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MURRAY-DARLING BASIN AUTHORITY

The Living Murray

Annual Environmental Watering Plan 2009–10



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# 1. INTRODUCTION

The Living Murray (TLM) was established in 2002 in response to evidence that the health of the Murray River system<sup>1</sup> is in decline. In November 2003 the Murray–Darling Basin Ministerial Council announced its historic Living Murray First Step Decision. An additional average of 500 GL of water per year (to be recovered by June 2009) and a structural works program are being delivered as part of this decision. The Living Murray's First Step focuses on the achievement of agreed ecological objectives at six 'icon sites' along the River Murray with a combination of 'water and works'. The six icon sites are:

- Barmah–Millewa Forest
- Gunbower–Koondrook–Perricoota Forests
- Hattah Lakes
- Chowilla Floodplain, Lindsay–Wallpolla Islands
- Lower Lakes, Coorong and Murray Mouth
- Murray River Channel.

The Annual Environmental Watering Plan was established by the TLM Business Plan. This document is the Annual Environmental Watering Plan 2009–10 which focuses on the water delivery aspects of TLM. It has been jointly developed by the Murray–Darling Basin Authority (MDBA) and Environmental Working Group (EWG). The plan sets out the decision framework for prioritising environmental watering actions across the Murray River system between 1 July 2009 and 30 June 2010.

Under the current arrangements post transition from the Murray–Darling Basin Commission the Annual Environmental Watering Plan will be approved by the Chief Executive of the MDBA based on the advice of EWG and The Living Murray Committee. This may change as appropriate arrangements are identified.

The annual water planning process is responsive to changing water resource conditions, opportunities and environmental priorities throughout the season. Implementation of the Annual Environmental Watering Plan, including any changes to priorities or other aspects of the Plan is recorded separately and reported at the end of the year.

For information about TLM go to <http://www.mdba.gov.au/programs/tlm>

<sup>1</sup> Murray River system includes: the main course of the Murray River and all its effluents and anabranches downstream of Hume Dam to the sea including the Edward–Wakool River system, the Mitta Mitta River downstream of Dartmouth Dam and the Darling River and Great Darling Anabranch downstream of Menindee Lakes.

## 2. ENVIRONMENTAL WATERING ACTIVITIES 2008–09

For the watering period 1 July 2008 to 30 June 2009, 6.728GL (of the available 13,046 GL) was allocated for the implementation of environmental watering actions at the icon sites. The environmental watering actions undertaken were targeted at critical locations within icon sites that would provide a material benefit to achieving TLM objectives. A summary of these actions and the allocated water volumes is provided in Table 1.

**Table 1. TLM environmental watering activities 2008–09**

Icon Site/Site	Watering Action	Volume committed (GL) (of 12.331 GL available)	Period of watering	Benefit
Barmah–Millewa Forest	Connect and replenish existing remnant pools in Barmah	0.3	Nov '08	Protect and maintain habitat for native fish and turtles; maintain water quality and habitat connectivity in upper reaches of Gulf Creek.
Chowilla Lindsay–Wallpolla	Watering critical drought refuge sites at Chowilla	2.403	Dec'08 – Jan'09 & Apr – May '09	Contribute to maintaining river red gums, black box, other high priority vegetation and wildlife; provide drought refuge
Gunbower–Koondrook–Perricoota	Watering of Pollock Swamp in Perricoota Forest	1	May '09	Maintain wetland vegetation, and contribute to the maintenance of bird breeding and foraging habitat.
Hattah Lakes	Watering of Lake Lockie, Lake Little Hattah and Little Lake Hattah	1	May – Jun '09	Maintain fringing red gum communities and provide drought refuge for water birds
Lower Lakes, Coorong and Murray Mouth  (Turvey Drain and Boggy Creek)	Replenish refuges to maintain fish populations	0.025	May – Jun '09	Maintain critical refuge habitat for threatened Murray hardyhead and Southern pygmy perch species in the Lower Lakes
Chowilla Lindsay–Wallpolla	Watering critical drought refuges at Lindsay–Wallpolla	2	May – Jun '09	Contribute to maintaining river red gum communities, and providing drought refuges for birds, frogs, tortoises and understorey communities
<b>TOTAL</b>		6.728		

Table 2 presents the reliability class of entitlements held by TLM in 2008–09 with their associated entitlement, allocation and net use volumes as well as carry over volumes to 2009–10. A volume of 0.050GL of River Murray Increased flows (RMIF) was not used in 2008–09. The interim RMIF rules allow for this water to be carried over for use until October 2009.

In 2008–09 TLM received 13.046 GL of water against entitlements held on the TLM Environmental Water Register (Table 2). 6.728 GL was allocated for environmental watering actions throughout the water year. As a significant proportion of the TLM water did not become available until later in the year, it has been carried over to 2009–10. Currently only 60% of carryover water is expected to be available on 1 July 2009. Goulburn-Murray Water has stated that the delivery of carryover will depend on the availability of sufficient water to operate distribution systems. It is estimated that the carry over available on 1 July 2009 will be 3.788 GL.

**Table 2. TLM Entitlements 2008–09**

Entitlement type	Entitlement (GL)	Allocation Available to TLM** (GL)	Use (GL)	Carryover to 2009–10 (GL)	Carryover available 1 July 09 (GL)
NSW High Security	1.597	0.398	0	0.398	0.239
NSW General Security	191.246	9.211	4	5.206*	3.123
NSW Supplementary water	350	0	0	0	0
VIC High Reliability	1.885	0.659	0	0.627****	0.376
VIC Low reliability	247.65	0	0	0	0
SA water licence	34.44	2.34	2.34	0	0
RMIF carried over 2007–08***	0	0.438	0.388	0.050	0.050
<b>TOTAL</b>	<b>826.818</b>	<b>13.046</b>	<b>6.728</b>	<b>6.281</b>	<b>3.788</b>

\*a small volume was used to pay back encumbrances.

\*\* some water allocated to entitlements purchased in 2008–09 has been utilised by the previous owner.

\*\*\*MDBA managed environmental water entitlement (not specifically TLM). This water is permitted to be carried over to October 2009.

\*\*\*\*5% transmission loss fee for carryover of allocation against Victorian water entitlements

## 3. FORECAST 2009–10

### 3.1 Inflows

Inflows for the 2008–09 water year (June 2008 to May 2009) were the third driest in 118 years of records (Figure 1). Inflows for May 2009 were only 90 GL which is well below the long term average of 390 GL. The persistence and severity of this drought, particularly over the past three years, is unprecedented.

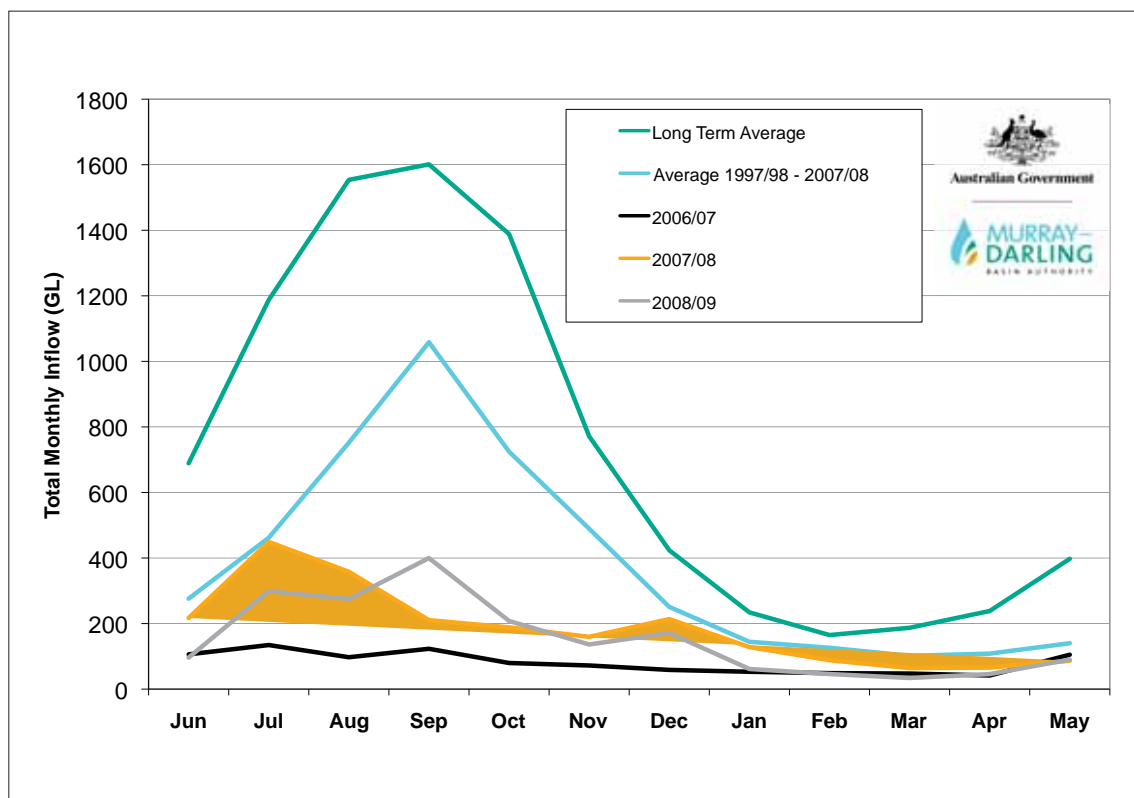


Figure 1. Comparison of inflows to River Murray system (excluding the Darling River and Snowy River) in selected years

### 3.2 Storage

Total MDBA active storage for the Murray system at the end of May 2009 was 980 GL (11 % of capacity) which is well below the end of May long term average of 4,670 GL (Figure 2). Total storage across the whole of the Murray-Darling Basin also remains low, at about 17 % capacity.

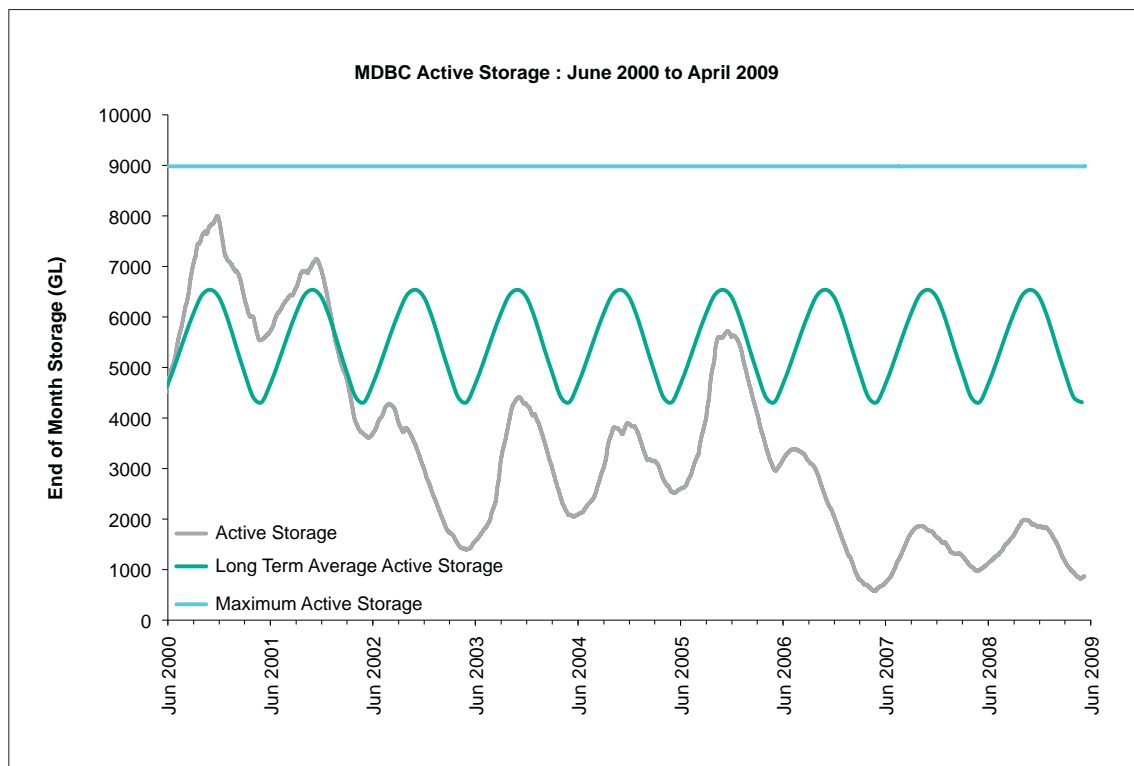


Figure 2. Comparison of active, long-term average and maximum active storage levels in the River Murray system June 2000 to June 2009.

### 3.3 Outlook

After good falls of rain across the southern Murray-Darling Basin in late April, there was very little follow-up rain in May. Whilst there was also very heavy rainfall in Queensland and northern NSW in May, little is expected to reach the Menindee Lakes due to small stream flow responses and high river transmission losses. As a result, Murray system inflows have remained close to record lows.

The latest rainfall outlook (June to August 2009) issued by the Bureau of Meteorology indicates that for the next three months above average rainfall is about as equally likely as below average rainfall. However, recent trends in Pacific climate patterns, and the latest computer models indicate an increased risk of an El Niño developing during winter and spring. The Indian Ocean Dipole has also become increasingly positive in recent months and this tends to suppress the formation of rain-bearing cloud bands across Australia.

Therefore there will need to be a sustained period of above average rainfall before system inflows show a significant improvement.

### 3.4 System-wide river operating strategy for 2009–10

The MDBA has been working closely with partner governments throughout the unprecedented drought to develop contingency plans to manage water supplies.

All three south-eastern States have set aside sufficient water to reasonably assure critical human water needs in 2009–10, but the prospects for irrigation will be highly dependent on future rainfall and system inflows. As in 2008–09, access to ‘carried over water’ may be restricted in early 2009–10.

Overall, the outlook for the beginning of the 2009–10 water year is grim, as was the case for the previous two years.

### 3.5 Outlook for TLM water entitlements 2009–10

Further entitlements are expected to enter the TLM Environmental Register throughout 2009–10. Table 3 provides estimates of the entitlement volumes and their reliability class.

**Table 3. Entitlements expected June 2009–10**

Reliability	Entitlement volume (GL)*
Low	267
General	194
High	78
<b>TOTAL</b>	<b>539</b>

\*Approximate forecasts only. Note the volumes are not Long Term Cap Equivalents.

An estimate of the potential allocations against TLM entitlements in 2009–10 is given in Table 4. This is only an approximate estimate as many of these purchases are yet to be settled. The lower range of figures is based on Goulburn-Murray’s outlook for 2009–10 and the higher range is based on allocations similar to 2008–09. As allocations in 2009–10 could vary depending on climatic variability, it is important to note there is potentially a greater range of available water volumes in 2009–10.

**Table 4. Forecasted available TLM water 2009–10**

Season	Forecasted allocation amounts (GL)	Carryover available (GL)	TOTAL (GL)
Spring 2009	2.5–7	3	6–10
Autumn 2010	25–65	5.57	31–73

## 4. TLM WATER PLANNING 2009–10

### 4.1 Regulated Flows

The increasing number of entitlements held by TLM has led to a potentially greater range of allocation volumes available in 2009–10 depending on climatic variability. This range could be expanded further with the possible supplementation of Commonwealth environmental water. Particularly in an extreme dry scenario, this water will need to be delivered as quickly and efficiently as possible to ensure the maximum benefits to the watering sites.

In order to respond to the potential variability in water resources, EWG agreed to utilise a model that outlines management objectives for different water resource scenarios (Table 5). This model is based on principles developed by the Victorian Department of Sustainability and Environment (DSE) and the Commonwealth Department of the Environment, Water, Heritage and the Arts (DEWHA). The ecological objectives for extreme dry/dry/median and wet scenarios outlined in the model provide guidance on how TLM water would be utilised under different flow and climatic conditions.

The primary objective of the Annual Environmental Watering Plan 2009–10 is to provide environmental benefit (in terms of the stated objectives for each site). Regardless of climatic conditions, EWG has agreed to use the following ranking criterion to prioritise between individual watering actions throughout the year. This ranking criterion constitutes the basis of the material benefit test for all watering actions.

#### Ranking criterion

- Significance of outcome
- Amount of benefit for the volume of water (including the opportunity to take advantage of other events)
- Risk of not watering – recovery or not
- Certainty/likelihood of benefit.

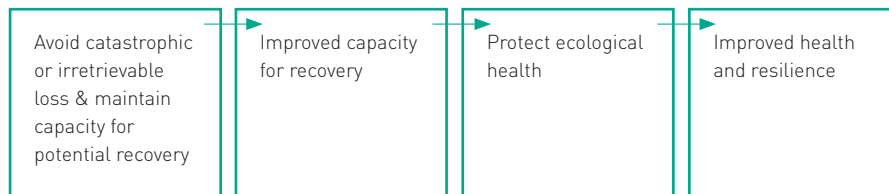
Due to the continuing drought and the forecasted low water availability, EWG adopted the management objectives for the extreme dry water resource scenario to identify critical environmental water requirements for 2009–10. Whilst there is the opportunity to review this during the water year all the proposed watering schedules presently use the extreme dry criteria. A transition to dry criteria would only occur if inflows and icon site conditions improved and/or most of the drought refuge actions had been completed.

The extreme dry objectives are:

- Avoid critical loss of threatened species
- Avoid irretrievable damage or catastrophic events
- Provide refuges to allow recolonisation following drought.

**Table 5. Proposed ecological watering objectives under different water resource availability scenarios (based on principles established by DSE Victoria and DEWHA)**

	Extreme Dry	Dry	Median	Wet
<b>Ecological watering objectives</b>	Avoid irretrievable loss of key environmental assets	Ensure priority river reaches and wetlands have maintained their basic functions	Ecological health of priority river reaches and wetlands have been protected or improved	Improve the health and resilience of aquatic ecosystems
<b>Management objectives</b>	<ul style="list-style-type: none"> <li>• Avoid critical loss of species, communities and ecosystems</li> <li>• Maintain key refuges</li> <li>• Avoid irretrievable damage or catastrophic events</li> </ul>	<ul style="list-style-type: none"> <li>• Maintain river functioning with reduced reproductive capacity</li> <li>• Maintain key functions of high priority wetlands</li> <li>• Manage within dry -spell tolerances</li> <li>• Support connectivity between sites</li> </ul>	<ul style="list-style-type: none"> <li>• Enable growth, reproduction and small-scale recruitment for a diverse range of flora and fauna</li> <li>• Promote low-lying floodplain-river connectivity</li> <li>• Support medium flow river and floodplain functional processes</li> </ul>	<ul style="list-style-type: none"> <li>• Enable growth, reproduction and large-scale recruitment for a diverse range of flora and fauna</li> <li>• Promote higher floodplain-river connectivity</li> <li>• Support high flow river and floodplain functional processes</li> </ul>
<b>Management actions</b>	<ul style="list-style-type: none"> <li>• Water refugia and sites supporting species and communities</li> <li>• Undertake emergency watering at specific sites of priority assets</li> <li>• Use carryover volumes to maintain critical environmental needs</li> </ul>	<ul style="list-style-type: none"> <li>• Water refugia and sites supporting threatened species and communities</li> <li>• Provide low flow and freshes in sites and reaches of priority assets</li> <li>• Use carryover volumes to maintain critical needs</li> </ul>	<ul style="list-style-type: none"> <li>• Prolong flood/high-flow duration at key sites and reaches of priority assets</li> <li>• Contribute to the full-range of in-channel flows</li> <li>• Provide carry over to accrue water for large watering events</li> </ul>	<ul style="list-style-type: none"> <li>• Increase flood/high-flow duration and extent across priority assets</li> <li>• Contribute to the full range of flows incl. over-bank</li> <li>• Use carryover to provide optimal seasonal flow patterns in subsequent years</li> </ul>



In order to prioritise the watering actions, EWG recognised there was a need for a decision framework that could address some of the issues that arose during the 2008–09 water year. These issues included:

- assessment of material benefit to Lower Lakes
- water delivery costs
- possibility to bank water
- potential combination of Commonwealth and TLM water.

These issues have been incorporated into a flexible decision framework that will guide the prioritisation of environmental watering actions in 2009–10 (Table 6). This decision framework provides the focus for the initial prioritisation of environmental watering actions, an assessment of the associated risks and the timeframes for the review of all other potential watering actions. These reviews will compare TLM water availability against the ranking criteria to determine material benefit to all sites including the Lower Lakes. The reviews will consider factors including the availability of other sources of environmental water, conditions at the sites, antecedent and forecasted flows. The flow chart in Figure 3 shows how the issues stated above are incorporated into the process for prioritising environmental water actions.

To be event ready EWG have identified proposed watering actions which align with the decision framework (refer Schedule A, B & C). Schedule A provides a list of refuge sites that require annual or regular watering in order to consolidate the benefits achieved by previous watering events. Schedule B expands the list of critical drought refuge sites (including sites that don't require annual/regular watering) whilst Schedule C includes sites that require larger volumes of water. As outlined in the framework, actions recommended for implementation throughout the year will not be limited to those identified in the schedules to this plan.

During the 2009–10 water year, EWG will review the list of environmental watering proposals at designated periods utilising the process outlined in Figure 3. The availability of other sources of water will be incorporated into these reviews. Based on the outcomes of the review, EWG will provide advice to the MDBA on whether any environmental watering actions should be implemented at that stage.

All watering actions will be implemented in accordance with the decision framework and prioritisation process outlined in the Annual TLM Watering Plan 2009–10. It is proposed that the approval of any environmental watering actions recommended by EWG within icon sites will be delegated to the Executive Director of Natural Resource Management.

Table 6. TLM Environmental Watering Decision Framework

Timing	Decision steps	Water resource scenario	Associated risks
July 2009 initial allocation	0-16 GL prioritise* critical refuge sites that require annual/regular watering to consolidate previous watering events. # Watering actions may include but not be limited to those identified in <b>Schedule A</b> .	Extreme Dry Scenario	<ul style="list-style-type: none"> <li>Critical drought refuges that have not been watered on a regular basis will be excluded</li> <li>Water would not be banked for potential larger actions in the future</li> </ul>
July – mid-November 2009	Bank any additional water (above 16 GL) to enable a wider scope of watering actions to be considered, including the material benefit to the Lower Lakes. Banking would not be considered if other proposed watering sites could be irretrievably lost during this period.	Extreme Dry Scenario	<ul style="list-style-type: none"> <li>Banking could limit the water available for drought refuges</li> <li>Banking water could delay the watering of critical drought refuges</li> </ul>
Mid-November 2009	Review of TLM water availability against the benefit to all sites including the Lower Lakes using the ranking criteria* (this constitutes the basis of material benefit for the Lower Lakes). Factors to be considered include local site conditions/other potential sources of environmental water/antecedent flows/forecasted flows.# Based on the review, EWG to use available water to, EITHER the available TLM water will be banked in order to enable a wider scope of watering actions to be considered in February OR TLM water will be allocated to sites that may include, but not be limited to, those identified in <b>Schedule B</b> . OR a combination of banking and use of water	Extreme Dry Scenario Depending on rainfall, icon site condition and the volume of water available, there may be a possibility to incorporate some management objectives of the dry scenario within the prioritisation process if the volumes of water available to TLM increase significantly through the year.	<ul style="list-style-type: none"> <li>Banking or larger watering actions could limit the water available for drought refuges</li> <li>Water may be delivered at a time that does not maximize environmental outcomes</li> <li>A focus on smaller drought refuges could limit larger watering actions</li> <li>Banking may not result in sufficient water being accumulated for larger scale future watering actions</li> <li>Risk associated with carry over</li> </ul>
November – February 2009 – 10	Continue to bank water. Banking would not be considered if other proposed watering sites could be irretrievably lost during this period.	Extreme Dry / Dry Scenario depending on conditions	<ul style="list-style-type: none"> <li>Banking could limit the water available for drought refuges</li> <li>Banking water could delay the watering of critical drought refuges</li> </ul>
February 2010 onwards	Review watering actions against the ranking criteria* to allocate water to proposed sites or continue to hold any water if appropriate#	Extreme Dry / Dry Scenario depending on conditions	<ul style="list-style-type: none"> <li>As listed above</li> </ul>

Note: Exceptions that arise throughout the water year will be reviewed by EWG as required using the process outlined in the decision framework

\*Watering actions will be prioritized within this framework using the ranking criteria outlined in this Annual Environmental Watering Plan

# The availability of other sources of environmental water will be considered for any proposed watering actions

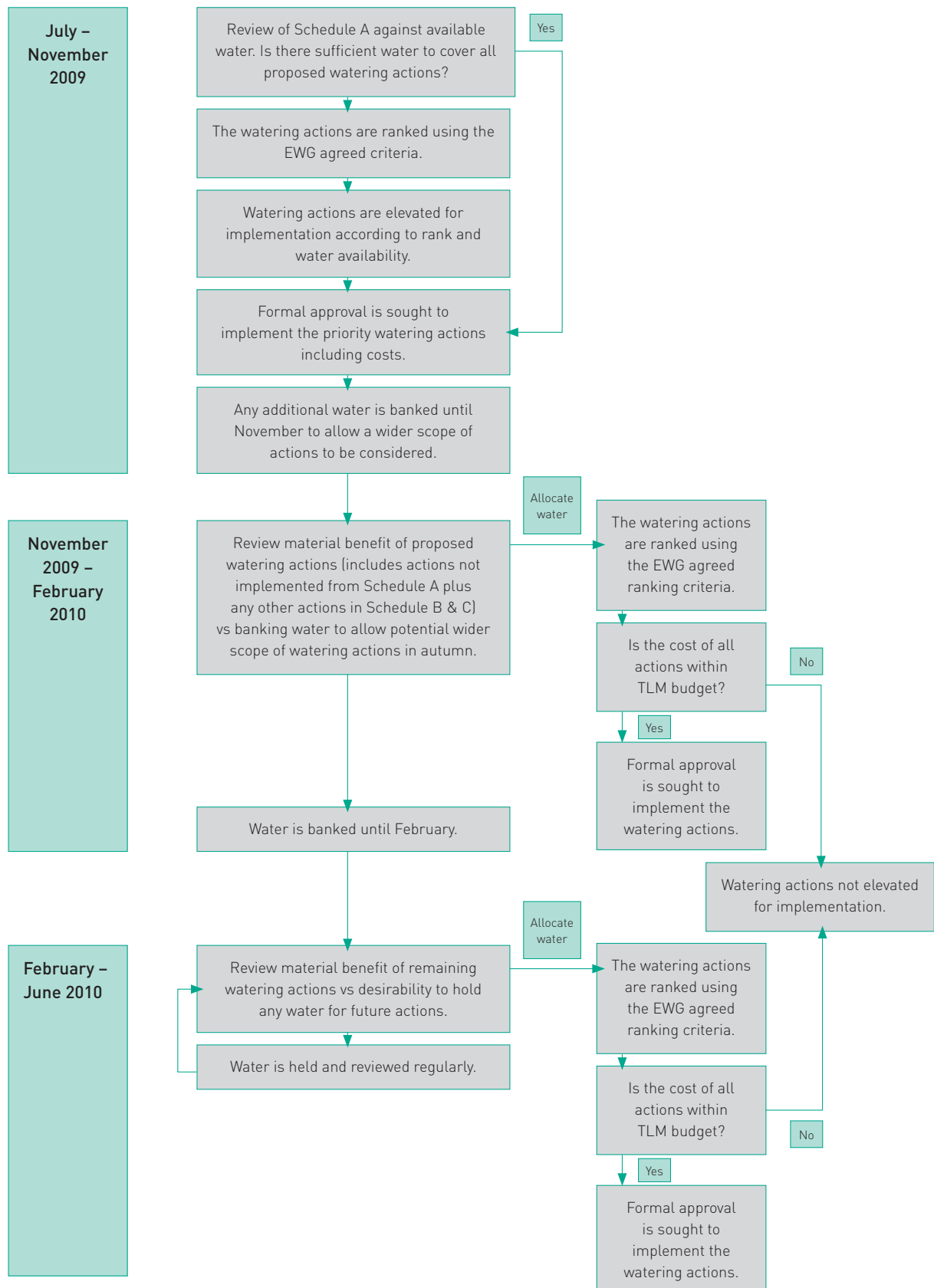


Figure 3. Flow chart of prioritisation process for regulated flows

## 4.2 River Murray Unregulated Flows

In 2008–09 EWG agreed to trial the prioritisation of environmental watering actions during a River Murray Unregulated Flows (RMUF) event. Although a simulation exercise was held in April – May 2009, there was no opportunity to test this prioritisation process during a real-time RMUF event. Therefore this trial will continue during 2009–10.

As each RMUF event varies in location, duration and operational opportunities, it is not possible to prioritise watering proposals prior to a RMUF event. To be event ready EWG has pre-prepared both small and large unregulated watering actions for 2009–10 (refer Schedule D & E, respectively). These actions will need to be reviewed/updated as an unregulated event occurs and supplementary information is included so that filters such as location, magnitude and feasibility can be evaluated before the prioritisation of the environmental watering actions in real time.

The prioritisation of environmental watering actions during RMUF events in the River Murray system will in principle:

- be based upon a RMUF event declared by River Murray Operations
- be consistent with a one-river approach in that the areas of highest environmental need and benefit are given priority
- recognise existing obligations, initiatives and rights
- maximize/optimize environmental outcomes including integration with planned environmental water releases
- be based upon opportunity and relative environmental priority following ranking criteria agreed by the EWG; and
- be agreed on a case-by-case basis in real-time.

Recognising the critical condition of the Lower Lakes, EWG recommended the following high-level principles to be applied in the first instance:

- For each RMUF event the material benefit for the Lower Lakes be assessed before any other environmental asset is considered for prioritisation; and
- Deliberately surcharging weir pools for environmental benefit would be a low priority unless it can be guaranteed that any return flows will remain solely for environmental purposes.

To assist in a real-time event, the extreme dry climate objectives and ranking criteria adopted for the prioritisation of TLM regulated watering actions are also applied to the unregulated watering actions. Figure 4 outlines the process for prioritising watering actions during a RMUF event. This process was refined during the RMUF simulation exercise in April – May 2009.

The decision to implement a RMUF environmental watering action is the responsibility of the relevant jurisdiction in both physically implementing the agreed priority and in allowing the declared RMUF to be used according to the EWG agreed principles.

The environmental water volumes delivered during a RMUF event will be collated by the EWG and reported as part of TLM environmental water reporting. This will enable a more comprehensive understanding of environmental water delivered in the River Murray system.

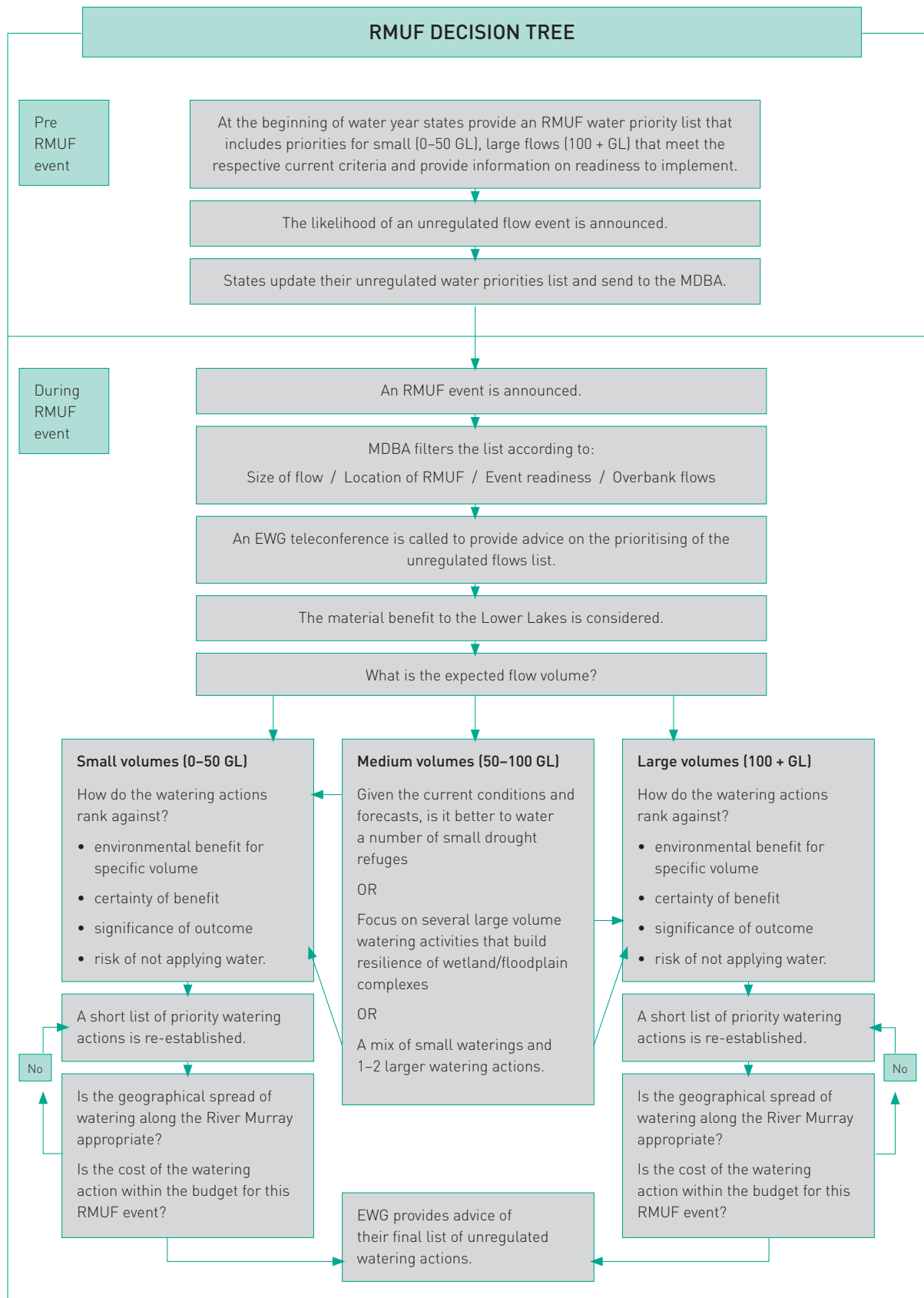


Figure 4. Prioritisation process for unregulated flows

## 5. ECOLOGICAL MONITORING FOR TLM

Monitoring and evaluating the achievement of the environmental objectives is part of the TLM Business Plan. A monitoring framework titled the Outcomes Evaluation Framework (OEF) has guided the development of monitoring arrangements and outlines the types of monitoring undertaken in The Living Murray. These are Murray River system, condition, intervention and compliance monitoring and knowledge generation. A key principle of TLM monitoring is to use information from monitoring in an adaptive-management sense to optimise the approaches to achieving positive ecological outcomes for the Murray River system.

The Living Murray Environmental Monitoring program coordinates with other MDBA programs including the Sustainable Rivers Audit, Native Fish Strategy and Natural Resources Information, to provide a coordinated approach to monitoring across the Murray-Darling Basin.

### 5.1 Murray River system-scale monitoring

Monitoring at the Murray River system scale to determine if the health of the Murray River system improves following implementation of the First Step decision. The questions addressed by monitoring at this scale differ from those of the Sustainable Rivers Audit (SRA), which provides a condition assessment for the Murray-Darling Basin (i.e. the scale is different and hence the design is not tailored to address questions at the Murray River system scale). However, some data collected through SRA will be applicable to the Murray River system and where possible, monitoring at this scale will utilise data collected for the SRA. Currently the approach for fish, birds and vegetation are

- A co-ordinated fish monitoring approach is being implemented to monitor fish response to TLM along the Murray River linked to fishway construction and the Native Fish Strategy.
- The Annual Aerial Waterbird Survey has been implemented in October – November, linked to the Eastern Australia Aerial waterbird Survey, so that geographical context is incorporated.
- A Red Gum and Black Box Stand Condition assessment is being implemented using remote sensing approaches (Landsat) to allow reporting annually on stand condition.

### 5.2 Icon site condition monitoring

Icon site condition monitoring will determine change in the environmental condition of individual icon sites resulting from water application and implementation of works programs under The Living Murray. Icon site condition monitoring is specifically tailored to determine if the objectives for each icon site are being met. Monitoring and evaluation at the icon site-scale is surveillance in type and typically undertaken on a medium frequency (months to years).

Condition monitoring activities planned for 2009–10 include ongoing monitoring as per the icon site condition monitoring plans that have been developed for each icon site. These plans detail the approaches and methods for monitoring the fish, bird and vegetation communities as they relate to the ecological objectives for the site. A core set of consistent approaches to monitoring the condition of fish, birds and vegetation has been developed and agreed across the icon sites. These approaches will be implemented during 2009–10 and include linkages to the system assessments identified in the system monitoring section. For example, the river red gum and black box on ground condition assessment will provide key support to the Red Gum and Black Box Stand Condition remote sensing assessments.

### 5.3 Intervention monitoring

Intervention monitoring assesses the ecological response to types of interventions or environmental management actions implemented under The Living Murray. In doing so, it will provide the major link to understanding how the ecological responses to specific environmental management actions result in changes at icon sites. It will also provide the foundation information for adopting an adaptive-management approach to implementing The Living Murray. Intervention monitoring will not occur for each watering action, but will be targeted at watering actions that provide the opportunity to test key hypotheses that evaluate and quantify cause-and-effect relationships. The information can subsequently be extrapolated to other icon sites.

Event monitoring has become important in managing implementation of environmental watering activities during the drought to inform real-time decision making in relation to achieving ecological outcomes and minimising risks. This monitoring is focused on the specific objectives of the environmental watering event or to avoid risks, and is targeted in both temporal and spatial scales.

The process for event monitoring will need to be responsive to the environmental watering plan, including recognition that speedy resourcing and implementation will be required. The trigger for event monitoring will be impacted by the water available for environmental watering, and it is possible that events may not be monitored or monitoring will need to be prioritised. Reporting processes for event monitoring will recognise the level of monitoring undertaken.

During 2009–10, monitoring interventions will be focused around three broad areas.

- Monitoring the impacts of fishways and resnagging on fish populations throughout the Murray River.
- Obtaining and compiling key information needs on the response of vegetation, birds, habitat and fish recruitment to watering and works interventions.
- Monitoring the direct impacts of watering events at icon sites in relation to the event watering objectives.

### 5.4 Compliance monitoring

Compliance monitoring assists TLM to meet its obligations concerning monitoring against certain environmental management actions and to determine if actions, works or measures are implemented in the manner intended. Measuring the volume of water used at icon sites and the timing, volume and quality of any return flows is needed to account and report for the use and management of environmental water.

There are a number of existing long-term projects funded by the MDBA that provide data and information within and around the icon sites. The compliance monitoring program for TLM draws upon this information where appropriate, however in 2009–10 further work will be undertaken on water accounting needs for each icon site.

## 6. ACCOUNTING FOR TLM ENVIRONMENTAL WATERING

Environmental water accounting provides information on the volume of water released, delivered and used at each icon site, volume of water returned to the Murray River and the environmental water account figures.

The Living Murray Business Plan (2007) states the accounting and reporting of environmental water should be incorporated into environmental management planning, reporting to the Murray-Darling Basin Ministerial Council and development of national standards for water accounting. In addition to the requirements outlined in The Living Murray Business Plan, The Living Murray Outcomes and Evaluation Framework (2007) requires environmental water used at icon sites to be measured, accounted and reported. The Living Murray Environmental Watering Plan outlines policy and procedural frameworks for how environmental water will be measured and accounted for in accordance with the TLM Business Plan.

Measurement and accounting of environmental water will depend on the properties of the water, where the water is being used and the delivery mechanism or technique. Some of these techniques include, incorporating Murray River Operations accounts who gather data from regulating structures and gauges throughout the Murray River system, mathematical models to calculate water savings and water behaviour on wetlands, permanent and temporary gauging stations within icon sites and at pumping sites.

## 7. REPORTING ON TLM ENVIRONMENTAL WATERING

As mentioned previously, environmental water accounting provides information on the volume of water released, delivered and used at each icon site, volume of water returned to the Murray River and the environmental water account figures. The Living Murray Business Plan requires these aspects to be reported on annually, consistent with The Living Murray Environmental Watering Plan.

Environmental water is accounted and reported for at an icon site and River Murray system scale throughout and at the end of the watering season. This information will be incorporated into the development of the National Standards for Water Accounting (Intergovernmental Agreement on a National Water Initiative 2004), the Annual Environmental Watering Report and Murray-Darling Basin Authority Annual Report.

## SCHEDULE A: Critical regulated watering actions (critical drought refuges that require water to consolidate previous waterings)

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Risk level	
									Likelihood of benefit (High, Medium, Low)	Risk of NOT applying water (High, Medium, Low)
<b>Barmah–Millewa</b>										
Barmah/Millewa–Douglas Swamp	3	Water small terminal wetland system	Action will facilitate maintenance and recovery of wetland vegetation, and will contribute to the maintenance of bird breeding and foraging habitat.	0.5	September – November	Via Neestrons regulator (river >10,000 ML/day @ Yarrawonga)	Desilt inlet	Approx \$5000	Low risk	High risk, loss of drought refuge
Barmah/Millewa–Walthours Swamp	3	Water small terminal wetland system	Action will facilitate maintenance and recovery of wetland vegetation, and will contribute to the maintenance of bird breeding and foraging habitat.	0.25	September – November	Via Walthours regulator (river >10,000 ML/day @ Yarrawonga)	Desilt inlet	Approx \$5000	Low risk	High risk, loss of drought refuge
Barmah–Millewa–Reed Beds	3	Re-watering to maintain vegetation health and potential bird breeding event	Action will provide refuge habitat and potential breeding site for colonial bird.	0.5	September – November	Regulator direct from Murray River (>= 1000 ML/day)	Monitoring, regulator operation.		Low (Unlikely to fail to maintain habitat)	Moderate (Likely moderate impact).
Barmah–Gulf Creek	3	Use pumps to water river red gums around wetlands and creeklines	Maintain drought refuge for native fish and turtles – one of last refuges in the forest. This site was watered in 2008–09 (0.25 GL).	0.25	Spring – Summer	Via Gulf Ck Regulator (when river flows > 4,000 ML/day downstream Yarrawonga)	None	N/A	High	High

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Risk level	
									Likelihood of benefit (High, Medium, Low)	Risk of NOT applying water (High, Medium, Low)
<b>Gunbower–Koondrook – Perricoota Forest</b>										
Perricoota–Koondrook–Pollack’s Swamp	7	Water Pollack Swamp (118 ha) via private irrigation channel in order to maintain wetland vegetation.	Action will facilitate maintenance and recovery of wetland vegetation, and will contribute to the maintenance of bird breeding and foraging habitat.	0.5	September – November	Via private irrigation channel.	Monitoring, regulator operation.	\$20,000	Low (Unlikely risk of minor impact if bird breeding is triggered and unsustainable)	Significant (Likely moderate impact – no wetting phase this year).
Gunbower wetlands	4	Open regulators on Gunbower creek to top up small area of wetlands (~ 300 ha)	Maintain drought refuge in Little Gunbower Complex and Reedy Lagoon	3	September – October	Temporary pumps	None	\$58,500 (3000 ML @ \$19.5/ML)	High	High
<b>Chowilla Floodplain, Lindsey and Wallpolla Islands</b>										
Coppermine	15	Use temporary pumps to inundate wetland complex, including lignum habitat and the large Coppermine waterhole	<b>1. Avoid catastrophic loss</b> – prevent decline in health/loss of long-lived vegetation. <b>2. Maintain drought refuge</b> – provide drought refuge for large numbers of waterbirds. <b>3. Prevent critical loss of threatened species</b> – provide breeding opportunities for Environmental Protection and Biodiversity Conservation (EPBC) Act listed southern bell frog and NSW listed long-thumb frog to enable recovery when more water is available	2	August – October	Temporary pumps	N/A	\$110,000	High	High
Werta Wert	15	Use temporary pumps to inundate the wetland basin and fringing long-lived vegetation	<b>1. Avoid catastrophic loss</b> – prevent decline in health/loss of long-lived vegetation. Prevent loss of flood-dependent seedbank. <b>2. Maintain drought refuge</b> – provide drought refuge for large numbers of waterbirds. <b>3. Prevent critical loss of threatened species</b> – provide breeding opportunities for the EPBC Act listed southern bell frog to enable recovery when more water is available.	0.75	August – October	Temporary pumps	N/A	\$41,500	High	High

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Risk level	
									Likelihood of benefit (High, Medium, Low)	Risk of NOT applying water (High, Medium, Low)
Lake Littra	15	Use temporary pumps to inundate wetland basin and fringing long-lived vegetation	<b>1. Avoid catastrophic loss</b> – prevent loss of long-lived vegetation. <b>2. Maintain drought refuge</b> – provide drought refuge for large numbers of waterbirds. <b>3. Prevent critical loss of threatened species</b> – provide breeding opportunities for the EPBC Act listed southern bell frog to enable recovery when more water is available.	1	August – October	Temporary pumps	N/A	\$55,000	High	High
Twin Creeks	15	Use temporary pumps to water river red gums, replenish freshwater lens and support river red gum recruits	<b>1. Avoid catastrophic loss</b> – prevent loss of long-lived vegetation. Prevent loss of large number of river red gum recruits that germinated after previous watering.	0.14	August – October	Temporary pumps	N/A	\$7,700	High	High
Monoman Island Horseshoe	15	Use temporary pumps to inundate wetland basin, replenish freshwater lens and support river red gum recruits	<b>1. Avoid catastrophic loss</b> – prevent decline in health/loss of long-lived vegetation. Prevent loss of flood-dependent seedbank. Prevent loss of large number of river red gum recruits that germinated after previous watering.	0.15	August – October	Temporary pumps	N/A	\$8,250	High	High
Kulkurna	15	Use temporary pumps to inundate wetland basin and water long-lived vegetation	<b>1. Avoid catastrophic loss</b> – prevent decline in health/loss of long-lived vegetation. Prevent loss of flood-dependent seedbank. <b>2. Prevent critical loss of threatened species</b> – provide breeding opportunities for the EPBC Act listed southern bell frog to enable recovery when more water is available. <b>3. TLM objectives</b> – maintain high value wetlands, maintain current area of river red gum, and maintain ≥ 20% original area black box	0.14	August – October	Temporary pumps	N/A	\$7,700	High	High

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing (window (range))	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Risk level	
									Likelihood of benefit (High, Medium, Low)	Risk of NOT applying water (High, Medium, Low)
Pilby Lagoon	15	Open regulators to inundate wetland and maintain semi-permanent ecological character	<b>1. Avoid catastrophic loss</b> – prevent loss of semi-permanent ecological character. <b>2. Maintain drought refuge</b> – provide drought refuge and breeding opportunities for large numbers of waterbirds (incl. up to 9 state-listed species).	0.16	August – October	Gravity	N/A	N/A	High	High
Punikh Creek	15	Use temporary pumps to raise water levels in the anabranch and water fringing long-lived vegetation	<b>1. Avoid catastrophic loss</b> – prevent decline in health/loss of long-lived vegetation, including mature river red gum and black box.	0.05	August – October	Aqua dam or rock bank	N/A	\$30,000	High	High
Wallpolla Island	14	Use temporary pumps to water river red gums along anabranches and around wetlands	Water stressed river red gums and provide some drought refuge	3	Spring or autumn (July – November or May – June)	Temporary pumps	Maintenance of 2 levees to pond water	\$219,000 (3000 ML @ \$65/ML + 2 earthen levees @ \$12,000 each)	High	High
Lindsay Island	12	Use pumps to water river red gums around wetlands and creeklines	Water stressed river red gums and provide some drought refuge	3	Spring or autumn (July – November or May – June)	Temporary pumps	Maintenance of 2 levees to pond water	\$253,000 (3000 ML @ \$71/ML + 2 earthen levees @ \$20,000 each)	High	High

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complementary works required	Costs (water delivery and complementary works)	Risk level	
									Likelihood of benefit (High, Medium, Low)	Risk of NOT applying water (High, Medium, Low)
<b>Lower Lakes, Coorong and Murray Mouth</b>										
Channels on Mundoo Island	15	Use temporary pumps to top-up water levels for threatened fish populations	<p><b>1. Prevent critical loss of threatened species –</b> Prevent the loss of one of only two populations of the genetically-distinct Lake Alexandrina subpopulation of southern pygmy perch (SA listed), and loss of the largest remaining population of the genetically-distinct Lower Lakes subpopulation of Murray hardyhead (EPBC listed).</p> <p><b>2. Avoid catastrophic event –</b> prevent acidification upon drawdown. <b>3. Maintain drought refuge –</b> maintain one of only a few remaining aquatic refuges within the Lower Lakes icon site for numerous aquatic species endemic to the area, including threatened species.</p>	0.02	ASAP	Trucking/pumping	N/A	\$15,000	High	High
Turveys Drain	15	Use temporary pumps to maintain water levels for threatened fish populations	<p><b>1. Prevent critical loss of threatened species –</b> Prevent the loss of one of only two populations of the genetically-distinct Lake Alexandrina subpopulation of southern pygmy perch (SA listed), and loss of a population of the genetically-distinct Lower Lakes subpopulation of Murray hardyhead (EPBC listed). <b>2. Maintain drought refuge –</b> maintain one of only a few remaining aquatic refuges within the Lower Lakes icon site for numerous aquatic species endemic to the area, including threatened species. Provide recruitment opportunities to enable recovery when more water is available.</p>	0.008	ASAP	Temporary pumps	Some excavation of existing water delivery channel	\$5,600	High	High

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Risk level	
									Likelihood of benefit (High, Medium, Low)	Risk of NOT applying water (High, Medium, Low)
Narrung	15	Use temporary pumps to inundate wetland area	<b>1. Maintain drought refuge</b> – maintain one of only a few remaining aquatic refuges within the Lower Lakes icon site, providing refuge to numerous aquatic species endemic to the area. Provide recruitment opportunities to enable recovery when more water is available. Provide habitat for numerous EPBC-listed migratory waders. Prevent loss of aquatic vegetation, including state-listed <i>Muehlenbeckia horrida</i> .	0.45	late July & early Sept	Temporary pumps	Minor earthworks to prevent leakage	\$17,050	High	High

## SCHEDULE B: Key regulated watering actions (drought refuges)

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering, Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing	Water delivery mechanism	Complementary works required	Costs (water delivery and complementary works)	Risk level	
									Likelihood of benefit (High, Medium, Low)	Risk of NOT applying water (High, Medium, Low)
<b>Barmah–Millewa</b>										
Barmah–Millewa–Moira/ Sheldrake Lakes	5	Prevent encroachment of giant rush. Maintaining character of wetland	Action will facilitate maintenance and recovery of wetland vegetation, and will contribute to the maintenance of bird breeding and foraging habitat.	8	September – November	Regulators on Swifts, Bunnydigger Cks (>= 1000ML/day)	Monitoring, regulator operation.	\$35,000.00	Low (Unlikely to fail to maintain habitat)	Significant (Likely moderate impact – vegetation change likely)
Barmah–Millewa–Duck Lagoon	5	Water Duck Lagoon via Gulpa Creek in order to assist recovery of wetland vegetation.	Action will enable recovery of wetland vegetation following wildfire.	2	September – November	Via Gulpa Creek (assumes > 350 ML/day in Gulpa Creek)	Monitoring, regulator operation.	\$10,000.00	Low (Unlikely to fail to support vegetation response)	Significant (Likely moderate impact – vegetation recovery prevented)
Barmah–Millewa–Reed Beds	3	Re-watering to maintain vegetation health and potential bird breeding event	Action will provide refuge habitat and potential breeding site for colonial birds.	2	September – November	Regulator direct from Murray River (>= 1000ML/ day)	Monitoring, regulator operation.		Low (Unlikely to fail to maintain habitat)	Moderate (Likely moderate impact).
Barmah–Millewa–Toupana Creek	3	Consecutive dry years has severely impacted on in stream habitat and limited connection with main river channel.	Action will provide refuge habitat for threatened fish species.	2	September – November	Regulator direct from Murray River (>= 1000ML/ day)	Fish species monitoring, regulator operation.	\$10,000.00	Low (Unlikely to fail to maintain habitat)	Moderate (Likely moderate impact).

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complementary works required	Costs (water delivery and complementary works)	Risk level	
									Likelihood of benefit (High, Medium, Low)	Risk of NOT applying water (High, Medium, Low)
Barmah-Top Island	3	Open Island & Sapling Creek regulators to allow inflows at river flows of >8000 ML/day (100 ML/day)	Provide ~500 ha drought refuge for waterbirds and water stressed vegetation (trees and wetlands)	2.5	Spring	Via Island & Sapling creek regulators (when river flows > 8,000 ML/day downstream Yarrowongal)	Removal of silt upstream of regulators (towards Murray confluence)	7,000	High	Medium
Barmah-Boals Deadwoods	3	Open Boals Ck regulator at flows of 6000 ML/day, water will pond in wetland	Provide ~100 ha drought refuge for waterbirds	1	Spring	Via Boals Ck Regulator (when river flows > 7,500 ML/day downstream Yarrowongal)	None	N/A	High	Medium
Barmah-Goose Swamp	3	High flows in Broken Creek or pumping to deliver water	Provide ~100 ha drought refuge for waterbirds and water stressed vegetation (trees and wetlands)	0.5	Spring – Summer	Broken Creek flows >300 – 600 ML/day, otherwise need to pump	None	N/A or ~\$30,000 (500 ML @ \$60/ML)	High	Medium
<b>Gunbower–Koondrook – Perricoota Forest</b>										
Perricoota-Koondrook-Pollack's Swamp	7	Water Pollack Swamp (118 ha) via private irrigation channel in order to maintain wetland vegetation.	Action will facilitate maintenance and recovery of wetland vegetation, and will contribute to the maintenance of bird breeding and foraging habitat.	1	September – November	Via private irrigation channel.	Monitoring, regulator operation.	\$5,000.00	Low (Unlikely risk of minor impact if bird breeding is triggered and unsustainable)	Significant (Likely moderate impact – no wetting phase this year).
Gunbower wetlands	4	Open regulators on Gunbower creek to top up small area of wetlands (~ 300 ha)	Maintain drought refuge in Little Gunbower Complex and Reedy Lagoon	5	September – October	Via Little Gunbower, Yarran and Reedy regulators	None	\$97,500 (5000 ML @ \$19.5/ML)	High	High

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complementary works required	Costs (water delivery and complementary works)	Risk level	
									Likelihood of benefit (High, Medium, Low)	Risk of NOT applying water (High, Medium, Low)
<b>Hattah Lakes</b>										
Hattah Lakes	14	Pump water into Chaika Creek to flood wetlands	Water stressed river red gum and provide ~500 ha drought refuge in wetlands	5	Spring or Autumn (July – November or May – June)	Temporary pumps	Installation of 2 aqua dams	\$355,000 (5000 ML @ \$65/ML + 2 aqua dams @ \$15,000 each)	High	High
<b>Chowilla Floodplain, Lindsay and Wallpolla Islands</b>										
Coombool Swamp (incl Brandy Bottle)	15	Use temporary pumps to inundate wetland complex and connecting floodplain	<b>1. Avoid catastrophic loss</b> – freshen groundwater to prevent decline in health/loss of long-lived vegetation. Prevent loss of flood-dependent seedbank. <b>2. Maintain drought refuge</b> – provide drought refuge for large numbers of waterbirds.	4.65	August – October	Temporary pumps	Some earthworks may be required	\$260,000.00	High	High
Lake Limbra (Hancock Creek)	15	Use temporary pumps to inundate wetland basin and associated anabranch	<b>1. Avoid catastrophic loss</b> – halt saline groundwater intrusion and prevent ecosystem decline. <b>2. Maintain drought refuge</b> – provide drought refuge for large numbers of waterbirds (incl. colonial nesting species).	4.5	August – October	Temporary pumps	Some earthworks may be required	\$247,500.00	High	High
Slaney Creek Anabranches	15	Use temporary pumps to inundate anabranches	<b>1. Avoid catastrophic loss</b> – prevent decline in health/loss of long-lived vegetation (incl. river red gum and black box). Prevent decline in health of floodplain vegetation	0.2	August – October	Temporary pumps	Some earthworks may be required	\$11,000.00	High	High
Kulkurna Blackbox Site 1	15	Use temporary pumps to inundate black box community	<b>1. Avoid catastrophic loss</b> – prevent decline in health/loss of long-lived vegetation	0.15	Spring – early summer	Temporary pumps	Some earthworks may be required	\$8,250.00	High	High

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complementary works required	Costs (water delivery and complementary works)	Risk level	
									Likelihood of benefit (High, Medium, Low)	Risk of NOT applying water (High, Medium, Low)
Lindsay Island	12	Use pumps to fill Lake Wallawalla from Lindsay River	Water stressed river red gums around the lake and provide ~840 ha drought refuge	12	Spring or autumn (July – November or May – June)	Temporary pumps	Construction of 2 levees to pond water	\$852,000 (12,000 ML @ \$71/ML)	High	High
<b>Lower Lakes, Coorong and Murray Mouth</b>										
Lake Alexandrina	15	Release water from Lake Victoria/ River Channel to provide material benefit to Lake	<b>1. Avoid catastrophic event</b> – delay water levels in Lake Alexandrina falling below -1.5m AHD, leading to acidification and ecosystem loss. <b>2. Prevent critical loss of threatened species</b> – prevent loss of in-situ populations of threatened fish. <b>3. Maintain drought refuge</b> – drain/channel refuges will remain connected to Lake Alexandrina and be maintained as drought refuge for small-bodied threatened fish and other obligate aquatic species	>25?	ASAP	Gravity	N/A	-	High	High
<b>Murray River Channel</b>										
River Murray Channel	1 – Hume to Yarrawonga	Using the elevated flows associated with the irrigation season, provide a short term boost to the hydrograph. The spike in flows will enable up to 200 ha. of wetlands, anabranches and billabongs which have not received water for at least the last 2 years to be watered. Ecosystems watered would include Croppers Lagoon, Dairy Lagoon, Coyles Creek and Maggies Lagoon.	Protect and enhance riparian ecosystems. Ecosystems watered would contain areas of open water, emergent macrophytes as well as limited areas of river red gums	1 – 1.5	Summer (1 week)	Gravity flow	Nil	Nil	Medium	Low

## SCHEDULE C: Key regulated watering actions (require larger volumes of water)

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Risk level	
									Likelihood of benefit (High, Medium, Low)	Risk of NOT applying water (High, Medium, Low)
<b>Barmah–Millewa</b>										
Barmah–Steamer/ War Plains	3	None – high flows in river	Provide ~1500 ha drought refuge for waterbirds and water stressed vegetation (trees and wetlands)	7.5*	Winter-early summer	River flows >10,500ML/day downstream Yarrawonga	None	N/A	High	Medium
Barmah–Smiths Creek	3	Open Sandspit regulator to provide connecting flows to access Smiths Creek.	Provide drought refuge, also water stressed red gums lining creek banks	0.5 – 1	Spring	Via Sandspit Ck Regulator (when river flows >8,700ML/day downstream Yarrawonga), ~14 days to deliver	None	N/A	High	Medium
Barmah–network of 15 small wetlands in northern forest	3	Open regulators as required	Provide drought refuge for waterbirds and water stressed vegetation in network of small wetlands, some have supported colonial waterbird breeding in past	2	Spring	Various regulators once flows 10,000–15,000 ML/day	None	N/A	High	Medium

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complementary works required	Costs (water delivery and complementary works)	Risk level	
									Likelihood of benefit (High, Medium, Low)	Risk of NOT applying water (High, Medium, Low)
<b>Gunbower–Koondrook – Perricoota Forest</b>										
Gunbower	4	Via regulators on Gunbower Creek (Yarran, Reedy & Little Gunbower) or via River Murray regulators (Shillinglaws and Barham Cut) if flows are high enough	Significant contribution to meeting wetland objectives; maintain drought refuge and water fringing river red gum; water Reedy Lagoon (permanent wetland now dry for over 2 years); maintain flows in Gunbower Ck and critical habitat for Murray cod and freshwater catfish	16 (assumes Gunbower Creek is charged, otherwise up to 40 GL needed to charge creek)	Spring or autumn (July – November or May – June)	Via regulators on Gunbower Creek or River Murray	None	Up to \$312,000 (16,000 ML @ \$19.5ML)	High	High
<b>Hattah Lakes</b>										
Hattah Lakes	14	Pump water into Chaika Creek to flood up to 15 wetlands	Water stressed river red gum and provide ~ 1100 ha drought refuge in wetlands	25	Spring or autumn (July – November or May – June)	Pumping	Installation of 2 aqua dams	Total \$1,297,500. delivery of 19500 ML @ (\$65/ML) aqua dams (2 @ \$15000)	High	High
<b>Chowilla Floodplain, Lindsay and Wallpolla Islands</b>										
Mulcra Island	14	Water stressed river red gums and flood ~500 ha (assumes TLM structures in place)	40 (note that 35 GL returns)	40 (note that 35 GL returns)	Spring or autumn (July – November or May – June)	Lock 8 surcharge	None	N/A	High	High

## SCHEDULE D: Unregulated Watering Actions (small)

Site	Reach – Section of River Murray	Objectives of watering. Relate to TLM objectives or current drought criteria	Minimum effective volume (GL)	Maximum effective volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Preferred duration of RMUF availability (range)	Complementary works required	Costs (water delivery and complementary works)	Readiness to implement		Ranking criteria				Is this action on the regulated flow list (Y/N)?
										Set up time	Volume that can be delivered in 4–5 days	Environmental benefit for volume (high, medium or low)	Significance of outcome (high, medium or low)	Certainty of benefit (high, medium or low)	Risk of not applying water (high, medium or low)	
<b>Barmah–Millewa Forest</b>																
Barmah–Millewa Duck Lagoon (NSW)	5	Water Duck Lagoon via Gulpa Creek in order to assist recovery of wetland vegetation.	2	5	September – November	Via Gulpa Creek (assumes > 350 ML/day in Gulpa Creek)		Monitoring, regulator operation.	\$10,000						Significant (Likely moderate impact – vegetation recovery prevented)	Y
Gulpa Creek–Reed Beds	5	Action will facilitate maintenance and recovery of wetland vegetation, and will contribute to the maintenance of bird breeding and foraging habitat.	1	1	September – November	Via Gulpa Creek (assumes > 350 ML/day in Gulpa Creek)		Monitoring, regulator operation.	\$10,000						Moderate. Reduced bird breeding opportunities becoming critical for populations.	N
<b>Gunbower–Koondrook – Perricoota Forest</b>																
Pollack Swamp	7	Action will facilitate maintenance and recovery of wetland vegetation, and will contribute to the maintenance of bird breeding and foraging habitat.	0.8	1.5	September – November	Via private irrigation channel.	40 days	Monitoring, regulator operation, liaison with Brangan Irrigation Trust.	\$25,000						Significant (Likely moderate impact – no wetting phase this year).	Y

Site	Reach – Section of River Murray	Objectives of watering. Relate to TLM objectives or current drought criteria	Minimum effective volume (GL)	Maximum effective volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Preferred duration of RMUF availability (range)	Complimentary works required	Costs (water delivery and complimentary works)	Set up time	Volume that can be delivered in 4-5 days	Environmental benefit for volume (high, medium or low)	Significance of outcome (high, medium or low)	Certainty of benefit (high, medium or low)	Risk of not applying water (high, medium or low)	Is this action on the regulated flow list (Y/N)?
Lower Lakes, Coorong and Murray Mouth	15 (Below Lock 1)	TLM Objectives: enhanced migratory wader bird habitat in the Lower Lakes – by maintaining water levels in the Lower Lakes over winter/spring, mudflats will remain saturated and benthic invertebrate populations will be maintained and enhanced, leading to increased food resources for migratory wading birds in the Lower Lakes; more frequent estuarine fish recruitment – releasing greater volumes of fresh water over current dilution flows into the Lower Lakes will provide localised salinity gradients, leading to recruitment in estuarine fish populations.	30	50	ASAP	Releases from Lake Victoria/River Channel	June – October	No complimentary works required	No costs associated with watering	No set-up time required	Depends on volumes able to be passed over Lock 1 – assume 20-25 GL in 5 days?	Medium	High	Medium	High	Y



Site	Reach – Section of River Murray	Objectives of watering. Relate to TLM objectives or current drought criteria	Minimum effective volume (GL)	Maximum effective volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Preferred duration of RMUF availability (range)	Complementary works required	Costs (water delivery and complementary works)	Readiness to implement		Ranking criteria				Is this action on the regulated flow list (Y/N)?
										Set up time	Volume that can be delivered in 4–5 days	Environmental benefit for volume (high, medium or low)	Significance of outcome (high, medium or low)	Certainty of benefit (high, medium or low)	Risk of not applying water (high, medium or low)	
<b>River Murray Channel</b>																
Werai Forest–Niemur River	6 – Edward Wakoot	Based on previous trail, provide environmental water to 500 Ha's of floodplain ecosystems (ecosystems watered would contain areas of emergent macrophytes as well as areas of river red gum).	2	7	Spring – (September – November)	Open Regulators	2 weeks	Nil	Nil	Immediate	100%	High	High	High	Low	N
<b>Non Icon Site</b>																
Werai State Forest–Edward River	6	To facilitate recovery of a significant area of wetland vegetation, particularly Phragmite beds.	0.5	7	September – November	Via Tummmudgery Creek if Edward exceeds 2100ML/day. The maximum volume includes raising Edward River – may include extra costs	14 days	Monitoring, regulator operation, liaison with State Water.	\$10,000.00						Significant (Likely minor impact – continued decline).	N

## SCHEDULE E: Unregulated Watering Actions (Large)

Site	Reach – Section of River Murray	Objectives of watering. Relate to TLM objectives or current drought criteria	Minimum effective volume (GL)	Maximum effective volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Preferred duration of RMUF availability (range)	Complimentary works required	Costs (water delivery and complimentary works)	Readiness to implement – set up time	Time period since last watering	Env. benefit for volume (high, medium or low)	Significance of outcome (high, medium or low)	Certainty of benefit (high, medium or low)	Risk of not applying water (high, medium or low)	Is this action on the regulated flow list (Y/N)?
Lower Lakes, Coorong and Murray Mouth																
Lake Alexandrina	15 (below Lock 1)	<p><b>TLM Objectives:</b></p> <ul style="list-style-type: none"> <li>enhanced migratory wader bird habitat in the Lower Lakes – by maintaining and raising water levels in the Lower Lakes, mudflats will remain saturated and benthic invertebrate populations will be maintained and enhanced, leading to increased food resources for migratory wading birds in the Lower Lakes; more frequent estuarine fish recruitment – releasing fresh water into the Lower Lakes greater than current dilution flows will provide localised salinity gradients, leading to recruitment in estuarine fish populations. <b>Drought Criteria:</b> ‘maintain drought refuge’ – drain/channel refuges still connected to Lake Alexandrina will be maintained as drought refuge for small-bodied threatened fish and other obligate aquatic species, and the important ‘littoral zone’ on the edge of the water can be enhanced by maintaining and/or raising lake levels;</li> </ul>	100GL	unlimited (i.e. barrage out-flows required)	ASAP	Releases from Lake Victoria/ River Channel	Any time of year	No complimentary works required	No costs associated with watering	Can begin ASAP	Pool level from which barrage releases could be made last achieved in January 2007	High	High	High	High	Y

Site	Reach – Section of River Murray	Objectives of watering. Relate to TLM objectives or current drought criteria	Minimum effective volume (GL)	Maximum effective volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Preferred duration of RMUF availability (range)	Complementary works required	Costs (water delivery and complementary works)	Readiness to implement – set up time	Time period since last watering	Env. benefit for volume (high, medium or low)	Significance of outcome (high, medium or low)	Certainty of benefit (high, medium or low)	Risk of not applying water (high, medium or low)	Is this action on the regulated flow list (Y/N)?
<b>Lower Lakes, Coorong and Murray Mouth (continued)</b>																
		<ul style="list-style-type: none"> <li>avoid catastrophic loss' – water levels need to be maintained in Lake Alexandrina above – 1.5m AHD to avoid the onset of acidification, and to prevent the irretrievable loss of ecosystem function;</li> <li>'prevent critical loss of threatened species' – last remaining habitat for Murray hardyhead and southern pygmy perch can be preserved through maintaining or enhancing lake levels.</li> </ul>														
<b>Non Icon Sites</b>																
Poon Boon lakes		Action will facilitate maintenance and recovery of wetland vegetation, and will contribute to the maintenance of bird breeding and foraging habitat.	5 GL	12 GL	Any time	Gravity operated regulators	60 days	Monitoring, regulator operation.								N
Wakool System		Action will provide a replenishment/flushing flow to the system. Aim to provide benefits to instream habitat, riparian vegetation and low commence to fill connected wetlands	10 GL+	60 GL	Any time	Gravity operated regulators	60 days	Monitoring, regulator operation.								N



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