2014-15 SUPPORTING INFORMATION

ANNUAL ENVIRONMENTAL WATERING PLAN FOR THE SOUTH AUSTRALIAN RIVER MURRAY

July 2014

Government of South Australia
Department of Environment, Water and Natural Resources

2014-15 Supporting Information: Annual Environmental Watering Plan for the South Australian River Murray

July 2014

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Preferred way to cite this publication

Supporting Information: 2014-15 Annual Environmental Watering Plan for the South Australian River Murray, Government of South Australia, through Department of Environment, Water and Natural Resources, Adelaide

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Cover photo: Purple Swamp Hens, by Callie Nickolai

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INTRODUCTION

About this Document

This document accompanies the *2014-15 Annual Environmental Watering Plan for the South Australian River Murray* (the Annual Plan). Department of Environment, Water and Natural Resources (DEWNR) staff contributed a significant amount of technical information during development of the Annual Plan, and this is presented here.

Information presented in this document relates to the management of watering sites, drawing on data gathered through existing management and monitoring programs. This data is fundamental to determining how much water a site needs and when it is required, and assists State prioritisation of watering actions.

This data is fundamental to determining how much water a site needs and when it is required

The following information has been collated and is presented in this document on a site-by-site basis:

- description of proposed watering actions;
- for each water action – objectives, triggers, estimated volume required;
- ecological rationale for watering, including evidence of current site condition; and
- monitoring arrangements.

A summary of proposed watering actions for 2014-15 under different water resource availability scenarios is presented in the Annual Plan.

This document provides a means of consolidating and retaining background information for future reference.

Planning Scenarios

South Australia has developed proposed environmental watering actions for 2014-15 based on scenario planning using the multi-year history run provided by the Murray-Darling Basin Authority (MDBA) in February 2014 (see Figure 1 below).

This modelled outlook shows the probability of flows to South Australia occurring based on the full historical record, with some minor forced adjustments for releases from Menindee Lakes. As this is a probabilistic outlook, the actual flow to South Australia is likely to be different.

Planning was undertaken for four Annual Exceedence Probabilities (AEPs) (the percentage of historical records that achieved the respective flow rate): 90 percent (dry), 75 percent (median-dry), 50 percent (median), 25 percent (wet)[1]. For example, the 90 percent AEP indicates that 90 percent of the historical record achieved this flow rate.

[1] South Australia has defined the scenarios for 2014-15 slightly differently to MDBA with the 90% AEP representing a 'dry' scenario and 75 percent representing a 'dry-median' scenario rather than 'extremely dry' and 'dry', respectively. This is to better reflect local conditions. From a South Australian perspective a 'very dry' scenario would apply under below-entitlement conditions or if we had only received entitlement flow for a number of consecutive years. These minor differences in definitions were accepted by MDBA TLM staff.

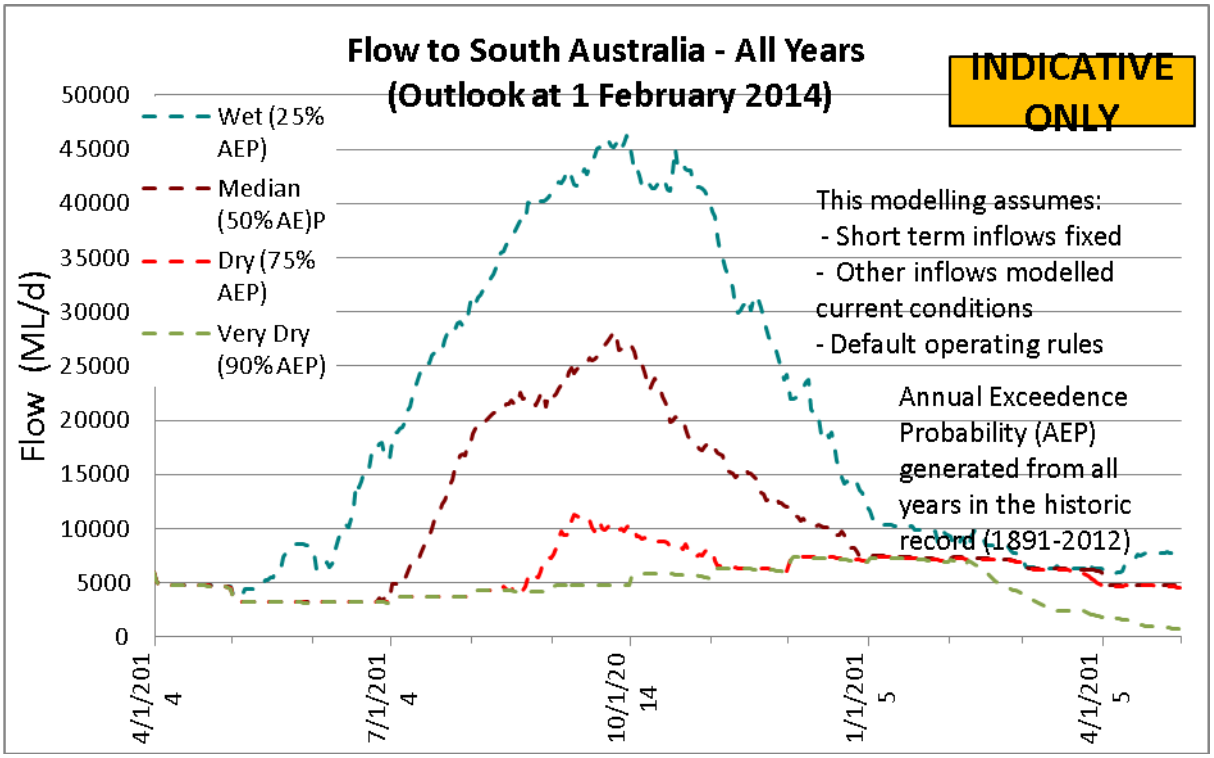

Figure 1: Flow outlook for South Australia: Annual Exceedence Probabilities from MDBA's 'all years' multi-history run, end January 2013

Planning for environmental watering actions in 2014-15 has focussed on the 90 percent, 75 percent and 50 percent scenarios. Minimal planning for a wet (25 percent) scenario was undertaken as it is relatively unlikely to occur. Planning for the extreme dry scenario was not undertaken as this is defined as less than entitlement flow and it has already been confirmed that South Australia will receive entitlement flow in 2014-15. Table 1 shows the approximate maximum flow rate associated with each of these scenarios.

Table 1: Scenario definitions used in 2014-15 planning

Scenario	AEP (%)	Approximate Flow Peak
Extreme Dry	n/a	< Entitlement flows
Dry	90	7,000 ML/day (entitlement flows)
Dry - Median	75	10,000 ML/day
Median	50	25,000 ML/day
Wet	25	45,000 ML/day

Actual flow conditions that occur in 2014-15 could be significantly different to those indicated by the AEP scenarios. Therefore, the delivery pattern of environmental water will be determined through real-time management as actual conditions become clearer.

Approach

Environmental asset managers identified the suite of sites that would require watering in 2014-15. The priority watering actions for these sites were then identified by the managers based on seasonal, operational and management considerations as described below.

Long-term ecological objectives and targets for the assets were considered. These are identified in a range of reports and management plans depending on the site. The need for water was informed by the conceptual understanding of the environmental water requirements (EWRs) needed to achieve the objectives and targets, compared to the recent hydrological regime experienced at the site. This comparison included the consideration of the magnitude, return frequency, timing and duration of actual flows and the metrics specified by the EWRs. The types of parameters assessed included the inundation of floodplain vegetation, how often temporary wetlands had been inundated based on their commence-to-flow level and pump history, and barrage outflows and delivery patterns in recent years.

Where available, the need for water was also informed by monitoring results. For example, data available through the SA MDB Natural Resources ongoing monitoring program has been used to identify temporary wetlands that would benefit from inundation in 2014-15 e.g. due to evidence of declining tree health.

Operational feasibility was considered to determine what actions could realistically be delivered under each water resource availability scenario, including:

- the extent to which flows to South Australia (QSA) could be manipulated through environmental water delivery. Due to system constraints such as Lake Victoria works and Menindee Lakes being under NSW control, it was assumed that QSA could be enhanced by a maximum of approximately 5,000 ML/day;
- the ability to re-regulate flows in the Lower Lakes; and
- cost of delivery associated with pumping and embankment works, and the amount of funding likely to be available.

The estimated volume of environmental water likely to be available for use in South Australia under each scenario was also taken into account. This was based on information provided by the water holders on the total volume likely to be available in the Southern Connected Basin, the proportion of the total volume that may be delivered to South Australia (based on data from past years) and the assumption that South Australia would receive return flows from upstream watering activities.

This work was undertaken by each of the environmental asset managers, with input from scientific experts and stakeholders. The background information and resulting 2014-15 priority environmental watering actions are presented within this document on a site-by-site basis.

Two pieces of work were subsequently undertaken:

1. The prioritisation of all watering actions and the identification of the 2014-15 annual environmental watering priorities for the South Australian River Murray. The prioritisation process and subsequent outputs are described in the Annual Plan, and were provided to the MDBA as per requirements in Chapter 8 of the Basin Plan.

2. The development of a South Australian River Murray multi-site watering action. The objectives, actions and potential environmental water delivery pattern for a South Australian multi-site watering action are described below.

2014-15 South Australian River Murray Multi-Site Watering Action

Large-scale environmental watering actions along the Lower Murray in 2014-15 were developed for the following locations:

1. Lower Lakes, Coorong and Murray Mouth;
2. Main channel and floodplain (border to Wellington), including raisings of Locks 1 and 2;
3. Chowilla Floodplain.

There are strong links between these watering actions that present the opportunity for a multiple-use watering action within South Australia. The multi-site watering action aligns the proposed site-specific watering actions and objectives but also focuses on delivering additional system-wide benefits.

The objectives of a multi-site action are to:

- Coordinate the delivery of environmental water to South Australia to maximise the potential outcomes throughout the South Australian Lower Murray system;
- Provide pathways for the dispersal, migration and movement of native water-dependent biota; [2]
- Provide pathways for the dispersal and movement of organic and inorganic sediment, and maximise the delivery of resources to downstream reaches and to the ocean;[2]
- Deliver environmental water to the LLCMM while providing benefits to upstream environmental assets en route;
- Facilitate the potential testing of the Chowilla regulator (which includes raising Lock 6 under some scenarios);[3] and
- Implement a raising of Lock 1 and/or Lock 2 to trial the approval process and communication protocols for weir manipulation while minimising the impacts on in-channel functions and, if flows are sufficient, to achieve the best possible ecological outcomes.

Planning for the multi-site action was undertaken for two scenarios; 90 percent AEP and 75 percent AEP. An iterative process was undertaken to align watering actions and delivery patterns for the key sites, and produce a combined environmental water delivery pattern to achieve the ecological objectives (Table 13. Proposed monthly environmental water delivery pattern for 2014-15 SA River Murray multi-site watering action (based on MDBA multi-history run dated 1 February 2014)The delivery pattern describes the volume of environmental water to be added to the AEP hydrographs each month, and this was then modelled to estimate hydrological outcomes at the South Australian border and the LLCMM (Lake Alexandrina water levels and average monthly barrage outflows). More detail is provided in Appendix A.

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[2] Modified from Basin Plan Schedule 9 - Criteria for identifying an ecosystem function

[3] A decision whether to test has not yet been made. A final decision to proceed with testing of the Chowilla regulator will be made following consideration of a number of factors, including risks associated with legal proceedings and the availability of the required environmental conditions. The South Australian Government is undertaking preparations to satisfy all pre-conditions for testing should a decision to proceed with testing be made.

90 percent AEP Scenario

The proposed multi-site watering actions under a 90 percent scenario are:

- Potential testing of the Chowilla regulator to trial low-level in-channel rise in spring;
- Raising Lock 1 and Lock 2 by maximum of 15 – 20 cm in September, coinciding with the delivery of a small volume of environmental water so that flow to South Australia (QSA) is above entitlement;
- Slowly bring Lock 1 and Lock 2 back to normal operating pool level through October as the volume of environmental water delivered to SA increases;
- Lower weirs back to normal operating level by November, coinciding with maximum environmental water delivery and QSA so that in-stream velocities are higher thereby facilitating the downstream transport of resources and propagules that have been drawn into the River through weir manipulation;
- Late spring in-channel flow pulse, with a median discharge of ~10,000 ML/day but with +/- 2,000 ML/day variability;
- Maximum QSA to occur in November to coincide with higher water temperatures needed for large-bodied fish breeding requirements and to match with LLCMM needs;
- Baseline barrage outflow to operate fishways required throughout the year (~160 ML-day);
- Key water delivery period for LLCMM from September to January to increase lake levels and provide for barrage releases. Maintain average barrage releases of 2000 ML/day, ideally with releases continuing through January;
- Peak environmental water delivery in November-December to surcharge Lake Albert and Lake Alexandrina. Water levels to be at maximum in November-December, then drop late in December and January to expose shoreline. Continue drawdown into later summer-autumn; and
- Decrease barrage releases in December so that releases can continue into January and February, then a gradual decline in March. Finishing barrage release pulse later will have a greater benefit for the Coorong South Lagoon salinity and the availability of suitable estuarine habitat.

The modelling outputs indicate that the proposed pattern of environmental water delivery under the 90 percent scenario is likely to achieve the actions described, including:

- Generation of a small spring-summer in-channel flow pulse with QSA $\geq$10,000 ML/day from October through December and peak flows in November (Figure 2);
- Lake Alexandrina water levels ranging from 0.50 to 0.80 mAHD, with maximum levels in mid-November to mid-December before starting to drop in late December, and continuing to decline until March (Figure 3). This pattern reflects the proposed pattern of lake levels for 2014-15 shown in Figure 8, and allows barrage releases to continue through summer and early autumn; and
- Barrage outflows peaking in December (Figure 4), with median monthly barrage outflows likely to be sufficient to run the fishways throughout the year (> 160 ML/day) except in April and May (noting minimal environmental water has been added to these months in the modelling and this will be revisited later in the water year).

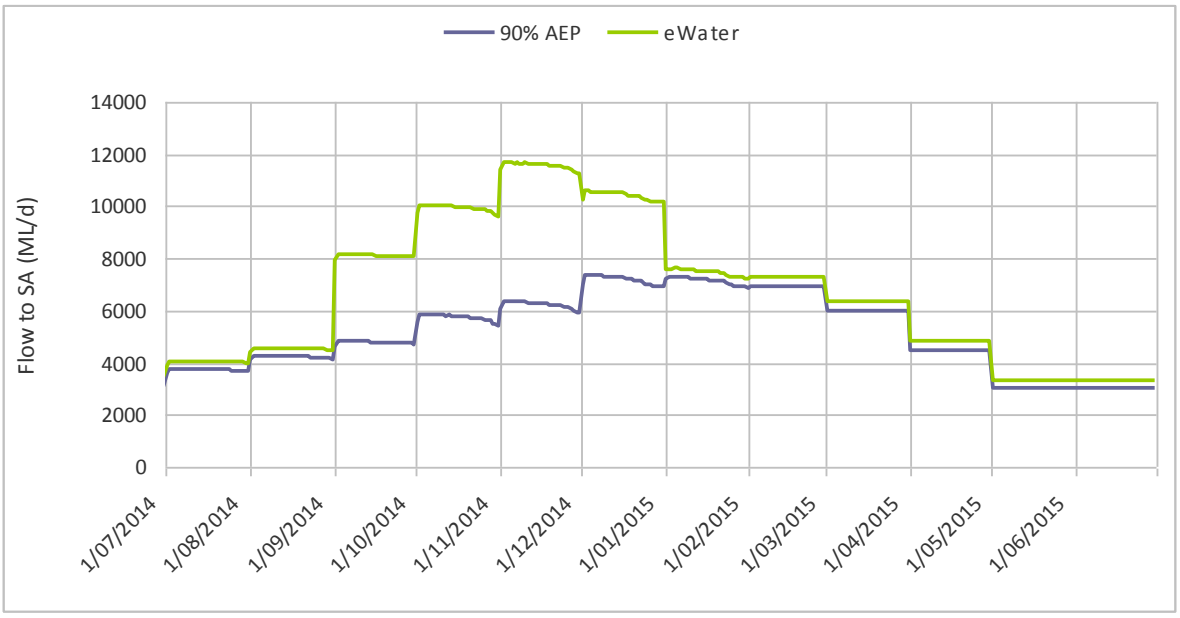

Figure 2. Flows to SA with and without environmental water under the 90 percent AEP scenario (based on the MDBA multi-history run dated 1 February 2014)

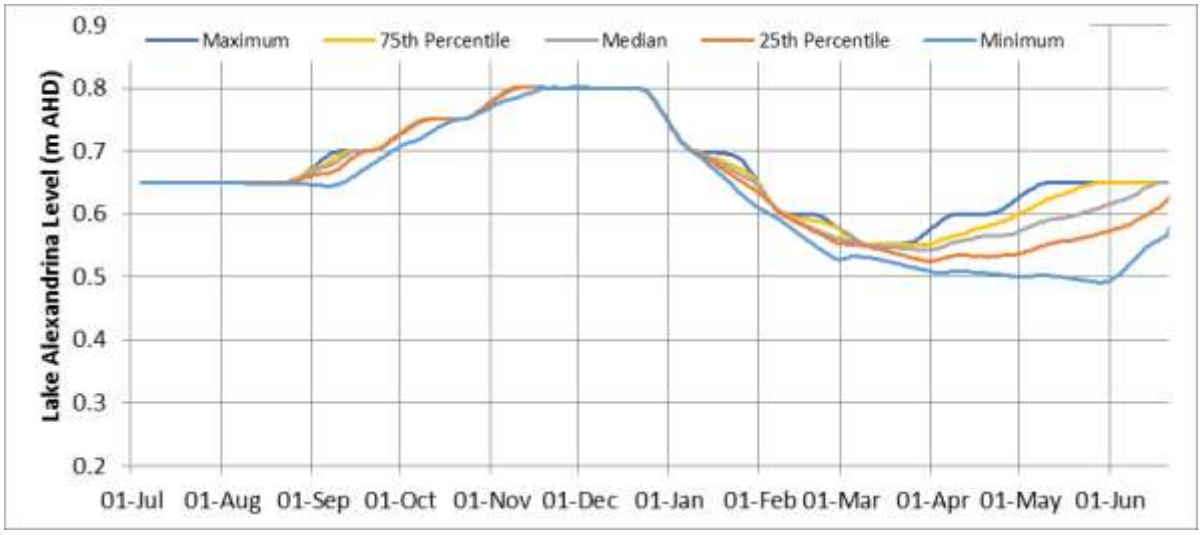

Figure 3. Modelled Lake Alexandrina water levels in 2014-15 under a 90 percent AEP scenario (based on MDBA multi-history run dated 1 February 2014) with environmental water added

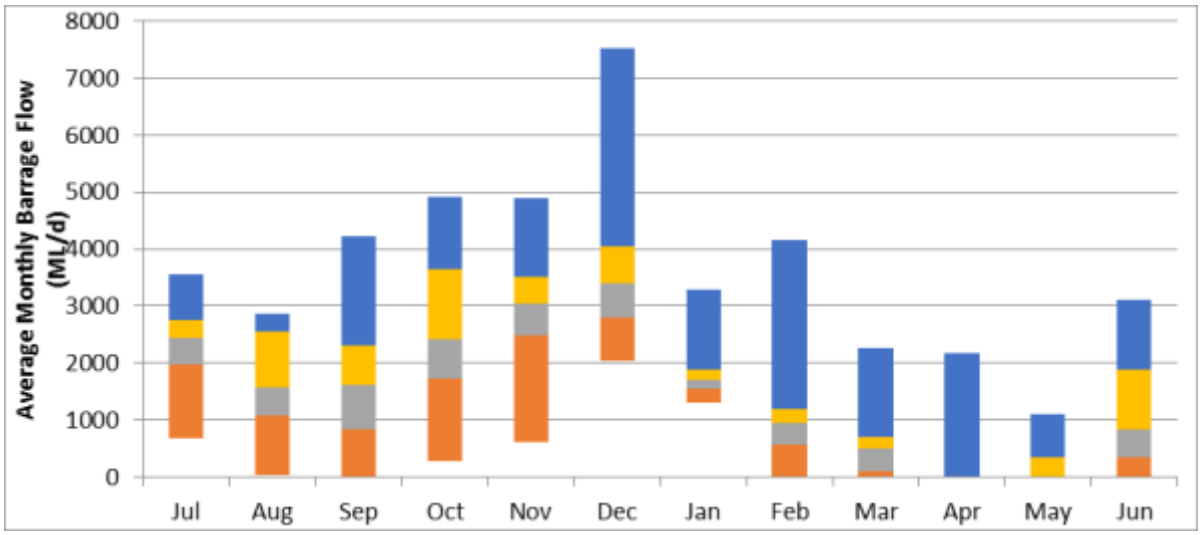

Figure 4. Modelled average monthly barrage outflows in 2014-15 under a 90 percent AEP scenario (based on MDBA multi-history run dated 1 February 2014) with environmental water added

75 percent AEP scenario

The proposed multi-site watering actions under a 75 percent scenario are similar to that for the 90 percent scenario however the timing of weir manipulation and environmental water delivery may need to be altered in response to any natural in-channel flow peaks. The types of outcomes under both scenarios are likely to be the same although the increased volumes and flow rates provided by unregulated flows may provide greater certainty or an increased response.

Under the 75 percent scenario, Lock 6 can also be raised to facilitate the potential testing of the Chowilla regulator and testing operations will continue for the duration of any flow peaks.

The modelling outputs indicate that the proposed pattern of environmental water delivery under a 75 percent scenario is likely to achieve the actions described and build on the outcomes under a 90 percent scenario, including:

- Turning a small natural flow peak into an extended spring in-channel flow pulse, with QSA $\geq$ 12,000 ML/day for approximately 90 days (Figure 5). Environmental water delivery also contributes to keeping QSA around 10,000 ML/day in early-mid summer. Hence the flow pulse is higher and longer under the 75 percent scenario than under the 90 percent scenario;
- Lake Alexandrina water levels ranging from 0.50 to 0.80 mAHD, with maximum levels in mid-November to mid-December before starting to drop in late December, and continuing to decline until March (Figure 6). This pattern reflects the proposed pattern of lake levels for 2014-15 shown in Figure 8, and allows barrage releases to continue through summer and early autumn; and
- Delivering a spring-summer pulse of elevated barrage outflows, with median barrage outflows between 3,500 and 6,000 ML/day from September to January (Figure 7). Median monthly barrage outflows are likely to be sufficient to run the fishways throughout the year (> 160 ML/day) except in April and May (noting minimal environmental water has been added to these months in the modelling and this will be revisited later in the water year).

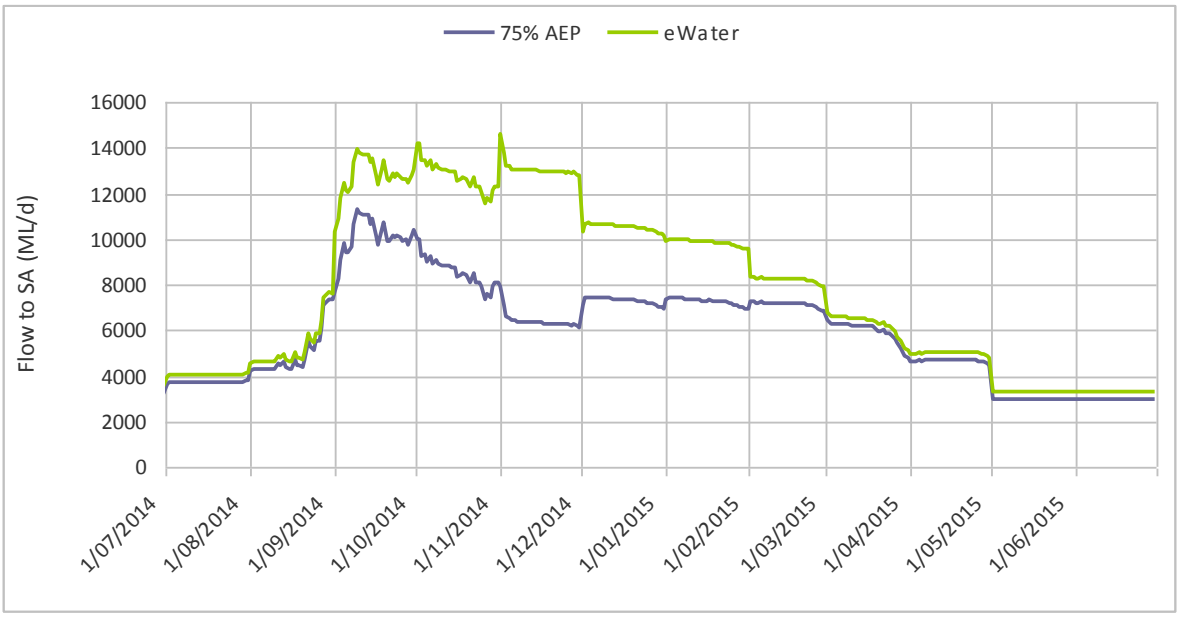

Figure 5. Flows to SA with and without environmental water under the 75 percent AEP scenario (based on the MDBA multi-history run dated 1 February 2014)

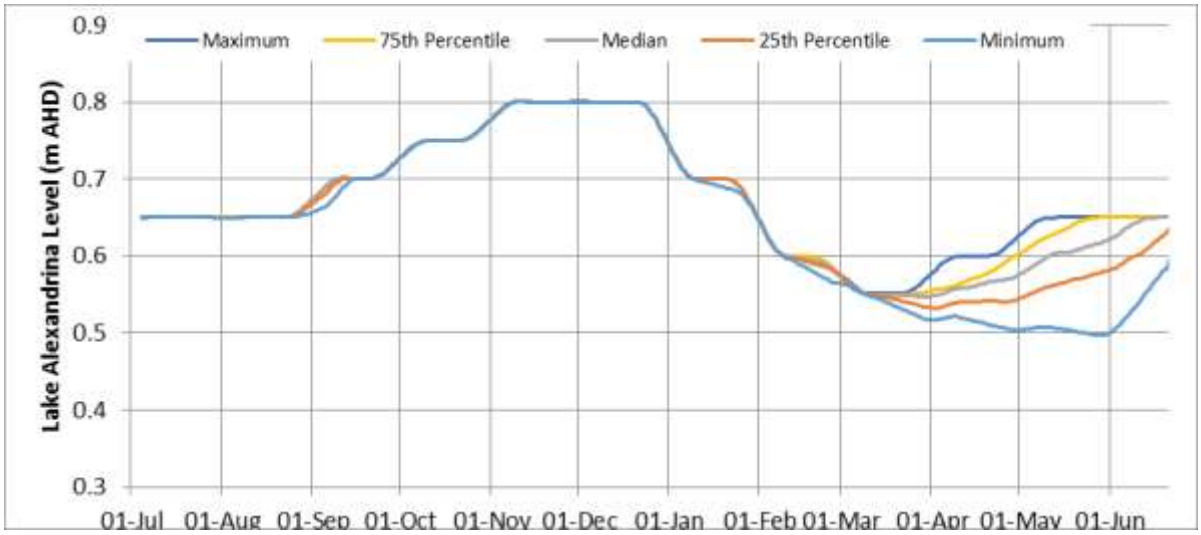

Figure 6. Modelled Lake Alexandrina water levels in 2014-15 under a 75 percent AEP scenario (based on MDBA multi-history run dated 1 February 2014) with environmental water added

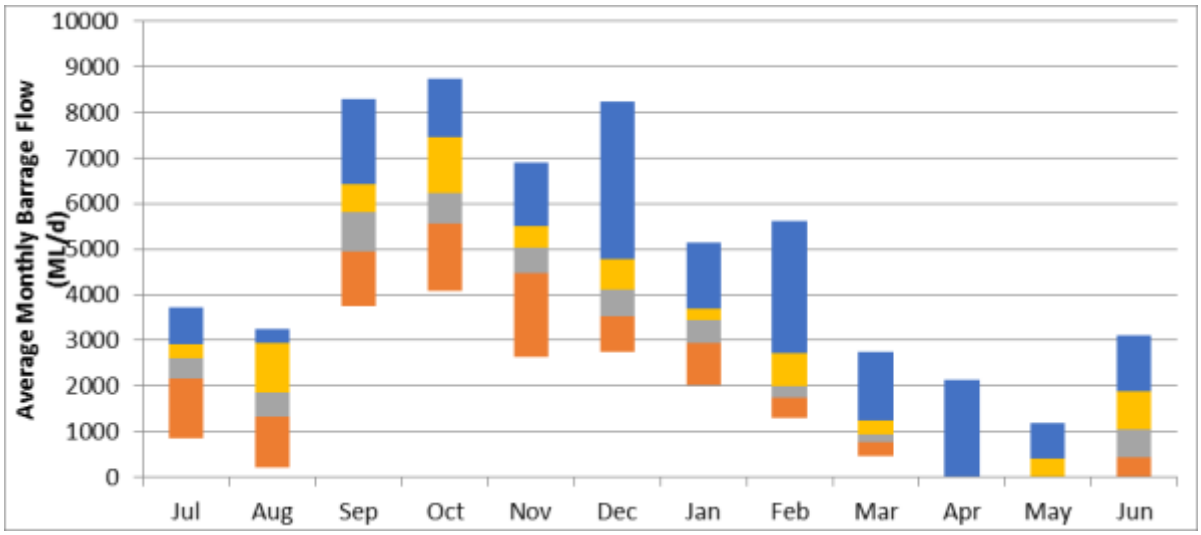

Figure 7. Modelled average monthly barrage outflows in 2014-15 under a 75 percent AEP scenario (based on MDBA multi-history run dated 1 February 2014) with environmental water added

PART A: LOWER LAKES, COORONG AND MURRAY MOUTH

1. Proposed Watering Actions and Objectives

Seven priority watering actions and objectives have been identified for the LLCMM in 2014-15 and are described below. Not all of the actions are deliverable under all of the water resource scenarios. The water resource scenarios to which each watering action applies and hydrological metrics for the actions (magnitude, duration, timing) and approximate volumes are provided in Table 2.

Action 1: Lake level manipulation

High level objective	LLCMM Objective 1 - Wet-dry fringing wetlands
Description	Provide flows to raise lake levels through July - December 2014 as part of a seasonal lake level fluctuation. The proposed pattern of lake levels for 2014-15 is shown in Figure 8.
Watering objectives	• Small scale wetting and drying in fringing wetlands • Promote zooplankton emergence and germination • Promote growth of submerged aquatic macrophytes • Provide food and habitat for EPBC listed threatened fish and frogs, including Yarra pygmy perch, Murray hardyhead and Southern bell frog • Maintains key functions of high priority wetlands in the Lower Lakes • Supports the icon site condition monitoring targets F2, V3 and I1
Trigger	Seasonal trigger

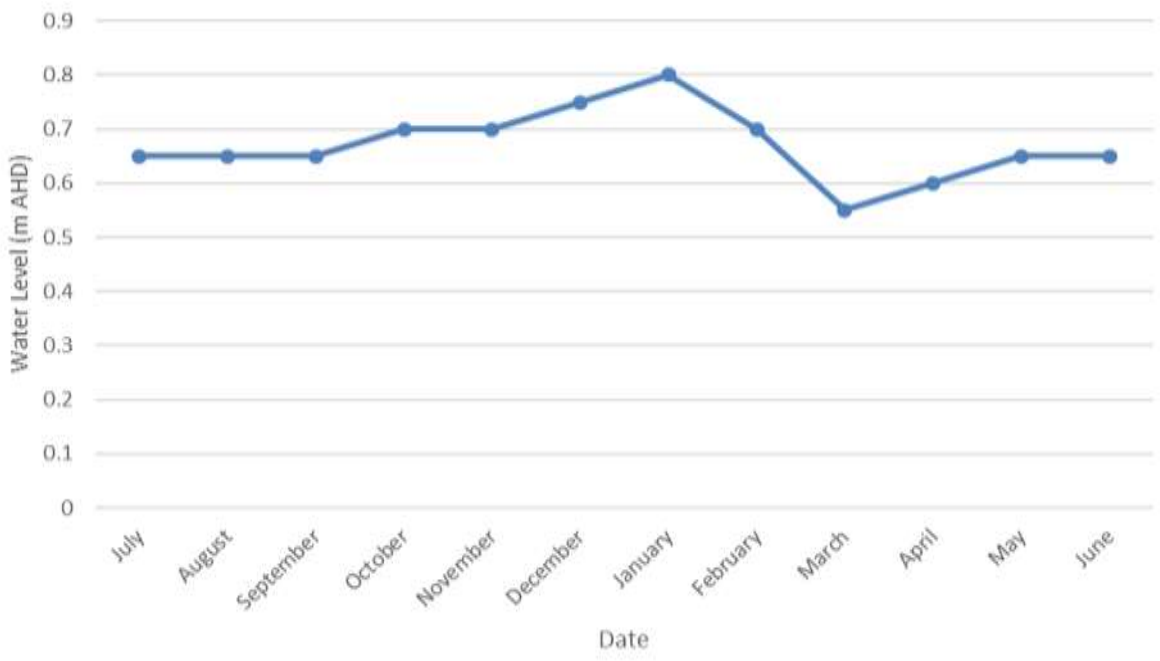

Figure 8: Proposed lake water level management regime for 2014-15

Action 2: Twelve months continuous barrage releases

High level objective	LLCMM Objective 2 – Support diadromous fish
Description	Ensure lake levels are sufficient to release water through barrage fishways and deliver continuous fishway releases (as a minimum) for the full twelve months of the year
Watering objectives	• Provide passage for diadromous and catadromous fish throughout the year, leading to enhanced recruitment and an increase in population of congolli, common galaxiads and lamprey • Supports the icon site condition monitoring targets F1, F4, I1, I2, M3 and W3. • Supports connectivity between the lakes, estuary and coastal zones which contributes to Murray Mouth openness (an ECD ecological objective)
Trigger	Not applicable to this action

Action 3: Short spring-early summer barrage pulse

High level objective	LLCMM Objective 3 – Support *Ruppia tuberosa* in the Coorong
Description	Provide flows at the border through late September – December 2014 to enhance barrage releases from mid October 2014 to mid-January 2015. Preferred timing is to extend any unregulated flow pulses that occur between late August and early October. Flows are targeted through Tauwitchere Barrage to provide salinity benefits to the Coorong North Lagoon
Watering objectives	• Minimise the rate of fall of water levels in the Coorong South lagoon during this period, providing more optimal conditions for *Ruppia tuberosa* reproduction • Provide suitable conditions for benthic invertebrates in the North and South Lagoons, estuarine fish habitat in the North and South Lagoons, and migratory wading bird habitat during October – January • Supports the icon site condition monitoring plan targets V2 and W1 • Enables growth, reproduction and small-scale recruitment for a range of flora and fauna.
Trigger	This action is triggered by an unregulated flow event occurring in early-to-mid spring. For the 75 percent Water Availability Scenario, the decision to use the majority of environmental water in a three month period from October – December (i.e. Action 3) following an unregulated event is dependent on: • Strong evidence of widespread germination of *Ruppia tuberosa* at a range of elevations within the Coorong South Lagoon in late winter; • Favourable wind conditions and forecasts of wind conditions; • *Ruppia tuberosa* flowering by early November and having at least 0.30m of water depth. If one or more of these conditions are not met, environmental water delivery should be spread over a longer period through summer, and target fish and waterbird outcomes instead of a specific *Ruppia tuberosa* outcome (i.e. Action 4).

Action 4: Longer spring-summer barrage pulse

High level objective	LLCMM Objective 4 – Support Waterbirds and Fish in the Coorong
Description	Provide flows at the border through September 2014 – February 2015 to enhance barrage releases from mid October 2014 to mid-March 2015. Preferred timing is to extend any unregulated flow pulses that occur between late August-early October. Flows are targeted through Tauwitchere Barrage to provide salinity benefits to the Coorong North Lagoon.
Watering objectives	• Continued barrage flows through to mid-March provides freshening of the North-South Lagoons upon reconnection • Large, extended freshwater releases through this period provides suitable conditions for benthic invertebrates and migratory waders throughout the entire 'overwintering' period • Extended freshwater releases through summer extends to period of suitable habitation of estuarine fish species in the Coorong South Lagoon • Supports the icon site condition monitoring plan targets F3, F4, B1, I1 and W1. • Enables growth, reproduction and small-scale recruitment for a range of flora and fauna
Trigger	This action is triggered by an unregulated flow event occurring in early-to-mid spring. For the 75 percent Water Availability Scenario, the decision to use the majority of environmental water in a three month period from October – December (i.e. Action 3) following an unregulated event is dependent on: • Strong evidence of widespread germination of *Ruppia tuberosa* at a range of elevations within the Coorong South Lagoon in late winter; • Favourable wind conditions and forecasts of wind conditions; • *Ruppia tuberosa* flowering by early November and having at least 0.30m of water depth. If one or more of these conditions are not met, environmental water delivery should be spread over a longer period through summer, and target fish and waterbird outcomes instead of a specific *Ruppia tuberosa* outcome (i.e. Action 4).

Action 5: Lake level cycle

High level objective	LLCMM Objective 5 – Support Lake Albert Ecology
Description	Provide large flows at the border in March-April 2015 to provide a refill volume for the Lower Lakes, so that a rapid water level 'cycle' can occur (fluctuate levels between 0.55 and 0.80 m AHD over 2 weeks). Only implement if a 50 percent AEP scenario (or wetter) is achieved.
Watering objectives	• Water level fluctuation enhances mixing between Lakes Alexandrina and Albert, leading to a net reduction in salinity in Lake Albert • A net salinity reduction may lead to enhanced submerged aquatic vegetation, fish and waterbird communities in Lake Albert • Enhanced barrage releases in March-April will lead to a freshening of the North Lagoon during the period when reconnection occurs with the South Lagoon. This in turn will reduce salinity in the South Lagoon, and provide a greater chance of staying below the 100 ppt threshold in the Coorong South Lagoon during summer 2015-16. • Supports the icon site condition monitoring plan targets V3 and W2. • This action aims to protect ecological health
Trigger	Lake Albert salinity >2,000 EC

Action 6: Pumping to fringing lakes wetlands

High level objective	LLCMM Objective 6– Inundate higher-elevation fringing wetlands
Description	Pump to selected wetlands that are not influenced by lake level manipulations under a 90 percent scenario (more detail provided in the Wetland section)
Watering objectives	• Extends period of inundation for EPBC-listed migratory waders and Southern Bell Frog • May include sites such as Milang (targeting Latham's Snipe) and Tolderol (targeting a range of EPBC listed waterbirds and the Southern Bell Frog) • Supports the icon site condition monitoring plan targets B1 and V3. • Manages within dry-spell tolerances
Trigger	Various, as per Wetland section

Action 7: Large base flows through autumn-winter

High level objective	LLCMM Objective 7– Support Coorong ecology
Description	Under a 25 percent Scenario, provide environmental water to extend higher barrage releases during autumn and winter. Can be on the back of a lake level cycle event.
Watering objectives	• Assists with maintaining salinity in the Coorong South lagoon below 100 ppt during summer 2015-16. • Maintains an Open Murray Mouth • Provide suitable conditions in the Coorong South Lagoon for estuarine fish communities and waterbirds • Provides salinity cues past the Murray Mouth for the upstream movement of diadromous species such as lamprey
Trigger	April-May, extending to the end of June.

Table 2. Description of proposed 2014-15 watering actions for LLCMM under four water resource scenarios

Water Resource Scenario	Action targeted	Trigger Flow-Event (e.g. bird breeding, unregulated flow)	Desired hydrology			Vol Required (GL)	Vol Returned (GL)
			Hydrological metric	Duration	Timing		
90 percent AEP	Action 1 (Lake Level Manipulation)	Seasonal trigger	Maximum lake level 0.8 mAHD	6 months	July - Dec	380	N-A
	Action 2 (12 Months Fishway Releases)	N-A	~10 GL-month barrage releases	12 months	July – June	120	N-A
	Action 6 (Pump to Fringing Wetlands)	Various	N-A	As required	October - February	2	N-A
75 percent AEP	Action 1 (Lake Level Manipulation)	Seasonal trigger	Maximum lake level 0.8 mAHD	6 months	July - Dec	200[4]*	N-A
	Action 2 (12 Months Barrage Releases)	N-A	~10 GL-month barrage releases	12 months	July – June	70*	N-A
	Action 3-4 (Spring - Summer Pulse) [5]	QSA 9,000 ML/d in September	Maintain barrage releases (≥ 2 GL-d) through September – early December (or February)	4 – 6 months	September – December (or February)	330	N-A
50 percent AEP	Action 4 (Spring - Summer Pulse)	QSA >20,000 ML/d in September	Maintain higher barrage releases through September - February	6 months	September – February	500	N-A
	Action 5 (Lake Level Cycle)	Lake Albert salinity > 2000 EC	Lake level fluctuates from 0.8 to 0.5 to 0.8 m AHD	4 weeks	March - April or July - August	300	N-A
25 percent AEP	Action 4 (Spring - Summer Pulse)	QSA 40,000 ML/d in September	Maintain higher barrage releases through September - February	6 months	September – February	650	N-A

[4] Reduced environmental water volumes are required for lake level manipulation and 12-month barrage releases in the 75% scenario than in the 90% scenario as a small unregulated flow-delivery of additional dilution flow will contribute water needed to achieve these outcomes

[5] Target Objective 3. However, if there is a rapid drop in Coorong South Lagoon water levels (due to winds-tides), then reduce outflows and target Objective 4

	Action 5 (Lake Level Cycle)	Lake Albert salinity > 2000 EC	Not applicable	4 weeks	March – April or July - August	300	N-A
	Action 7 (Large Winter Base Flows)	April-May (seasonal)	Extend barrage releases through autumn-winter	2-3 months	April-June	250	N-A

2. Ecological Rationale

The LLCMM Icon Site Environmental Water Management Plan (EWMP) (MDBA 2014a) First Step Decision (FSD) objectives include:

- an open Murray Mouth;
- more frequent estuarine fish spawning and recruitment; and
- enhanced migratory waterbird habitat in the Lower Lakes and Coorong.

The alignment of these FSD objectives with the watering actions proposed for 2014-15 is shown in Table 3 and demonstrates that the appropriate delivery of environmental water in 2014-15 will contribute to meeting these overarching objectives.

Table 3. Alignment of 2014-15 watering actions with the LLCMM Icon Site First Step Decision Objectives

Proposed 2014-15 LLCMM Watering Action	FSD Objective		
	Open Murray Mouth	Estuarine Fish	Waterbirds
Action 1 (Lake Level Manipulation)			X
Action 2 (12 Months Barrage Releases)	X	X	
Action 3 (Short Pulse)	X	X	X
Action 4 (Longer Pulse)	X	X	X
Action 5 Lake Level Cycle)	X		X
Action 6 (Pumping to Wetlands)			X
Action 7 (Large Baseflows)	X	X	X

A snapshot of data collected in March 2014 provides an indication of the current condition of the LLCMM icon site in comparison to target conditions specified in the LLCMM Icon Site EWMP, the 2013-14 LLCMM Icon Site annual environmental watering bid and the Basin Plan (Table 4). While some values are currently well within target range (e.g. Lake Alexandrina salinity), others are approaching (e.g. Coorong South Lagoon salinity) or already exceed target thresholds (e.g. Lake Albert salinity).

Table 4. LLCMM physiochemical data as at March 2014 and target values

Parameter Description	Current Condition	Target Condition during 2014-15
Daily barrage outflow	300-400 ML/d	≥ 2,000 ML/d (Murray Mouth target)
Lake Alexandrina average daily salinity	650 EC	<1,000 EC (Basin Plan target)
Lake Albert average daily salinity	2,650 EC	1,500 EC (Annual water bid target)
Lake Alexandrina average daily water level	0.62 m AHD	0.55 – 0.80 m AHD (Annual water bid target)
Lake Albert average daily water level	0.58 m AHD	0.55 – 0.80 m AHD (Annual water bid target)
Coorong South Lagoon average daily salinity	~90 ppt	<100 ppt (Basin Plan target)
Coorong South Lagoon average daily water level	-0.1 m AHD	Not applicable – critical time for ruppia recruitment is October to December. The target water level during this time depends on the elevation at which plants germinate
Murray Mouth 'openness'	DTRs above target levels	0.05 Tauwitchere and 0.2 Goolwa (Dredging Targets)

South Australian Entitlement Flow alone is not enough to achieve the ecological objectives for the LLCMM icon site or to maintain the physiochemical conditions below target thresholds. A significant volume of environmental water is required to enhance lake operation and barrage releases for environmental outcomes. The timing of environmental water delivery is critical for triggering ecological outcomes.

If environmental water is not provided the associated risks include:

- Salinisation of the Coorong South Lagoon, and the possibility of breaching the 100 ppt trigger in summer 2014-15 (and exceeding critical tolerance thresholds for key species);
- Salinisation of Lake Albert, leading to freshwater species loss;
- Low water levels in the Coorong South Lagoon over summer 2014-15; leading to the exposure of translocated and naturally re-establishing *Ruppia tuberosa* beds and a mass die-off of this species, and a loss of the benefits gained from the 2012-13 and 2013-14 environmental water delivery;

- A lack of connectivity during summer between Lake Alexandrina and the estuary, preventing upstream movement of diadromous fish (and potential lack of recruitment) and a loss of estuarine conditions downstream of the barrages, preventing recruitment opportunities for estuarine fish species;
- High salinity levels and low water levels in the Coorong will lead to a lack of food resources (ruppia, small-bodied fish and benthic macroinvertebrate); providing unsuitable feeding habitat for EPBC-listed migratory waders and piscivorous bird species. Recruitment failure will lead to a decline in bird numbers, including migratory species;
- Inability to flush salt and nutrients from the MDB if the barrages remain shut for the majority of the year; and
- Murray Mouth closure, leading to the need to implement a multi-million dollar dredging program and a lack of coastal and estuarine and reduced habitat complexity (e.g. diadromous fish).

The following species and communities are dependent on flows to the LLCMM and are at risk if no or limited water is delivered:

- Swamps of the Fleurieu Peninsula (a critically endangered ecological community under the EPBC Act, that provide habitat for the endangered Mount Lofty Ranges Southern Emu-Wren);
- Orange-bellied Parrot;
- Southern Bell Frog;
- Yarra Pygmy Perch;
- Murray Cod;
- Murray hardyhead;
- Big-bellied seahorse;
- Silver perch;
- Australasian Bittern;
- Migratory waterbirds (25 species) as listed under the JAMBA, KAMBA and ROKAMBA agreements

3. Consultation

The LLCMM Community Advisory Panel (CAP) and LLCMM Scientific Advisory Group (SAG) were consulted in mid February 2014 on what the priority uses of environmental water should be under different water availability scenarios for the LLCMM icon site. This involved presentations and group discussions.

On 12 March 2014 a workshop was held with key scientists who collect data on the SA River Channel and LLCMM icon site, and environmental water managers, to develop a QSA hydrograph incorporating outcomes in the LLCMM, Channel, Chowilla (potential testing) and for weir pool manipulations.

A targeted session with the Ngarrindjeri Regional Authority (NRA) was planned for late April 2014 but had to be postponed until June 2014, where participants were generally supportive of the proposed watering objectives and actions.

The watering proposal for 2014-15 was also influenced by knowledge and experience gained through interactions with stakeholders during the 2013-14 year, including:

- Updates and discussion at SAG, CAP and KNYA meetings;
- Weekly environmental flow reference group teleconferences during spring-summer (scientists and managers);
- Direct contact with scientists in the field; and
- Updates at Environmental Water Working Group (EWG), Operations Advisory Group (OAG), barrage operations and Commonwealth Environmental Water Office (CEWO) teleconferences.

4. Management and Monitoring

The following condition monitoring programs are assumed to be funded through TLM for 2014-15:

- Lower Lakes aquatic vegetation monitoring;
- Lower Lakes threatened fish monitoring;
- Lower Lakes and Coorong benthic invertebrate and mudflat monitoring;
- Lower Lakes and Coorong waterbird census;
- Lower Lakes monthly waterbird monitoring;
- Coorong fish monitoring; and
- Independent review of condition monitoring.

Intervention monitoring priorities are likely to focus on:

- Barrage fishway monitoring (specifically diadromous fish movement);
- *Ruppia tuberosa* recruitment during spring-summer in the Coorong South Lagoon; and
- Lake Albert ecology (if a lake level cycle is implemented).

The following ecological and environmental monitoring programs will be funded by the Murray Futures CLLMM Recovery Project in 2014-15:

- Coorong South Lagoon *Ruppia tuberosa* monitoring during autumn-winter and *Ruppia tuberosa* translocation monitoring;
- Coorong benthic invertebrate monitoring (focusing on recruitment);
- Coorong fish monitoring (focusing on recruitment);

- Coorong monthly waterbird monitoring;
- Coorong and Lower Lakes water quality (salinity, alkalinity-acidity, DO, nutrients) monitoring;
- Coorong and Lower Lakes microalgae and zooplankton monitoring;
- Lower Lakes acid sulfate soils (and shallow groundwater) monitoring;
- Lower Lakes Southern Bell Frog (and other frogs) monitoring; and
- Lower Lakes habitat vegetation and revegetation monitoring (littoral zone).

To inform operational decision-making, salinity and water level will be monitored and reported on through the network of telemetered water quality stations through the Lower Lakes and Coorong. Barrage outflow will be estimated using the BMT-WBM spreadsheet calculator and the 'SA Water' method.

It is assumed that Murray Mouth 'openness' monitoring will be funded by SA Water and include data collection on Diurnal Tide Ratios (DTRs), bathymetry of the Mouth and channels and aerial photography. However, this may also be dependent on the outcomes of the MDBA Joint Programs Review.

PART B: SOUTH AUSTRALIA'S RIVER MURRAY CHANNEL AND FLOODPLAIN

1. Proposed Watering Actions and Objectives

Five priority watering actions and eighteen priority watering objectives have been identified for the South Australian River Murray channel and floodplain (SARM channel-floodplain) in 2014-15. These actions and objectives are described below.

The watering actions for the SARM channel-floodplain involve adding environmental water to enhance flows at the South Australian border (QSA). Not all of the actions are deliverable under all of the water resource scenarios. The flow height and duration that can be achieved will depend on the 'natural' flows experienced but it is generally assumed that a maximum of 5,000 to 10,000 ML/day can be added through environmental water delivery. The ecological outcomes achieved will depend on the magnitude, duration and timing of the flow but generally more outcomes are achieved with larger volumes.

The hydrological metrics for each watering action and objective (magnitude, duration, timing), and approximate volumes of environmental water required are provided in Table 5.

Action 1: 10,000 ML/day flow pulse

High level objectives	Channel Objective 1 – Tailwaters Channel Objective 2 – Velocity Channel Objective 3 – Pulse Channel Objective 4 – Thermal Stratification
Description	Enhance QSA to create an in-channel flow pulse with a median discharge of 10,000 ML/day with +/- 2,000 ML/day variability , and targeting a duration of 60 to 90 days

Watering objectives	• Generate small variations in water levels (particularly in lock reach tailwaters) to produce localised benefits including:
	  ○ Improving the quality of food resources by promoting bacterial biofilms
	  ○ Increasing lateral recharge resulting in the freshening of near-bank groundwater
	  ○ Growth and recruitment of emergent aquatic and floodplain understorey vegetation
	  ○ Improved condition of long-lived vegetation
	• Increase hydraulic complexity (i.e. diversity of velocity classes present)
	• Create a flow pulse in late spring-early summer to support golden perch and silver perch larval dispersal and survival
	• Reduce the risk of persistent thermal stratification occurring during the warmer months

Trigger	Forecast QSA is between entitlement and 12,000 ML/day during spring-summer

Action 2: 15,000 ML/day flow pulse

High level objectives	Channel Objective 1 – Tailwaters Channel Objective 2 – Velocity Channel Objective 4 – Thermal Stratification Channel Objective 5 – Golden and silver perch Channel Objective 6 – Murray cod
Description	Enhance QSA to create an in-channel flow pulse with a median discharge of 15,000 ML/day and including within-event variation generating short-term increases to 20,000 ML/day. Target duration is 60 to 90 days.

Watering objectives	• Generate small variations in water levels (particularly in lock reach tailwaters) to produce localised benefits including:
	  ○ Improving the quality of food resources by promoting bacterial biofilms
	  ○ Increasing lateral recharge resulting in the freshening of near-bank groundwater
	  ○ Growth and recruitment of emergent aquatic and floodplain understorey vegetation
	  ○ Improved condition of long-lived vegetation
	• Increase hydraulic complexity (i.e. diversity of velocity classes present)
	• Promote spawning by golden perch and silver perch, and facilitate downstream transport of larvae
	• Improve larval survival and promote recruitment by Murray cod
	• Reduce the risk of persistent thermal stratification occurring during the warmer months

Trigger	Forecast QSA is between ~10,000 and 15,000 ML/day during spring-summer

Action 3: 25,000 ML/day flow pulse

High level objectives	Channel Objective 2 – Velocity Channel Objective 5 – Golden and silver perch Channel Objective 6 – Murray cod Channel Objective 7 - Productivity Channel Objective 8 - Redgum condition Channel Objective 9 - Redgum recruitment Channel Objective 10 - Redgum germination Channel Objective 11 - Macrophytes Channel Objective 12 - Temporary wetlands Channel Objective 13 - Frogs Channel Objective 14 - Waterbirds
Description	Enhance QSA to create an flow pulse with a median discharge of 25,000 ML/day with +/- 5,000 ML-day variability, and targeting a duration of 60 to 90 days
Watering objectives	• Increase hydraulic complexity (i.e. diversity of velocity classes present) • Promote spawning by golden perch and silver perch, and facilitate downstream transport of larvae • Improve larval survival and promote recruitment by Murray cod • Reduce the risk of persistent thermal stratification occurring during the warmer months • Improve the availability and quality of in-stream resources due to increased carbon and nutrient loads, increased heterotrophic activity and establishment of early successional state biofilms • Maintain and/or improve the condition of adult river red gums (in riparian and low-lying floodplain areas) • Support establishment of river red gum seedlings and saplings • Create favourable soil moisture conditions to coincide with period of peak seed fall by river red gums • Support the germination, growth, flowering and seed-set by native macrophytes in littoral and low-lying floodplain-wetland areas • Maximise the inundated area of low-lying temporary wetlands • Support frog recruitment by maintaining the presence of water for sufficient time for tadpoles to complete metamorphosis • Support waterbird breeding by maintaining the presence of water for sufficient time for chicks to fledge
Trigger	Forecast QSA is between ~20,000 and 30,000 ML/day

Action 4: Manage flow recession

High level objectives	Channel Objective 15 - Recession
Description	Manage flow recession so that water levels do not change by >2 - 5 cm/day
Watering objectives	• Manage the rate of flow recession to prevent negative impacts such as bank slumping and stranding of aquatic fauna.
Trigger	Forecast indicates a sharp drop in QSA will occur at the end of a high flow event

Action 5: Enhance high flows

High level objectives	Channel Objective 16 - Enhance flow peaks
Description	Deliver environmental water to the SA border to increase the magnitude of a flow peak by ~5,000 - 10,000 ML/day, and-or extend the flow peak targeting a minimum duration of 40 - 60 days
Watering objectives	• Extend duration and-or increase magnitude of flow peak to provide floodplain vegetation benefits (growth and recruitment) • Allow water-dependent fauna species to complete breeding cycles • Support ecosystem functions
Trigger	Forecast QSA >30,000 ML/day

Table 5. Description of proposed 2014-15 watering actions for SA River Murray channel and floodplain under four water resource scenarios

Water Resource Scenario	Objective targeted	Trigger Flow/Event (e.g. bird breeding, unregulated flow)	Desired hydrology			Vol Required (GL)	Vol Returned (GL)
			Hydrological metric	Duration	Timing		
90 percent AEP	Objective 1 (Tailwaters); Objective 2 (Velocity)	Forecast QSA between entitlement and 12,000 ML/day for spring/summer	Median discharge QSA 10,000 ML/day with +/- 2,000 ML/day variability	60 days	Sep - Mar	~250 – 300 GL	~250 – 300 GL
	Objective 3 (Pulse)	Forecast QSA between entitlement and 12,000 ML/day for spring/summer	Median discharge QSA 10,000 ML/day with +/- 2,000 ML/day variability	90 days[6]	Mid-Sep - mid-Dec	~300 – 400 GL	~300 – 400 GL
	Objective 2 (Velocity); Objective 4 (Thermal stratification)	Chowilla regulator potentially tested or at least one weir in SA raised and QSA between entitlement and 10,000 ML/day	Median discharge QSA 10,000 ML/day with +/- 2,000 ML/day variability	TBC	During and after recession phase of operation of the Chowilla regulator and weir raising	TBC	TBC
75% percent AEP	Objective 1 (Tailwaters); Objective 2 (Velocity)	Forecast QSA between ~10,000 and 15,000 ML/day for spring/summer	Median discharge QSA 15,000 ML/day including within event variation generating short-term increases to 20,000 ML/day	60 days	Sep - Mar	~200 - 250 GL	~200 - 250 GL
	Objective 5 (Golden and silver perch); Objective 6 (Murray cod)	Forecast QSA between ~10,000 and 15,000 ML/day for spring/summer	Median discharge QSA 15,000 ML/day including within event variation generating short-term increases to 20,000 ML/day	90 days[7]	Mid-Oct – mid-Jan	~500 GL	~500 GL
50 percent AEP	Objective 8 (Redgum condition); Objective 11 (Macrophytes); Objective 12 (Temporary wetlands)	Forecast QSA ~20,000 to 30,000 ML/day	Median discharge QSA 25,000 ML/day with +/- 5,000 ML/day variability	60 days[8]	Sep - Mar	~150 - 300 GL	~150 - 300 GL

[6] Action may have a shorter duration of 60 days with mid-Oct to mid-Dec timing however this may reduce the likelihood of achieving the desired ecological outcome
[7] Action may have a shorter duration of 60 days with Nov-Dec timing however this may reduce the likelihood of achieving the desired ecological outcome
[8] Action may have a shorter duration of 30 days with Apr - Aug timing however this may reduce the likelihood of achieving the desired ecological outcome

Water Resource Scenario	Objective targeted	Trigger Flow/Event (e.g. bird breeding, unregulated flow)	Desired hydrology			Vol Required (GL)	Vol Returned (GL)
			Hydrological metric	Duration	Timing		
	Objective 9 (Redgum recruitment)	Forecast QSA ~20,000 to 30,000 ML/day	Median discharge QSA 25,000 ML/day with +/- 5,000 ML/day variability	60 days[9]	Sep - Dec	~150 - 300 GL	~150 - 300 GL
	Objective 10 (Redgum germination)	Forecast QSA ~20,000 to 30,000 ML/day; red gum fruit development observed	Median discharge QSA 25,000 ML/day with +/- 5,000 ML/day variability	60 days	Sep - Feb	~150 - 300 GL	~150 - 300 GL
	Objective 13 (Frogs); Objective 14 (Waterbirds)	Forecast QSA ~20,000 to 30,000 ML/day; evidence of frog breeding; waterbird nesting observed	Median discharge QSA 25,000 ML/day with +/- 5,000 ML/day variability	90 days	Oct - Dec[10]	~300 - 450 GL	~300 - 450 GL
	Objective 2 (Velocity); Objective 7 (Productivity)	Forecast QSA ~20,000 to 30,000 ML/day	Median discharge QSA 25,000 ML/day with +/- 5,000 ML/day variability	60 days[11]	Oct - Dec	~150 - 300 GL	~150 - 300 GL
	Objective 5 (Golden and silver perch); Objective 6 (Murray cod)	Forecast QSA ~20,000 to 30,000 ML/day	Median discharge QSA 25,000 ML/day with +/- 5,000 ML/day variability	90 days[12]	Mid-Oct – mid-Jan	~300 - 450 GL	~300 - 450 GL
	Objective 15 (Recession)	Forecast indicates sharp drop in QSA	Water levels do not change by >2 - 5 cm/day	TBC	In response to natural peaks	TBD	TBD
25 percent AEP	Objective 17 (Enhance flow peaks)	Forecast QSA >30,000 ML/day	Increase magnitude of flow peak by ~5,000 - 10,000 ML/day; and/or extend flow peak targeting a minimum duration of 40 - 60 days	40 – 60 days	In response to natural peaks	TBD	TBD

[9] Action may have a shorter duration of 30 days with Apr - Aug timing however this may reduce the likelihood of achieving the desired ecological outcome
[10] Alternative timing is Jan – Mar or Aug – Sep but this may reduce the likelihood of achieving the desired ecological outcome
[11] Action may have a shorter duration of 30 days with Sep - Mar timing however this may reduce the likelihood of achieving the desired ecological outcome
[12] Action may have a shorter duration of 60 days with Nov - Dec timing however this may reduce the likelihood of achieving the desired ecological outcome

Water Resource Scenario	Objective targeted	Trigger Flow/Event (e.g. bird breeding, unregulated flow)	Desired hydrology			Vol Required (GL)	Vol Returned (GL)
			Hydrological metric	Duration	Timing		
	Objective 16 (Recession)	Forecast indicates sharp drop in QSA	Water levels do not change by >2 - 5 cm/day	TBC	In response to natural peaks	TBD	TBD

2. Ecological Rationale

An Environmental Watering Management Plan (EWMP) for The Living Murray River Murray Channel icon site (TLM-RMC) is currently under development through which a set of proposed objectives and sub objectives has been developed but not yet finalised. The 2014-15 priority watering actions for the SA River Murray channel and floodplain are consistent with the following objectives proposed for the TLM-RMC[13]:

- Objective 1 - Contribute to the protection and restoration of biodiversity within the River Murray Channel Icon Site (Adapted from BP s. 8.05(3))

- Objective 2 - Contribute to the protection and restoration of ecosystem functions including connectivity, carbon-nutrient exchange, wetting and drying cycles (Adapted from Basin Plan s. 8.06)

The 2014-15 watering actions are aimed at meeting the interim environmental water requirements (EWRs) developed by the South Australian Government for the SA River Murray floodplain and channel. The interim floodplain targets and EWRs were established during the development of the Basin Plan (DWLBC 2010; Gibbs et al. 2012) and reviewed by the Goyder Institute for Water Research as part of their review of the Guide to the Proposed Basin Plan (Pollino et al. 2011). The channel targets and EWRs have been developed through a separate project with the Goyder Institute for Water Research (Wallace et al 2014a). The floodplain and channel EWRs are aimed at providing a range of flows to sustain populations, promote ecosystem functions and deliver water to wetlands and habitats within the River channel and on the floodplain between the SA-Vic-NSW border and Wellington. The EWRs describe the flow regime or hydrological metrics (flow magnitude, duration, timing and average return frequency) needed to support these functions, habitats and species.

An understanding of the current condition of the SA River Murray floodplain and channel can be derived from comparing recent flow history to the hydrological metrics of the EWRs. The frequency in the past 10-years that an event of a given magnitude, duration and timing (as specified by the EWR) has occurred was determined using calculated flow to SA data (Water Connect site A4261001) and then compared to the preferred average frequency of the EWR (Table 6). Results show that the actual frequency is less than the preferred frequency for all EWRs and indicates that the frequency and duration of inundation has not been sufficient to support the targeted functions, habitats and species of the SA River Murray channel and floodplain. This conclusion is further supported by data gathered through various research and monitoring projects, and is summarised below for floodplain vegetation and two large-bodied native fish species.

Floodplain vegetation

The following information on the current condition of floodplain eucalypts has been taken from Wallace et al (2014b). The age-class distribution of woodland trees is an indicator for recruitment and survival, and the growth of young trees must at least match the mortality of old trees if a stand is to remain viable (George et al., 2005b). Assessments of population demographics at wetlands in the lower River Murray (Aldridge et al., 2012b), Banrock Station (George et al., 2005b), Pike Floodplain (Wallace, 2009) and Chowilla Floodplain (Wallace, 2013b) demonstrate that there is insufficient recruitment to sustain the existing forest and woodland communities.

[13] TLM-RMC proposed objectives are provided in the papers for the Environmental Watering Group, Meeting 9 held on 6 February 2014, Agenda Item 6, Attachment A, RMC Objectives Paper Jan 14

Golden perch

The following information on the current condition of golden perch population has been taken from Wallace et al (2014b). Golden perch is long-lived (20-25 years). Therefore the species does not need to recruit every year. However, there is evidence that the types of flow events that have been correlated with spawning post-regulation (i.e. seasonal within-channel flow pulses), would have occurred in the lower River Murray on a near annual basis prior to river regulation (Zampatti and Leigh, 2013b). In 2011, the population demographic was dominated by fish spawned in 2009-10 (54 percent) and 2010-11 (29 percent). The remaining demographic was comprised of 5, 10 and 12 year old fish.

Larval fish sampling in 2012-13 detected golden and silver perch larvae in samples from late October to January, indicating spawning may have been associated with an increase in flow in late spring-early summer 2012 (Ye et al 2013). Early results from monitoring indicate spawning of flow-cued fish species (golden perch and silver perch) occurred (as evidence by the presence of eggs, larvae or adult reproductive biology) in the Lower River Murray channel associated with the in-channel flow pulse during the late spring-early summer of 2013-14 (Ye pers. comm. 2014).

Murray cod

Assessments of Murray cod population demography in the lower Murray suggest limited recruitment results from spawning in low flow years, but rather strong cohorts of fish have resulted from years of high flow (typically >40,000 ML/day) (Ye and Zampatti 2007 in Wallace et al 2014b). Spawning occurs annually over a well-defined season in spring to early summer irrespective of flow conditions, but rather in response to increasing photoperiod and water temperature (Humphries 2005, Koehn and Harrington 2006 in Wallace et al 2014b). Calculated flow to SA data indicate that in the past 10-years flows >40,000 ML/day have only occurred once (2010-11) during Murray cod spawning season. Murray cod populations in South Australia are now relatively small in numbers and have been severely impacted by the drought. Very little recruitment has been detected so far in response to more recent high flow events (Ye pers. comm. 2013).

Table 6. Comparison of SA River Murray channel EWR hydrological metrics to recent actual flow history

SA River Murray Channel EWR				QSA data (Water connect site A4261001)	
Magnitude (ML/day)	**Duration (days)**	**Timing**	**Average Return Frequency (%)**	**Actual Frequency (2003-04 - 2012-13)**	**Years in which EWR was met**
10,000	60	Sep - Mar (incl)	95%	30%	2010-11; 2011-12; 2012-13
15,000	60	Sep - Mar (incl)	95%	30%	2010-11; 2011-12; 2012-13
20,000	90	Sep - Mar (incl)	55%	30%	2010-11; 2011-12; 2012-13
25,000	60	Sep - Mar (incl)	59%	20%	2010-11; 2012-13
30,000	60	Sep - Mar (incl)	53%	20%	2010-11; 2012-13
35,000	50	Sep - Mar (incl)	53%	20%	2010-11; 2012-13
40,000	40	Sep - Mar (incl)	48%	20%	2010-11; 2012-13

Failure to meet the EWRs for the floodplain and channel is a result of river regulation and over-extraction, which were further exacerbated by the extended period of very low flow into South Australia during the millennium drought. Prior to 2010 there were five years where flows did not exceed, and were in fact often below, entitlement. The extended duration of low flow and highly stable water levels placed the ecological communities of the River and its floodplain under extreme stress. Overbank flows in 2010-11 generated a significant response in terms of growth and breeding. Since then, unregulated flows have remained near or within-channel and, follow up watering is critical for continued recovery and to build resilience. It is critical that any opportunities to deliver water to temporary wetland and floodplain areas are taken, particularly if there is a return to drier conditions when less environmental water will be available and the feasibility of delivering landscape-scale actions is reduced.

The environmental risks of not applying water include:

1. Loss of ecosystem resilience - failure to build on the partial recovery from drought by key floodplain and wetland habitats, missed opportunities to provide water to floodplain habitats as we once again enter into drier conditions

2. Loss of habitat - the gap between preferred and actual frequency of a given EWR being delivered will widen and result in further decline in the condition of floodplain and wetland communities

3. Lack of adequate food resources to support the trophic web - lack of lateral connectivity leads to reduced carbon and nutrient inputs leading to an energy constrained habitat

4. Failure to support ecosystem functions - including salt export, connectivity and hydraulic diversity

5. Failure to breed and maintain a diverse population structure - Murray cod populations in South Australia are now relatively small and have been severely impacted by the drought. Very little recruitment has been detected so far in response to more recent high flow events (Ye, pers. comm. 2013).

6. Loss of populations of native species and subsequent loss of biodiversity - Failure to deliver flows that support Murray cod larval survival and recruitment will result in a continued decline in an already stressed population.

7. Failure to support natural cues - natural high flow events may trigger breeding events that cannot be completed as the high flows are not of sufficient duration, e.g. failure to support tadpole metamorphosis for the nationally threatened southern bell frog

8. Exceeding Basin Plan thresholds (including water quality and LLCMM thresholds)

3. Consultation

No specific community group exists for the SA River Murray floodplain and channel however a variety of stakeholder groups were consulted during the development of watering proposals and state annual priorities through the distribution of factsheets, with queries and comment invited.

Key SA River Murray scientists and environmental asset managers participated in a workshop held on 12 March 2014 to discuss the channel and LLCMM watering proposals, and to assist in designing a South Australian multi-site watering action. Further advice has been sought from individual experts as required.

A targeted session with the Ngarrindjeri Regional Authority (NRA) was planned for late April 2014 but had to be postponed until June 2014, where participants were generally supportive of the proposed watering objectives and actions. Regional staff presented to the First Peoples of the River Murray and Mallee Region (FPRMM) on landscape-scale watering actions in 2014-15.

4. Management and Monitoring

Operational monitoring of flow will be undertaken at existing gauging stations. This data will be used to determine if the hydrological metrics of the watering actions have been met as an indication of likely environmental outcomes resulting from environmental water delivery.

Where possible, results from existing monitoring programs and projects at specific wetland and floodplain sites will be used to infer ecological responses to channel-floodplain watering actions. These programs may include:

- Chowilla Icon Site (in-channel, wetland and floodplain monitoring) on the Chowilla floodplain;
- DEWNR regional wetland program (monitoring managed permanent and temporary wetlands between the border and the Murray Mouth);
- Katfish floodplain project (monitoring on the Katarapko floodplain); and
- Riverine Recovery Project (monitoring associated with wetland management and weir manipulation between the border and Lock 1).

On-ground monitoring associated with the CEWO Long-Term Intervention Monitoring (CEWO LTIM) project is scheduled to commence at the start of the 2014-15 water year. Monitoring under the CEWO LTIM project will be undertaken within seven selected areas, one of which is the Lower Murray River. CEWO LTIM has defined the spatial extent of the Lower Murray River selected area as the Murray River from the South Australian border to Wellington, including floodplain areas inundated by flow of up to 60,000 ML/day at the South Australian border. The monitoring and evaluation plan for the Lower Murray River selected area is currently under development. However, specific aims of the Project include monitoring the ecological response and evaluating the ecological outcomes of Commonwealth environmental watering at each Selected Area.

PART C: CHOWILLA

1. Proposed Watering Actions and Objectives

Priority watering actions on the Chowilla floodplain for 2014-15 may include the potential testing of the Chowilla environmental regulator and ancillary structures, which would also provide ecological benefits for the Chowilla anabranch and floodplain. However, the proposed range of Chowilla testing operations will not result in inundation of high level floodplain wetlands and therefore the pumped delivery of environmental water to discreet wetland sites is also a priority. This will be implemented if the potential testing operation of the Chowilla Regulator does not occur or if potential testing can only be undertaken to a minimal extent; and resources for pumping are available. The pumped delivery of water to priority wetland sites will be undertaken to consolidate existing improvements in the condition of the Icon Site. This will improve the Icon Site's capacity to respond to potential delivery of environmental water via the Chowilla Regulator and ancillary structures, and increase capacity of the floodplain to withstand, and recover from future droughts. The watering actions and objectives are described below.

Action 1: Potential testing of Chowilla Regulator to 18.1 mAHD

High level objective	Chowilla Objective 1 – In-channel rise
Description	Operation of Chowilla Regulator to 18.1 mAHD; Chowilla Island Loop channel and regulator engaged
Watering objectives	*Ecological objectives* • Rise in water level in the range of 0.8m to 1.8m within the Chowilla Anabranch • Punkah Island Horseshoe connected • Reduced salinity of near-bank groundwater • Improved soil salinity and soil moisture availability and thus improved riparian vegetation growth. • Connectivity established with early commence to flow wetlands *Works & measures commissioning objectives* • Allow first potential testing of the Chowilla Regulator and ancillary structures to enable the testing of the structures and mechanical equipment associated with the regulators and fishways. • Ensure potential testing activities occur within identified critical operational limits to: • Maintain flows >0.18 ms-1 in 75% of core fish habitat at all times • Maintain minimum daily water exchange ≥20 percent • Limit the maximum rate of rise to 0.1 mday-1 • Limit the maximum rate of drawdown to ≤0.1 mday-1 whilst surface water levels are out of channel and to ≤0.05 mday-1 when surface water levels are within channel • Maintain conditions suitable for the management of salinity and other water quality risks.
Trigger	QSA > 6,000 ML/day

Action 2: Potential testing of Chowilla Regulator to 18.7 mAHD

High level objective	Chowilla Objective 2 – Low floodplain inundation
Description	Potential testing of Chowilla Regulator to 18.7 mAHD; Chowilla Island Loop channel and regulator engaged; Lock 6 raised to 19.45 mAHD
Watering objectives	*Ecological objectives* • Rise in water levels at the Chowilla regulator equivalent to that which would be generated by flows of QSA ca. = 52,000 ML/day • Werta Wert, Coppermine, Lake Limbra and Punkah Island Horseshoe connected • Reduced salinity of near-bank groundwater leading to improved soil salinity and soil moisture availability and thus improved riparian vegetation growth • Connectivity established with low elevation floodplain and several key wetlands • Opportunities for small-scale breeding for waterbirds, amphibians, invertebrates and aquatic plants • Germination of flood dependent and flood responsive vegetation • Improved habitat availability and increased food resources leading to improved population demographics of key fauna *Works & measures commissioning objectives* • Allow first potential testing of the Chowilla Regulator and ancillary structures to enable the potential testing of the structures and mechanical equipment associated with the regulators and fishways • Ensure potential testing activities occur within identified critical operational limits to: • Maintain flows >0.18 ms-1 in 75 percent of core fish habitat at all times • Maintain minimum daily water exchange ≥20 percent • Limit the maximum rate of rise to 0.1 mday-1 • Limit the maximum rate of drawdown to ≤0.1 mday-1 whilst surface water levels are out of channel and to ≤0.05 mday-1 when surface water levels are within channel • Maintain conditions suitable for the management of salinity and other water quality risks.
Trigger	QSA > 10,000 ML/day

Action 3: Potential testing of Chowilla Regulator to 19.0 mAHD

High level objective	Chowilla Objective 3 – Low-mid floodplain inundation
Description	Potential testing of Chowilla Regulator to 19.0 mAHD; Chowilla Island Loop channel and regulator engaged; Woolshed East regulator and Woolshed South regulator engaged; Lock 6 raised to 19.65 mAHD
Watering objectives	*Ecological objectives* • Rise in water levels at the Chowilla regulator equivalent to that which would be generated by flows of QSA ca. = 59,000 ML/day • Werta Wert, Coppermine, Lake Limbra, Punkah Island Horseshoes connected • Reduced disconnection between river hydrology and inundation • Reduced salinity of near-bank groundwater leading to improved soil salinity and soil moisture availability and thus improved riparian vegetation growth • Connectivity established with low elevation floodplain and several key wetlands • Opportunities for small-scale breeding for waterbirds, amphibians, invertebrates and aquatic plants • Germination of flood dependent and flood responsive vegetation • Improved habitat availability and increased food resources leading to improved population demographics of key fauna *Works & measures commissioning objectives* • Allow first potential testing of the Chowilla Regulator and ancillary structures to enable the potential testing of the structures and mechanical equipment associated with the regulators and fishways • Ensure potential testing activities occur within identified critical operational limits to: • Maintain flows >0.18 ms-1 in 75 percent of core fish habitat at all times • Maintain minimum daily water exchange ≥20 percent • Limit the maximum rate of rise to 0.1 mday-1 • Limit the maximum rate of drawdown to ≤0.1 mday-1 whilst surface water levels are out of channel and to ≤0.05 mday-1 when surface water levels are within channel • Maintain conditions suitable for the management of salinity and other water quality risks.
Trigger	QSA > 11,500 ML/day

Action 4: High level potential testing

High level objective	Chowilla Objective 4 – Increased scale of inundation and ecological benefits
Description	Higher potential testing may also be possible under 25 percent AEP conditions if Lock 6 can be raised to a sufficient level to ensure that critical testing limits are adhered to and if risk mitigation measures and monitoring are in place and deemed effective. This action will be further developed if high flow events appear likely for 2014-15.
Watering objectives	TBD
Trigger	TBD

Action 5: Pumping to wetlands

High level objective	Chowilla Objective 3 – Inundation of high level floodplain wetlands
Description	Deliver water via pumping to up to five wetlands
Watering objectives	• Reduce soil salinity in inundated areas • Improve soil moisture availability in inundated and riparian zones • Halt observed increase in proportion of trees for which condition scores are below the Ecological Target • Support ongoing growth of seedlings and saplings of river red gum, black box and cooba that have established in response to flooding and environmental watering recent years • Improve condition of Lignum in inundated areas • Provide conditions conducive to growth of flood dependent and aquatic vegetation in inundated and riparian zones • Provide breeding habitat for waterbirds, amphibians and invertebrates • Re-establish habitat condition to sustain high value fauna communities
Trigger	Wetlands will not be influenced by Chowilla Regulator testing or unregulated flows

Table 7. Description of proposed 2014-15 watering actions for the Chowilla Floodplain under four water resource scenarios

Water Resource Scenario	Action targeted	Trigger Flow-Event (e.g. bird breeding, unregulated flow)	Desired hydrology			Vol Required (GL)	Vol Returned (GL)
			Hydrological metric	Duration	Timing		
90 percent AEP	Action 1: Potential testing of Chowilla Regulator to 18.1 mAHD	QSA = ca. 6,000 ML/day	Chowilla Regulator target height = 18.1 mAHD	90-100 days	August – November	23.5 GL (consisting of 3 GL use; 8.5 GL filling; 12 GL to boost QSA[14])	20.5 GL
	Action 5: Pumping to wetlands	Flows lower than commence to fill for targeted wetlands and unable to potentially test regulator to a level which will generate wetland filling	Inundation of Lake Limbra - Gum Flat - Brandy Bottle Lagoon - Monoman Depression - Kulcurna	N-A	Spring (or summer – autumn)	Up to 6.4 GL	N-A
75 percent AEP	Action 1: Potential testing of Chowilla Regulator to 18.1 mAHD	QSA = ca. 6,000 ML/day	Chowilla Regulator target height = 18.1 mAHD	90-100 days	August – November	23.5 GL (consisting of 3 GL use; 8.5 GL filling; 12 GL to boost QSA[14])	20.5 GL
	Action 2: Potential testing of Chowilla Regulator to 18.7 mAHD	QSA = ca. 10,000 ML/day	Chowilla Regulator target height = 18.7 mAHD	90-100 days	August – November	130 GL (consisting of 6 GL use; 15 GL filling; 109 GL to boost QSA[14])	124 GL
	Action 3: Potential testing of Chowilla Regulator to 19.0 mAHD	QSA = ca. 11,500 ML/day	Chowilla Regulator target height = 19.0 mAHD	140 days	August – November	290 GL (consisting of 20 GL use; 20 GL filling; 250 GL to boost QSA[14])	270 GL
	Action 5: Pumping to wetlands	Flows lower than commence to fill for targeted wetlands and unable to potentially test regulator to a level	Inundation of Lake Limbra - Gum Flat - Brandy Bottle Lagoon - Monoman Depression	N-A	Spring (or summer – autumn)	Up to 6.4 GL	N-A

[14] Additional flow boost requirement has been calculated as modelled flow required in addition to SA entitlement flows. As any above entitlement flow occurs and increases the requirement for additional environmental water flow boost decreases. The additional flow boost requirement is estimated based on flow requirements for the period during and following the Chowilla regulator operation to ensure effective risk mitigation.

Water Resource Scenario	Action targeted	Trigger Flow-Event (e.g. bird breeding, unregulated flow)	Desired hydrology			Vol Required (GL)	Vol Returned (GL)
			Hydrological metric	Duration	Timing		
		which will generate wetland filling	- Kulcurna				
50 percent AEP	Action 3: Operation of Chowilla Regulator to 19.0 mAHD	QSA = ca. 20,000 ML/day	Chowilla Regulator target height = 19.0 mAHD	140 days	August – November	≥ 40 GL (consisting of 20 GL use; 20 GL filling; volume needed to boost TBD)	≥ 20 GL (depends on volume used to boost QSA)
	Action 4: High level commissioning	TBD	TBD	TBD	TBD	TBD	TBD
	Action 5: Pumping to wetlands	Flows lower than commence to fill for targeted wetlands and unable to potentially test regulator to a level which will generate wetland filling	Inundation of Lake Limbra - Gum Flat - Brandy Bottle Lagoon - Monoman Depression - Kulcurna	N-A	Spring (or summer – autumn)	Up to 6.4 GL	N-A
25 percent AEP	Action 3: Operation of Chowilla Regulator to 19.0 mAHD	QSA = ca. 45,000 ML/day	Chowilla Regulator target height = 19.0 mAHD	TBD	August – November	40 GL (consisting of 20 GL use; 20 GL filling)	20 GL
	Action 4: High level commissioning	TBD	TBD	TBD	TBD	TBD	TBD
	Action 5: Pumping to wetlands	Flows lower than commence to fill for targeted wetlands and unable to operate regulator to a level which will generate wetland filling	Inundation of Gum Flat or Coombool Swamp - Brandy Bottle Lagoon - Monoman Depression - Kulcurna	N-A	Spring (or summer – autumn)	Up to 6.4 GL	N-A

2. Ecological Rationale

The watering actions proposed for Chowilla Floodplain in 2014-15 will contribute to the achievement of the following TLM First Step Decision Icon Site objectives (MDBA 2011):

- High value wetlands maintained;
- Current area of river red gum maintained; and
- At least 20 percent of the original area of black box vegetation maintained.

The watering actions will also contribute to achieving the following Icon Site Ecological Objectives outlined in the Chowilla Floodplain Environmental Water Management Plan:

- Maintain viable river red gum populations within 70 percent of river red gum woodland;
- Maintain viable black box populations within 45 percent of the black box woodland;
- Maintain viable river cooba populations within 50 percent of river cooba, and mixed red gum and river cooba woodland areas;
- Maintain viable lignum populations in 40 percent of areas;
- Improve the abundance and diversity of flood-dependent understorey vegetation;
- Improve the abundance and diversity of submerged and emergent aquatic vegetation;
- Maintain sustainable communities of the eight riparian frog species;
- Improve the distribution and abundance of the nationally listed southern bell frog at Chowilla; and
- 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.

Data from the 2013 condition monitoring program, combined with the management action thresholds specified in the Chowilla Operations Plan (MDBA 2014b) has been used to assess the need to deliver environmental water. Tree condition data collected in November 2013 indicates that the trajectory of the condition of river red gums and black box at most assessment sites is away from the Ecological Target. Assessments of population demographics of river red gums and black box demonstrate that the existing population is not sustainable (i.e. there is insufficient juvenile trees to replace the existing mature trees, and replace those lost during the Millennium drought).

Serial inundation is required to stabilise environmental condition and consolidate the improvements in condition achieved from past delivery of environmental water and unmanaged inundation. Without management action there will be an increasing proportion of trees in condition categories from which recovery is unlikely or very slow, hence ecosystem resilience will be degraded. Inundation is required to maintain soil salinity and soil moisture availability to support growth of cohorts of seedlings and saplings that have generated as a result of previous environmental watering and unmanaged flooding. Loss of these cohorts would delay ecosystem recovery and extend the time frame required to achieve ecological objectives.

Failure to deliver environmental water to the Chowilla Floodplain in 2014-15 would pose serious risks to the sustainability of vegetation communities due to loss of condition of long-lived vegetation, and death of seedlings and saplings. These risks in turn impact on habitat availability for wildlife including breeding habitat for waterbirds, amphibians and invertebrates, and habitat for threatened fauna.

3. Consultation

The Chowilla Coordinating Committee is a cross-agency, cross-jurisdictional governance committee. Input from the Committee was sought through bi-monthly meetings that included detailed updates regarding proposed Chowilla Floodplain environmental watering activities.

Ongoing community engagement occurs through the Chowilla Community Reference Committee (CRC) and, on their advice, with key stakeholder groups in the community. The CRC receive regular, detailed updates regarding environmental watering activities, and were consulted during Operations and Event Planning and the development of proposed commissioning and environmental watering activities.

The Chowilla Operations Planning group were engaged at a specific workshop that was held to review Operations and Event Plans and potential commissioning scenarios.

A stakeholder fact sheet was developed in early February 2014 by the DEWNR Environmental Water, Trade and River Operations Policy Team, and was sent to key groups seeking their input on state environmental watering priorities for 2014-15.

In March 2014 a workshop was held with key South Australian scientists and environmental water managers to develop a potential SA River Murray multi-site watering action that incorporates actions and outcomes for the LLCMM, Channel (including weir pool raising) and Chowilla Floodplain.

The FPRMM traditional owners are engaged on an ongoing basis via Working Group meetings and via site tours and workshops. This includes detailed updates and consultation regarding environmental watering proposals and commissioning scenarios.

4. Management and Monitoring

Broadly, three types of monitoring are likely to be undertaken on the Chowilla Floodplain in 2014-15:

1. Monitoring directly related to risk management and achieving the ecological objectives and targets for the Chowilla icon site (Table 8)
2. Proposed monitoring of the structural integrity of the Chowilla Regulator

3. Table **9**)
4. TLM icon site condition monitoring

The following condition monitoring programs are assumed to be funded through TLM for 2014-15:

- annual understorey and aquatic vegetation monitoring
- annual fish survey
- annual tree condition survey
- annual Stand Condition Assessment
- monthly waterbird monitoring
- bushbird monitoring
- soil condition monitoring
- groundwater monitoring
- surface water monitoring and maintenance of monitoring network (conducted by DEWNR regional staff)

Table 8. Chowilla Floodplain risk management and ecological target monitoring in 2014-15

Ecological Target	Monitoring
Maintain dissolved oxygen above 50 percent saturation	Dissolved oxygen data available in real time from telemeted DO stations established in the anabranch (x3), key floodplain sites (x2) and river channel (x2)
Salinity to be <580 EC in River Murray downstream of Chowilla Creek (Station No. A4260704)	Surface water EC data from stations A4260510 and A4260704
Maintain dissolved oxygen above 50 percent saturation; Biovolume <4 mm3L-1 for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume; <10 mm3L-1 total biovolume of all cyanobacteria where known toxins are not present	Water samples for laboratory analysis from telemeted DO stations and key wetlands (analysis includes) BOD5, dissolved organic carbon (DOC) biodegradable DOC (bDOC), nutrients, chlorophyll a and phytoplankton biovolume collected from DO stations
Thermal stratification is not allowed to persist for more than 5 days in the anabranch creeks or adjacent reach of river channel	Temperature data from surface and bottom loggers at telemeted DO stations
Maintain flows >0.18 ms-1 in 75 percent of core fish habitat at all times	Velocity data - Fixed ADCP and gauging at key points in conjunction 1D MIKE11 and 1D-2D MIKE FLOOD model outputs
Mass bank failures are restricted to <2 percent of stream length	Rate of drawdown via water levels at key structures and existing gauging stations AND observational transects - photopoints during operations
Minimum inundation periods required for successful breeding by a range of water bird species are provided during 80 percent of flood events	Hydrology; Inundation period including timing, depth and duration
Ecological Targets related to fish community and understanding response to changes in anabranch hydrology	Radiotracking study of fish movement; Recording of use of fish passage by tagged fish via PIT tag reader installed at Chowilla regulator vertical slot fishway

Table 9. Chowilla Regulator structural integrity monitoring in 2014-15

Monitoring	Frequency-Timing	Responsibility
• Condition of left abutment • Condition of overflow • Condition of right abutment • Reservoir storage level • Standpipe piezometer readings [weekly] • General site condition	• Routine inspections are to be conducted at least 3 times per week or with every 0.5m rise in water level upstream of Chowilla Creek, whichever is more frequent	Operator
• Deformation survey, picking up all the survey targets installed on the piers of the regulators	• Prior to filling • Once the water level upstream of Chowilla Regulator reaches the highest point of filling as flows allow. • After release of water and removal of all stop-logs • Additional survey may be recommended if anomalous results are observed	Surveyor
• On-site observations of conditions at key stages of the first filling of the floodplain	At key stages, which are anticipated to be: • Level of approximately 18.0 m when flow first starts entering the Chowilla Island Loop • When flow first enters and Woolshed Creek System, and reaches the Woolshed Creek regulators, at approx. 18.9 – 19 mAHD • Level 19.25 m to inspect the structures prior to filling to 19.87m • Level 19.87 m or peak water level for the event to inspect when completely full at maximum head • Additional inspections may be warranted based on routine surveillance observations	Designer
• Potential testing and assessment of effectiveness of fishways at Chowilla Regulator and Pipeclay and Slaney Creek weirs	TBD	TBD

PART D: WEIR MANIPULATION

1. Priority watering actions and objectives

The raising of at least one weir has been identified as a priority environmental watering action for 2014-15. Proposed locations are Lock 1, Lock 2 and Lock 6. Flow conditions in 2014-15 will influence whether weir raisings proceed as well as the height to which the weirs are raised (Table 11). Objectives and triggers for the raising of Locks 1 and 2 are described below. Watering objectives are consistent between locations and resource scenarios although increased flows and weir heights result in a greater area of influence and hence increased outcomes (Table 10). Lock 6 raising is a component of the potential testing of the Chowilla regulator (refer Chowilla section above for more detail).

A moderate raising event is proposed for spring 2014 to trial the operational requirements and effects in a conservative manner. This event will contribute to the development of a Standard Operating Procedure for future weir pool events and enables the assessment of the risks and opportunities associated with using the weirs to raise and lower the river level for environmental benefit. It will also provide a basis to trial the communications plan and confirm that water modelling systems are reliable and accurate. The main aim of this event is to keep the community informed about, and supportive of, any future weir pool manipulation events carried out.

Action 1: Raise Lock 1 and/or Lock 2

High level objective	Increased in-channel water level variability
Description	Raise Locks 1 and 2 in spring (height of raising depends on location and QSA – refer Table 11)
Watering objectives	*Ecological objectives* • Enhanced diversity in the riparian vegetation • Temporary seasonal habitats • Stimulation of germination and hatching from sediments • Improved riverine and wetland productivity • Improved hydrological connectivity of anabranch channels • Creation of small scale inundation events in low lying temporary wetland and floodplain habitats to enable feeding, breeding and recruitment opportunities for flood-dependent biota • Promotion of cycling of carbon and nutrients within the river, anabranches, floodplain and wetlands • Provide food for waterbirds and fish • Increase the growth of native vegetation • Inundate vegetation and provide habitat for frog breeding (including the nationally threatened Southern Bell Frog) • Freshen localised groundwater *Trial objectives* • Trial the approval process and communication protocols for weir manipulation
Trigger	QSA >10,000 ML/day in spring

Table 10. Modelled additional area of vegetation and wetlands inundated through weir raising. Additional area is the area above the normal level inundation for the given flow.

		Vegetation				Wetlands			
Lock	Scenario	Area inundated (ha)	Additional area inundated (ha)	% of total vegetation area not inundated at normal level, now inundated	% increase in inundated area when compared to normal level for same flow	Area inundated (ha)	Additional area inundated (ha)	% of total wetland area not inundated at normal level, now inundated	% increase in inundated area when compared to normal level for same flow
	10GL/d normal	45				972			
	10GL/d 15cm	98	53	0.9%	118%	1037	65	6%	7%
1	10GL/d 50cm	223	178	3%	395%	1189	217	22%	22%
	20GL/d normal	121				1041			
	20GL/d 15cm	173	52	0.9%	43%	1106	65	7%	6%
	20GL/d 50cm	294	173	3%	143%	1257	216	23%	21%
	10GL/d normal	58				724			
	10GL/d 20cm	91	33	0.7%	57%	766	42	9%	6%
2	10GL/d 50cm	139	81	1.7%	140%	831	106	23%	15%
	20GL/d normal	99				780			
	20GL/d 20cm	138	39	0.8%	39%	814	34	8%	4%
	20GL/d 35cm	167	68	1.5%	69%	839	59	15%	7.5%

Table 11. Description of proposed 2014-15 watering actions for weir raising under four water resource scenarios

Water Resource Scenario	Action targeted	Trigger Flow-Event (e.g. bird breeding, unregulated flow)	Desired hydrology			Vol Required (GL)	Vol Returned (GL)
			Hydrological metric	Duration	Timing		
90% AEP	No weir pool raising to minimise impact on velocity [15]	N-A	N-A	N-A	N-A	N-A	N-A
75% AEP	Weir raising at Lock 1	Flow rate between 10,000 and 20,000 ML/day at Lock 1	Weir 1 raising 15cm Maintain flow rate at 10GL/d	60 days	Sep - Dec	3.7GL [16]	3.0 GL
	Weir raising at Lock 2	Flow rate between 10,000 and 20,000 ML/day at Lock 2	Weir 2 raising 20cm Maintain flow rate at 10GL/d	60 days	Sep - Dec	3.2GL [16]	2.6 GL
50% AEP	Weir raising at Lock 1	Flow rate between 20,000 and 40,000 ML/day at Lock 1	Weir 1 raising 50cm Maintain flow rate at 20GL/d	60 days	Sep - Dec	12.2GL [16]	9.8 GL
	Weir raising at Lock 2	Flow rate between 20,000 and 30,000 ML/day at Lock 2	Weir 2 raising 35cm Maintain flow rate at 20GL/d	60 days	Sep - Dec	5.0GL [16]	4.0 GL
25% AEP	No weir pool raising as flow rate exceed weir pool raising capacity	N-A	N-A	N-A	N-A	N-A	N-A

[15] If channel watering action is undertaken and QSA is above entitlement then weir raisings proposed under 75% scenario may be undertaken (refer multi-site section for more details)
[16] Volume indicated in the table is the modelled volume required at the Lock however transmission losses from the border are assumed to be zero therefore this also represents the volume required at the border

2. Ecological rationale

The weir pool raising events planned for the Lock 1 and 2 reaches of the River Murray will contribute towards meeting the proposed objectives and sub objectives in the TLM-RMC EWMP (refer Ecological Rationale for the SA River Murray Channel and Floodplain section above).

The water level of the River Murray in South Australia is managed by a series of six weirs. Historically these weirs have been managed to provide a stable pool level upstream of each weir (±5 cm). This prolonged stabilisation of river level has had a number of negative ecological consequences, primarily by reducing the connectivity between the river and its floodplain. By changing the way in which weirs are managed and providing higher water levels in the spring-summer and lower levels in autumn-winter the effects of past management can begin to be redressed.

Some aspects of the river's natural flow regime (including for low-level wetlands and floodplain areas) can be reinstated by using the River Murray locks to manipulate weir pool height and thereby achieve desired water levels. Such manipulations can vary in magnitude, rate of change, duration, timing and frequency: the aim is to manipulate these variables to more closely mimic pre-regulation conditions that native species are adapted to and thereby achieve the greatest ecological benefits for a given volume of water. Weir pool manipulation can be used to enhance the environmental benefits received from small to medium flows by increasing the area of inundation.

Results from modelling indicate that the effect of increasing the height of the weir varied between weirs and for the different flow and weir height scenarios. The relative area of permanent and temporary wetlands inundated differed between weirs. Generally, the river red gum woodland vegetation group was preferentially inundated under the different scenarios, with lignum shrubland and samphire shrubland also often inundated. For all weirs, healthy and unhealthy stands of river red gum trees were inundated by the different weir raising scenarios, although the area varied considerably between weirs. Only in a few scenarios were healthy black box trees inundated. The influence of the weir raising was generally noticed closer to the weirs, but there were examples of wetlands near the adjacent upstream weir being inundated. Weir pool raising can promote productivity, health and diversity of floodplain vegetation in areas inundated and contribute towards meeting the landscape –scale SA River Murray channel and floodplain targets and EWRs, to a certain degree, independent of flow.

Weir pool raising for environmental benefit has been undertaken a number of times in the Lower Murray. The first occasion occurred in conjunction with the October 2000 flow augmentation. At this time the weir at Lock 5 on the main channel of the River Murray was raised by 50 cm for a period of two weeks. This was done to prolong the flood and increase the area and depth of floodplain inundation. The weir at Lock 4 was also raised by 40 cm to ease pressure on the Lock 5 weir. This rise in weir pool level inundated 11% of the floodplain in the Lock 5-6 reach, an extent that under normal operating conditions would require a 70 000 ML/day flow (Siebentritt et al., 2004). Further raisings were undertaken in 2005 when in March and April Lock 6 was raised by 15 cm. Later in the year, from September through to January, Lock 1 was raised by 10 cm; Lock 4 by 30 cm; Lock 5, 50 cm and Lock 6, 15 cm. This raising corresponded with a change in biofilm communities and an improvement in riparian tree condition (Souter et al., 2010).

3. Consultation

The proposed weir pool raising event for spring 2014 will be managed in conjunction with the MDBA, CEWO, SA Water and Nature Foundation South Australia (NFSA). Each has representation on the Weir Pool Manipulation Steering Committee (WPMSC). A Weir Pool Manipulation Advisory Committee (WPMAC) will continue to provide technical input into the event. The WPMAC comprises members from DEWNR, University of Adelaide and NFSA. Landholders and relevant stakeholder groups in the Lock 1 to Lock 2 river reaches will be advised about the event.

They are invited to have a conversation with DEWNR and meetings will be proposed to people who are interested in the event. Phone calls to relevant council, NRM groups and Local Action Planning Groups are being made to inform them and organise meetings where required. Information sheets, web site information and a media release will be tailored for the planned spring 2014 weir pool raising event. An interview with Riverland ABC is being organised to talk about the RRP weir pool project and its ecological benefits.

4. Management and Monitoring

A detailed monitoring plan, with a focus on both benefits and risks, was developed for a similar planned event in 2013 and will be revisited for 2014-15. Broadly, the monitoring seeks to answer a range of questions:

- Did raising inundate the area expected?
- What was the impact on private infrastructure?
- Over how much of the area did the vegetation respond?
- What was the nature of the vegetation response in the short and long term?
- For how long did the response last?
- When do we need to repeat the weir pool management intervention?

It is proposed that all monitoring and evaluation for weir pool manipulation events will be undertaken in accordance with the monitoring and evaluation plans developed through the Riverine Recovery Project (insert ref for Monitoring and Evaluation Program: Conceptual understanding of the ecological response to water level manipulation and Riverine Recovery Monitoring and Evaluation Program: Technical Design.)

PART E: WETLANDS

1. Proposed Watering Actions and Objectives

Three types of priority actions targeting discreet wetland areas have been identified for 2014-15: pumping to temporary wetland basins or floodplain areas; water delivery to Berri Evaporation Basin and Disher Creek, and; implementation of hydrological cycles at managed pool-connected wetlands.

Pumping environmental water to up to 28 temporary wetland basins or floodplain areas along the SA River Murray (including the Lower Lakes) has been identified as a priority watering action for 2014-15. The broad objective for this action is to maintain diverse habitats and refuge areas across the landscape in the absence of natural flows. This pumping action also contributes towards the broader floodplain or channel targets when flows are insufficient to meet them at a landscape scale. For instance, one of the SA River Murray channel targets is that 70 percent of river red gums in the area inundated by flows of 10,000-40,000 ML/day have a Tree Condition Index score ≥ 10. The EWR for this target is flows of 40,000 ML/day for 90 days with an average return frequency of 2 years, which is only likely to occur in 2014-15 under a wet scenario (25 percent AEP). The watering history at the pumped sites will be closer to that specified by the EWR and acts to support localised stands of trees at higher elevations that otherwise would not receive water. The watering objectives for individual sites vary (see Table 18 in Appendix A).

For most wetlands, pumping to fill plus a number of regular (monthly) top-ups is proposed so that water levels are maintained for at least four months. Other sites require a fill volume only. Many wetlands have existing infrastructure to retain water and prevent it from flowing back to the River, while others require the installation of temporary embankments.

The number of sites requiring pumping will depend on the water resource scenario experienced (Table 12). As flows increase, the commence-to-flow levels of more wetlands are exceeded and these areas are inundated naturally, hence removing the need for pumping. The implementation of SA River Murray channel watering actions (see section above) may also result in higher flows and water levels, and therefore contribute to the inundation of some of the proposed pumping sites. Water delivery through connection with the River is preferred as it reduces the cost of water delivery and provides increased ecological benefits such as improved lateral connectivity. Funding availability may mean that water cannot be delivered to all temporary wetlands identified, and further prioritisation will then be undertaken by Natural Resources SA MDB in consultation with stakeholders.

Action 1: Pump to temporary wetland basins and floodplain areas

High level objective	Maintain diverse habitats and refuge areas
Description	Generally pump to fill, plus undertake regular (monthly) top-ups to maintain water levels for at least four months
Watering objectives	Site-dependent, but may include: • Maintain/improve River red gum condition • Maintain condition and support establishment of River red gum-black box seedlings • Maintain lignum condition • Improve groundcover beneath black box • Maintain condition of understorey vegetation • Stimulate germination of aquatic vegetation and allow completion of life cycle to increase seed bank resilience • Maintain water quality to within known thresholds of wetland biota • Provide habitat for frogs including the nationally threatened Southern Bell Frog • Provide suitable frog breeding habitat • Provide suitable foraging habitat for migratory waders • Support waterbird breeding and habitat • Maintain habitat (including nesting, roosting and foraging resources) for the nationally threatened Regent Parrot
Trigger	Seasonal (spring) and River flows will not reach the commence to flow level (CTF) of the wetlands and the sites will not inundated by natural flows in 2014-15

Action 2: Maintain water level at Berri Evaporation Basin and Disher Creek

High level objective	Support Murray hardyhead populations
Description	Deliver water via gravity to maintain water level at or above pool all year round. Disher Creek may require the structure to be closed and water delivered via pumping
Watering objectives	• Maintain water quality in core Murray hardyhead habitat at levels in which a healthy Murray hardyhead population, including breeding events, can be sustained (i.e. salinity 10,000 - 31,000 EC) • Maintain suitable Murray hardyhead habitat in Disher Creek to support a healthy breeding population of Murray hardyhead (i.e. salinity 10,000 - 31,000 EC and water levels 13.2 - 13.4 m AHD) • Maintain suitable Murray hardyhead habitat in the Berri Evaporation Main Basin, Surface Channel and Outlet Creek to support a healthy breeding population of Murray hardyhead (i.e. salinity 10,000 - 31,000 EC and water level 13.2 m AHD) • Support habitat for waterbird species, including threatened and migratory species, and provide breeding opportunities within the Berri Evaporation Basin
Trigger	Salinity or water levels predicted to go outside described tolerance thresholds listed above

Action 3: Implement hydrological regimes at managed pool-connected wetlands

High level objective	Maintain/improve maintain wetland condition
Description	Operate flow regulators to implement wetting and drying regimes (refer individual wetland management plans)
Watering objectives	Site-dependent (refer individual wetland management plans)
Trigger	Variable (refer individual wetland management plans)

Table 12. Description of proposed 2014-15 watering actions for discreet wetland areas under four water resource scenarios

Water Resource Scenario	Action targeted	Trigger Flow/Event (e.g. bird breeding, unregulated flow)	Desired hydrology			Vol Required (GL)	Vol Returned (GL)
			Hydrological metric	Duration	Timing		
90 percent AEP	Action 1: Pump to temporary wetland basins-floodplain areas	River flows/water levels below commence-to-flow of wetland	Fill to top-of-bank +/- regular top-ups (up to 28 sites)	4 months	Spring-summer +/- top-ups over summer	~10.0 GL	N-A
	Action 2: Maintain water level at Berri Evaporation Basin and Disher Creek	Water quality or levels predicted to go outside described tolerance thresholds	Maintain water level above 13.2 mAHD; maintain salinity between 10,000 – 31,000 EC	12 months	Throughout 2014-15	~1.5 GL	N-A
	Action 3: Implement hydrological regimes at managed pool-connected wetlands[17]	Site-specific – refer individual management plans				~35.0 GL[18]	N-A
75 percent AEP	Action 1: Pump to temporary wetland basins-floodplain areas	River flows/water levels below commence-to-flow of wetland	Fill to top-of-bank +/- regular top-ups (up to 22 sites)	4 months	Spring-summer +/- top-ups over summer	~9.5 GL	N-A
	Action 2: Maintain water level at Berri Evaporation Basin and Disher Creek	Water quality or levels predicted to go outside described tolerance thresholds	Maintain water level above 13.2 mAHD; maintain salinity between 10,000 – 31,000 EC	12 months	Throughout 2014-15	~1.5 GL	N-A
	Action 3: Implement hydrological regimes at managed pool-connected wetlands	Site-specific – refer individual management plans				~35.0 GL	N-A

[17] Note Action 3 incorporates maintaining flow through Bookmark Creek throughout 2014-15. A management plan is currently under development for this site.
[18] Specific water allocation (Class 9 water) available to undertake this action - refer to the Annual Plan for further detail

Water Resource Scenario	Action targeted	Trigger Flow/Event (e.g. bird breeding, unregulated flow)	Desired hydrology			Vol Required (GL)	Vol Returned (GL)
			Hydrological metric	Duration	Timing		
50 percent AEP	Action 1: Pump to temporary wetland basins-floodplain areas	River flows/water levels below commence-to-flow of wetland	Fill to top-of-bank +/- regular top-ups (up to 15 sites)	4 months	Spring-summer +/- top-ups over summer	~6.0 GL	N-A
	Action 2: Maintain water level at Berri Evaporation Basin and Disher Creek	Water quality or levels predicted to go outside described tolerance thresholds	Maintain water level above 13.2 mAHD; maintain salinity between 10,000 – 31,000 EC	12 months	Throughout 2014-15	<1.5 GL[19]	N-A
	Action 3: Implement hydrological regimes at managed pool-connected wetlands	Site-specific – refer individual management plans				<35.0 GL[19]	N-A
25 percent AEP	Action 1: Pump to temporary wetland basins-floodplain areas	River flows/water levels below commence-to-flow of wetland	Fill to top-of-bank +/- regular top-ups (up to 8 sites)	4 months	Spring-summer +/- top-ups over summer	~3.0 GL	N-A
	Action 2: Maintain water level at Berri Evaporation Basin and Disher Creek	Water quality or levels predicted to go outside described tolerance thresholds	Maintain water level above 13.2 mAHD; maintain salinity between 10,000 – 31,000 EC	12 months	Throughout 2014-15	<1.5 GL[19]	N-A
	Action 3: Implement hydrological regimes at managed pool-connected wetlands	Site-specific – refer individual management plans				<35.0 GL[19]	N-A

[19] Volume of environmental water required will depend on magnitude and duration of unregulated flows

2. Ecological Rationale

Management plans exist for most of the sites identified for watering in 2014-15, and the watering actions are consistent with the objectives of these plans.

Five-year hydrographs have been developed for managed pool-connected wetlands and these will be adhered to in 2014-15 unless a change in management is triggered due to monitoring results or a change in climatic conditions e.g. unregulated flows.

Each of the temporary wetlands' need for water in 2014-15 has been determined by the wetland and floodplain team within Natural Resources SA MDB (DEWNR) in consultation with other stakeholders (see Consultation below). This assessment was based on monitoring data, hydrology (actual versus desired), a conceptual understanding of the water requirements of different species or communities, and observed responses from previous watering

Monitoring data indicating a need for watering in 2014-15 varies between sites but may include a change in trajectory or decline in the condition of long-lived vegetation (adults and -or juveniles). Where significant fauna species (e.g. southern bell frogs; regent parrots) are known to use a site, watering may be required to provide conditions that support these species' survival or breeding.

Hydrology was determined by taking into consideration what the natural flooding frequency may have been under natural conditions and what the flooding frequency has been over the past ten to twenty years, and determining a preferred frequency (which is below natural and above current).

Berri Saline Water Disposal Basin and Disher Creek Saline Water Disposal Basin provide habitat for two of four remaining Murray hardyhead populations within South Australia. The current conservation status of the Murray hardyhead is:

- National: (EPBC Act 1999) Listed 'Endangered';
- South Australia: 'Endangered' (Action Plan for SA freshwater fishes);
- NSW and Vic: 'Critically Endangered'; and
- International: IUCN Redlist for threatened species.

Murray hardyhead were historically widespread throughout the Murray-Darling Basin but now have a very restricted and declining distribution within Victoria and South Australia, occurring in a few wetlands and saline basins along the Lower Murray and in the Lower Lakes. Murray hardyhead are assumed 'extinct' in NSW. Murray hardyhead are relatively short-lived, generally only surviving for one year, therefore failed recruitment over one year may result in that populations' failure to survive.

Berri Saline Water Disposal Basin and Disher Creek Saline Water Disposal Basin are high priority sites for conservation of the Murray hardyhead and the fish populations within both sites in February 2014 are considered to be healthy and stable. Maintenance of both the Disher Creek and Berri Evaporation Basin populations is a key strategy to ensure the survival of the species in the Lower Murray and is a key action outlined in the Action Plan for South Australian Freshwater Fishes (Hammer *et al* 2009).

3. Consultation

Natural Resources SA MDB runs an ongoing monitoring and management program and have existing strong connections to community wetland groups and landholders. Landholders, Wetland Groups, Local Action Planning Groups and Traditional Owners (i.e. FPRMM), as well as the SA MDB Basin NRM Board and River Murray Advisory Committee, have been consulted on the proposed pumping and are supportive of the actions.

A variety of stakeholder groups were consulted during the development of watering proposals and state annual priorities through the distribution of factsheets, with queries and comment invited. In response to the information sheets provided to stakeholders, several people contacted DEWNR regarding specific sites for environmental watering. These included Pike-Mundic floodplain, Whirlpool Corner, Gurra wetland and Calperum station. All of these sites have been incorporated into the priorities for 2014-15.

4. Management and Monitoring

Operational monitoring will be undertaken at all sites, with parameters monitored including volumes and timing of water delivery, and water quality.

Ecological monitoring will depend on resources. Where possible, monitoring will focus on the objectives stated for each site (Table 18).

Glossary

Units of measurement commonly used (SI and non-SI Australian legal)

Name of unit	Symbol
Day	d
Gigalitre	GL
Megalitre	ML

Terms and Acronyms

AEP – Annual Exceedence Probability

ASS – Acid Sulfate Spils

AHD – Australian Height Datum

Barrage — Specifically, any of the five low weirs at the mouth of the River Murray constructed to exclude seawater from the Lower Lakes

Basin — The area drained by a major river and its tributaries

CEWH – The Commonwealth Environmental Water Holder; the person charged with responsibility for the Commonwealth Government's water that is held for environmental purposes

CEWO – The Commonwealth Environmental Water Office; the office that supports the CEWH

CWMB – Catchment Water Management Board

DEWNR — Department of Environment, Water and Natural Resources (Government of South Australia)

DWLBC — (former) Department of Water, Land and Biodiversity Conservation (Government of South Australia)

Diversity — The distribution and abundance of different kinds of plant and animal species and communities in a specified area

EC — Electrical conductivity; 1 EC unit = 1 micro-Siemen per centimetre (µS/cm) measured at 25°C; commonly used as a measure of water salinity as it is quicker and easier than measurement by TDS

Ecosystem — Any system in which there is an interdependence upon, and interaction between, living organisms and their immediate physical, chemical and biological environment

Endangered species — (1) Any species in danger of extinction throughout all or a significant portion of its range

Entitlement flows — Minimum monthly River Murray flows to South Australia agreed in the Murray-Darling Basin Agreement 1992

Environmental water requirements — The water regimes needed to sustain the ecological values of aquatic ecosystems, including their processes and biological diversity, at a low level of risk

Fishway — A generic term describing all mechanisms that allow the passage of fish along a waterway; specific structures include fish ladders (gently sloping channels with baffles that reduce the velocity of water and provide resting places for fish as they 'climb' over a weir) and fishlifts (chambers, rather like lift-wells, that are flooded and emptied to enable fish to move across a barrier)

Floodplain — Of a watercourse means: (1) floodplain (if any) of the watercourse identified in a catchment water management plan or a local water management plan; adopted under the Act; or (2) where (1) does not apply —

the floodplain (if any) of the watercourse identified in a development plan under the *Development (SA) Act 1993*; or (3) where neither (1) nor (2) applies — the land adjoining the watercourse that is periodically subject to flooding from the watercourse

Flow bands — Flows of different frequency, volume and duration

Flow regime — The character of the timing and amount of flow in a stream

Habitat — The natural place or type of site in which an animal or plant, or communities of plants and animals, live

Indigenous species — A species that occurs naturally in a region

Infrastructure — Artificial lakes; dams or reservoirs; embankments, walls, channels or other works; buildings or structures; or pipes, machinery or other equipment

KEAs - Key Environmental Assets

LAP – Local Action Planning

LLCMM – Lower Lakes, Coorong and Murray Mouth; one of the TLM icon sites

MDBA – Murray-Darling Basin Authority

MDBC – (former) Murray-Darling Basin Commission

MERI Framework – Monitoring, Evaluation, Reporting and Improvement Framework

Model — A conceptual or mathematical means of understanding elements of the real world that allows for predictions of outcomes given certain conditions. Examples include estimating storm run-off, assessing the impacts of dams or predicting ecological response to environmental change

Monitoring — (1) The repeated measurement of parameters to assess the current status and changes over time of the parameters measured (2) Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, animals and other living things

NFSA – Nature Foundation of South Australia

NGO – Non-governmental Organisation

QSA – Flow to South Australia, as measured at the State border

Ramsar Convention — An international treaty on wetlands titled *The Convention on Wetlands of International Importance Especially as Waterfowl Habitat*

SA MDB NRM Board – South Australian Murray-Darling Basin Natural Resources Management Board

Threatened species — Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range

TLM – The Living Murray (MDBA program)

Water allocation — (1) In respect of a water licence means the quantity of water that the licensee is entitled to take and use pursuant to the licence; (2) in respect of water taken pursuant to an authorisation under s.11 means the maximum quantity of water that can be taken and used pursuant to the authorisation

WAP — Water Allocation Plan; a plan prepared by a CWMB or water resources planning committee and adopted by the Minister in accordance with the Act

Water dependent ecosystems — Those parts of the environment, the species composition and natural ecological processes, that are determined by the permanent or temporary presence of flowing or standing water, above or

below ground; the in-stream areas of rivers, riparian vegetation, springs, wetlands, floodplains, estuaries and lakes are all water-dependent ecosystems

Water licence — A licence granted under state legislation entitling the holder to take water from a prescribed watercourse, lake or well or to take surface water from a surface water prescribed area; this grants the licensee a right to take an allocation of water specified on the licence, which may also include conditions on the taking and use of that water; a water licence confers a property right on the holder of the licence and this right is separate from land title

Water year - The period between 1 July in any given calendar year and 30 June the following calendar year; also called a licensing year or a water-use year.

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Appendices

A. SA River Murray multi-site modelling methods

Modelling was undertaken by the Science, Monitoring and Knowledge area of DEWNR. Inputs included:

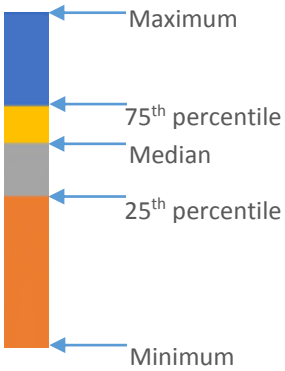
- Data for the 90 percent and 75 percent AEP from the MDBA multi-history run dated 1 February 2014. This data was provided by MDBA.
- The proposed monthly environmental water delivery pattern (Table 13), which describes the volume of environmental water to be added to the AEP hydrographs each month

Table 13. Proposed monthly environmental water delivery pattern for 2014-15 SA River Murray multi-site watering action (based on MDBA multi-history run dated 1 February 2014)

Scenario	Indicative volume (GL) of environmental water required-per month												Total est. volume (GL)
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	
90% AEP	10	10	100	130	160	100	10	10	10	10	10	10	570
75% AEP	10	10	80	130	200	100	80	30	10	10	10	10	680

Each scenario was simulated over a 30 year period, with the historical diversions and evaporative losses adopted over the period 1 July 1980 – 30 June 2011. At the end of each water year the Lake Alexandrina and Lake Albert water level was reset to 0.65 m. June barrage flow results should be ignored, as they may also include artificial volumes used to reset the lakes.

From the range of results obtained, the minimum, 25th percentile, median, 75th percentile and maximum values were calculated for each day for Lake Alexandrina water level. The automated barrage flow calculation is influenced by small changes in water level, as such the daily results simulated have unrealistically fast changes in flow (i.e. swapping from 0 to 2000 ML/d each day over a number of days). In order to present more representative results, the average barrage flow over each month is presented using the symbology below.



B. Lower Lakes, Coorong and Murray Mouth Targets and Objectives

Table 14 below is taken from the LLCMM Icon Site Environmental Water Management Plan (MDBA 2014) and illustrates the agreed ecological targets and icon site objectives and how they relate to each other for the LLCMM. These do not directly correlate with the watering objectives for the planned watering actions, but the planned watering actions will contribute to their achievement.

Table 14: Targets and objectives of the LLCMM icon site

Target ID#	Ecological Target	Icon Site Objective		
		Open Mouth	Fish Recruitment	Bird Habitat
B1	Maintain or improve bird populations in the Lower Lakes, Coorong and Murray Mouth	✓		✓
F1	Maintain or improve recruitment success of diadromous fish in the Lower Lakes and Coorong	✓	✓	
F2	Maintain or improve recruitment success of endangered fish species in the Lower Lakes		✓	
F3	Provide optimum conditions to improve recruitment success of Small-mouthed Hardyhead *Craterocephalus fluviatilis* in the South Lagoon		✓	
F4	Maintain or improve populations of Black Bream *Acanthopagrus butcheri*, Greenback Flounder *Rhombosolea tapirina* and Mulloway *Argyrosomus japonicas* in the Coorong	✓	✓	
I1	Maintain or improve invertebrate populations in mudflats (both exposed and submerged)	✓	✓	✓
I2	Provide freshwater flows that provide food sources for Goolwa Cockles *Donax deltoides*	✓		
M1	Facilitate frequent changes in exposure and submergence of mudflats	✓		✓
M2	Maintain habitable sediment conditions in mudflats			✓
V1	Maintain or improve *Ruppia megacarpa* colonisation and reproduction		✓	✓
V2	Maintain or improve *Ruppia tuberosa* colonisation and reproduction		✓	✓
V3	Maintain or improve aquatic and littoral vegetation in the Lower Lakes		✓	✓
W1	Establish and maintain variable salinity regime with >30 percent of area below sea water salinity concentrations in estuary and North Lagoon		✓	✓
W2	Maintain a permanent Murray Mouth opening through freshwater outflows with adequate tidal variations to improve water quality and maximise connectivity	✓	✓	✓
W3	Maximise fish passage connectivity between the Lower Lakes and Coorong		✓	
W4	Maximise fish passage connectivity between the Coorong and the sea	✓	✓	

Icon Site Objectives – Open Mouth: an open Murray Mouth; Fish Recruitment: more frequent estuarine fish recruitment; Bird Habitat: enhanced migratory wader bird habitat in the Lower Lakes. Target ID – B: bird-related; F: fish-related; I: invertebrate-related; M: mudflat-related; V: vegetation-related; W: water-related.

C. South Australian River Murray Floodplain Interim Targets and Environmental Water Requirements

Table 15: Interim Environmental Water Requirements and targets for the SA River Murray Floodplain

SA EWR #	Target	Environmental Water Requirement			
		Flow (ML/day)	Duration (days)	Timing	Average Frequency (years)
BB1	Maintain and improve the health of 80% of the Black Box *Eucalyptus largiflorens* woodlands	>100,000	20	Spring or summer	1 in 6 (max interval 8 years)
BB2	Maintain and improve the health of ~60% of the Black Box woodlands	100,000	20	Spring or summer	1 in 5 (max interval 8 years)
BB3	Maintain and improve the health of ~50% of the Black Box woodlands	85,000	30	Spring or summer	1 in 5 (max interval 8 years)
BBr1	Successful recruitment of cohorts of Black Box at lower elevations	85,000	20	Spring or early summer	1 in 10 (+ successive years[20])
BBr2	Successful recruitment of cohorts of Black Box at higher elevations	>100,000	20	Spring or early summer	1 in 10 (+ successive years[20])
FP	Stimulate spawning, provide access to the floodplain and provide nutrients and resources	80,000	>30	Jun to Dec	1 in 4 (max interval 5 years)
Lig1	Maintain and improve the health of ~50% of the Lignum *Muehlenbeckia florulenta* shrubland	70,000	30	Spring or early summer	1 in 3 (max interval 5 years)
Lig2	Maintain and improve the health of 80% of the Lignum shrubland	80,000	30	Spring or early summer	1 in 5 (max interval 8 years)
Mos1	Provide mosaic of habitats (i.e. larger proportions of various habitat types are inundated)	90,000	30	Spring or early summer	1 in 5 (max interval 6 years)
Mos2	Provide mosaic of habitats (i.e. larger proportions of various habitat types are inundated)	80,000	>30	Spring or early summer	1 in 4 (max interval 5 years)
Mos3	Provide mosaic of habitats (i.e. larger proportions of various habitat types are inundated)	70,000	60	Spring or early summer	1 in 4 (max interval 6 years)
Mos4	Provide mosaic of habitats (i.e. larger proportions of various habitat types are inundated)	60,000	60	Spring or early summer	1 in 3 (max interval 4 years)
RG	Maintain and improve the health of 80% of the River Red Gum *Eucalyptus camaldulensis* woodlands and forests (adult tree survival)	80,000 to 90,000	>30	Jun to Dec	1 in 4 (max interval 5 yrs)
RGr	Successful recruitment of cohorts of River Red Gums	80,000	60	Aug to Oct	1 in 5[21] (+ successive years[20])
TW1	Inundation of (~80%) temporary wetlands for large-scale bird and fish breeding events	80,000	>30	Jun to Dec	1 in 4 (max interval 5 years)
TW2	Maintain and improve majority of lower elevation (~20%) temporary wetlands in healthy condition; and Inundate lower elevation temporary wetlands for small-scale bird and fish breeding events and microbial decay/export of organic matter	40,000	90	Aug to Jan	1 in 2 (max interval 3 years)

[20] EWR for Black Box and River Red Gum recruitment includes the need for flooding in successive years – i.e. floods must occur in at least two consecutive years for successful recruitment.

[21] The EWR for River Red Gum recruitment in DWLBC 2010 did not specify preferred frequency. To enable analysis, the frequency provided within Ecological Associates, 2010 was used.

WB1	Maintain Lignum inundation for waterbird breeding events	70,000	60	Aug to Oct	1 in 4 (max interval 6 years)
WB2	Provide habitat (River Red Gum communities) for waterbird breeding events	70,000	60	Aug to Oct	1-in-4 (max interval 6 years)

D. South Australian River Murray Channel Targets and Environmental Water Requirements

Table 16. SA River Murray channel ecological objectives and targets

Type	Asset or Function	Ecological Objective	Ecological Target
Ecosystem processes	Function	Provide for the mobilisation of carbon and nutrients from the floodplain to the river to reduce the reliance of instream foodwebs on autochthonous productivity.	Open-water productivity shows a temporary shift from near zero or autotrophic dominance (positive Net Daily Metabolism) towards heterotrophy (negative Net Daily Metabolism) when QSA >30,000 ML/day.
	Function	Provide diverse hydraulic conditions over the range of velocity classes in the lower third of weir pools so that habitat and processes for dispersal of organic and inorganic material between reaches are maintained.	Habitat across the range of velocity classes is present in the lower third of weir pools for at least 60 consecutive days in Sep–Mar, at a maximum interval of 2 years.
	Function	Maintain a diurnally-mixed water column to ensure diverse phytoplankton and avoid negative water quality outcomes	Thermal stratification does not persist for more than 5 days at any time.
	Function	Ensure adequate flushing of salt from the Murray to the Southern Ocean.	Basin Plan Target: Salt export, averaged over the preceding 3 years, is ≥2 million tonnes per year.
Water Quality	Function	Maintain water quality to support aquatic biota and normal biogeochemical processes.	Biovolume <4 mm3 L-1 for all Cyanobacteria, where a known toxin producer is dominant.
			Biovolume <10 mm3 L-1 for all Cyanobacteria, where toxins are not present.
			Basin Plan Target: Maintain dissolved oxygen above 50% saturation throughout water column at all times.
Biofilms	Asset	Promote bacterial rather than algal dominance of biofilms and improve	Annual median biofilm composition is not dominated (>80%) by filamentous

Type	Asset or Function	Ecological Objective	Ecological Target
		food resource quality for consumers.	algae.
			Annual median biofilm C:N ratios are <10:1.
Riparian vegetation	Asset	Throughout the length of the river channel asset (i.e. SA border to Wellington), establish and maintain a diverse native flood-dependent plant community in areas inundated by flows of 10,000–40,000 ML/day.	In standardised transects spanning the elevation gradient in the target zone†, 70% of river red gums have a Tree Condition Index score ≥ 10.
			A sustainable demographic is established to match the modelled profile for a viable river red gum population in existing communities spanning the elevation gradient in the target zone.
			Species from the Plant Functional Group 'flood-dependent/responsive' occur in 70% of quadrats spanning the elevation gradient in the target zone† at least once every 3 years.
Wetland vegetation	Asset	Throughout the length of the river channel asset (i.e. SA border to Wellington), establish and maintain a diverse macrophyte community in wetlands inundated by flows up to 40,000 ML/day.	Native macrophytes from the emergent, amphibious and flood-dependent functional groups occur in 70% of quadrats spanning the elevation gradient in the target zone† at least once every 3 years.
Wetlands	Asset	Maintain habitats and provide for dispersal of organic and inorganic material and organisms between river and wetlands.	Inundation periods in temporary wetlands have unrestricted lateral connectivity between the river and wetlands in >90% of inundation events.
Groundwater and soil	Asset	Throughout the length of the river channel asset (i.e. SA border to Wellington), establish and maintain groundwater and soil moisture conditions conducive to improving	Establish and maintain freshwater lenses in near-bank recharge zones.
			Maintain soil water availability, measured as soil water potential > -1.5 MPa at soil depth 20–50 cm, to sustain

Type	Asset or Function	Ecological Objective	Ecological Target
		riparian vegetation.	recruitment of long-lived vegetation across the elevation gradient in the target zone
			Reduce soil salinity (measured as EC 1:5) to <5000 µS cm-1 to prevent shifts in understorey plant communities to salt-tolerant functional groups across the elevation gradient in the target zone.
Fish	Asset	Restore the distribution of native fish.	Expected species occur in each mesohabitat (channel, anabranch, wetlands) in each weir pool/reach.
		Restore resilient populations of Murray cod (a long-lived apex predator).	Population age structure of Murray cod includes recent recruits, sub-adults and adults in 9 years in 10.
			Population age structure of Murray cod indicates a large recruitment event 1 year in 5, demonstrated by a cohort representing >50% of the population.
			Abundance (CPUE5) of Murray cod increases by ≥50% over a 10-year period.
		Restore resilient populations of golden perch and silver perch (flow-dependent specialists).	Population age structure of golden perch and silver perch includes YOY with sub-adults and adults in 8 years in 10.
			Population age structure of golden perch and silver perch indicates a large recruitment event 2 years in 5, demonstrated by separate cohorts representing >30% of the population.
			Abundance (CPUE) of golden perch and silver perch increases by ≥30% over a 5-year period.

Type	Asset or Function	Ecological Objective	Ecological Target
Fish	Asset	Restore resilient populations of freshwater catfish.	Population age structure of freshwater catfish includes YOY, with sub-adults and adults in 9 years in 10.
			Population age structure of freshwater catfish indicates a large recruitment event 2 years in 5, demonstrated by separate cohorts representing >30% of the population.
			Abundance (CPUE) of freshwater catfish increases by ≥30% over a 5-year period.
		Restore and maintain resilient populations of foraging generalists (e.g. Australian smelt, bony herring, Murray rainbowfish, unspecked hardyhead, carp gudgeons, flathead gudgeons).	The length-frequency distributions for foraging generalists include size classes showing annual recruitment.
		Minimise the risk of carp recruitment.	The relative abundance and biomass of common carp does not increase in the absence of increases in abundance and biomass of flow-dependent native fish.

Table 17. SA River Murray Channel Environmental Water Requirements

EWR #	Median discharge (ML day^{-1})	Discharge (ML day^{-1})	Duration (days)	Preferred timing	Average return frequency (years)	Percentage of years flow is required	Maximum return interval (years)
IC1	10,000	7000 - 12,000	60	Sep-Mar	1.05	95	2
IC2	15,000	15,000 -20,000	90	Sep-Mar	1.33	75	2
IC3	20,000	15,000 - 25,000	90	Sep-Mar	1.8	55	2
IC4	25,000	20,000 - 30,000	60	Sep-Mar	1.7	59	2
IC5	30,000	25,000 - 35,000	60	Sep-Mar	1.8	55	2
IC6	35,000	30,000 - 40,000	60	Sep-Mar	1.8	55	2
IC7	40,000	35,000 - 45,000	90	Sep-Mar	2.1	48	3

Reference: Wallace, T.A., Daly, R., Aldridge, K.T., Cox, J., Gibbs, M.S., Nicol, J.M., Oliver, R.L., Walker, K.F., Ye, Q., Zampatti, B.P. 2014, *River Murray Channel: Environmental Water Requirements: Ecological Objectives and Targets,* Goyder Institute for Water Research Technical Report Series No. 14/4, Adelaide, South Australia.

A. Temporary wetlands and floodplain areas identified for pumped environmental water delivery in 2014-15

Table 18. Proposed sites and watering objectives for pumping in 2014-15

Site	Commence-to flow (QSA ML/day)	Surface area (ha)	Volume to fill (ML)	Volume to top-up (ML)	2014-15 Watering action	Watering objectives										
						Redgum	Black box	Lignum	Aquatic veg	Understorey	Frogs	Fish	EPBC birds	Waterbirds	Regent parrots	Water quality
Milang	NA (Lower Lakes)	8.5	43	-	Pump in spring-summer				√				√			
Tolderol (bays 7, 12 and 13)	NA (Lower Lakes)	38.6	232	104	Pump in spring-summer						√		√			
Point Sturt	NA (Lower Lakes)	8.0	22	16	Pump in spring-summer						√					√
Gollan's Waterhole	NA (Lower Lakes)	1.0	4	-	Pump in summer						√	√		√		√
Templeton	10,000	8.0	80	40	Pump in spring-summer	√					√					
Old Loxton Road	10,000 -15,000	1.6	18	10	Pump and top-up in spring-summer			√			√					√
Overland Corner - Larger basin	15,000 -30,000	93.0	500	200	Pump in late winter-early spring with top ups to maintain water levels throughout spring and summer for ~ 3 months. Embankment required.	√		√			√					
Overland Corner - lignum basins	15,000 -30,000	93.0	500	200	Pump in winter-early spring with top ups to maintain water levels throughout spring and summer for ~ 3 months. Embankment required	√		√			√					

Site	Commence-to flow (QSA ML/day)	Surface area (ha)	Volume to fill (ML)	Volume to top-up (ML)	2014-15 Watering action	Watering objectives										
						Redgum	Black box	Lignum	Aquatic veg	Understorey	Frogs	Fish	EPBC birds	Waterbirds	Regent parrots	Water quality
Whirlpool Corner	15,000 - 30,000	11.0	60	30	Pump in spring with potential top ups to maintain water levels throughout spring and summer, plus water seedlings via sprinklers.	√	√		√		√					
Yabby Creek and Katarapko Basins	15,000 - 40,000	100.0	1500		Pump	√	√							√		
Sugar Shack Temporary S0000556	20,000 - 23,000	5.4	40	25	Pump. Embankment required.						√		√			
Morgan Conservation Park (South Lagoons)	20,000 - 30,000	15.0	140	50	Pump	√		√			√				√	
Piggy Creek	25,000	33.2	300	64	Pump. Embankment required.	√							√	√		
Martins Bend temporary wetlands	25,000 - 65,000	16.0	230	-	Pump	√	√	√			√					
Akuna Station	30,000	6.0	105	-	Pump	√				√	√					
Markaranka South	30,000	69.0	1800		Pump. Embankment required.	√			√					√	√	
Wiela - pumped site	30,000	7.0	220	35	Pump in spring with potential top ups to maintain water levels throughout spring and summer.	√		√			√					
Morgans East	30,000	7.0	101	40	Pump	√		√								
Wiela Shedding Basin	30,000 - 40,000	2.0	1		Monthly watering of red gum seedlings via dripper irrigation	√										
Sugar Shack Temporary S0000555	40,000 - 45,000	1.2	5	3	Pump to inundate the wetland to 1.7mAHD for 3 months	√					√					
Wigley Reach	50,000	10.0	278	48	Pump	√					√					

Site	Commence-to flow (QSA ML/day)	Surface area (ha)	Volume to fill (ML)	Volume to top-up (ML)	2014-15 Watering action	Watering objectives										
						Redgum	Black box	Lignum	Aquatic veg	Understorey	Frogs	Fish	EPBC birds	Waterbirds	Regent parrots	Water quality
Molo Flats (incl East and West Basins and Floodrunner)	60,000	62.2	450	250	Pump. Embankment required.	√					√					
Katarapko Creek	60,000	4.0	23	10	Pump	√					√			√		
Markaranka East	65,000	9.0	600	200	Pump from South Basin into East Basin.	√		√			√					
Gerard Black Box waterings	High	5.0	2		Pump into tanks then gravity via pipe infrastructure		√			√						
Gerard Lignum Basins	TBD	TBD	TBD	TBD	Pump. May need embankment or sandbags.	√		√			√					
Nikalapko	TBD	46.0	800	226	Pump. Embankment (or aquabarrier) required.	√					√				√	
Island Reach	TBD	TBD	TBD	TBD	TBD	√									√	

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