works not yet built								1 <sup>st</sup> Use	Used	Used	Not used							
Gunbower	E-watering GL	0.5	8	3	3	natural flooding	0.6 + natural flooding	Nil	10	37	28	3 + natural flooding								
	TLM Works	Works not yet built								1 <sup>st</sup> Use	Used	Used	Not used							
Koondrook-Perricoota	E-watering GL	Nil	Nil	1	0.5	natural flooding	natural flooding	Nil	Nil	26	1.5	1.4 + natural flooding								
	TLM works	Works not yet built								1 <sup>st</sup> Use	Not used	Not used								
Hattah Lakes	E-watering GL	13.5	Nil	5	13	14 + natural flooding	natural flooding	Nil	67	76	7	32 + natural flooding								
	TLM works	Works not yet built								1 <sup>st</sup> Use	Used	Used	Used							
Lindsay-Mulcra-Wallpolla	E-watering GL	4.6	7	7.5	11	14 + natural flooding	6+natural flooding	Nil	3.7	6.6	9	0.5+ natural flooding								
	TLM works	Works not yet built								1 <sup>st</sup> Use	Used	Not used	Not used							
Chowilla	E-watering GL	4.2	2.3	4.3	12	1.8 + natural flooding	9 + natural flooding	0.1	4.7	106	3.2	natural flooding								
	TLM works	Works not yet built								1 <sup>st</sup> Use	Used	Used								
LLCMM	E-watering GL	4.7	15.1	0.007	68.6	397	400	1,090	764	867	893	1,000								

## Appendix B — Performance across icon sites from 2006–07 to 2016–17 by ecological theme

Site	Vegetation Objectives	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
Barmah-Millewa	Promote healthy and diverse vegetation communities in at least 55% of the Barmah–Millewa icon site by:	Not Met	Not Met	Not Met	Partial	Partial	Partial	Partial	Partial	Partial	Partial	Partial <sup>1</sup>
	• Restoring natural extent and health of Giant rush	Not met	Not met	Not met	Partial	Met	Not met	Not met	Not met	Met	Met	Met
	• Restoring natural extent and health of Moira grass	Not met	Not met	Not met	Not met	Not met	Not Met	Not met <sup>1</sup>				
	• Restoring natural extent and health of River red gum forest	Not met	Not met	Not met	Not met	Met	Met	Met	Met	Met	Met	Met
	Facilitate healthy and diverse vegetation to provide suitable breeding and foraging habitat for a diverse range of waterbirds and bush birds.	Not met	Not met	Not met	Partial	Met	Partial	Partial	Partial	Partial	Partial	Met
Gunbower	Promote functioning floodplain and wetland ecosystems that are resilient under a range of climatic conditions.	Not monitored	Partial	Partial	Partial	Partial	Partial	Partial	Partial	Partial	Partial	Partial <sup>2</sup>
	Successful recruitment of wetland and floodplain vegetation resulting in a structurally diverse landscape.	Not monitored	Not met	Partial	Not met	Partial	Partial	Not met	Partial	Partial	Met	Met
	Provide suitable habitat for wetland and floodplain dependent fauna e.g. waterbirds, macroinvertebrates, frogs and fish.	Not monitored	Not met	Not met	Partial	Met	Partial	Partial	Met	Met	Met	Met
	Facilitate an increase in abundance of threatened flora species.	Not monitored	Not met	Partial	Met	Partial	Not met	Met	Met	Met	Met	Met
Koordrook-Perricoota	80% of permanent and semi-permanent wetlands in a healthy condition:	Not monitored	Not monitored	Inconclusive	Not met	Not met	Partial	Partial	Partial	Partial	Partial	Not Met <sup>3</sup>
	30% river red gum sites in healthy condition	Not monitored	Not met	Not met	Inconclusive	Not met	Not met	Not met	Not met	Not met	Not met	Met <sup>4</sup>
	Floodplain understorey	Not monitored	Not monitored	Not monitored	Not met	Not met	Partial	Not met	Not met	Not met	Not met	Met <sup>4</sup>
Hattah Lakes	Maintain and where practical restore sustainable populations of river red gum	Not monitored	Not met	Not met	Not met	Partial	Partial	Partial	Met	Not monitored	Met	Met
	Maintain and where practical restore sustainable populations of black box	Not monitored	Partial	Not met	Partial	Partial	Met	Met	Met	Not monitored	Met	Met
	Healthy wetland vegetation communities	Not monitored	Not met	Not met	Not met	Not met	Partial	Partial	Met	Not monitored	Met	Met
	Healthy floodplain vegetation communities	Not monitored	Not met	Not met	Not met	Not met	Not met	Partial	Partial	Not monitored	Partial	Partial <sup>5</sup>
	Healthy Lignum (LCI score > 4)	Not monitored	Met	Not met	Met	Not met	Met	Met	Met	Not monitored	Met	Not monitored
Lindsay-Mulcras-Wallpolla	Maintain current condition and extent of River Red Gum communities to sustain species assemblages and processes typical of such woodland	Not monitored	Not met	Not met	Not met	Not monitored	Met	Partial	Met	Not monitored	Met	Partial <sup>6</sup>
	Improve condition to sustain species assemblages and processes typical of Black Box woodland.	Not monitored	Not met	Not met	Not met	Not monitored	Not met	Partial	Partial	Not monitored	Partial	Partial <sup>7</sup>
	Increase the diversity, extent and abundance of wetland vegetation	Not monitored	Not met	Partial	Partial	Partial	Met	Not met	Partial	Not monitored	Met	Met
	Increase the diversity, extent and abundance of floodplain vegetation	Not monitored	Not met	Partial	Not monitored	Not monitored	Partial	Not met	Partial	Not monitored	Not met	Partial <sup>8</sup>

	Increase the extent and abundance of Lignum	Not monitored	Not met	Not met	Not met	Not met	Not met	Not met	Not met	Not monitored	Not met	Not met	
	Limit Cumbungi	Not monitored	Not met	Not met	Not met	Met	Met	Met	Partial	Not monitored	Met	Not monitored	
Chowilla	Maintain viable river red gum populations within 70% [2,414 ha] of river red gum woodland.	Not monitored	Not monitored	Not met	Not met	Not met	Not met	Not met	Not met	Not met	Not met	Met	
	Maintain viable black box populations within 45% [2,075 ha] of black box woodland.	Not monitored	Not monitored	Not met	Not met	Not met	Not met	Not met	Not met	Not met	Not met	Partial <sup>9</sup>	
	Maintain viable river cooba populations within 50% of river cooba, and mixed red gum and river cooba woodland areas.	Not monitored	Not monitored	Not met	Not met	Not met	Not met	Not met	Not met	Not met	Not met	Partial <sup>10</sup>	
	Maintain viable lignum populations in 40% of areas	Not monitored	Not monitored	Not monitored	Not met	Not met	Not met	Not met	Not met	Not met	Not met	Met	
	Improve the abundance and diversity of grass and herb-lands	Not monitored	Not monitored	Not met	Partial	Not met	Not met	Met	Not met	Partial	Partial	Met	
	Improve the abundance and diversity of flood-dependent understorey vegetation.	Not monitored	Not monitored	Not met	Partial	Partial	Partial	Partial	Partial	Partial	Partial	Met	
	Maintain or improve the area and diversity of grazing sensitive plant species.	Not monitored	Not monitored	Not met	Partial	Met	Met	Met	Met	Not monitored	Not monitored	Not Monitored	
	Limit the extent of invasive [increaser] species including weeds.	Not monitored	Not monitored	Partial	Met	Partial	Partial	Partial	Partial	Met	Partial	Partial	Partial <sup>11</sup>
	Improve the abundance and diversity of submerged and emergent aquatic vegetation.	Not monitored	Not monitored	Partial	Partial	Met	Partial	Partial	Partial	Partial	Partial	Partial	Partial <sup>12</sup>
LLCMM	Maintain or improve Ruppia tuberosa colonisation and reproduction	Not Monitored	Not Monitored	Not Monitored	Not Monitored	Not met	Not met	Partial	Partial	Partial	Not met	Partial <sup>13</sup>	
	Maintain or improve aquatic and littoral vegetation in the Lower Lakes	Not Monitored	Partial	Partial	Partial	Partial	Partial	Partial	Partial	Partial	Partial	Partial <sup>14</sup>	

 = TLM works used

Note: <sup>1</sup> Objective not fully met as Moira grass not returning to natural extent.

Note: <sup>2</sup> Tree canopy still suffering from millennium drought. Wetland vegetation condition adversely affected by carp and millennium drought.

Note: <sup>3</sup> Wetland vegetation monitored after natural flooding had a lower richness and cover of aquatic plants compared to wetlands previously inundated with environmental water alone.

Note: <sup>4</sup> Tree and understorey vegetation demonstrated a good response to the 2016 flood event

Note: <sup>5</sup> Low and middle terraces of floodplain met targets, higher terraces still dominated by dry community species.

Note: <sup>6</sup> 1 of 2 targets met – target for population age structure not met.

Note: <sup>7</sup> 1 of 2 targets met – target for population age structure not met at sites that had not been flooded (low number of newly germinated seedlings).

Note: <sup>8</sup> Sites on higher floodplain dominated by drought tolerant species

Note: <sup>9</sup> 67% of trees in good condition (target is 70% by 2020); 20 of 38 sites indicate that further watering is warranted

Note: <sup>10</sup> 39% of trees in good condition (target is 70% by 2020); 41% of trees exceed the threshold for management action; Percentage of non-viable trees has stabilised

Note: <sup>11</sup> Met for temporary wetlands but not floodplain.

Note: <sup>12</sup> Three of five targets met (targets for species richness not met)

Note: <sup>13</sup> 25% of targets met for littoral zone; 25% of targets met for aquatic zone.

Note: <sup>14</sup> Three of four targets met at regional scale; At local scale, 2 of 5 targets met.

Site	Waterbird Objectives	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
Barmah-Millewa	Promote and/or sustain successful breeding events for thousands of colonial and migratory waterbirds in at least three years in 10 by inundating selected floodplain and wetland areas to provide suitable nesting and feeding habitat	Not Met	Met	Met	Met	Met	Met	Met				
Gunbower	A suite of waterbirds present including waterfowl, colonial waterbirds and other wetland dependant species.	Not monitored	Partial	Partial	Partial	Partial	Met	Met	Met	Met	Met	Met
	Successful waterbird breeding events that are proportionate to the scale of flooding across the forest.	Not monitored	Not met	Not met	Not met	Met	Not met	Met	Not met	Partial	Partial	Partial <sup>1</sup>
	A contribution to population recovery of threatened waterbird species by supporting frequent recruitment events.	Not monitored	Not met	Not met	Not met	Met	Met	Met	Not monitored	Met	Not met	Not met
	Provide refuge and feeding grounds for waterbirds in drier years.	Not monitored	Met	Met	Partial	Not monitored	Not monitored	Met	Partial	Not monitored	Met	Met
Koondrook-Perricoot	Successful breeding of thousands of colonial waterbirds at least three years in 10.	Not monitored	Not met	Not met	Not met	Not met	Not met	Partial <sup>2</sup>				
	Records of intermediate egret breeding at least three years in ten	Not monitored	Not met	Not met	Not met	Not met	Not met	Not monitored				
Hattah Lakes	Maintain habitat for the freckled duck, grey falcon and white bellied sea eagle in accordance with action statements	Not monitored	Not monitored	Not monitored	Not monitored	Not met	Not met	Partial	Not met	Not monitored	Not met	Met
	To provide conditions for successful breeding of colonial nesters at least twice every ten year	Not monitored	Not met	Not met	Not met	Met	Met	Met				
	Provide suitable habitat for a range of migratory bird species (including Latham's snipe, red necked stint and sharp tailed sandpiper.	Not monitored	Not monitored	Not monitored	Not monitored	Not met	Partial	Partial	Partial	Partial	Partial	Not met
Lindsay-Mulcrum-Waipollia	Sustainable communities of colonial nesting waterbirds, waterfowl, waders and piscivores.	Not monitored	Not monitored	Not monitored	Not monitored	Partial	Partial	Partial	Partial	Not monitored	Met	Met
Chowilla	Create conditions conducive to successful breeding of colonial waterbirds in a minimum of three temporary wetland sites at a frequency of not less than one in three years.	Not monitored	Not monitored	Met	Met	Met	Met	Met	Met	Not met	Met	Met
	Maintain or improve the diversity and abundance of key bird species.	Not monitored	Not monitored	Inconclusive	Not monitored	Not monitored	Not monitored	Not met	Not met	Not met	Not met	Partial <sup>3</sup>
	Maintain the current abundance and distribution of regent parrots.	Not monitored	Met	Met	Met	Met	Not monitored <sup>4</sup>					
	Maintain the current abundance and distribution of bush stone-curlew	Not monitored	Not met	Not Monitored	Not met	Not met	Inconclusive					
LLCMM	Maintain or improve waterbird populations in the Lower Lakes, Coorong and Murray Mouth	Not met	Met	Met	Met	Met	Not Met	Not Met				

 = TLM works used

Note <sup>1</sup> Limited bird breeding considering the wet conditions

Note <sup>2</sup> 700 Heron pairs and 115 Egret pairs bred at the Pollack

Note <sup>3</sup> Observed:Expected ratios targets met for bushbirds in river red gum for the summer and winter surveys, but not for other vegetation types.

Note <sup>4</sup> Targeted Regent parrot surveys not undertaken however Regent parrots were recorded during general bird surveys.

Site	Fish Objectives	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
B-M	Promote successful recruitment of native fish species by improving flow variability in spring and early summer to replicate natural cues, and by inundation of floodplain and wetland areas to provide breeding and nursery habitat.	Partial	Partial	Partial	Partial	Partial	Partial	Not Met	Not Met	Partial	Partial	Met
Gunbower	Increase in the abundance of native fish species so that each exhibits a robust population structure with a focus on the recovery of threatened species.	Not monitored	Partial	Met	Not met	Partial	Partial	Partial	Partial	Partial	Partial	Partial <sup>1</sup>
	Restore presence of locally extinct fish species to Gunbower Island.	Not monitored	Not met	Not met	Not met	Not met	Not met					
	Allow for movement of native fish in and out of habitat types (creek, river, wetlands and floodplain) for feeding and breeding.	Not monitored	Not met	Met	Met	Met						
Koordrook-Perricoota	Nativeness – proportion of native fish of total fish recorded	Not monitored	Not monitored	Not monitored	Not monitored	Not met	Not met	Not met	Not met	Not met	Partial	Not met
	Expectedness – native fish expected to occur at site	Not monitored	Not monitored	Not monitored	Not monitored	Not met	Not met	Not met	Not met	Not met	Not met	Not met
	Recruitment – types of native fish recruiting and proportion of total fish species recruited	Not monitored	Not monitored	Not monitored	Not monitored	Not met	Not met	Partial	Not met	Not met	Partial	Not met
Hattah Lakes	Increase distribution, number and recruitment of local wetland fish including hardyhead, Australian smelt and gudgeon by providing appropriately managed habitat	Not monitored	Not met	Not met	Not met	Met	Met	Not met	Met	Not monitored	Met	Met
	Maximise use of floodplain habitat for recruitment of all indigenous freshwater fish	Not monitored	Not met	Not met	Not met	Partial	Partial	Not met	Partial	Not monitored	Partial	Met
LMW	Maintain native fish populations, their relative abundance and diversity	Not monitored	Partial	Not met	Not met	Partial	Partial	Not met	Not met	Not monitored	Met	Partial <sup>2</sup>
Chowilla	Maintain or increase the diversity and extent of distribution of native fish species.	Not monitored	Not monitored	Met	Met	Met	Met	Met	Met	Met	Met	Met
	Maintain successful recruitment of small and large bodied native fish.	Not monitored	Not monitored	Met	Met	Met	Met	Met	Met	Met	Met	Met
LLCMM	Promote the successful migration and recruitment of diadromous fish species in the Lower Lakes and Coorong	Partial	Not Met	Not Met	Partial	Not Met	Partial	Not Monitored	Partial	Partial	Partial	Partial <sup>3</sup>
	Ensure recruitment success of threatened fishes in the Lower Lakes to maintain or establish self-sustaining populations	Not Monitored	Not Monitored	Not Met	Partial	Not Met	Not Met	Partial	Partial	Partial	Partial	Partial <sup>4</sup>
	Maintain abundant self-sustaining populations of small-mouthed hardyhead in the North Lagoon and South Lagoon of the Coorong	Not Monitored	Not Monitored	Not Met	Not Met	Not Met	Met	Met	Not Met	Not Met	Not Met	Met
	Restore resilient populations of black bream and greenback flounder in the Coorong	Not Monitored	Not Monitored	Not Met	Not Met	Not Met	Partial	Not Met	Not Met	Not Met	Not Met	Not Met

 = TLM works used

Note:<sup>1</sup> Population structure good for small bodied natives, but mixed results for large bodied natives

Note:<sup>2</sup> Target for diversity met at 69% of sites; Targets for biomass and recruits not met.

Note:<sup>3</sup> Target met for Congolli but not Common Galaxias or Lamprey

Note:<sup>4</sup> Target met for Murray Hardyhead but not Southern Pygmy Perch or Yarra Pygmy Perch

Site	Other Objectives	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	
Barmah-Millewa	Facilitate successful breeding and feeding opportunities for native frog species by seasonal inundation of selected floodplain and wetland areas for appropriate season and duration as required for each species.	Not monitored	Not monitored	Not monitored	Not monitored	Not monitored	Not monitored	Not monitored	Not monitored	Not monitored	Not Monitored	Not monitored <sup>1</sup>	
	Facilitate appropriate management to ensure the sustainability of crayfish populations.	Inconclusive	Inconclusive	Inconclusive	Inconclusive	Inconclusive	Inconclusive	Inconclusive	Inconclusive	Not monitored	Inconclusive	Partial	
	Facilitate appropriate management measures to control the abundance and spread of invasive aquatic species.	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met	Partial	Met	
	Facilitate successful breeding of native turtle species by inundation of selected floodplains and wetland areas to provide suitable breeding and nursery habitat.	Not monitored	Not monitored	Not monitored	Inconclusive	Inconclusive	Inconclusive	Not monitored	Not monitored	Inconclusive	Not Monitored	Not monitored <sup>2</sup>	
Gunbower	Restore resident populations and breeding events of native frogs, especially threatened species.	Not monitored	Not met	Partial	Partial	Not monitored	Partial	Not monitored					
Chowilla	Maintain sustainable communities of the eight riparian frog species recorded at Chowilla.	Not monitored	Not monitored	Partial	Partial	Partial	Not met	Partial	Partial	Partial	Partial	Partial <sup>3</sup>	
	Improve the distribution and abundance of the nationally listed southern bell frog at Chowilla.	Not monitored	Not monitored	Not met	Partial	Met	Not met	Not met	Partial	Partial	Partial	Partial	
LLCMM	Maintain or improve mudflat invertebrate communities that are of high condition relative to southern Australian estuarine mudflat ecosystems	Partial	Not Met	Partial	Partial	Partial	Partial	Met					
	Maintain or improve habitable sediment conditions in mudflats	Not met	Not met	Not met	Not met	Met	Met	Met	Met	Met	Met	Met	
	Support aquatic habitat by establishing and maintaining variable salinity regimes in the Murray Mouth Estuary, North Lagoon and South Lagoon <sup>8</sup>	Data yet to extracted from reports						Met	Met	Met	Met	Partial	Partial <sup>5</sup>
	Maintain a permanent Murray Mouth opening through freshwater outflows to improve water quality and maximise connectivity <sup>9</sup>	Data yet to extracted from reports						Met	Met	Met	Not met	Met	Partial <sup>6</sup>
	Maximise fish passage connectivity between the Lower Lakes and Coorong	Data yet to extracted from reports						Met	Met	Met	Met	Met	Partial <sup>7</sup>

 = TLM works used

Note:<sup>1</sup> Frogs not formally monitored at Barmah-Millewa, but calls from six species were recorded at various sites

Note:<sup>2</sup> Turtles not formally monitored, but preliminary evidence suggests that environmental flows do improve the health of turtles occupying ephemeral floodplain habitats (Howard et al. 2016).

Note:<sup>3</sup> All eight known frog species were recorded at Chowilla, but two species had limited distribution

Note:<sup>4</sup> Southern Bell frogs recorded calling and as tadpoles, metamorphs and adults, but distribution limited

Note:<sup>5</sup> One of three salinity targets met (Goolwa to Pelican Point met, but Pelican point to North Lagoon not met, nor was South Lagoon target).

Note:<sup>6</sup> Two of three indices met (target for daily barrage release met, but barrages closed 23 days and mouth had to be dredged)

Note:<sup>7</sup> One of two targets met (barrages open every day)

Note:<sup>8</sup> This objective varied slightly in 2015/16, previously "Establish and maintain variable salinity regime with >30% of area below sea water salinity concentrations in estuary and North Lagoon"

Note:<sup>9</sup> Prior to 2015/16 this was two separate objectives – one for an open Murray mouth and one for connectivity between the Coorong and sea.

# Appendix C — 2016–17 Icon site monitoring reports

## Barmah–Millewa Forest

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- Borrell, A. (2017) Barmah–Millewa Forest Bush Bird Condition Monitoring 1999–2017.
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## Koondrook–Perricoota Forest

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## Gunbower Forest

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## Hattah Lakes

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- Moxham C, Kenny S and Maloney P (2017) The Living Murray Hattah Lakes Intervention Monitoring Annual Report: Understorey Vegetation Program, The Arthur Rylah Institute for Environmental Research, Heidelberg,
- Biosis 2017. Monitoring waterbirds in response to environmental watering at the Hattah Lakes Icon Site: 2017. Report for Mallee Catchment Management Authority.
- Loyn, R., Dutson, G. and Cheers, G. (2017) Waterbird assessments for condition monitoring in the Hattah Lakes and Lindsay–Mulcra–Walpolla Island Icon Sites, 2014–17. Unpublished report for the Mallee CMA by Eco Insights.

## Lindsay–Mulcra–Wallpolla Islands

- Brown P, Freestone F, Wood D, Lampard B, Gehrig S, Campbell C (2017) The Living Murray Condition Monitoring at Lindsay, Mulcra and Wallpolla Islands 2016–17. Draft report: <http://www.malleecma.vic.gov.au/jobs-tenders/expired/tender-tlm-condition-monitoring-2017-18-rfq00204/Reference%20document%20Brown%20et%20al.%202017%20-%20Draft%20ONLY.pdf>
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- Dittmann, S. Jessup-Case, H., Lam Gordillo, O. & Baring R. 2017. Benthic macroinvertebrate survey 2016–2017: Coorong and Murray Mouth Icon Site. Report for the Department of Environment, Water and Natural Resources and the Murray–Darling Basin Authority

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Office locations  
Adelaide  
Albury-Wodonga  
Canberra  
Toowoomba

 [mdba.gov.au](https://mdba.gov.au)

 1800 230 067

 [engagement@mdba.gov.au](mailto:engagement@mdba.gov.au)