Murray-Darling Basin Commission submission to Senate Inquiry into water management of the Lower Lakes and Coorong:

Executive Summary

In considering water needs of the Lower Lakes and Coorong, there are different timeframes and urgencies with regard to various pressures and environmental issues. For work currently being progressed by the Commission office (supported by partner governments in the Basin), the short term focus has been on avoiding irreversible damage to the lake system with regard to the threat of acidification.

Under the worst case scenario (of minimum record inflows and maximum temperatures) a relatively small amount of water would be required to avoid acidification before next winter. Under anything less than the worst case, the lakes are at low risk of acidification before the next winter inflow period.

These predictions are based on the best available science / modelling which is currently being peer reviewed on behalf of partner governments. Given the unprecedented situation of predicting the acidification process on this scale in Australia in a complex environment, the prediction of the acidification point could change. Any change to the prediction would be based on real time monitoring of the actual changes taking place in the lakes (South Australia is currently implementing an enhanced monitoring program with “in principle” funding by the Commission). This “real time” approach is the proposed management strategy for the short-term situation.

With regard to seeking additional water, the availability of resource in the Basin is still at an all time low. As at 31st August, there was approximately 5840 GL of water in active storage across the Basin (24% of capacity) and approximately 1850 GL had been allocated to users across the Basin which is approximately 16% of average annual diversions. These very low allocations have had serious impacts on the irrigation sector in the Basin.

Since 31st August a further 250 GL has been allocated in the southern connected system. These allocations may be available for purchase on the market from willing sellers.

With regard to other water sources, few other options exist. Limited environmental water is available in the Murray in 2008/09. It should be noted that the delivery of 350 GL of water to the lakes as “dilution flow” in South Australia is assumed in observing that limited water may be needed to avoid acidification until mid 2009.

Losses in transferring water from upstream to the lakes could vary significantly with major loss expected if water is sourced from the northern Basin. If water is transferred from the southern connected system the losses would be much lower and would generally already be “accounted” for in general losses put aside for running these rivers.

If water is sought from the north, losses should be estimated in gigalitres (GL) relative to any volume sourced rather than relying on a percentage loss estimate which could vary depending on volume sourced, location and prevailing river and climate conditions. “Strategies” to minimise loss are outlined in the submission and are fairly well accepted.

Management options for the Lower Lakes, including any potential acquisition and delivery of fresh water, need to be considered in the context of current overall water availability, current and future MDBC water sharing, social and environmental pressures elsewhere in the Basin, and outlooks for 2009-10 and beyond. Whilst the Murray system is experiencing record low water availability and continuing severe drought, any decision which increases usage or draws upon reserves may add additional risk to supplying critical human needs in future seasons.

The very poor condition of other environmental assets (including Living Murray Icon sites) is a major concern to the Commission and Ministerial Council and tradeoffs between delivering water downstream past these sites needs to be considered.

The general ecological decline in the Lower Lakes and Coorong has occurred over many decades and needs to be addressed in the context of climate change, sea level rise and wider Basin reforms such as the Basin Plan. The Commission office [or Authority in the future] will supply further information on the long term risks and options in our submission to the second stage of the senate inquiry into water management in the Coorong and Lower Lakes.

In providing information to inform the Committee’s deliberation on the first stage of this inquiry, the office of the Commission has provided a submission in two parts, one directly addressing the Terms of Reference for the inquiry and the other providing further details on key background information.

- Part 1 directly addresses the Terms of Reference. It outlines the volume of water required to keep the lakes at various levels, includes updated information on water held in storage across the Basin and identifies potential losses in transferring water from different parts of the Basin

- Part 2 contains background information including key facts about the Basin, water sharing in the Murray system both under normal times and the “interim” sharing arrangements over past few years of drought, contextual information on The Living Murray and the condition of the Lower Lakes, Coorong and Murray Mouth Icon Site and other Icon Sites along the Murray River.

Murray Darling Basin Commission submission to Senate Inquiry into water management of the Lower Lakes and Coorong: Part 1 of 2 (directly addressing the Inquiry Terms of Reference)

The MDBC submission contains two parts, one directly addressing the Terms of Reference for the inquiry and the other providing further details on key background information.

Part 1 directly addresses the Terms of Reference. It outlines the volume of water required to keep the lakes at various levels, includes updated information on water held in storage across the Basin and identifies potential losses in transferring water from different parts of the Basin.

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Murray Darling Basin Commission submission to Senate Inquiry into water management of the Lower Lakes and Coorong: Part 1 of 2 (directly addressing the Inquiry Terms of Reference)

This document provides information against the specific terms of reference for this inquiry. In several places it refers to Part 2 of the MDBC submission which provides other relevant background information.

ToR (a) the volume of water which could be provided into the Murray-Darling system to replenish the Lower Lakes and Coorong;

Key questions relating to this Term of Reference is how much water is "required" and how much might be available in the Basin. These 2 issues are explored below with a focus on the immediate needs of the lakes as these have been the focus of recent work in the Commission. It should be recognised that the options for the lakes and the Coorong may be different, as will be options that are suitable in the short term versus those that might be considered for the long term.

Broader information on water sharing arrangements in the Murray and special sharing arrangements for this year is outlined in the MDBC background material (Part 2 of 2).

Volume of water required for Lakes

The volume of water required to achieve specified Lake Levels from September 2008 to June 2009 has been estimated in Figure 1. Volumes read off this graph represent the estimated volume of flow to the Lakes that would be required to achieve the particular levels on the vertical axis (lake heights) to 3 future dates – December 2008, March 2009 and June 2009.

The volumes calculated in Figure 1 are driven by the assumptions made regarding evaporation and rainfall that are used to calculate the net evaporation and to a lesser extent the assumed re-filling pattern of the Lakes. Revising the assumptions within realistic limits will not greatly alter the results. Please see Box 1 regarding the assumptions and methods in developing this information.

To date, in considering the outlook for the Lower Lakes, the focus has been almost exclusively on the worst case net evaporation scenario. <u>While it is appropriate to plan for the worst case it should be noted that a worst case outlook is not a forecast of likely future conditions.</u>

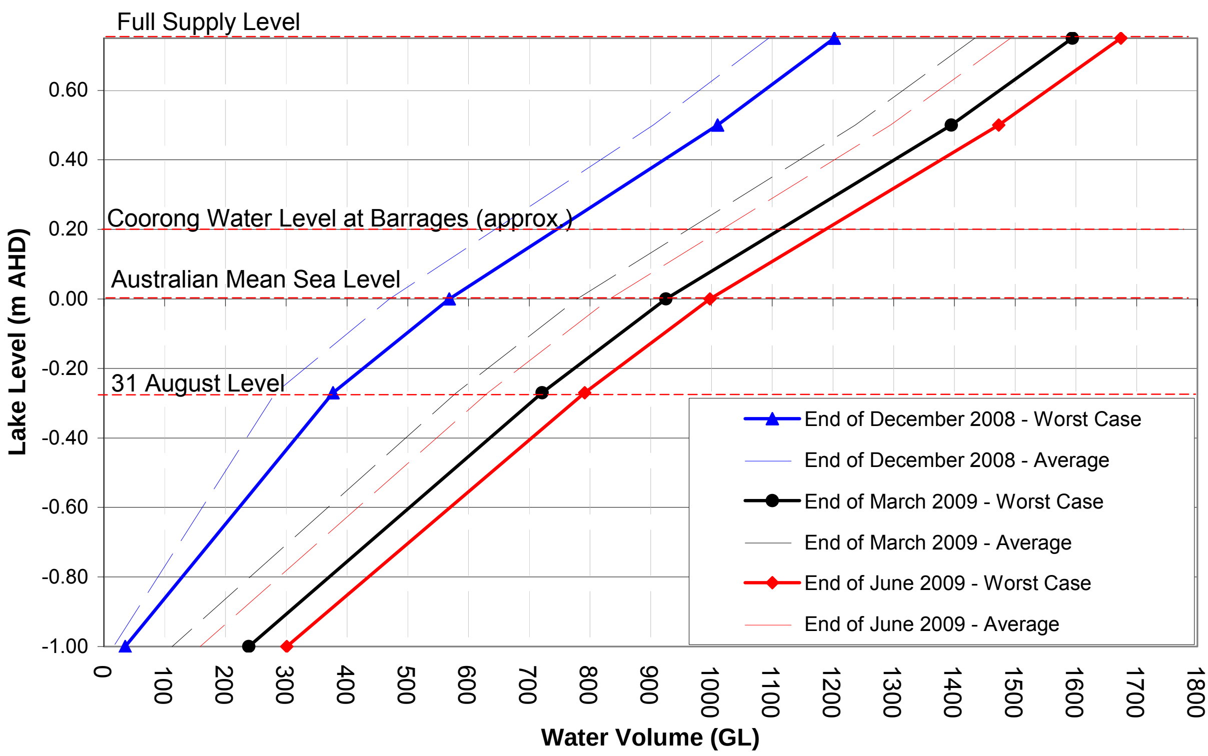


Figure 1: Volume of water required to fill and hold the lakes to various lake heights until December 2008, March 2009 and June 2009 (based on a starting point of the actual lake heights at 31.08.08) (see assumptions Box)**.**

Box 1: Assumptions/methods for Figure 1

- The analysis commences from 1 September 2008. Levels at 31 August 2008 were used as a starting point (-0.27m Lake Alexandrina and -0.13m for Lake Albert).
- Only the level of Lake Alexandrina is shown in figure 1. In generating these estimates, the level of Lake Albert has not been allowed to fall below -0.4m AHD for any scenarios (-0.4 is the level currently agreed for management of this lake in the Lake Albert Pumping Project).
- At 0.0 m AHD and above, the two lakes have been assumed to be connected (i.e. the levels of the two Lakes are the same).
- Data points have been calculated at -1.0m, 0.0m, 0.5m, 0.75m and the level that the lake was at on 31 August. The lines plotted in figure 1 are an interpolation between these points.
- It has been assumed that there are no water extractions from the Lakes.
- The graph represents total inflows required. If the 350 GL currently allocated for dilution flows to Wellington during the 2008-09 water year is delivered into the lakes this would reduce the volumes read off the graph by the component of the 350 which has not been delivered by 1st September 2008 (this would be a minimum of 262 GL (assuming that one quarter of the years 350 has been delivered so far prorate) but may be as much as 296 GL (based on the pattern of delivering the 350GL assumed by South Australia for modelling).
- The timing of any additional flow into the lakes has been simplified (the graph assumes you supply any extra water straight away). Assuming any other pattern of supply would influence volume required by less than 5 %.
- Historical rainfall at Tailem Bend (Station 024536) has been used.
- The Bureau of Meteorology's SILO pan evaporation data has been used. For Lake Albert the average Meningie and Tauwitchere evaporations have been used. For Lake Alexandrina a weighted average Milang, Tauwitchere and Tailem Bend pan evaporation has been used (in the ratio 4:3:3).
- The assumed worst case annual net evaporation for Lake Alexandrina is 1.209m, based on 1982 data. The average annual net evaporation is 0.907m which is derived from 117 years of recorded and SILO data, as described above.
- A pan factor of 0.85 has been applied to the evaporation data. This is the value derived in the calibration of the Murray-Darling Basin Commission's MSM-BIGMOD model and includes consideration of seepage losses and local catchment inflows.

Volume to keep lakes at sea level until June 2009.

Figure 1 shows that approximately 830GL of water would be required to (fill and to) keep Lakes Albert and Alexandrina at 0.0 m AHD until June 30 2009 assuming average evaporation. Note that mean sea level is 0.0 m AHD but the average water level adjacent to the barrages in the Coorong is around +0.2 m AHD. 1,000 GL would be required to (fill to and) keep Lakes Albert and Alexandrina at 0.0 m AHD until June 30 2009 assuming worst case evaporation. The volumes shown are total water required, if the 350 GL currently allocated (in 2008/09 drought planning) for dilution flows to Wellington is delivered into the lakes this would reduce the 830 and 1,000 GL figures by the component of the 350 which has not been delivered by 1st September 2008.

Volume to avoid "acidification" of the lakes

- Under the worst case scenario, a relatively small volume of water[1] would be required to keep the Lakes above the current management trigger level until June 2009 which should avoid acidification (see MDBC submission Part 2, Commission related processes in the Lower Lakes, Short Term Management Options).
- Under anything but the worst case scenario and assuming that the 350GL of dilution flow goes into the Lakes, Lake heights will stay above the acidification threshold until winter 2009.
- The volume will change if the acidification triggers are revised. The volume will increase or reduce depending on the how quickly alkalinity is actually consumed in the lakes (i.e. whether reality aligns with the modelled predicted rates). Furthermore, there may still be localised areas of acidification in small areas adjoining the lakes (small relative to the size of the lakes proper).

Volumes to achieve other ecological outcomes

- The Living Murray *Icon site Environmental Management Plan for the Lower Lakes, Coorong and Murray Mouth* (Table 4.1) identifies other environmental objectives that may be desirable to achieve. However, these are more likely to be relevant for future management of the site.
- It has been estimated that 550 GL would be required annually for optimum (year round) operation of the 3 fishways that have been built in the barrages. Approximately 270 GL would be required if the fishways were only operated for six months from September to February (approximately 45 to 50 GL/month). However, the lake levels would need to be increased to approximately 0.3 m AHD to begin to operate the fishways (at this height there is little "attractant" flow for the fish) or 0.65 m AHD for the fishways to be operated at their maximum effectiveness.
- The volume frequently cited to keep the Murray Mouth open is 2000ML/day passing from Lake Alexandrina to the Coorong via the barrages. This equates to 730GL/per annum. Again, the water level in Lake Alexandrina would need to be raised to above the water level in the Coorong to pass flow

[1] The additional volume that may be required depends on the assumptions made about the current and future delivery into the lakes of the 350 GL dilution flow provided for in the drought planning for the 2008-09 water year (June to May).

out through the barrages. The combination of freshwater inflow and the increased exchange of Coroong water with seawater would have major benefits in the Coorong.

Water availability in the Basin

Table 1 and Figure 2 contain updated information on the volume of water currently held in storages across the Basin. It should be noted that that these figures are only for water currently held in storage and do not account for anticipated inflows and expected losses for the remainder of the water year. The exceptions are: the figures for the Murray River where committed end of system tributary flows have been treated as assured inflow to the Murray, and; the Murrumbidgee and Murray where minimum releases from the Snowy into the upper Murrumbidgee and Murray have been included.

It should be noted that Attachment 1 is an update of the preliminary assessment of water availability as at 31st July compiled by the Commission office and released on 7 August 2008. It is not an “audit” of water available but represents the volumes that State water managers are reporting are in public storages, the likely breakdown in committing those resources and an estimate for private storages (which is not field verified).

In updating the estimates of volumes in storage from the July 31st estimates, the lower lakes have been added. It is evident that the largest freshwater resource currently in the Basin is the lower lakes with 1,100 GL in storage, followed by Lake Hume which is currently holding 821 GL.

As at 31st August, there was approximately 5840 GL of water in active storage across the Basin (24% of capacity) and approximately 1850 GL had been allocated to users across the Basin representing approximately 16% of the long-term average annual use. These very low allocations have had serious impacts on the irrigation sector in the Basin.

Since Attachment 1 has been complied, allocations have increased in South Australia (high reliability from 6% to 11%), NSW (high reliability in Murrumbidgee up from 60% to 75 %, and high reliability in Murray up from 25% to 50%), and Victoria (Goulburn high reliability up from 0% to 4%, Murray high reliability from 0% to 6%). This means there is approximately 250 GL more water potentially available on the market than is described in Attachment 1.

ToR (b) options for sourcing and delivering this water:

see relevant sub-points below

ToR b(i) possible incentive and compensation schemes for current water holders who participate in a once-off voluntary contribution of water to this national emergency,

The Commission office does not have information to table on this component of the terms of reference.

Table 1: Water in major storages in the Basin as at 31st August (not factoring in future inflows)

1. Valley and Storage	2. Capacity (GL)	3. Current Level (GL)	4. Dead Storage (GL)	5. Active Storage (GL)	6. Critical Water Requirements (GL)	7. Total allocated water remaining including individual carryover from 2007-08 (GL)	8. Losses (GL) ##	9. End of System Flows (GL - included in Murray minimum planning inflow)	10. Private Storages (GL)*	11. Current Balance in Public Storage (GL)**	12. Comments
	Storage figures				Commitments to end June 2009						
NSW											
Border Rivers				164	10	84	40	N/A	30	2	NSW share of Glenlyon Dam and Pindari (NSW only) is 136 GL in total. NSW controls all the Pindari Dam resources and shares the Glenlyon Dam resources
Glenlyon Dam (Qld)	254	74	0.2	73.8							
Pindari Dam	312	90	0.1	90.3							
Lower Darling				475	11	25	217	172	0	50	59GL is set aside for meeting losses in the 09/10 water year, for the delivery of critical water and all other uses until Autumn 2010. Non-critical water will be released to the Murray in Spring 2008.
Menindee Lakes	1 678	511	36	475							NSW 100% Lower Darling High Security Allocation (at 5 August 2008) equates to a total of 8GL.
Barwon-Darling								N/A	150	N/A	There is less than 150 GL in private storages along the Barwon-Darling from Mungindi to Wilcannia. Water is being lost to evaporation and also used to irrigate existing crops.
Gwydir Valley				254.3	32	132	62	N/A	20	28	The Gwydir Valley uses a system of continuous accounting. The "unallocated" water is required to meet critical human needs in 2009/10 under severe drought conditions.
Copeton Dam	1 361	273	18.5	254.3							
Namoi Valley				152.9	31	43	23	N/A	10	56	The Namoi Valley uses a system of continuous accounting. The "unallocated" water is required to meet critical human needs in 2009/10 under severe drought conditions, including supply to the city of Tamworth.
Keepit Dam	425	89	6.6	82.5	19	33	8				
Split Rock Dam	397	24	3.2	21.0							
Chaffey Dam	61	52	2.4	49.4	12	10	15				Chaffey Dam is the primary source of supply for the city of Tamworth and some water is reserved for 2009/10..
Macquarie Valley				287.0				N/A	N/A		
Burrendong Dam	1 188	232	33.7	198.7	25	61	170			-57	The deficit will be met by the minimum drought inflows and transfer of water from Windamere Dam.
Windamere Dam	368	89	1.1	88.3	2	10				76	
Lachlan Valley				128.6				N/A	N/A		The Lachlan Valley remains in the worst drought on record.
Wyangala Dam	1 220	126	0.7	125.7	14	11	120			-19	
Carcoar Dam	36	3	0.2	3.0	0	1	2			0	
Murrumbidgee Valley				1242.8	40	462	500	142	N/A	99	The water in Blowering Dam includes pre-releases from Snowy Hydro. End of system flow includes inter-valley trade to NSW Murray and interstate with an account balance of 73 GL.
Burrinjuck Dam, Yass	1 026	465	3.3	461.7							
Blowering Dam, Tumut	1 631	805	24.0	781.2							Murrumbidgee High Security Allocation were increased to 60% on 1 September .
Victoria											
Goulburn				641	50	238	379	86	N/A	-112	End of system flow does not include 125 GL of Goulburn Vallley Account that is available as a supplement to the Murray. This volume is included in the carry over and announced allocation column.
Eildon	3334	712	84	628							
Waranga Basin	432	138									73 GL further inflow is required for a 1% allocation, assuming continued pumping at Waranga Basin (44 GL of inflow has been assumed for allocation purposes, resulting in 29 GL shortfall)
			125	13							
Broken				30	1	8	37	N/A	N/A	-16	
Nillahcootie	40	13	1	12							
Mokoan	365	21	3	18							
Campaspe								N/A	N/A		
Eppalock	305	21	1	20	15	3	10			-10	
Loddon				4.5	1.5	1	13	N/A	N/A	-11	
Cairn Curran	147	8	0.5	7.5							
Tullaroop	72	4	7	-3							
Ovens				25	8	0	34	45	N/A	-62	
Buffalo	23	17	5	12							
William Hovell	13.5	14	1	13							
Queensland											
Condamine								N/A	65		
Leslie	106.2	15.6	2.13	13.47	See comments					0	Storage level must be above 18% for allocations, storage below 12% is reserved for town water supply.
Cooby	23.1	3.97	2.1	1.87	1.87					0	Cooby Dam is 100% committed to town water supply for Toowoomba and surrounding area, current low level has resulted in level 5 water restrictions.
Chinchilla	9.78	5.73	0.28	5.45	3.4					0	Allocation releases cease at 60%, storage below 35% is reserved for Town water supply for Chinchilla.
Border								N/A	120		
Glenlyon Dam (Qld)	See NSW Glenlyon				7	27	14			-11	This dam is located in Queensland. Use is shared with NSW. Queensland has 37GL of current storage volume
Coolmunda	69	46.8	0.3	46.5						0	
Moonie								N/A	20		
Lower Balonne				35.43				N/A	310		Town water supply for St. George is medium priority and delivered on availability as per other entitlements.
Beardmore	81.7	30.9	3.12	27.78	See comments					0	Town water is otherwise supplied from GAB groundwater sources.
Jack Taylor	10.1	9.32	1.67	7.65	See comments					0	Storage is used for town water supply, visual amenity and recreational use and as a balance for releases from Beardmore.
Warrego								N/A	15		
MDBC											
Murray Valley				2312	300	750	1170	260	N/A	-168	The 260 GL is the volume to the Lower Lakes over 9 months from September 08 to May 09. River losses upstream of Wellington.
Hume	3038	821	30	791							SA 6% Murray Allocation (at 5 August 2008)
Dartmouth	3906	761	80	681							NSW 25% Murray High Security Allocation
Lake Victoria	677	315	100	215							There are currently no Victorian allocations but water has been put aside to cover supply losses
in transit				55							Murray.
End of system inflow from tributaries (column 9)				570							There is also 75 GL of Advance of Snowy Hydro releases for 2009-10 currently in Hume Reservoir. Murray tributary inflows include Lower Darling, Murrumbidgee, Goulburn and Ovens end of system flows, plus 125 GL of Goulburn Inter-valley Trade Account.
Lower Lakes	2015	1100		N/A							

* Private storage estimates are indicative only, based on an estimate of the total harvest and estimated use since summer 07/08. The ability to extract water from these storages is limitec

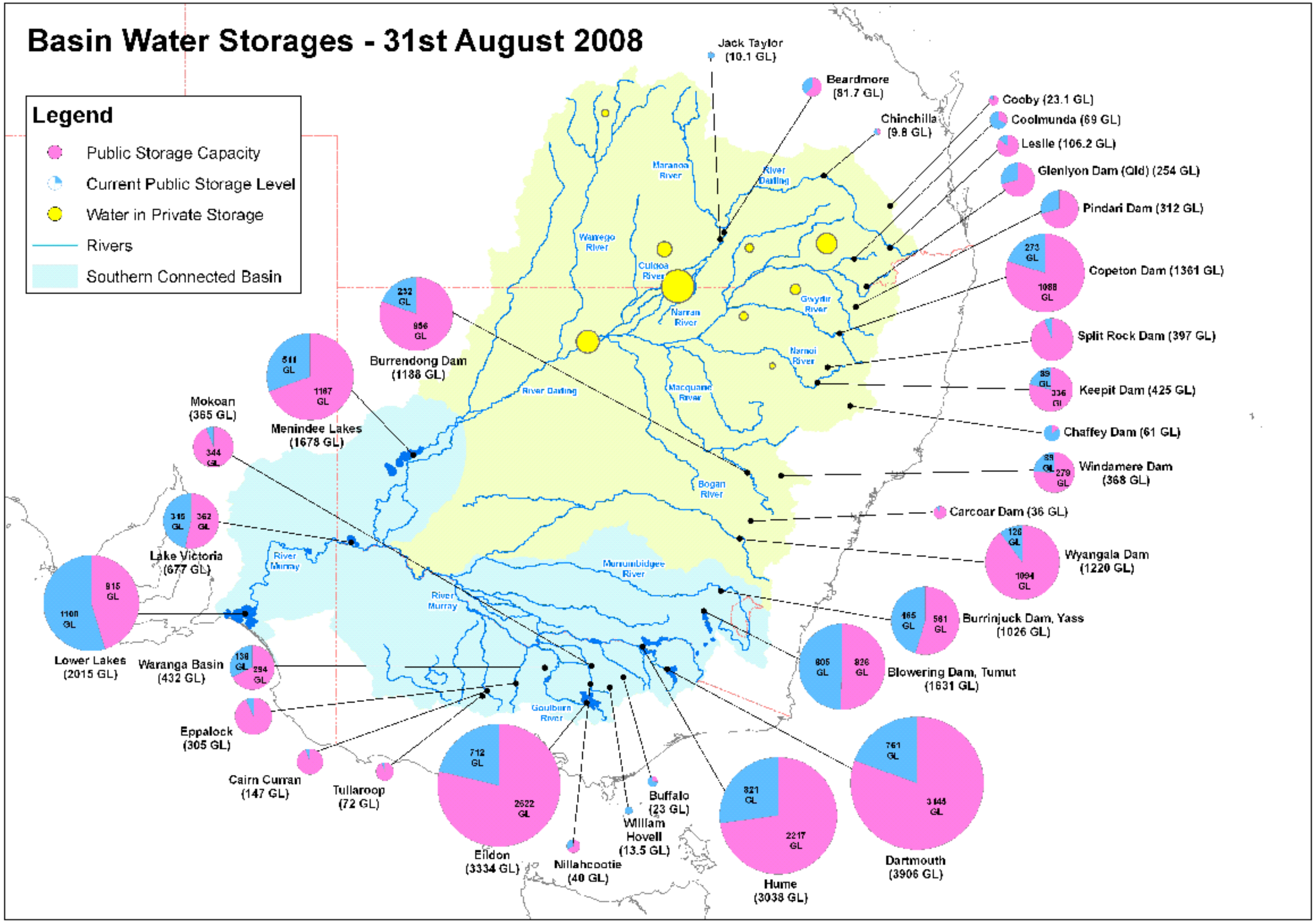
** Future inflows in each valley are not explicitly included in the table but may have been included when water resources assessments and allocations were made

Minimum Snowy Hydro inflows are included in the Murray and Murrumbidgee assessments.

There is approximately 96 GL in ACT storages (approximately 46%), for urban use only.

Losses include the volume reserved to meet natural river channel transmission losses and also the water to meet large scale irrigation channel losses. Applicable in the Murrumbidgee and Goulburn Valleys

Figure 2: Basin Water Storage as at 31st August 2008



ToR b(ii) alternative options for the acquisition of sufficient water,

Planned flows to South Australia
The 2008-09 drought planning for the River Murray system currently identifies 350 GL "dilution flow" for the River at Wellington. This is provided to ensure the water quality at the major SA off-takes down to Wellington is of acceptable salinity. This 350 GL should flow past Wellington into Lake Alexandrina. Should salinity levels in the River be lower this year there is potential that not all of the 350GL would be required for dilution. If this is the case, South Australia and the Senior Officials Group will reconsider the requirements for dilution flow.

With regard to any improvement in water availability this year (advised to South Australia by the Commission office), South Australia decides how to allocate these improvements in resources. As such, the volume that the lakes might get through improvements to South Australia's water share, would depend on the relative priority South Australia places on the needs of the lakes versus carrying a reserve for critical needs next year and allocations to other users this year.

Contingency measures identified in drought planning
During the previous 2 years, "contingency measures" have been identified to assist with providing enough water in the River Murray System to meet Critical Human Needs. These contingencies have included:

- additional tributary inflows from NSW
- additional tributary inflows from Victoria
- turn off the Edward River System (to reduce transmission losses)
- disconnection of specific wetlands (to reduce losses)
- draw on in-river storage including lowering weir pools
- access water in the Snowy Scheme

The volumes available via these sources are generally low. Some of these sources may need to be relied on for meeting critical human needs in 2009/10 although the mix may change as the above contingencies were specific to 2008-09 and cannot be assumed to be available in future years.

Commission held Environmental Water in the Murray System
The volume of regulated water currently available for the environment under The Living Murray is only 1.2GL. In prioritising areas to receive environmental water in 2008/09, the Commission's Environmental Watering Group noted that the volume of environmental water available through The Living Murray is not sufficient to be of any material benefit to the Lower Lakes.

In setting priorities for the use of unregulated flow at environmental sites, a rule has been agreed by Commission to test the material benefit of the flow to the Lower Lakes before water is committed to any of the environmental priorities identified upstream.

Part 2 of the MDBC submission contains basic information on The Living Murray Program and the delivery of environmental water under that Program over past few years. In future years (once the TLM 500 GL has been fully recovered and water is available against entitlements), The Living Murray will contribute additional freshwater to the Lower lakes and Coorong.

Market options

Market options include the purchase or allocation, which may include water carried over by individuals from last year, and purchase of entitlement. Government agencies have seldomly purchased allocation for environmental purposes as it only has a one-off benefit for the environment.

In March 2006, the Murray-Darling Basin Commission published a report on the opportunities to use market based measures to recover water for The Living Murray. This report, titled *Issues and options in applying market based measures in the Living Murray first step* (http://thelivingmurray.mdbc.gov.au/_data/page/196/MDBC11156_WEB.pdf) , identifies a number of possible methods for using market approaches to recover water. These include;

- Purchase of entitlement
- Purchase of seasonal allocation
- Lease agreements (where either an irrigator or the environment owns the water entitlement, with the seasonal allocation leased to the other party under certain circumstances)
- Covenants
- Options contracts (including both 'put' and 'call' options contracts)

This report built on an earlier report, titled '*A market approach to the Living Murray Initiative: A discussion paper*', completed in August 2003 (http://thelivingmurray.mdbc.gov.au/_data/page/196/Market_approach_to_TLM_-_FINAL.pdf).

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ToR b(iii) likely transmission losses and the most efficient and effective strategies to manage the delivery of this water,

Table 2 contains estimates of the losses that might be incurred in transferring water to the lower lakes from NSW and Victorian catchments in the Basin. Note that estimates from catchments in Queensland could not be sourced in time for this submission.

A range of losses is provided to reflect possible highest and lowest loss estimates due to various effects including the volume to be transferred, the time of the year, the dryness of the Valley's river bed (a dry river bed has a high "initial loss") and likely valley water allocation levels and abstraction rates. In all valleys except for the Murray, the estimated loss is from the headwater storage to where the water meets and enters the Murray and/or Darling River as appropriate.

Table 2: Range of transmission losses in transferring water from valleys in the Basin (the estimated loss is from the headwater storage in the relevant valley to where the water meets and enters the Murray and/or Darling).

Valley	Low estimate Transmission Losses (%)	High estimate Transmission Loss (%)	Comments
Murrumbidgee	0 % (losses already set aside)	0 % (losses already set aside)	Any losses incurred in transferring to the Murray are borne by the valley loss allowance (335 GL in 2008-09).
Lachlan	N/A	N/A	The Lachlan is not practically connected to the Murrumbidgee except in very large floods.
Macquarie To Barwon River only	20 %	90 %	To deliver water to the Darling River requires transmission via first the Macquarie Marshes bypass channel which involves large losses, and then through an unregulated watercourse downstream of the marshes.
Namoi. To Barwon River only	0 % (losses already set aside if flow is established to Walgett)	Up to 100 %	Normal practice would be to deliver water anywhere in the system including to the Barwon River at Walgett and the loss would be included in the valley loss allowance. However, delivery to the lower sections of the Namoi and to the Barwon River can involve large losses if the lower reaches have dried out. 20 GL can be lost in re-establishing flow to Walgett.
Gwydir To Barwon River only	0 % (losses already set aside if flow is established to the Barwon	30 % (if water required when there is no existing demand, but loss debited against the valley loss allowance)	Normal practice would be to deliver water anywhere in the system including to the Barwon River upstream of Collarenebri without incurring any additional loss (above the valley loss allowance).
Border Rivers To Barwon River only	0 % (losses already set aside if there is a flow established to the Barwon)	30 % (if river allowed to dry out but loss debited against the valley loss allowance)	Normal practice would be to deliver water anywhere in the system including to the Barwon River at Mungindi without incurring any additional loss (above the valley loss allowance).
Barwon-Darling	20% (if there is a flow already established)	25%+ 50GL	See additional notes after table in document text.
Lower Darling (Menindee lakes to the Murray)	0% (if there are existing flows in the Lower Darling River)	see comment column of table	A loss of up to about 20 GL could occur if a water transfer is made along the Lower Darling when the river bed is dry (which may occur after April 09 depending on prior conditions).
Goulburn	10%	30%	
Broken	30%	50%	
Campaspe	60%	80%	
Loddon	N/A	N/A	Extreme low water availability means there is currently no prospect of water being available. Should conditions improve substantially, there would be large losses of water particularly in getting water to the downstream end of the Loddon.
Ovens	20%	50%	
Murray	0 % (losses already set aside)	0 % (losses already set aside)	additional losses associated with transferring water along the Murray would be small and are already covered by the valley loss allowance.

In some valleys, the transmission losses are identified as zero in Table 2. This is because the losses in transferring regulated water are already fully met from a valley loss allowance (there may be a small additional loss but it may already be fully met from valley loss allowances). In the highly regulated systems of the Murrumbidgee and Murray, this valley loss is the mechanism that lets a trade of water occur without any adjustment for changed losses.

In general, transmissions losses vary considerably depending on the timing of transfer, the volume being transferred and the antecedent conditions. The lowest transmission losses can be expected when:

- ambient temperatures are low (transferring outside of summer),
- the river channel is already wet/delivering other water needs for its entire length (piggy-backing on another event or delivery)
- a large volume of water is being transferred (initial transmission losses may be much higher than later transmission losses, and
- water is delivered within the river channel (not overbank).

In some parts of the Basin, if a transfer was being made downstream, special arrangements may need to be made to stop downstream users from accessing the water (being transferred) under their water entitlements.

Additional notes on losses in the Barwon-Darling provided by NSW (relating to Table 2)

The Barwon-Darling now has only very small flows from Mungindi to near Louth where it has stopped flowing. To re-establish flow to Menindee Lakes will require an initial volume of at least 10 GL, plus an on-going loss component.

Similar situations exist throughout the system and the losses will increase as the water is sourced from further upstream. It is estimated that the loss from Mungindi to Menindee would be about 20 to 25% after flows were established. The initial volume required to re-establish flows will increase with the increasing length of time that the river downstream of the source of flow has ceased-to-flow. If flows cease soon and flows do not occur until summer the initial loss to re-establish flows and the initial on-going loss will be higher. If flows cease now and are not re-established by January the losses from Mungindi to Menindee could require an initial volume of 50 GL. The ongoing loss is a greater proportion of a lower flow.

Small rates and volumes could be completely consumed by river transmission losses and refilling of public fixed crest weirs if they are depleted when the flow occurs.

The on-farm-storages on the Barwon-Darling and in other areas in the north of the Basin are usually only designed for extraction from the river. To return water to the river may require substantial infrastructure changes and also require pumping to obtain significant volumes at useful rates.

Estimating total losses

Table 2 shows that losses can be significant and need to be estimated depending on the source of the water. Both the loss in the source valley plus the loss in the Barwon and Lower Darling Rivers need to be added together to estimate losses in transferring water from the Northern Basin. In the event that water is purchased or acquired from the northern Basin to provide water for the lower lakes, the transmission losses are likely to be very high. In this event, it is probably more suitable to estimate a volume of loss in GL relative to any volume to be transferred rather than relying on an estimate of % loss.

ToR b(iv) Commonwealth powers to obtain and deliver water and possible legislative or regulative impediments,

The Commission office does not have information to table on this component of the terms of reference.

ToR b(v) assessment of the potential contribution of bringing forward irrigation infrastructure spending under the Council of Australian Governments agreement to deliver water to save the Coorong and lower lakes;

The Commission office does not have information to table on this component of the terms of reference.

ToR (c) the impact of any water buybacks on rural and regional communities and Adelaide including compensation and structural adjustment;

The Commission office does not have contemporary information on this item of the terms of reference. The information cited below was collected for The Living Murray and was developed at a time when there was a more optimistic perspective on future Basin climate and rainfall patterns. Under the current and prospective climate and rainfall patterns, the relevance of these studies could be questioned.

Relevant information collected for The Living Murray

Prior to the commencement of The Living Murray there were a number of studies of the potential social and economic impacts that could result from returning water to the environment from irrigation. These reports often assumed that much or all of the water to be recovered for The Living Murray would be sourced through market based water recovery. These reports include;

- *A preliminary assessment of the economic and social implications of environmental flow scenarios for the River Murray System, MDBC, July 2002 (Prepared by CSIRO Land and Water and PIRSA Rural Solutions)*
- *Scoping Study: Social impact assessment of possible increased environmental flow allocations to the River Murray System, MDBC, August 2003 (Prepared by Hassall & Associates and the University of Queensland)*

- *Development of a framework for social impact assessment in the Living Murray: Water Recovery in the Murray Irrigation Area of NSW, MDBC, November 2003 (Prepared by EBC)*
- *Scoping of economic issues in the Living Murray, with an emphasis in the irrigation sector, MDBC, July 2004.*

A key finding from the last report listed above (MDBC, July 2004) is that for The Living Murray *'In total across all regions, irrigation gross margin is estimated to fall by around $17.5m annually, as irrigation water use falls on average by around 385 GL/year. The reduction in total gross margin of about 1.2% is significantly less than the proportionate fall in water use of around 6%...'*

A brief analysis, titled *'Brief assessment of the merits of purchasing water entitlements during a time of low water availability'* was prepared for the Murray-Darling Basin Ministerial Council by The Living Murray Social and Economic Reference Panel. This advice concluded that;

- *'After reviewing the available evidence the Social and Economic Reference Panel finds no reason to discontinue or delay the purchase of water entitlements for environmental purposes in periods of low-water availability.'*
- *'market-based water recovery at a time of low-water availability is not expected to exacerbate third party effects associated with the transfer of water to its highest value in consumptive or environmental use…'*

During 2007-08, MDBC implemented a trial water purchase project to recover water for the environment. This Living Murray water recovery measure, the *Pilot Environmental Water Purchase project*, purchased permanent water entitlement in the trading zones that form the southern connected Murray-Darling Basin. It demonstrated, at a small scale, that

- government agencies can participate in the water market within existing rules
- existing safeguards in the market effectively limit large volumes being traded out of irrigation districts to any purchaser, including the environment
- the willing sellers in the project participated for a range of reasons, including realising assets, re-structuring businesses, rationalising watering plans and contributing to the environment.

Market analysis used to underpin the project highlighted a paucity of publicly available trade data. Analysts also reported that available data had to be filtered to ensure the integrity of the analysis, for example, excluding trades for which there was no price reported.

Trade as a mechanism to help reduce impacts

The water market within the southern connected Murray-Darling Basin (Basin) is relatively new and the processes associated with it are evolving at a rapid rate. The market is assisting irrigators to independently manage their agricultural businesses and minimise on-farm impacts as a result of periods of drought where water allocations are substantially reduced.

This has been demonstrated during the 2007/08 water year where interstate and intrastate transfers of allocations have set new records for the southern connected Basin in both the total number of transactions and the total volume. Allocation transfers (both inter and intrastate) for the 2007/08 water year were around 40% of the total volume of allocations available to water users.

The expansion of water trade within the southern connected Basin has helped lessen the burden of the current drought by providing a mechanism for water users to manage their risks. As a result, water markets have demonstrated that they are able to facilitate the efficient reallocation of water in a way that government agencies can not perform.

Modelling undertaken by the Productivity Commission during 2004 suggests that allowing water trade to occur within the southern Murray-Darling Basin more than halved the impact of the reductions in water (caused by drought conditions) on the gross regional product.

ToR (d) any other related matters.

A number of matters are raised in this section as related but further relevant information is contained in Part 2of the MDBC submission.

Lower Lakes under Natural Conditions

There are a number of different views about how the Lower Lakes would have functioned under natural conditions (prior to the development and regulation of the River Murray and construction of the barrages). The overwhelming evidence supports that the lakes were predominantly fresh but with periods of salt water inflow. The frequency and duration of these periods of sea water incursion is still under debate. The points below contain relevant information:

MDBC Water Resources Group Modelling

- Modelling of natural conditions (no developments or diversions) from 1891 to 2007 shows that there would have been periods when the evaporation from the Lakes exceeded the fresh water inflow and water would have flowed into the Lakes from the sea. These reverse flow events would have caused periods of higher salinity.

- The modelling indicates that the net monthly reverse flows would have occurred in 17% of the years, net monthly reverse flows of more than 30 GL in 12% of these years, and more than 70GL in 5% of these years. The modelling does not take account of the effect that tides would have on the exchange of water between the lakes and Coorong.

Charles Sturt's 1829-1830 Expedition Diary

- Charles Sturt made a number of observations regarding the quality of water in the Lower Lakes on his 1829-1830 expedition. As his party travelled past Pomanda Island, where the Murray enters Lake

Alexandrina, firstly they observed that the water immediately became salty and was unpalatable" "*Thus far, the waters of the lake had continued sweet; but on filling a can when we were abreast of this point, it was found that they were quite unpalatable, to say the least of them. The transition from fresh to salt water was almost immediate, and it was fortunate we made the discovery in sufficient time to prevent our losing ground. But, as it was, we filled our casks, and stood on, without for a moment altering our course*." Sturt also observed tidal influences within Lake Alexandrina and seals upstream of where the Goolwa Barrage is now sited.

A Fresh History of the Lakes (Sim and Muller 2004)
Cites historic material to support that the lakes were predominantly freshwater.

Other historic accounts
Other historical accounts of the Murray prior to regulation and large scale diversion indicate that during times of drought the Murray was reduced to a chain of saline ponds. It has been reported to have stopped flowing between Tocumwal and Moama in 1850 (1902 Interstate Royal Commission on the River Murray) and one could walk across it at Echuca at times(1910 Interstate Royal Commission on the River Murray). In 1839, the Murray at Albury was reduced to "only a small stream trickling among pebbles" (Royal Commission – Conservation of Water 1887). Further downstream, in 1902, "not a drop of river water has reached the sea mouth of the Murray during the past six or seven months" and water was so brackish as to be unusable from the mouth to Murray Bridge (1902 Interstate Royal Commission on the River Murray). The first paddle steamer on the Murray, PS Mary Ann, on her maiden voyage in 1853, could not pass Penns Reach near Morgan due to a low river (Tucker 1985).

Water Sources into the Coorong -Paleo ecological History
Research led by Professor Peter Gell analysed sediment core samples to reconstruct the water quality and water source history of the Coorong. This work utilised diatom analysis and dating techniques.

Interpretations from this analysis indicate the Coorong has been an estuarine-marine system and that it is likely that inflows from the upper south east system, not from the Murray River, may have been the major freshwater input into the Coorong. This work concludes that Murray River water moved through the Goolwa Channel to keep the Murray Mouth open, allowing for the tidal influx of marine water into the Coorong.

SE drainage Scheme (Coorong)
The Commission office has funded an initial feasibility assessment of the proposal to redirect water into the Southern lagoon from a drainage network around the South-East Kingston district. These areas currently drain to the sea but naturally drained into the Coorong providing a valuable source of

freshwater. While it appears that there are significant volumes of water that could be rerouted back to the Coorong, the feasibility assessment of engineering works has not been completed, the cost/benefit is not yet known to be favourable and the impact of climate change needs to be assessed. This option is relevant to the long term management of the Coorong rather than the immediate situation.

South Australia have also assessed a number of other infrastructure/pumping options for the Coorong. While some of these are longer terms options like the SE drainage proposal, there is a proposal currently being assessed with Murray Futures(Commonwealth) funding for pumping between the ocean and the Coorong which the Commission office understands may provide some short term lowering of salinities in the Coorong.

Why has this drought been so severe?
Information on this drought and water sharing arrangements are outlined in part one of the MDBC submission. A number of factors have exacerbated the current drought and its impact on irrigators, causing record low inflow and water availability despite rainfall which is comparable to other dry periods. The factors are: higher temperatures, changed rainfall patterns, the lowest inflow year on record and two consecutive very dry years and over allocation. Additional activation of sleeper entitlements and likely impacts of increased groundwater extraction are also likely to be affecting water availability.

Climate Change Scenarios
Climate change has recently been modelled by the CSIRO led Sustainable Yields project. The Murray Sustainable Yields report was released in July 2008 (CSIRO 2008). It modelled a range of possible climate change scenarios for 2030.

Assuming current levels of development the CSIRO modelling concluded that under the median 2030 climate change scenarios end of system flows would fall by 24 percent, while under the dry extreme 2030 climate change scenario that end of system flows would fall by 69 percent. The report (CSIRO 2008) also found that:

- Under a long-term continuation of the recent (1997 to 2006) climate and current water sharing arrangements, average surface water availability would decrease by 27 percent for the MDB and by 30 percent for the Murray region. End-of-system flows at the barrages would decrease by 50 percent, and the volume of water diverted for use within the Murray region would decrease by 13 percent.

- Under the median 2030 climate scenario average surface water availability for the MDB would fall by 12 percent and for the Murray region would fall by 14 percent. Total diversion volumes in the region would fall by 4 percent and end-of-system flows would fall by 24 percent.

- Under the dry extreme 2030 climate scenario average surface water availability for the MDB would fall by 37 percent and in the Murray region would fall by 41 percent. Total diversions in the region would fall by 23 percent and end-of-system flows would fall by 69 percent.

- For the Lower Lakes, Coorong and Murray Mouth, water resource development has increased the average period between the flood events required to flush the river mouth and help sustain the lake and estuarine ecosystems from 1.2 years to 2.2 years. Flood volumes have also been greatly reduced such that the average annual flood volume is only a fifth of the volume under without-development conditions.

The lower lake may also be impacted by sea level rises predicted under climate change. To date, the Commission office has not undertaken an assessment of the various predictions of sea level rise on the Coorong, lower lakes, barrages or Murray Mouth but this will need to be undertaken to inform long term management options. The Barrages already overtop on high tides with storm surges.

Providing water for avoiding catastrophic events (including acidification) versus general environmental health

There is a clear difference, in volume required, between targeting water for the lakes to avoid acidification versus securing an improvement in general health of the lower lakes, Coorong and Murray Mouth. Whilst improving the overall health is of paramount importance, the short term focus has been on ensuring there is no catastrophic collapse of the lakes from acidification or related processes including mobilisation of metals and de-oxygenation (see Part 2 of the MDBC submission “commission related processes in the lower lakes).

Trade-off with upstream environments

With regard to securing water to improve the general health of the Lower lakes, Coorong and Murray Mouth, consideration also needs to be given to the condition of other River Murray habitats and Icon sites upstream. The majority of Icon sites are now in very poor condition as a result of over a decade with no flooding and exacerbated by the worst drought on record.

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Murray-Darling Basin Commission submission to Senate Inquiry into water management of the Lower Lakes and Coorong: Part 2 of 2: Background information

The MDBC submission contains two parts, one directly addressing the Terms of Reference for the inquiry and the other providing further details on key background information.

Part 1 directly addresses the Terms of Reference. It outlines the volume of water required to keep the lakes at various levels, includes updated information on water held in storage across the Basin and identifies potential losses in transferring water from different parts of the Basin.

Part 2 contains background information including key facts about the Basin, water sharing in the Murray system both under normal times and the “interim” sharing arrangements over past few years of drought, contextual information on The Living Murray and the condition of the Lower Lakes, Coorong and Murray Mouth Icon Site and other Icon Sites along the Murray River.

Table of content

Basic Facts on the Basin 3
Hydro-geography 3
Land Use 4
Water Entitlements 4
Current Murray-Darling Basin Agreement 4
Cap on diversions 5
Water sharing under the *Agreement* 5
Summary of "Normal" Sharing 5
Basic sharing provisions 6
Water supply security under normal sharing 6
Normal sharing (in wetter times) 6
Sharing in drier times (during Periods of Special Accounting) 7
The Current Drought 7
Summary of interim water sharing arrangements 8
Interim Sharing in 2007-08 8
Interim Sharing in 2008-09 8
Drought response for individual carryover 9
Contingencies identified in 2007-08 and 2008-09 9
Accounting for Losses in the River Murray System 10
The Living Murray Overview 11
Icon Site Water Use 11
Current condition of Icon Sites 11
Commission related processes in the Lower Lakes 12
Lake Albert Pumping Project 12
Future Management Options Project 12
Short Term Management Options 12
Longer Term Management Options 13
References 13
Attachment 1: Why has this drought been so severe? 14
Attachment 2: Lower Lakes, Coorong and Murray Mouth – Summary of Current Condition 19
Attachment 3: Condition of other Living Murray Icon sites – Information from The Living Murray condition reports 34
Barmah-Millewa Forest 34
Hattah Lakes 35
Gunbower–Koondrook–Perricoota Forest 37
Chowilla Floodplain, Lindsay-Wallpolla Islands 39
Bird surveys across all sites 43
Attachment 4: Lower Lakes Fact sheet 45

Basic Facts on the Basin

Hydro-geography

The MDB covers approximately 1,059,000 square kilometres or 14% of Australia's land area (New South Wales 57%, Queensland 24%, Victoria 14% and SA 5% of the Basin's area; ABS, 2008). Two million people (10% of Australian's population) live in the Basin and are dependant on it for their drinking water, as are another 1.1 million residents of the city of Adelaide.

The Murray-Darling Basin is one of the driest catchments in the world. As a global comparison, the catchment of the Mississippi River contributes 20 times more runoff per square kilometre, and the Amazon catchment 75 times more runoff than the Murray-Darling Basin (Gill 1978). The average annual flow of the rivers of the Murray-Darling would pass through the Amazon River in less than a day.

The estimated long term average annual runoff into all rivers in the Murray-Darling Basin is approximately 23,609 GL which is approximately 4% of the average annual rainfall of 530,618 GL. There is considerable variation in runoff from one part of the Basin to another.

The catchments draining the Great Dividing Range on the south-east and southern margins of the Basin make the largest contributions to total runoff. For example, the Murrumbidgee and Goulburn, Broken and Loddon river catchments account for 35% of the Basin's total runoff from 12% of its area. The Upper Murray catchment alone accounts for 17.3% of runoff from just 1.4% of the Basin. In contrast, and further illustrating the Basin's climatic differences, runoff in the Darling Basin is estimated to be just 30% of total runoff in the entire Basin, despite the Darling Basin accounting for 70% of the Basin's total area (Crabb 1997).

Runoff variability in the Basin over time is also higher than in any other continental area in the world. Over the period from 1894-1993, the annual discharge at the mouth of the Murray-Darling system ranged from 1,626 GL to 54,168 GL (Maheshwari *et al.* 1995). Except during very wet years, some 86% of the Basin contributes virtually no runoff to the river systems.

It has been estimated that under natural conditions almost 11,000 GL/year were contained in wetlands, on the floodplains or lost to evaporation from the river surface and that only 12,890 GL/year or 54% of the runoff reached the sea. Some of the water that would have been consumed by wetlands and the floodplain under natural conditions is now used for irrigation or is evaporated from reservoirs (MDBC, 2005).

The CSIRO Sustainable Yield Project (CSIRO, 2008) has modelled the aggregated flow impacts through the connected rivers of the Basin and identified (under the current climate and development scenario) that the current development of the water resources in the Basin has reduced the flow to the Murray mouth by 61% and that the river now ceases to flow 40% of the time compared to 1% of the time without the current level of development. (CSIRO 2008, p5)

To regulate the River Murray system, River Murray Water utilises four major storages, sixteen weirs, five barrages and numerous other smaller structures. Major storage capacity in the Murray System (Dartmouth, Hume, Lake Victoria, Menindee) is approximately 9,000 GL and in all Basin storages is approximately 23,000 GL (MDBC Drought Update, September 2008).

The total open water evaporation from major water bodies within the Basin is in the order of 3,000 GL/year (Kirby *et al.* 2006). Of this, the Menindee Lakes account for about 460 GL/year, Lake Victoria 120 GL/year, and Lake Hume accounts for about 60 GL/year of evaporation (Kirby *et al.* 2006). The Lower Lakes account for evaporation of approximately 750 GL per year, almost a third of the total estimated evaporation (Kirby *et al*, 2006).

Inter-basin transfers are also a feature of the system with water being transferred into the Murray-Darling Basin via the Snowy Mountains scheme and the Wimmera-Mallee scheme from the Glenelg River system. However, these flows are only equivalent to 5 per cent of the natural run-off.

Land Use

The MDB accounts for 40% of the value of Australia's agricultural output (ABS 2008). 84% of the land in the MDB is owned by businesses engaged in agriculture and 67% of this land is used for growing crops and pasture (ABS 2008). The vast bulk of agricultural land in the MDB is not irrigated; only 2% of MDB land is irrigated (ABS, 2008); this produces 44% of the value of Australia's irrigated agricultural output.

The total gross value of production of agricultural crops in the Murray-Darling Basin in 2005-06 was $15 billion, which is nearly 39% of the total Australian gross value of agricultural production (ABS 2008).

Irrigated agriculture covers a total of almost 1.65 million hectares in the Basin and is the single greatest water user. Average annual diversions in the Basin are about 11,500 GL per year; about half of the annual flow in the Basin. Around 95% of this diversion is for irrigation (Kirby *et al.* 2006). In 2006/07, water diverted from the Murray, Murrumbidgee and Goulburn Rivers accounted for about 72% of all the water diverted in the Basin (MDBC,2007)

Irrigation within the Basin can be broadly characterised by four main industries with different patterns of water use (ABS, 2008). These are:

- *pasture* in the southeast which is often flood-irrigated and occurs throughout much of the year (17%);
- *rice* in the Murray and Murrumbidgee which is flood-irrigated (standing water) for about three months in the summer (16%);
- *Dairy farming* (17%)
- *cotton* in the Northern Basin catchments which is flood-irrigated for about three months in the summer (20%)
- *horticulture*, including grapes, other fruit, nuts and vegetables (13%)

The growth of irrigation in the Northern Basin has occurred rapidly over the last 30 – 40 years, expanding westward along virtually all of the major Northern Basin river valleys (Crabb 2004).

Water Entitlements

Long term average water diversion in the Murray system is approximately 4,068GL. However, there is a total of 5,280GL of River Murray water entitlements. There is 2,487 GL of high reliability water entitlements, and 2,793 GL of low reliability water entitlements.

The specific attributes of high and low reliability irrigation water entitlements vary between States and river valleys. On the River Murray, the long term average allocation against the high reliability Victorian entitlement, is called a 'high reliability water share'. The long term average allocation against the low reliability Victorian entitlement is called 'low reliability water share'. Approximately 350 GL of River Murray Water is used by urban and domestic consumers each year. The largest consumer of this water in dry years is South Australia (200 GL), near the end of the River Murray.

Current Murray-Darling Basin Agreement

The Murray-Darling Basin Agreement (the *Agreement*) sets out the objectives, functions, and composition of the oversighting bodies and procedures. It covers relevant natural resource management, water sharing (of the River Murray System), asset management and financial arrangements.

The *Agreement* exists through parallel legislation in the parliaments of all the partner governments. Amendments to the Agreement can only come into force after passing through each partner governments' parliament.

The *Agreement* sets out the water sharing arrangements for the River Murray System and is supported by a number of Schedules. The Schedules codify important components of some MDBC programs, including the Cap, Salinity and Water Trade. Unlike the *Agreement*, Schedules can be amended by unanimous Ministerial Council agreement.

The *Agreement* authorises the Ministerial Council and Commission to initiate additional programs which are not explicitly codified in the Agreement or Schedules, including the Risks to Shared Water Program, the Sustainable Rivers Audit and the Northern Basin Program.

Cap on diversions

In June 1995, a "Cap" was introduced to limit water extraction to 1993/94 levels of development (see Figure A1-2, Attachment 1). The Cap was seen as an essential first step in establishing management systems to achieve healthy rivers and sustainable water use.
The Cap volume varies year to year, depending on climate and inflow. Its main objective is to limit diversions. The Cap promotes sustainable use of Basin resources by generating the following benefits:

- preserving the existing security of supply for river valleys
- helping maintain water quality
- encouraging efficient use of water, which reduces waterlogging and land salinisation
- preventing further deterioration of the flow regime for the environment

The Cap audit for 2006–07 found that in all areas where a Cap applies, diversions were within targets.

Whilst the mechanisms of the Cap prevent further expansion in water diversions, the 1993/94 Cap levels do not necessarily reflect an environmentally sustainable level of extraction. Identifying and implementing a sustainable cap on water use is one of the main outcomes sought from the Basin Plan under a new Authority (which will set Sustainable Diversions Limits for all valleys in the Basin). More information is available on the current MDBC Caps from the Commission website and in published annual implementation and Independent Auditors reports.

Water sharing under the *Agreement*

The sharing of Murray water between New South Wales, Victoria and South Australia is covered by the Murray-Darling Basin Agreement, particularly *Part X 'Distribution of Waters'* which regulates the sharing of the waters of the 'Upper River Murray' (water upstream of the SA border). The waters of the Murray tributaries below Albury and the waters of the Darling River and its tributaries upstream of Menindee Lakes, remain under the control of the relevant State although only when below an agreed level for Menindee.

Summary of "Normal" Sharing

The fundamentals of "normal" water sharing are described below but it should be noted computer modelling is required to fully understand the sharing provisions of the *Agreement.* The provisions can be complex, particularly under dry periods when the 'Special Accounting' provisions apply.

The process by which the Commission enacts the sharing provisions requires computer models, through a system of *Accounting* and *Assessment*. The Commission's '*Water*

Resources Assessment' represents the formal determination of each State's water share through application of all the rules.

Basic sharing provisions

Water sharing upstream of the SA border is characterised by only two 'types' of water – that is water 'belonging' to New South Wales and water 'belonging' to Victoria.

South Australia is entitled to receive a minimum volume (1850 GL/year, specified monthly in the *Agreement*). The supply of this 'entitlement' water is provided equally from the upper States. This entitlement is made up of two components: 'dilution and loss' and 'non dilution'. Inflows to the Murray have historically been sufficient to meet this requirement as well as result in additional large volumes (through unregulated flows) to South Australia above its minimum entitlement.

The upper States retain access to their own tributary inflows to the Murray except for inflows upstream of Albury/Wodonga (including Snowy Scheme releases) and inflows to Menindee Lakes (when under MDBC control). These inflows above Albury and into Menindee Lakes (when under MDBC control) are 'shared' equally between NSW and Victoria.

The Commission keeps water accounts which show, in each major reservoir and reach of river, the relative shares belonging to New South Wales and Victoria.

Water supply security under normal sharing

The *Agreement* provides each State with flexibility to manage its water share as it wishes within certain limits. Each State can manage its water use according to its own water security profile. Victoria and NSW have equal access to the storage capacity of the major Commission reservoirs upstream of the SA border. Victoria, NSW and SA can each, by way of its own policy, choose to consume its share or hold it in storage for a future time. Each of the three states may also permit an individual water license holder to "carry over" water from one year to the next.

As reservoirs have an upper storage limit, and each State may only access half of a dam's capacity at any time, the share of storage available to an upper State will be limited by 'physical' spills from dams and 'internal' spills which limits a share to 50% of capacity.

Security for South Australia is provided for in a number of ways as follows:

a. South Australia's dilution and loss component (696 GL/annum) is the most secure water in the *Agreement*, together with system losses upstream of the South Australian border. These components must be met before the upper States can access water. The intent of this arrangement was to ensure that even during droughts the Murray would continue to flow in South Australia to meet critical needs.

b. the Special Accounting provisions of the *Agreement* which apply when reserves are low allow South Australia to carry water over from one year to the next, but its share cannot exceed the full annual entitlement (1,850 GL).

c. through the concept of a minimum reserve of water (held in major Commission storages) requiring that when South Australia's share reaches full entitlement (1,850 GL) the next 835 GL of improvement is reserved for its access in the following year.

Normal sharing (in wetter times)

South Australia will receive a total entitlement volume capped at 1,850 GL over a year period ending 31 May. This entitlement effectively ensures that sufficient water will flow across the SA border throughout the year to fully meet consumptive and dilution flow needs. Historically, the actual flow across the border has been significantly higher than 1,850 GL (the long-term median is about 4,800GL) due to floods and freshes. Such flood flows would normally replenish the Lower Lakes and result in releases through the barrages to the Murray Mouth.
After setting aside sufficient water to each supply half of South Australia's entitlement, the upper States may utilise access of their share for consumptive use or it may be held over to the following year.

Sharing in drier times (during Periods of Special Accounting)

In drier times the Special Accounting provisions of the *Agreement* maintains upper State access to their tributary inflows to the Murray. However, the 'shared inflows' are shared equally three ways between New South Wales, Victoria and South Australia.

In recent years there have been occasions where 'shared inflows' have been insufficient to meet river and storage losses upstream of the South Australian border and the 696 GL dilution and loss component of South Australia's entitlement flow. In such circumstances whilst South Australia receives the dilution and loss component it effectively incurs a debt to the upstream states. Until South Australia's one third share of improvements in 'shared inflows' is sufficient to meet this debt its entitlement remains at 696 GL.

Under extreme dry conditions the flow to South Australia may not be sufficient to meet:

- evaporative losses from the South Australian border to Wellington
- evaporative losses in the Lower Lakes
- allocations for consumptive use

This limitation was recognised in the original River Murray Waters Agreement of 1915 where South Australia's share was described as being for irrigation and "*domestic and stock supply, losses by evaporation and percolation….and lockage in the river from Lake Victoria to the river mouth (but not including Lakes Alexandrina and Albert)*(Murray Waters Agreement, 1915)*.*This is not stated in the current Murray-Darling Basin Agreement.

The Current Drought

For large parts of southern and eastern Australia, dry conditions have persisted since October 1996, a total of almost 12 years. During the last 7 years in particular, the Murray-Darling Basin has experienced severe rainfall deficiencies, and from September 2001 to August 2008 was the second driest seven-year period on record (the driest was from 1939 to 1946, see Figure A1-1) (Murphy and Timbal, 2007). This rainfall deficiency, particularly in the alpine areas, has been the main cause for the record low inflows to the Murray system.

The current dry period and low water availability can be put into perspective by comparisons with similar extended droughts in the early and mid twentieth century. The average annual Murray inflow of 3,800 GL/yr during the current drought (2002 to 2008) is lower than that experienced in the previous worst two droughts on record; 4,900 GL/yr in 1897 to 1904, and 5,600 GL/yr in 1938 to 1946.

Rainfall during this drought has been comparable to previous dry periods (Attachment 1). However, inflows and water availability have been considerably lower. A number of factors have exacerbated the current drought, causing record low inflow and water availability. The factors are higher temperatures, changed rainfall profile, the driest year on record, two consecutive very dry years and the extent of development. Further information on each of the five factors is provided in Attachment 1. Additional activation of sleeper entitlements and likely impacts of increased groundwater extraction are also likely to be affecting water reliability.

The current drought has also recorded the lowest inflows for virtually all periods from one month to ten years. In particular, for the two years ending August 2008, Murray system inflows were 3,540 GL which is almost half the previous two year minimum prior to this drought (of 6,800 GL in 1943-45).

Summary of interim water sharing arrangements

Despite the water sharing provisions in the Agreement, the record low inflows observed in 2006-07 combined with record low storage levels both in the Snowy Scheme and Commission storages, required interim water sharing arrangements to be agreed by Ministerial Council in 2007-08 and 2008-09. These arrangements aimed to ensure all three States would have sufficient water to meet critical human needs under a repeat of 2006-07 inflows. These arrangements are identified in the section "Summary of interim water sharing arrangements", below.

The extreme low inflows in 2006-07 water year resulted in the adoption of a much reduced 'minimum inflow' for planning purposes. Whilst 2007-08 water year saw inflows about double those of the record low year of 2006-07, reserves at commencement of water year were much lower resulting in water availability being at record low levels.

Interim Sharing in 2007-08

At the beginning of the 2007-08 water year water availability estimated under a repeat of the extreme inflows of 2006-07 was so low (only about 600 GL in total) that normal sharing would have provided the full amount to South Australia and the upper States would have had zero water availability.

A set of interim arrangements were agreed upon whereby South Australia's share was initially reduced to ensure availability of critical water to the upper States. Thereafter initial improvements in water availability were shared between all States, instead of going solely to South Australia, in order to provide water to protect industry and permanent plantings in all three States. The arrangements then directed further improvements towards increasing South Australia's share beyond its normal share in recognition of the earlier restrictions agreed to by South Australia. Under wetter conditions yielding significant improvements in water availability, each State's share would have gradually transitioned to where it would have been under normal sharing.

However, as 2007-08 remained very dry and inflows remained very low, there was insufficient improvement in water availability to permit a transition fully back to normal shares. At the end of the year South Australia's share remained greater than it would have been under the application of normal accounting and sharing methodologies. The debt owed by South Australia to the upper States at this time was referred to as 'drought imbalance'.

Interim Sharing in 2008-09

A new set of interim arrangements were agreed for 2008-09. These included possible contingency arrangements (se separate section) to ensure availability of South Australia's full 696 GL of dilution and loss. The arrangements permitted all three States to carryover water to meet critical human needs as well as those volumes carried over by individual license holders in each State. Whilst normal sharing allows such carryover, the agreed arrangements 'quarantined' this water to ensure all carryover remained available to each State under continuing extreme inflow conditions, rather than have such volumes treated under normal sharing rules.

The arrangements were again designed to ensure that each State's share would transition back to normal under wetter conditions.

At the commencement of 2008-09, the action of 'quarantining' meant that South Australia's share was 260 GL higher than it would have otherwise been under normal sharing arrangements.

The arrangements also permitted gradual increases to South Australia rather than remaining steady for a prolonged period. However, as was the case in 2007-08, it is now highly likely that conditions will not be wet enough to permit transition back to normal sharing in 2008-09. South Australia is again likely to owe the upper States a debt in the form of 'drought imbalance' at the end of this season.

Drought response for individual carryover

In Victoria, carryover was introduced in 2007/08 as a drought response measure. It gives entitlement holders like domestic and stock customers, irrigators, urban authorities and the environment, the ability to carry forward unused water allocated or purchased in 2006-07 to the 2007-08 season. Irrigators had the flexibility to use water in 2007-08 instead of this season, if they believe they could get a better return from it next season. Carryover is now available on an ongoing basis.

South Australian irrigators were able to carry-over all of their River Murray allocations not used in 2007-08 into the 2008-09 water year. Irrigators now have access to 100% of their approved carry-over water volume. The carry-over scheme does not allow licence holders to take more than 100 percent of their normal licensed water entitlements if allocations improve significantly during 2008-09.

NSW irrigators can carry-over allocations from one year to the next. It normally applies to general security water but during the current severe drought it has been extended to high security water.

Contingencies identified in 2007-08 and 2008-09

In order to 'reasonably assure' the delivery of critical human needs within the Murray System in 2008-09 it was necessary to rely, initially, on 366 GL of contingency measures.

The following contingency measures were either considered or actively put in place at the commencement of 2008-09 (note that these are specific to 08-09 only and cannot be considered available in future years):

- additional tributary inflows from NSW
- additional tributary inflows from Victoria
- turn off the Edward River System (to reduce transmission losses)
- disconnection of specific wetlands (to reduce losses)
- draw on in-river storage including lowering weir pools
- access water in the Snowy Scheme

Recent improvements in inflows and storage levels have eliminated the need to apply such contingency measures to meet critical human needs this season. Given the current low inflows it is highly likely that similar contingency and interim sharing arrangements will be needed to reasonably assure delivery of critical human needs in 2009-10. In addition, it is quite conceivable that overall water availability will set a new record low this year making the assurance of critical human needs in 2009-10 more difficult. Inevitably this will impact on other users and the environment.

Additional contingency measures may therefore need to be considered by Commission and States in order to have sufficient reserves by the end of June 2009. Options *may* include the limitation of allocations by States in order to build reserves or potentially even the purchase of water. The Commission office will continue to consider outlooks and provide advice to Senior Official's Group on potential contingency and sharing arrangements.

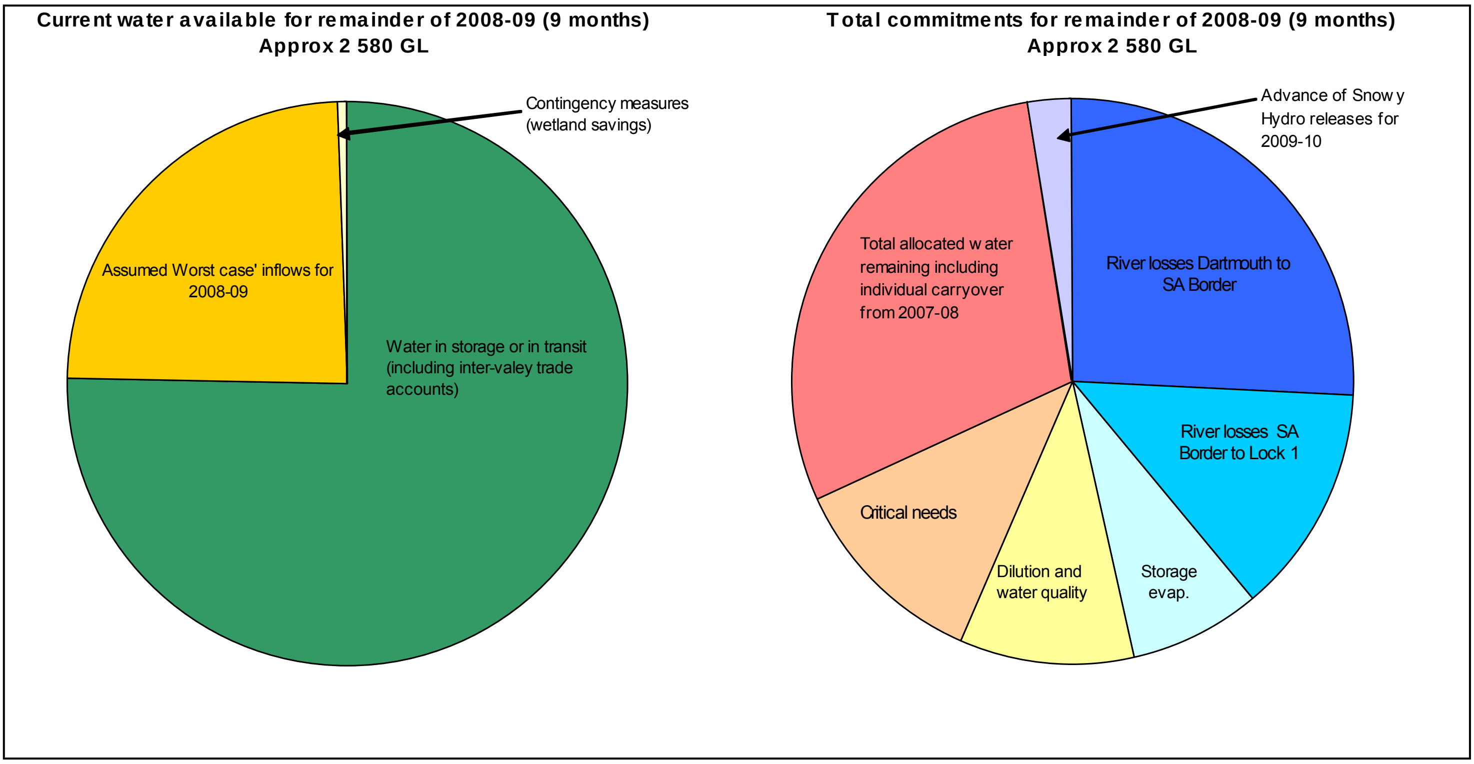

Figure 1: Current water availability in River Murray System (as at 31 August 2008)

Accounting for Losses in the River Murray System

Under normal Agreement sharing arrangements, river transmission losses under fully regulated flow conditions upstream of the South Australian Border are provided for from shared inflows.

In dry years, when South Australia does not have full entitlement, these losses have an influence on South Australia's share - for example if losses are reduced by a rainfall event the overall water availability will increase and South Australia will receive up to a third of any improvement brought about by the reduced loss.

Evaporation loss from storages upstream of SA border is borne by the upper States in proportion to their share in each reservoir. For instance if NSW occupies 75% of the volume in Lake Victoria at the end of a month, they will be debited 75% of that month's evaporation loss. Downstream of the border, South Australia covers the transmission losses out of its entitlement flow.

Loss sharing under the interim water sharing arrangements has not been altered. Minor changes to overall losses have been achieved through wetland disconnections etc but these have had negligible impact on sharing of bulk losses by the States. Losses for 2008-09 are identified in Figure 1.

The Living Murray Overview

The Living Murray Initiative includes a water recovery target of an average of 500 GL of water per year by 30 June 2009. This is being achieved through a coordinated effort by the State and Federal governments, and the MDBC, using a combination of infrastructure, regulatory, urban, and market based water recovery projects.

Significant progress has been made in recovering water for The Living Murray. There has been 133GL of water entitlements recovered to date, however the actual volume of water available at any time is dependent on allocations (see Table 1). At present there is only 1.218 GL of water available to the environment in 2008-09 although this may increase modestly if higher allocations are announced against entitlements this water year.

Icon Site Water Use

Environmental watering of TLM Icon Sites has been managed under The Living Murray Environmental Watering Plan since 2005-06. This framework has provided the opportunity for coordinated watering at Icon Sites, regardless of the type of environmental entitlement or source of water.

Since the establishment of the Living Murray Environmental Watering plan there have been contrasting climatic conditions ranging from the largest actively managed environmental watering event in 2005-06 to targeting small volumes of water to protect critical drought refuges during the period of lowest inflows on record in 2007-08. The limited amount of watering undertaken during 2006-07 and 2007-08 has been crucial for achieving TLM objectives and has demonstrated that excellent, though localised, environmental outcomes can be achieved where water is actively provided and managed for environmental outcomes.

Table 1: Environmental Water Managed under TLM for the Icon Sites from 2005-06 to 2008-09.

	2005-06	**2006-07**	**2007-08**	**2008-09**
TLM water		7.8 GL[2]	4.16 GL	0.780 GL[4]
RMIF	11 GL	14.2 GL	12.8 GL[3]	0.438 GL[5]
BM EWA	93[1]			
Unregulated flows	864.8	65 GL		

[1] Although 513 GL was released from the account, approximately 93 GL was 'used at the site' during BMF EWA release
[2] donation of SA water prior to listing on ewater register
[3] carry-over from unused 2006-07 allocation
[4] allocation for environmental register entitlements as of 5 September 2008
[5] carry-over from unused 2007-08 allocation

Current condition of Icon Sites

In general, the ecological objectives for each of the icon sites are not being achieved. This is due to both the timing of water recovery for The Living Murray (water was to be recovered by June 2009) and the severe impact of the current drought on the conditions of Icon Sites and on the availability of allocation against entitlements. The condition of the Lower Lakes is summarised in Attachment 2. The condition of other Living Murray Icon sites is summarized in Attachment 3.

Commission related processes in the Lower Lakes

In addition to the Lower Lakes being one of The Living Murray Icon Sites, a number of projects were initiated by the Ministerial Council in March 2008. These are described below.

Lake Albert Pumping Project

In response to the potential acidification risk in the Lower Lakes, Ministerial Council in March 2008 approved the Lake Albert Water Level Management project at a budget of $6m. A temporary structure has been built to separate the Lakes and pumping from Lake Alexandrina to Lake Albert commenced on 2 May 2008. This pumping is to ensure that no further sulfidic sediments are exposed and there is no further acidification of Lake Albert.

Future Management Options Project

The Ministerial Council 44 - 7 March 2008 directed the Murray-Darling Basin Commission to develop risk management strategies and future management options for the Coorong and Lower Lakes and to report to Council in October 2008. A number of inter-jurisdictional workshops have progressed the development of these options. Progress is broadly summarized below.

Short Term Management Options

Ministerial Council has agreed to the following short term (defined as the next 6-24 months) management objectives:

- Avoid irreversible damage, especially acidification of Lakes System (Lakes Alexandrina and Albert, tributaries and other fringing areas).
- Actions taken must not adversely impact on water quality for major water supply off-takes.
- Use (risk) treatments that as far as possible do not compromise long-term options.

In order to achieve these short term management objectives, critical acidification thresholds and water level management triggers have been developed by South Australian agencies based on the best available scientific advice.

The critical acidification threshold is the point at which acidity being formed in the lake sediments can no longer be buffered by the alkalinity of the sediments and lake waters and the pH of the lake body may decline relatively quickly. The water level management trigger represents the level above which the risk of acidification is expected to be negligible therefore maintaining lake levels above the water level management triggers should ensure the risk of acidification of the Lakes system as a whole is low.

Because of the unprecedented nature of the situation the modelling underpinning the critical acidification thresholds cannot be calibrated against real data. As a result, the model is being regularly reviewed against actual data to improve the predictive capacity of the model. This means that as more data become available and the modelling improves, the acidification threshold and therefore the water level management trigger may change.

A draft real time management strategy for 2008/09 was considered at Commission meeting 96 (26 August 2008) and is now being considered by Ministerial Council. A number of ongoing activities will support the proposed management strategy including regular review of lake levels, water quality and acidification data and forecasting of the projected date to reach the water level management trigger.

SA is also undertaking a feasibility study and conducting field trials on the potential for bioremediation to manage localised acid affected areas. Bioremediation aims to reduce acidified conditions through the addition of sulfate-reducing bacteria and organic matter.

In response to ongoing public interest in the Lower Lakes a fact sheet (Attachment 4) and preliminary water availability assessment analysis (MDBC submission Part 2 Attachment 1) was made publicly available on the Murray-Darling Basin Commission website on Thursday 7 August 2008.

Longer Term Management Options

The longer term options identified for further analysis broadly fall into three scenarios:

- A freshwater Lakes system
- A variable Lakes system (fresh with times of estuarine at low flow)
- A marine/estuarine Lake system

These scenarios will be developed in the light of long term water availability, climate change, and sea level rise forecasts. Potential risks with pursuing all of these scenarios need to be identified and assessed. This includes the impact of seawater on environmental (including acid sulfate soils), economic and social values should an estuarine/marine system be seen as a possible future. The first report on the development of the longer term options is expected to be provided to Commission and Council in early 2009.

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Attachment 1: Why has this drought been so severe?

The text below is an extract from a paper presented by Dr Wendy Craik at the Rosenberg International Forum on Water Policy, in May 2008.

Why has this drought been so severe?
Rainfall during this drought has been comparable to previous dry periods (Figure A2-1). However, inflows and water availability have been considerably lower. Five factors have made this drought worse than in the past.

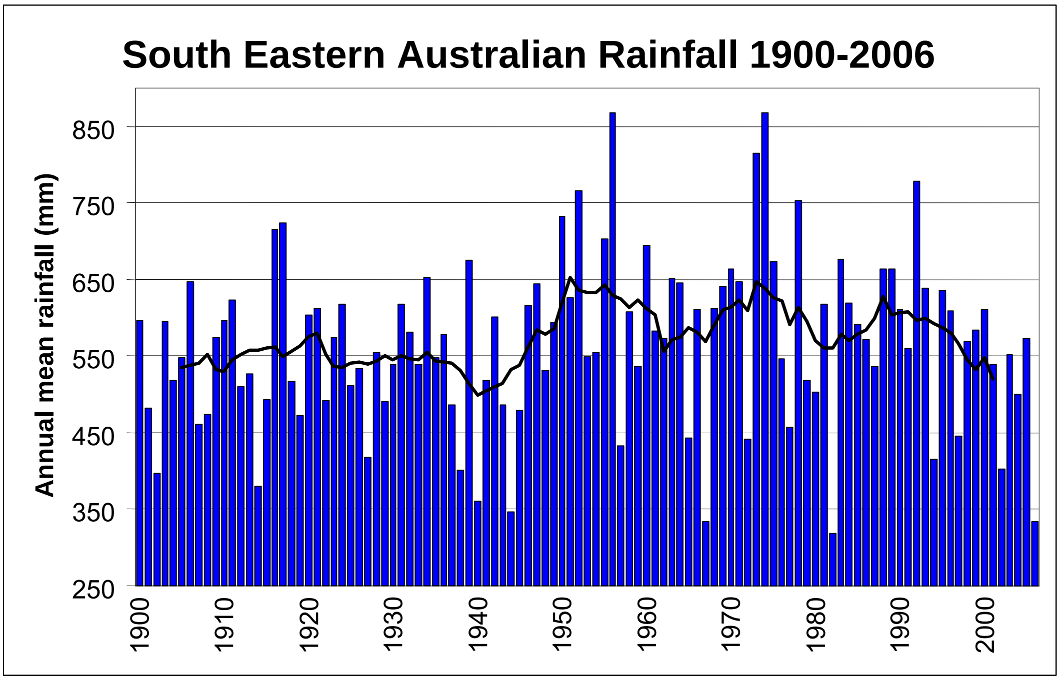

Figure A1-1: South Eastern Australian Rainfall 1900-2006 (Murphy and Timbal 2007).

Over allocation – the second half of the 21st century was significantly wetter than the first half. Consistently wet weather, dam construction between the 1950s and 1990, and the accepted wisdom that only a percentage of new entitlements would be utilised[2], underpinned an expansion in irrigation entitlements. A larger number of irrigators dependent on the resource than previous droughts exacerbate impact of the water shortage. The Cap, introduced in June 1995, limits water extraction to 1993/94 levels of development (Figure A2-2). However, whilst the mechanisms of the Cap prevent further expansion in water diversions, the 1993/94 Cap levels do not necessarily reflect an environmentally sustainable level of extraction.

[2] In 1995, the MDBC conducted and *Audit of Water use in the Murray-Darling Basin* which revealed that only 63% of entitlements were activated.

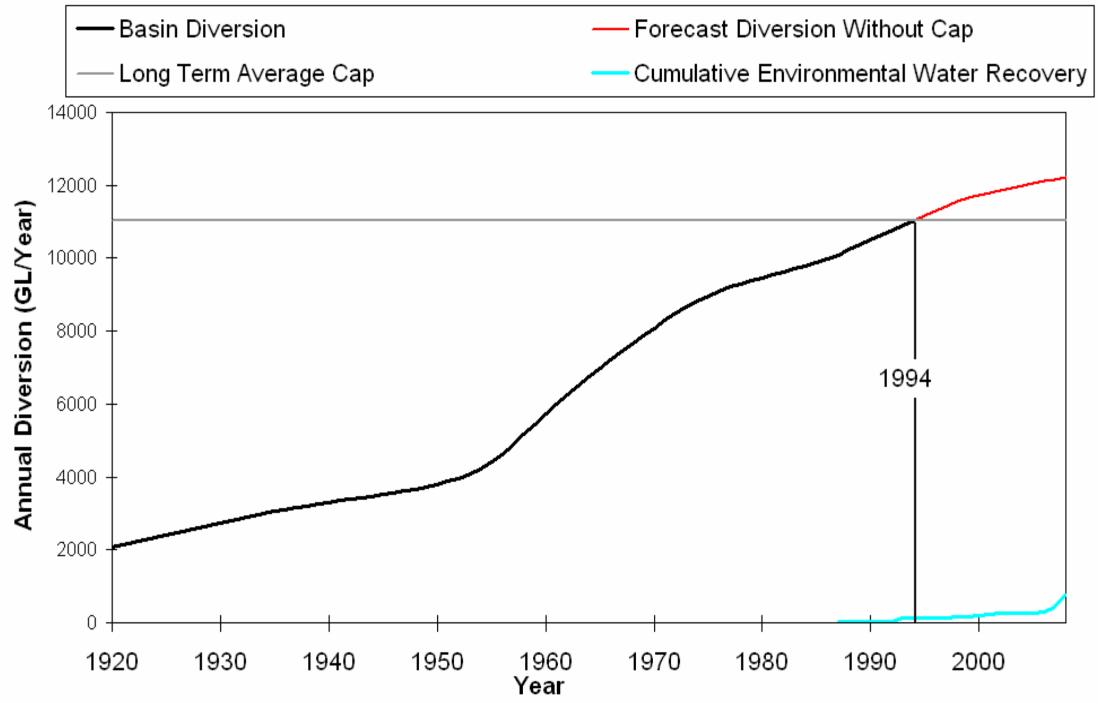

Figure A1-2: Total modelled MDB irrigation diversions (assumes average inflows).

Higher temperatures – according to the Bureau of Meteorology, three of the last five years, in the Basin, have been the hottest on record (of approximately 100 years of records). Higher temperatures increase evaporation and dry the catchment, resulting in less runoff. CSIRO research indicates that a 1°C increase in temperature will reduce runoff by 15% (Cai and Cowan 2008). The impact of higher temperatures and a drier catchment have been clearly evident since September 2007 when a La Nina system bought above average rainfall to most of the River Murray catchment between September 2007 and March 2008, yet inflows remained very low.

Changed rainfall patterns – Research by Murphy and Timbal (2007) indicates that a significant reduction in autumn rainfall has occurred over the MDB. Murphy and Timbal found that March, April and May have been proportionally more impacted by lower rainfall in the last decade than other months, when compared to 1961-90[3]. The explanation offered by Murphy and Timbal is the strengthening of a 'subtropical ridge' of high pressure over the Basin during the autumn months. Their research indicates that historically, the subtropical ridge is present in summer but weakens and moves rapidly north during autumn, allowing frontal systems to bring rain to the Basin (and south eastern Australia generally). Murphy and Timbal link the persisting southerly subtropical ridge to climate change and the effect diverting autumn storm systems to the south of the Basin (Murphy and Timbal 2007, and references therein).

[3] The MDBC has identified a high correlation between low inflows during the autumn months and a below average annual inflows.

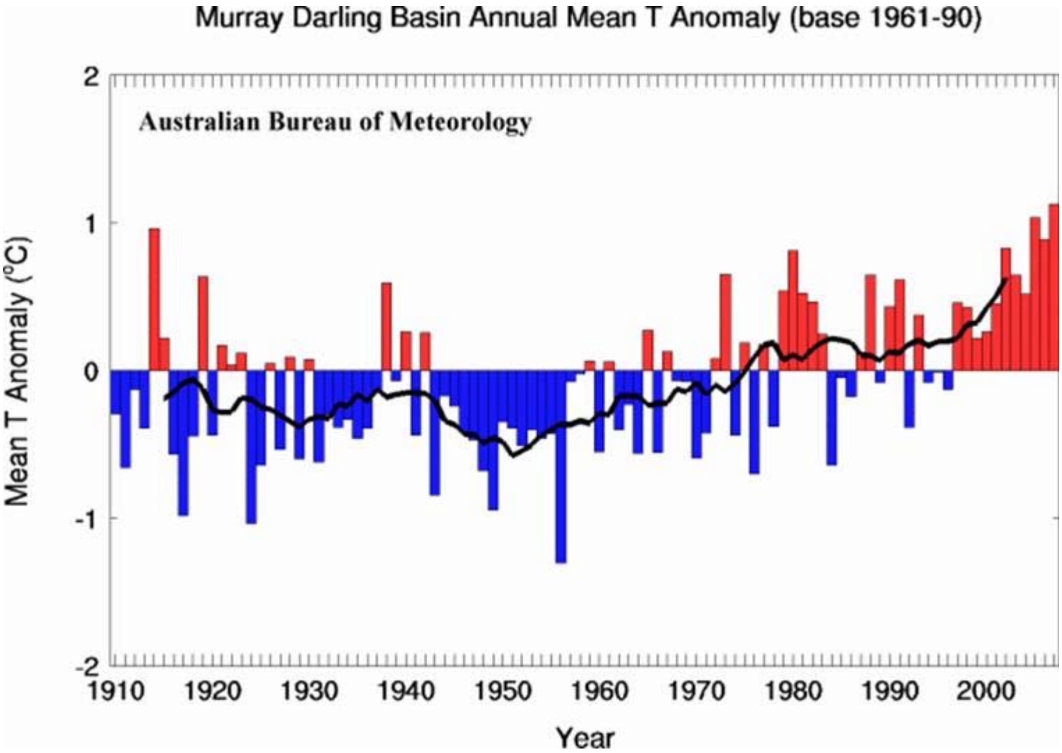

Figure A1-3: Murray-Darling Basin annual mean temperature anomaly (ABS, 2008)

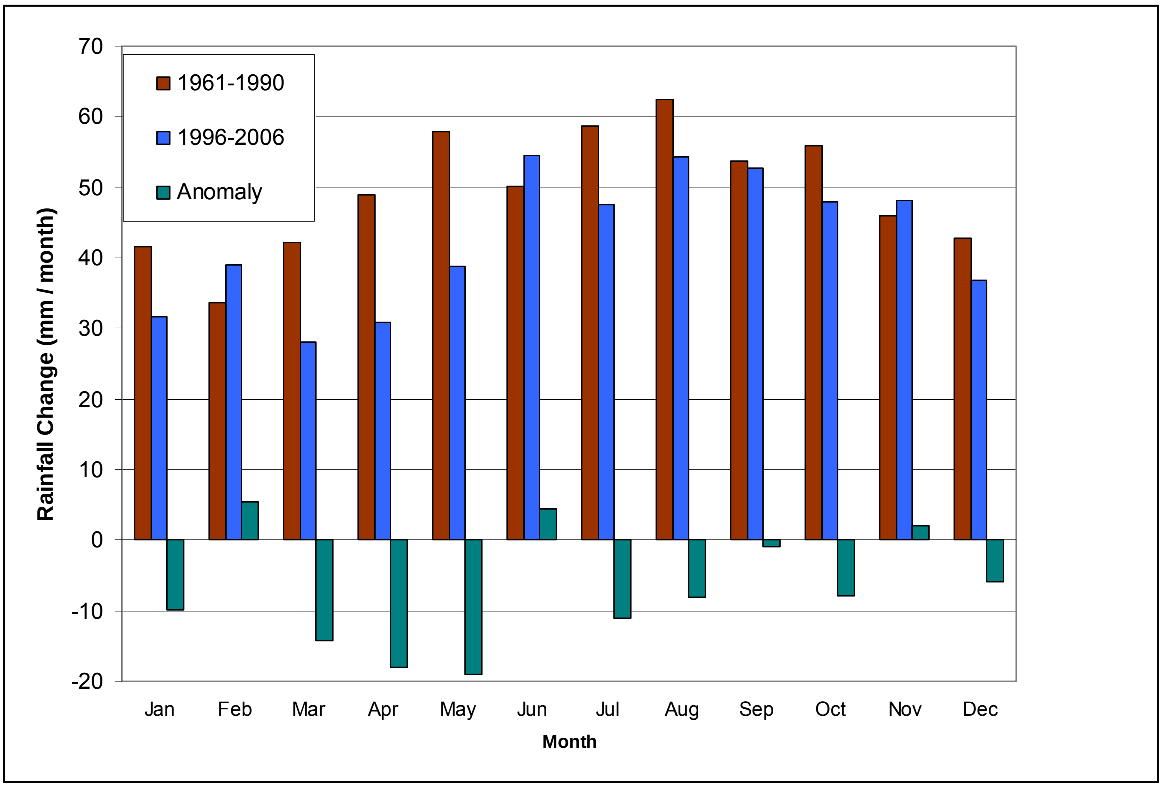

Figure A1-4: Monthly mean south eastern Australia rainfall, 1961-1990, 1996-2006 and anomaly (Murphy and Timbal 2007).

The lowest inflow year on record – total annual River Murray system inflow during 2006/07 was 1040GL, approximately 60% below the previous record minimum. Such an unprecedented dry year almost completely exhausted the River Murray's main drought storage, Dartmouth Dam. This has resulted in today's situation of allocations being almost entirely dependent on inflows. At the beginning of July 2006 Dartmouth Dam was approximately 65% of capacity, despite several years of very dry conditions. At the end of June 2007 it was approximately 13% of capacity. Such use of Dartmouth Dam is a measure of last resort under extreme dry conditions. Even if River Murray inflows return to long term average, under existing allocation policy, it will take several years for Dartmouth Dam storage levels to recover.

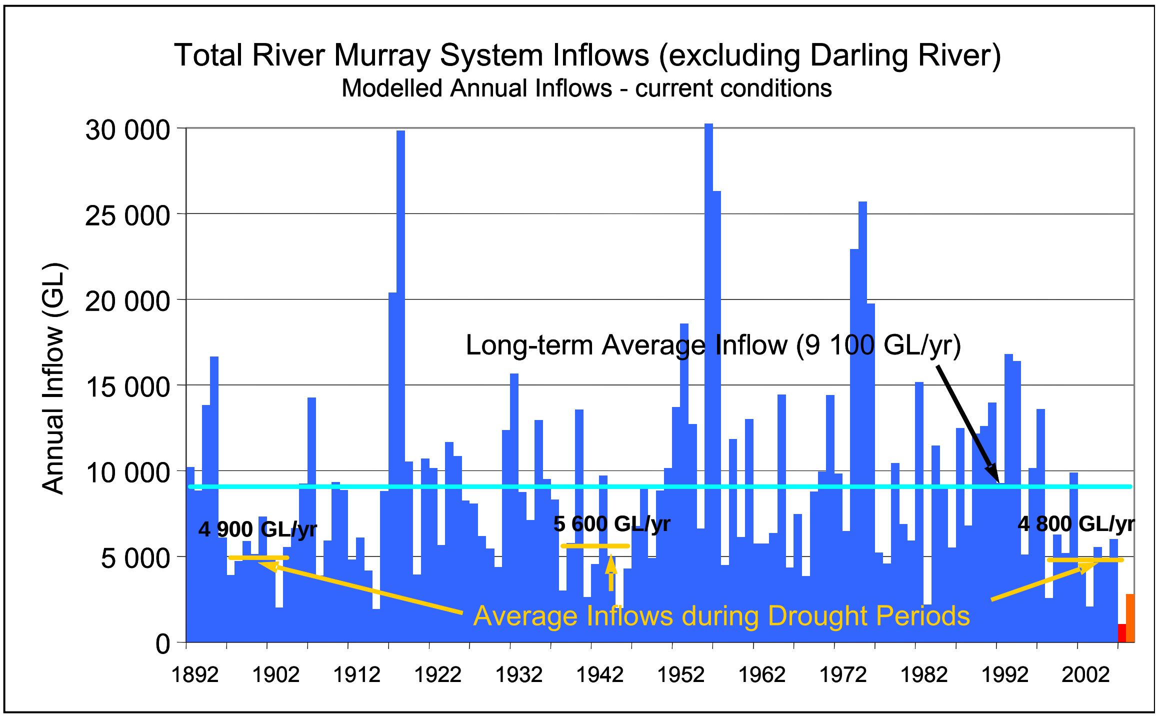

Figure A1- 5: Total Murray system inflow, all years on record.

Two consecutive very dry years – following 2006/07, the driest year on record, 2007/08 has also been a very dry year. Never before, in the historical record, has an extreme dry year, been followed by another very dry year. Previously, the driest years on record 1902/03, 1914/15 and 1982/83 were followed by significantly wetter years, 5,557 GL, 8,830 GL and 11,232 GL respectively.

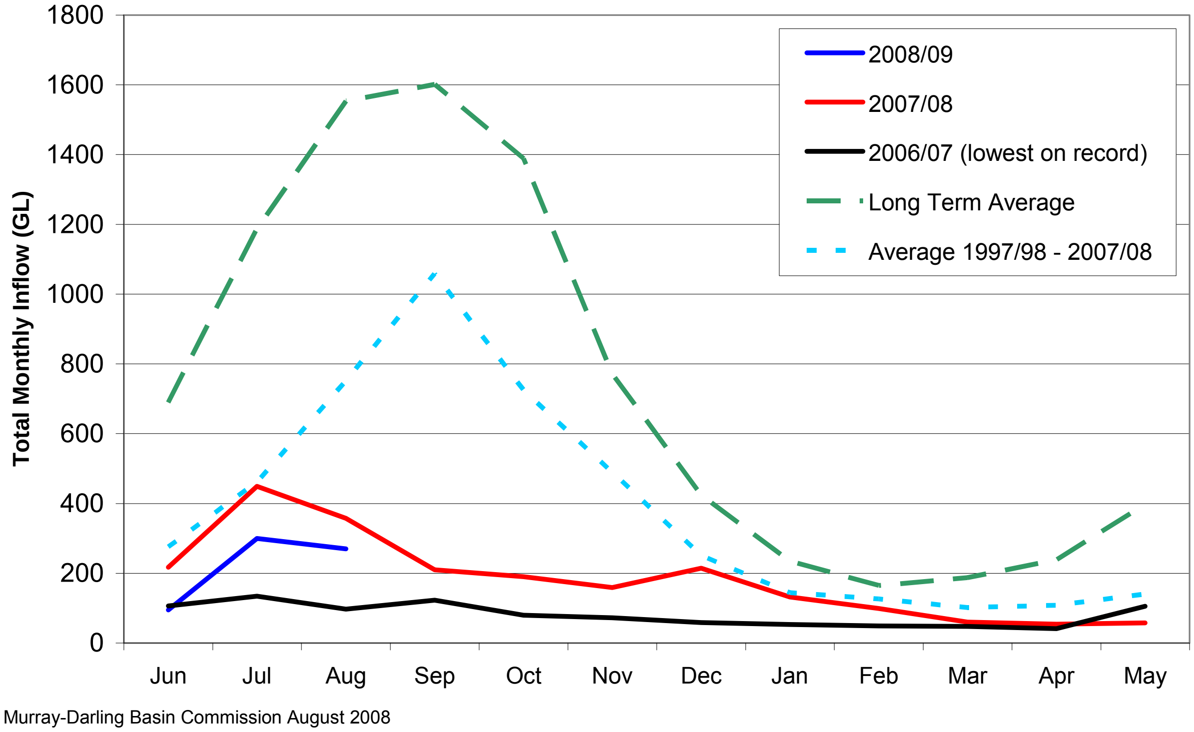

Figure A1- 6: Monthly inflows into the River Murray system.

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Attachment 2: Lower Lakes, Coorong and Murray Mouth – Summary of Current Condition

This information is quoted from a report by the South Australian Murray-Darling Basin Natural Resources Management Board – *2008 Icon Site Condition Report, Lower Lakes, Coorong and Murray Mouth* (July 2008). This work is funded by the Commission office under The Living Murray Program.

Summary

An open Murray Mouth at all times – The dredging operation allows for the artificial maintenance of an open Murray Mouth. As no flows have been released over the barrages during 2007/08, the dredging also maintains variable salinity and water regimes in the estuary and some parts of the North Lagoon.

More frequent estuarine fish spawning – Estuarine fish spawning has occurred for a limited number of species as a result of opening fishways. The closure of the fishways in early 2007 was necessary due to low levels in Lake Alexandrina and Lake Albert and the potential for reverse head (i.e. intrusion of salt water into the lower lakes because lake water levels can be lower than Coorong levels). There was a 96% and 99% decline in young-of-year Common galaxias and Congolli respectively within the estuary last year. Intermediate sized male Congolli were sampled on the Coorong side of Tauwitchere barrage, with female Congolli sampled on the other side. The separation of males and females has prevented spawning and recruitment for this species. No adult Lampreys were sampled attempting to migrate at the barrage fishways or (saltwater) leakage sites. Estuarine and catadromous fish spawning and recruitment has significantly declined due to a lack of freshwater outflows and subsequent loss of connection between the lakes and the estuary.

Enhanced migratory wader bird habitat in the lakes – Long-term monitoring indicates a steady decline in abundances of many key wading species in the Coorong. The exceptions to the rule are Banded Stilt and Red-necked Avocet, which are able to feed on brine shrimp in the South Lagoon and have been recorded in record numbers. While an increase in mudflat exposure in the Lower Lakes seems likely to be beneficial to wading birds, benthic invertebrate monitoring indicates that key food species are only able to survive up to one week without re-inundation, rendering the majority of exposed lake edge barren. The annual aerial waterbird survey of all icon sites indicated that the Lower Lakes, Coorong and Murray Mouth Icon Site has waterbird abundance an order of magnitude greater than any other Icon Site,

1. Introduction

The Lower Lakes, Coorong and Murray Mouth Icon Site (LLCMM) is located at the downstream end of the River Murray system. The River Murray terminates at the Southern Ocean in South Australia, where it passes through the Lower Lakes (Lakes Alexandrina and Albert), the Murray Estuary, the Coorong and, finally, the Murray Mouth. This partially accounts for its unique ecological qualities and the challenges in managing the area. The complex ecology of the area has been compounded by a system of barrages which isolate the Lower Lakes from the Murray Mouth and Coorong.

2. Interim Ecological Objectives for the Icon Site

A healthier lower lakes and Coorong estuarine environment

- An open Murray Mouth at all times;
- More frequent estuarine fish spawning; and
- Enhanced migratory wader bird habitat in the lakes.

The interim ecological objectives were translated into specific targets relating to trees, understorey and aquatic vegetation; vertebrate fauna such as endangered birds, amphibians and fish; water quality; pests and weeds, and cultural heritage. A monitoring program is being implemented for ongoing site condition monitoring against these targets. However, using an adaptive management process it was recognised that the targets require revision and recently the South Australian Murray-Darling Basin Natural Resources Management Board commenced this process as part of the revision of the Icon site Environmental Management Plans (EMP). The CLLMM Scientific Advisory Group has had a role in the review of the condition monitoring methodologies and targets, and may also play a part in the future review of the Icon Site EMP. It is expected that the Condition Monitoring Plan, including revised targets, will be completed in late 2008. The completion of the plan will allow for consistent long-term data collection within the Icon Site, resulting in the ability of managers to track the ecological condition of the keystone species and communities of the Lakes and Coorong. The monitoring plan will build on information collected to date.

Reporting for the 2008 condition report uses the initial targets. They have been reported against the higher level TLM objectives of fish, birds and vegetation (as below), except for those relating to the Murray mouth. Target numbering relates to the target numbers as listed in the draft monitoring framework and are hence not consecutive in this document.

Murray Mouth

h) The Murray Mouth open 100% of the time through freshwater outflows with adequate tidal variations to meet the needs of the Coorong ecosystem

Fish Condition

f) Lakes: Maintain and enhance habitat for native fish;
n) Coorong: Successful spawning and recruitment of Black bream and Greenback flounder;
o) Improved connectivity between the Lower Lakes and Coorong to facilitate required fish passage between freshwater and estuarine habitats that provides for the improved spawning and recruitment success of diadromous fish species such as Congolli and Common galaxias;
p) Improved connectivity between the Coorong and the sea to facilitate required fish passage between habitats for juvenile and adult life-history stages of diadromous fish species such as Lampreys and Eels or estuarine dependent species such as Mulloway;
q) South Lagoon: Management of flows to the South Lagoon to provide conditions for growth and spawning of Small-mouthed hardyhead;
r) Management of flows to the Southern Ocean to provide diatoms for off shore cockle communities;and
s) Improved spawning and recruitment success in the Lower Lakes for endangered fish species including Murray hardyheads and Pygmy perch.

Bird Condition

c) Coorong-North Lagoon & Estuary: Maintain and increase benthic diversity in the estuarine-lagoonal invertebrate populations in the North Lagoon;
d) Coorong-South Lagoon: Establish viable invertebrate populations in the South Lagoon;
i) Coorong and Estuary: Maintain the 1% flyway population level for: Sharp-tailed Sandpiper; Curlew Sandpiper, Red-necked Stint, Sanderling, Common Greenshank and Banded Stilt.
j) Lakes: Expose mudflats during summer around lake edge;
k) Coorong North Lagoon and South Lagoon (2 targets): Maximise mudflat exposure during summer;
l) North Lagoon: Maintain sediment size range in mudflats; and
m) Coorong North Lagoon: Establish and maintain organic content for mudflats.

Vegetation Condition

a) Coorong-North Lagoon: Enhance *Ruppia megacarpa* colonisation and reproduction;
b) Coorong-South Lagoon: Enhance *Ruppia tuberosa* colonisation and reproduction;
e) Lakes: Maintain aquatic and floodplain vegetation; and
g) Estuary and Coorong: Establish and maintain variable salinity regime with >30% of area below seawater salinity concentrations.

3. Condition of Icon Site

A description and synthesis of the current monitoring data that relates to each of the 'interim targets for achieving the Living Murray ecological objectives' is described below. Note that, while the majority of data collection has been funded by the MDBC through the SAMDBNRM Board to specifically inform these targets, many other monitoring programs such as those funded by DEH to inform Ramsar Management Plan objectives, have also been incorporated in this reporting.

Murray Mouth

h) The Murray Mouth open 100% of the time through freshwater outflows with adequate tidal variations to meet the needs of the Coorong ecosystem

No freshwater releases were made through the barrages during 2007/08. The Murray Mouth remains open due to the dredging operation. Diurnal tide ratio values between Victor Harbour and the Coorong are interpreted on a monthly basis for DWLBC as an indication of the effectiveness of the dredging operation (Figure A3- 5). Monitoring has indicated that on average, a tidal ratio of 0.05 is being attained at Tauwitchere and 0.25 at Goolwa, as required.

Murray Mouth has been kept open in 2007/08 due to dredging, not freshwater outflows; target not achieved. However, adequate tidal variations have been achieved.

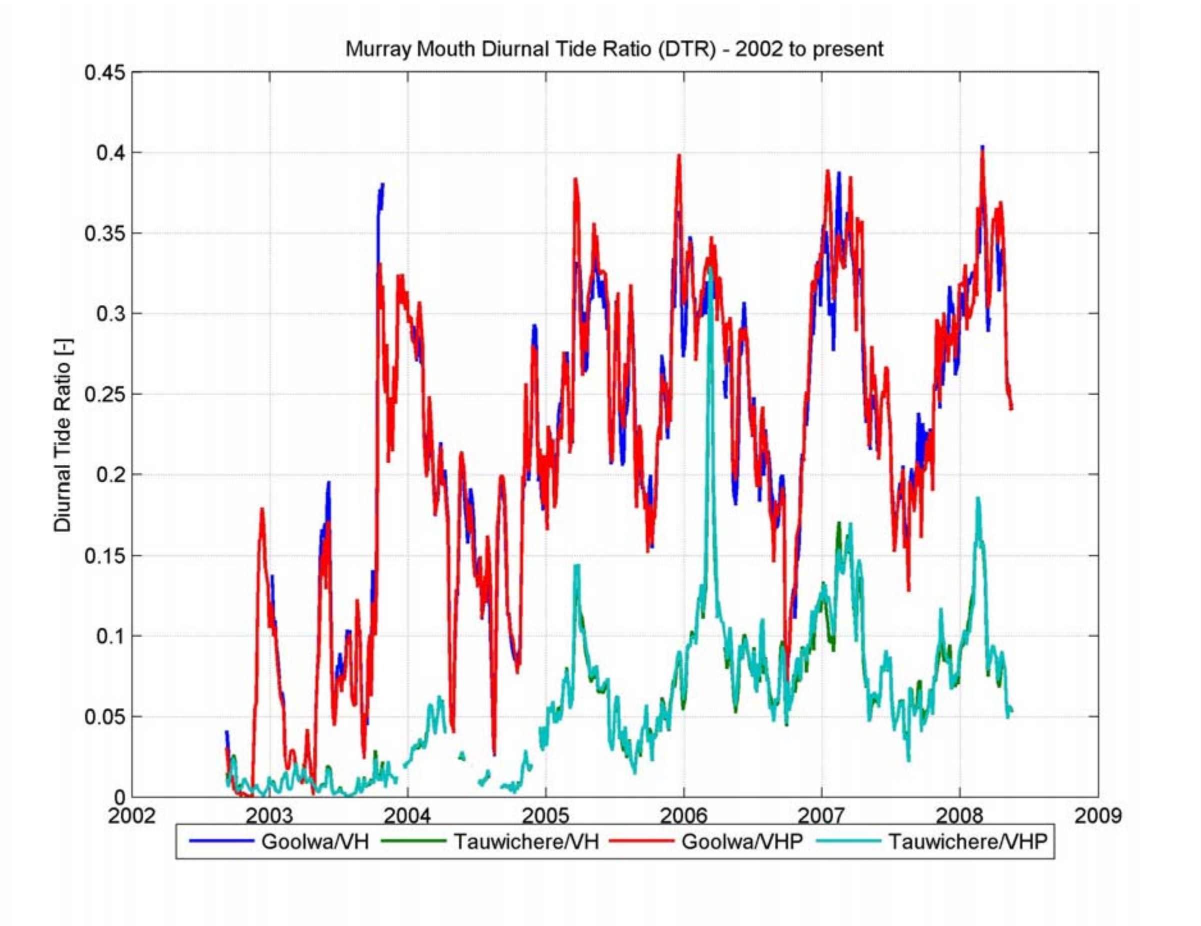


Figure A2-1. Murray Mouth diurnal tide ratio-2002 to present (WBM 2008)

Fish Condition

f) Lakes: Maintain and enhance habitat for native fish

Investigations are needed to establish the relationship between native fish and habitat preference (especially in relation to particular submerged aquatic plants). Current conditions are not suitable for assessing this relationship.

Not enough information to determine whether this target has been met.

n) Coorong: Successful spawning and recruitment of Black bream and Greenback flounder

Fish monitoring occurred in the Coorong during 2007 and 2008 (Noell 2008). Analysis of gonad stage proportions and gonadstomatic index trends in adult females indicate that spawning activity is likely to have occurred in spring (Sep-Nov) for black bream, winter (Jun-Jul) for Greenback flounder and early spring (Aug-Sept) for Congolli. No ripe or spent female Congolli were found and only one female Greenback flounder sampled was assessed as being spent (collected from the North Lagoon in Oct 2007).

Juvenile Black bream (<50mm total length) were caught using fyke nets in the estuary from Feb-Apr 2008. Juvenile Greenback flounder (<50mm total length) were also caught in the estuary using fyke nets from Sept-Dec 2007. These data suggest a level of recruitment of these species, but are inadequate to make a clear statement on recruitment success.

Not enough information to determine whether this target has been achieved. Target requires revision.

o) Improved connectivity between the Lower Lakes and Coorong to facilitate required fish passage between freshwater and estuarine habitats that provides for the improved spawning and recruitment success of diadromous fish species such as Congolli and Common galaxias

No freshwater releases were made over the barrages during 2007/08, resulting in a lack of connectivity for migrating fish. Zampatti (2008) reports a 96% and 99% decline in young of the year Common galaxias and Congollis respectively within the estuary compared to figures from 2006/07. During this year, intermediate sized male Congolli were sampled on the Coorong side of Tauwitchere barrage, with female Congolli sampled on the other side. The separation of males and females has prevented spawning and recruitment for this species. On the other hand, Common galaxia young-of-year recruits were present on the lake-side of Tauwitchere barrage between November 2007 and January 2008, after adults of both sexes had been recorded between September 2007 and November 2007. Zampatti (2008) hypothesises that this species has utilised the estuarine conditions on the lakeside of the barrages (from saltwater leakages) as an opportunistic recruitment strategy.

No connectivity between the Lakes and Coorong and a reduction in recruitment of Congolli and Common galaxias; target not achieved

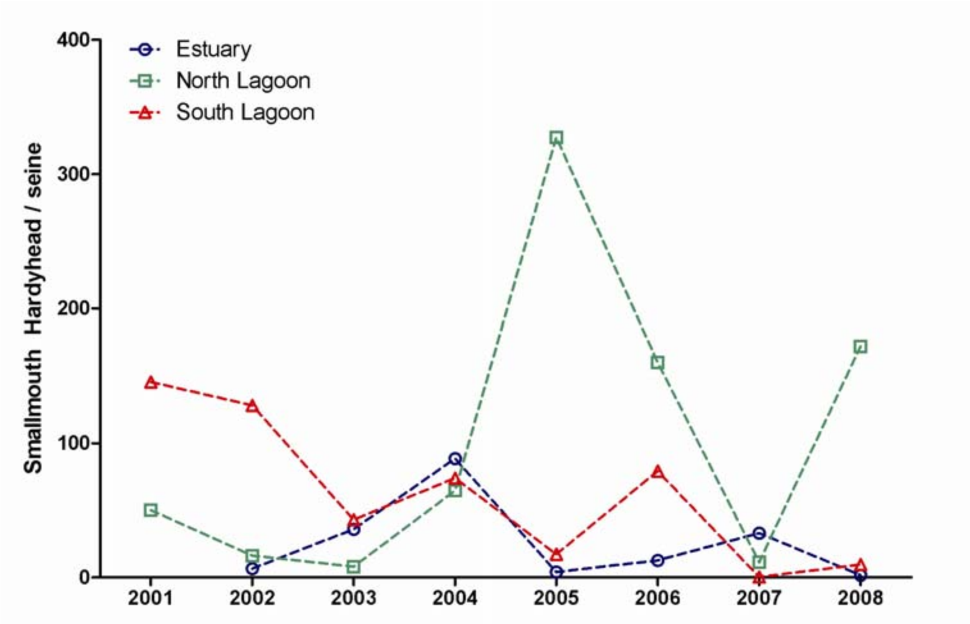
p) Improved connectivity between the Coorong and the sea to facilitate required fish passage between habitats for juvenile and adult life-history stages of diadromous fish species such as Lampreys and Eels or estuarine dependent species such as Mulloway.

The dredging operation at the Murray Mouth has maintained the connection between the Coorong and the sea. No adult Lampreys were sampled attempting to migrate at the barrage fishways or (saltwater) leakage sites during 2007/08 sampling. During 2006/07, when conditions allowed the fishways to operate, a total of 41 Lampreys from two species were monitored attempting to migrate upstream (Bice *et al* 2007). No Lampreys or Eels were sampled in the estuary or Coorong during 07/08 (Noell 2008), and while young-of-year Mulloway were abundant in 2006 and Jan 2007 sampling rounds, only two individuals have been recorded since in late 2007.

No Lampreys or Eels monitored attempting to migrate, and a significant reduction in Mulloway recruits; target not achieved

q) South Lagoon: Management of flows to the South Lagoon to provide conditions for growth and spawning of Small-mouthed hardyhead

While Smallmouth hardyhead are the most abundant of all fish in the Coorong, they have been absent from the South Lagoon of the Coorong since September 2007 (Noell 2008). However, Rogers and Paton (2008) found them in very small quantities in the South Lagoon in January 2008 (Figure A3-8), from nine seine net drags. Overall, they have recorded a steady decline in smallmouth hardyhead numbers in the South Lagoon since 2001. No flows have been released from the Upper South East via Salt Creek into the South Lagoon of the Coorong during 07/08.



No flows released into the South Lagoon from Salt Creek in 07/08 and no evidence of growth and spawning of Smallmouth hardyhead populations; target not achieved

Figure A2- 2. Mean abundance of Smallmouth hardyhead per seine, between 2001 and 2008, for the three regions of the Coorong (Rogers and Paton 2008).

r) Management of flows to the Southern Ocean to provide diatoms for off shore cockle communities

No freshwater flows have been released over the barrages during 07/08 therefore freshwater diatoms have not been released for the cockle community. In order to gauge 'baseline' or 'no-flow' diatom levels in the water on the marine-side of the barrages, the SAMDBNRM Board has commissioned a small study through Flinders University to monitor current (June 2008) water quality conditions. Monitoring sites are described in Figure 9 (below).

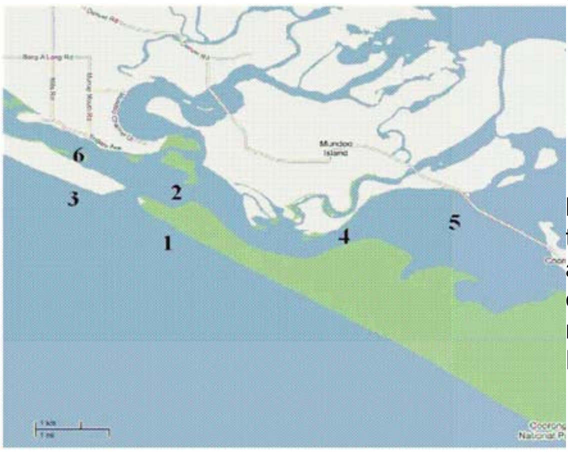


Figure A2-3. Location of the stations investigated from the barrages to each side of the Murray Mouth inside and outside the Coorong. Note that stations 1 and 3 correspond to stations where cockles must and must not be taken for human consumption, respectively. From Seuront & Leterme (2008).

The initial state of the phytoplankton populations (both diatoms and dinoflagellates) (Figure 10) as well as the abundance of viruses and bacteria (Figure 11) has been consistently assessed at each of the above monitoring stations.

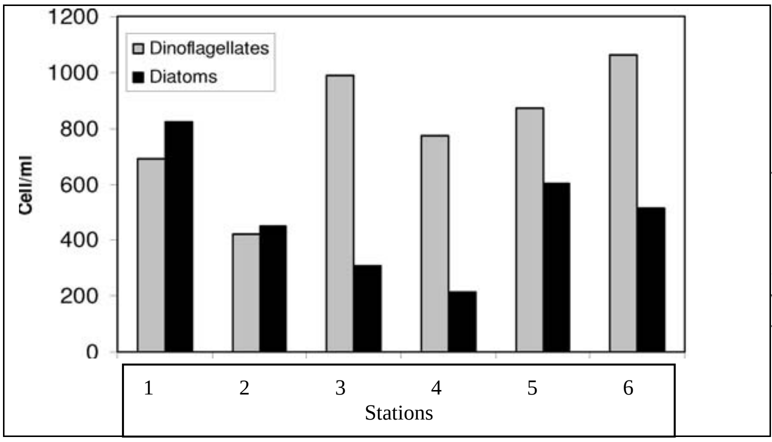


Figure A2-4. Abundance (cells per millilitre) of diatoms and dinoflagellates at the 6 stations investigated from the barrages to each side of the Murray Mouth inside and outside the Coorong. Note that stations 1 and 3 correspond to stations where cockles may be or must not be taken for human consumption, respectively. From Seuront & Leterme (2008)

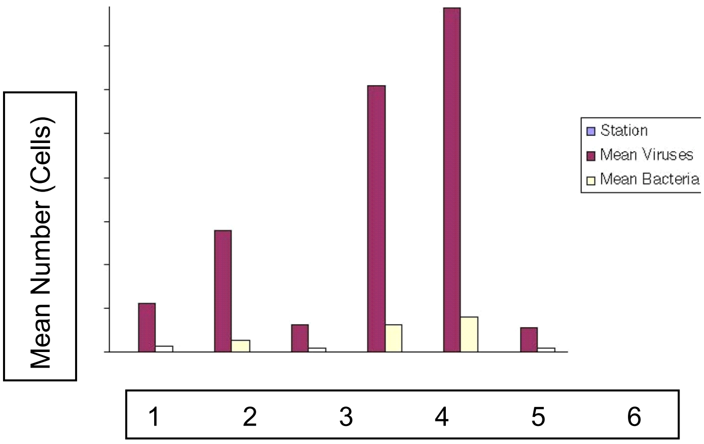


Figure A2-5. Abundances (cells per ml) of viruses (red) and heterotrophic bacteria (yellow) at the 6 stations investigated from the barrages to each side of the Murray Mouth inside and outside the Coorong. Note that stations 1 and 3 correspond to stations where cockles must and must not be taken for human consumption, respectively.

No freshwater flows released over the barrages; target not achieved

s) Improved spawning and recruitment success in the Lower Lakes for endangered fish species including Murray hardyheads and Pygmy perch

Bice et al (2008) report that the nationally vulnerable Murray hardyhead, nationally vulnerable Yarra pygmy perch and Southern pygmy perch (considered endangered in the lower Murray-Darling Basin) were collected from a limited distribution and in low to very low numbers, in spring 2007 and summer 2008 when compared to previous years in this region (Table 10). Twenty-two sites were sampled around the Lower Lakes, with many difficult to access in February 2008 due to receding lake edges

Some spawning and recruitment were detected for Murray hardyhead and Southern pygmy perch in 2007/08, but only in low levels. No Yarra pygmy perch <40 mm total length were collected during the 2007/08 surveys, indicating no spawning or recruitment. For Murray hardyhead, summer 2008 young-of-year fish represented < 10% of the population in comparison to >50% of the population, as detected in summer 2006 and summer 2007. Bice *et al* (2008) speculate that local extinction of these species is likely if years of poor or no recruitment continue, and if suitable habitat continues to disappear.

No improvement in recruitment in summer 2008; target not achieved

Table A2-1. Comparison of abundances of threatened species in spring and summer seasons of previous years, from Bice *et al* (2008). Figures for spring 2005 and summer 2005-2007 are taken from Bice and Ye (2006; 2007)

Species	2005	2006	2007	2008
	Spring season			
Murray hardyhead	35.45 ± 33.5	Not sampled	0.75 ± 0.3	Not sampled
Southern pygmy perch	113.8 ± 86.3	Not sampled	0.33 ± 0.26	Not sampled
Yarra pygmy perch	41.2 ± 33.7	Not sampled	0.08 ± 0.08	Not sampled
	Summer season			
Murray hardyhead	16.1 ± 5.2	18.6 ± 21.1	7.4 ± 4.5	4.08 ± 2.5
Southern pygmy perch	10.6 ± 6.5	6.5 ± 7.2	3.8 ± 6.8	0.08 ± 0.08
Yarra pygmy perch	2.8 ± 1.6	6.7 ± 12.2	1.8 ± 3.2	1 ± 1

Bird condition

c) Coorong-North Lagoon & Estuary: Maintain and increase benthi diversity in the estuarine-lagoonal invertebrate populations in the North Lagoon

Benthic mudflat macrofauna were monitored by Dittmann *et al.* in December 2007 in the Icon Site. While 16 different macrofaunal taxa were found throughout the whole site during this survey (Table A3-1), this is the lowest diversity recorded since the surveys began in 2004. The estuarine area near the Murray Mouth and barrages is the most ecologically valuable part of the ecosystem in terms of diversity, although many sites in this region recorded a significant drop in abundances of organisms in comparison to previous years.

A decline in amphipods, a reliable food-source for short-billed waders, has continued for a second year. However, some sites recorded a higher biomass of polychaetes, but at greater sediment depths. These could provide a food source for longer-billed waders. The highest macrofaunal diversities have been recorded in the past after freshwater barrage releases

No evidence of an increase in diversity of benthic invertebrates in the Estuary or North Lagoon; target not achieved

Table A2-2. Occurrence of macrobenthic taxa during the survey in December 2007, and species numbers per sites as well as per region. From Dittmann *et al.* 2008a

Phyla	Species	Murray Mouth					North Lagoon			South Lagoon		
		1	**HC**	**4**	**6**	**20**	**22**	**26**	**24**	**19**	**16**	**14**
Annelida	*Capitella* sp.		X	X	X	X	X					
	Australonereis ehlersi	X		X								
	Simplisetia aequisetis	X	X	X	X	X	X					
	Nephtys australiensis	X	X		X	X						
	Oligochaeta indet.			X								
Crustacea	Amphipod spp.		X	X	X				X	X	X	X
	Ostracod spp.									X		X
	Parartemia spp.											
Mollusca	*Salinator fragilis*	X		X								
	Hydrobia sp. 1		X									
	Hydrobia sp. 2				X							
	Arthritica helmsi	X	X	X	X							
Insecta	*Dolichopodid* sp. (larvae)			X		X	X					
	Chironomid sp. (larvae)						X	X	X	X		
	Empididae sp. (larvae)										X	
	Unidentified insect pupa					X	X					
Species number per site		5	6	8	6	5	5	1	2	3	2	2
Species number per region		12					6			4		

d) Coorong-South Lagoon: Establish viable invertebrate populations in the South Lagoon

Dittmann *et al.* (2008a) describe benthic biomass as being negligible in the South Lagoon of the Coorong (refer Table 2: macrobenthic abundances), and that shorebirds would need to switch to alternative food sources such as brine shrimp. Diversity is also lowest in the South Lagoon, with only four different taxa recorded (Table 1). Paton and Rogers (2008) report that chironomid larvae, a major food source for many waders, was completely absent from the South Lagoon in July 2007, due to the high salinities. Summer surveys by Rogers and Paton (2008) showed a significant drop in abundance also (Figure 3). Even though diversity and abundance were low in the South Lagoon, they did not differ significantly to previous years, indicating a long period of poor conditions in the region (Dittmann *et al.* (2008a).

Invertebrate populations were recorded in the South Lagoon; but no evidence of 'viability'. This target needs to be re-defined

Table A2-3. Mean macrobenthic abundances (Ind m^{-2}) and standard deviations (SD) in the study regions MM = Murray Mouth, NL = North Lagoon and SL = South Lagoon during the survey in December 2007. From Dittmann *et al.* 2008a.

Region	**Mean**	**SD**
MM (Sites 1,HC, 4, 6,20)	33297.57	52242.86
NL (22, 26, 24)	9733.56	15201.74
SL (19, 16, 14)	492.08	894.46

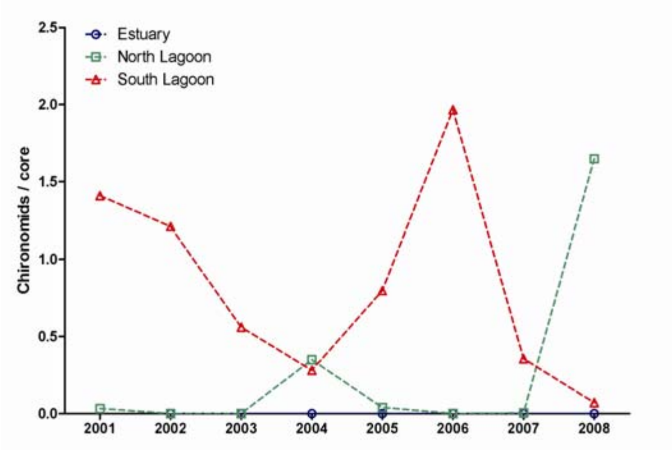


Figure A2-6. Mean abundance of chironomid larvae per core, between 2001 and 2008, for the three regions of the Coorong. From Rogers and Paton (2008).

i) Coorong and Estuary: Maintain the 1% flyway population level for: Sharp-tailed Sandpiper, Curlew Sandpiper, Red-necked Stint, Sanderling, Common Greenshank and Banded Stilt.

Rogers and Paton (2008) report that the 1% flyway population level was only achieved for three out of the six target species in the Coorong and Estuary in January 2008 (refer to Tables 3-8 for population size estimates). Curlew Sandpiper in particular have shown an 80% decline in the last year, with a total Coorong population that now falls below the 1% flyway population criterion for the first time in 2008. This target was rarely or never met for two of the Indicator species (Common Greenshank and Sanderling), suggesting that the Indicator status of these species requires review. Banded Stilt have increased in abundance, particularly since 2005, due to the increase in brine shrimp in the South Lagoon. Wainwright and Christie (2008) recorded a flock in the Southern Lagoon in February 2008 of 250,000 individuals, possibly the largest recorded flock in Australia.

The Coorong populations of a further five species (Chestnut Teal, Red-capped Plover, Red-necked Avocet, Pied Oystercatcher and Fairy Tern) of waterbird regularly meet the 1% flyway criterion. These include one species (Fairy Tern) whose international conservation status has recently been upgraded to Vulnerable by the IUCN. The large declines in abundance of many bird species in the South Lagoon of the Coorong appear to be linked to similar declines in the abundance of food resources. Measures of abundance for the key aquatic plant *Ruppia tuberosa*, Smallmouth Hardyhead fish and chironomid larvae all suggest an overall drop in the availability of food for a wide range of waterbirds in the South Lagoon over the census period (Rogers and Paton 2008). The area south of Parnka Point has become too saline to support most species of waders, with the exception of Banded Stilt and Red-necked Avocet which can feed on brine shrimp (Wainwright and Christie 2008).

1% flyway population only accomplished for 3 out of 6 target bird species; target not achieved

Table A2-4. Population size estimates for Sharp-tailed Sandpiper *Calidris acuminata* in each of nine censuses. Highlighted values indicate years and regions in which the 1% flyway population level has been met (population > 1,600 birds). From Rogers & Paton (2008).

Year	Estuary	North Lagoon	South Lagoon	TOTAL
2000	**5463**	**4808**	**2818**	**13089**
2001	1045	**2972**	382	**4399**
2002	**8319**	**3018**	**1998**	**13335**
2003	**6972**	**5103**	**5398**	**17473**
2004	**4564**	**2401**	**3170**	**10135**
2005	**2284**	**3058**	**6239**	**11581**
2006	**7042**	**5030**	**21825**	**33897**
2007	**4334**	**2037**	**3675**	**10046**
2008	**2849**	**3235**	**5763**	**11847**

Table A2-5. Population size estimates for Curlew Sandpiper *Calidris ferruginea* in each of nine censuses. Highlighted values indicate years and regions in which the 1% flyway population level has been met (population > 1,800 birds). From Rogers & Paton (2008).

Year	Estuary	North Lagoon	South Lagoon	TOTAL
2000	1459	**2147**	**4551**	**8157**
2001	193	**1996**	135	**2324**
2002	978	**2524**	131	**3633**
2003	1082	177	1105	**2364**
2004	1078	622	130	**1830**
2005	1605	502	81	**2188**
2006	**2676**	1596	241	**4513**
2007	**4447**	541	85	**5073**
2008	704	841	22	1567

Table A2-6. Population size estimates for Red-necked Stint *Calidris ruficollis* in each of nine censuses. Highlighted values indicate years and regions in which the 1% flyway population level has been met (population > 3,200 birds). From Rogers & Paton (2008).

Year	Estuary	North Lagoon	South Lagoon	TOTAL
2000	**5202**	2486	**17836**	**25524**
2001	**3368**	1475	**22204**	**27047**
2002	**9138**	2552	**16723**	**28413**
2003	**8920**	2580	**31800**	**43300**
2004	2367	**3771**	**27614**	**33752**
2005	1884	2623	**19099**	**23606**
2006	**16191**	1671	**19345**	**37207**
2007	**5100**	2991	**9387**	**17478**
2008	2046	896	**10902**	**13844**

Table A2-7. Population size estimates for Sanderling *Calidris alba* in each of nine censuses. Highlighted values indicate years and regions in which the 1% flyway population level has been met (population > 220 birds). From Rogers & Paton (2008)

Year	Estuary	North Lagoon	South Lagoon	TOTAL
2000	-	-	-	-
2001	-	-	-	-
2002	7	3	-	10
2003	**281**	8	-	**289**
2004	2	-	-	2
2005	-	-	-	-
2006	-	-	-	-
2007	-	-	25	25
2008	12	12	**-**	24

Table A2-8. Population size estimates for Common Greenshank *Tringa nebularia* in each of nine censuses. Highlighted values indicate years and regions in which the 1% flyway population level has been met (population > 1,000 birds). From Rogers & Paton (2008).

Year	Estuary	North Lagoon	South Lagoon	TOTAL
2000	333	162	84	579
2001	119	147	151	417
2002	241	240	110	591
2003	175	165	75	415
2004	167	178	91	436
2005	310	218	38	566
2006	212	260	149	621
2007	318	216	49	583
2008	287	204	43	534

Table A2-9. Population size estimates for Banded Stilt *Cladorhynchus leucocephalus* in each of nine censuses. Highlighted values indicate years and regions in which the 1% flyway population level has been met (population > 2,100 birds). From Rogers & Paton (2008)

Year	Estuary	North Lagoon	South Lagoon	TOTAL
2000	3	0	**2351**	**2354**
2001	12	55	**15404**	**15471**
2002	556	473	**13745**	**14774**
2003	38	1781	**4943**	**6762**
2004	49	15	**6292**	**6356**
2005	39	6	**32260**	**32305**
2006	0	18	**74606**	**74624**
2007	0	2	**64550**	**64552**
2008	0	0	**23470**	**23470**

j) Lakes: Expose mudflats during summer around lake edge

Extensive mudflats have been exposed for all of the 2007/08 period due to receding water levels in Lakes Alexandrina and Albert. Surface water in the Lower Lakes has dropped from around 0.15m AHD in June 2007 to –0.45m AHD in June 2008. However, recent studies through the CLLAMMecology program have determined that benthic invertebrates can only withstand up to a week of drying in mudflat sediments before dying (Rolston, pers com.). Therefore, even though extensive mudflats have been exposed, they may not provide a food resource for wading birds.

Further to this, the fall in water levels in the Lower Lakes has not resulted in increased diversity, abundance, or biomass of benthic macrofauna (Dittmann *et al* 2008b). Food for waders remains as scarce and patchily distributed as before. A survey conducted just three months prior within the Murray Mouth region indicated that there was almost seven times more food available for waders in this region than the current availability in Lake Alexandrina, indicating that Lower Lakes mudflat invertebrate populations are relatively depauperate.

Extensive mudflats exposed during summer; target achieved. However, this target requires revision.

k) Coorong North Lagoon and South Lagoon (2 targets): Maximise mudflat exposure during summer

No data is available for this parameter at this time. Surface water monitoring stations will provide information on water levels in the Coorong in the near future.

Not enough data to determine if this target has been met. Target needs revision.

l) North Lagoon: Maintain sediment size range in mudflats

Dittmann *et al.* (2008a) report that several North Lagoon sampling sites recorded a larger grain size than in 2006, possibly from input from the nearby Younghusband Peninsula dunes and from low water levels and longer exposure of mudflats. Grain size increased in coarseness from the estuary to the South Lagoon (Table A3-9).

Sediment size range increased in the North Lagoon from previous years; target not achieved.

Table A2-10. Sediment characteristics at the study sites of the mudflat survey December 2007, given by the organic matter content in the sediment and the median grain size in m with the sorting coefficient. From Dittmann *et al.* 2008a

	Site	Organic Matter (% dw)	Median	Sorting	Grain Size	Description
Murray Mouth	**1**	1.89	167.89	0.73	moderately sorted	fine sand
	HC	1.12	168.84	0.79	moderately sorted	fine sand
	4	2.82	190.00	0.70	moderately well sorted	fine sand
	6	1.94	174.78	0.75	moderately sorted	fine sand
	20	0.84	275.26	0.69	moderately well sorted	medium sand
North Lagoon	**22**	1.33	194.23	0.71	moderately sorted	fine sand
	26	0.91	214.87	0.75	moderately sorted	fine sand
	24	1.93	245.30	0.72	moderately sorted	fine sand
South Lagoon	**19**	5.58	211.62	0.69	moderately well sorted	fine sand
	16	2.09	208.98	0.69	moderately well sorted	fine sand
	14	3.50	258.07	0.68	moderately well sorted	medium sand

m) Coorong North Lagoon: Establish and maintain organic content for mudflats

Dittmann et al. (2008a) report that organic matter content in mudflats across the Coorong varied slightly between sites in late 2007, but did not differ significantly to records from previous years.

Organic content maintained from past years; target achieved. This target requires revision

Vegetation condition

a) Coorong-North Lagoon: Enhance* Ruppia megacarpa *colonisation and reproduction

An intensive *R. megacarpa* monitoring program was undertaken in the North Lagoon in March 2007 (Nicol 2007). Twenty-two sites were sampled, yet no live *R. megacarpa* plants were detected. Only two viable seeds were sampled out of 2,200 samples. Because no Ruppia remains in the North lagoon, this sampling program was stopped in 2007/08. Nicol (2007) speculates that the most likely reason for the demise of this species is the build up of salinity in the estuary prior to the dredging program starting and re-opening the mouth. While *R. megacarpa* has been found in a few patchy locations near Goolwa on the freshwater side of the barrages, these populations are under threat from receding water levels. A project has been funded that will determine where the remaining populations of Ruppia are in the Lakes, Coorong and fringing SE wetlands. If freshwater flows return to the North Lagoon in the future, this target can only be achieved via methods of live plant transplant and/or sediment transplant.

No colonisation or reproduction in the North Lagoon; target not achieved

b) Coorong-South Lagoon: Enhance* Ruppia tuberosa *colonisation and reproduction

Winter 2008 monitoring of *R. tuberosa* populations has only recently been completed, and indications are that like *R. megacarpa* in the North Lagoon*, R. tuberosa* is now absent from the South Lagoon of the Coorong (Daniel Rogers and David Paton pers comm.). A remnant population that was recorded at Villa dei Yumpa (northern end of the South Lagoon) up to winter 2007 (Figure A3-2) has now disappeared. A marked decline in Ruppia biomass has been recorded in the South Lagoon since 2001.

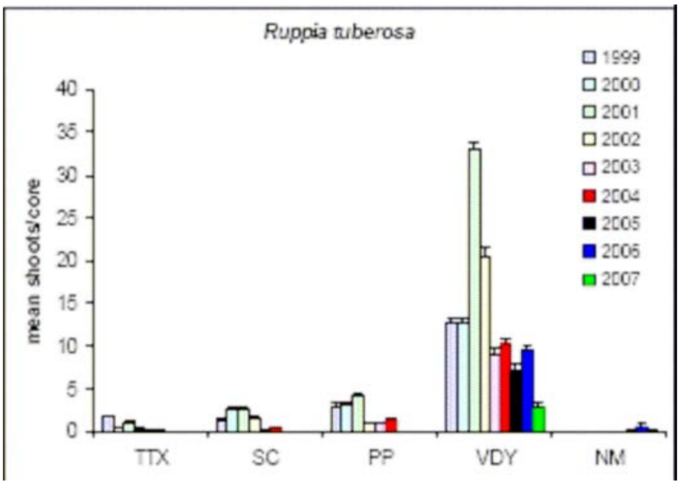


Figure A2-7. Mean number of *Ruppia tuberosa* shoots counted in 200 cores taken at each of 5 sites between 1997 and 2007. From Paton & Rogers (2008).

While *R. tuberosa* is now reportedly absent from the South Lagoon of the Coorong, seedlings have recently been observed in small quantities in the southern parts of the North Lagoon, especially near Noonameena (Rogers pers com, Frears pers com). Paton and Rogers (2008) speculate a reasonable ability of the plant to colonise less saline areas of the Coorong. A reduction in salinity in the South Lagoon is required in order for this target to be achieved.

No colonisation or reproduction in the South Lagoon; target not achieved

e) Lakes: Maintain aquatic and floodplain vegetation

While a dedicated TLM aquatic vegetation-monitoring program was not developed during 2007/08 for the icon site, some information can be taken from other monitoring programs in the Lower Lakes during 2007/08.

The TLM-funded intervention monitoring project 'Effect of weir pool lowering below Lock 1 including the Lower Lakes [Part 1]' has reported large rotting stands of submerged *Myriophyllum* near Goolwa, due to changes in surface-water salinity. Scant germination of seedlings was recorded at some sites on receding shorelines, while the majority of sites remained bare, likely due to the rapid rate of recession

An aquatic vegetation-monitoring program, incorporating targeted *Melaleuca halmaturorum* assessments will be undertaken by SARDI Aquatic Sciences from spring 2008 to assess this target

Not enough information to determine whether this target has been met

g) Estuary and Coorong: Establish and maintain variable salinity regime with >30% of area below seawater salinity concentrations

As no freshwater flows have been released over the barrages, the majority of the estuary and North Lagoon are similar to seawater salinities and the South Lagoon anywhere from two to five times seawater salinities during 2007/08. Figure 4 shows a trend of rising salinities since 1997 (including seasonal variability) at most sampling locations along the Coorong. This figure also shows the majority of sites sampled being >35,000 mg/L (~55,000EC).

Less than 30% of estuary and Coorong below seawater salinity concentrations, target not achieved.

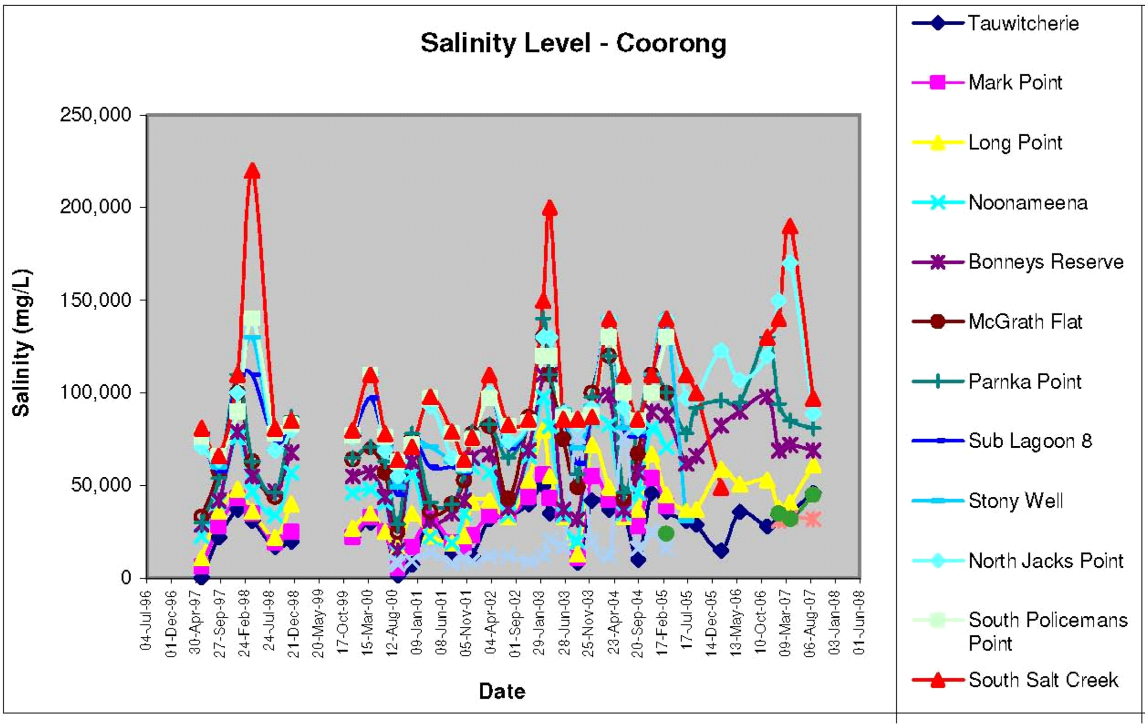


Figure A2-8. Surface water salinity (mg/L) at 12 different locations along the Coorong, to February 2008. From DEH/SWQC (Unpublished) Coorong surface water monitoring project. Note that seawater salinity is around 35,000 mg/L.

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Attachment 3: Condition of other Living Murray Icon sites – Information from The Living Murray condition reports

Barmah-Millewa Forest

This information is compiled from various condition monitoring reports funded by the Commission office under The Living Murray Program.

1. Introduction

The Barmah-Millewa Forest Icon site, composed of the Barmah Forest in Victoria and the Millewa group of forests in New South Wales, is the largest River Red Gum (*Eucalyptus camaldulensis*) forest in Australia. It covers approximately 66,000 ha between the townships of Tocumwal, Deniliquin and Echuca and contains a diverse range of environments.

Barmah-Millewa Forest contains a diverse range of and wetland environments including swamps and marshes, rush beds, lakes and billabongs, open grassland plains, River Red Gum and box forest, and interconnecting watercourses. These environments require regular, seasonal, extensive flooding to maintain their ecological functionality and health. Watercourses occur throughout the forest, which are important for connectivity, distribution of water, fish movement, aquatic vegetation, and in sustaining large River Red Gums along the banks, which are important waterbird habitat.

During major floods, large volumes of water are temporarily banked up behind the Barmah Choke (the narrowest reach of the River Murray). This flooding has created the area now known as the Barmah-Millewa Forest. These forests contain flora and fauna that would be typical of a region, which receives two or three times more rainfall than it does.

2. Summary against Interim Ecological Objectives for the Icon Site

Enhance forest, fish and wildlife values through

- Successful breeding of thousands of colonial waterbirds in at least three years in ten; and

  On ground waterbird surveys recorded 13 species present and 100 waterbirds on the wetlands within Barmah-Millewa Forest during the summer surveys. The autumn surveys recorded a total of 8 species and 66 individuals on the 12 monitored wetlands. Waterbirds were present on only two wetlands (Barmah Lake and Reed Beds South), as all remaining wetlands were dry

- Healthy vegetation in at least 55% of the area of the forest (including virtually all of the Giant Rush, Moira Grass, and River Red Gum forest).

  Continuing drought conditions have resulted in a general lack of understorey vegetation growth. Although a reasonable diversity of plant species continue to exist, these dry conditions are forcing very scant growth and flowering of plant species, with much of the wetland and forest floor instead being covered mostly by dry leaf litter or as bare ground. Poor growth of Giant Rush at historic important colonial-nesting waterbird locations is also likely to provide poor colonial waterbird nesting substrate

3. Condition of the Icon Site

Broadly the condition against the high level fish, birds and vegetation objectives of TLM are:

Fish condition:
Flows in the region were lower this year than last year, and as a result, most of the wetland sites had dried and could not be sampled. Consequently, total fish numbers caught this year were lower than last year, particularly for the smaller wetland specialist species such as carp gudgeon. Southern pygmy perch were not collected from any of the permanent sample sites, even after the site containing its major population, Toupna Creek, was provided with an environmental flow to prevent drying. Despite the continued low water levels there was a similar number of species collected to the previous year, indicating the Barmah-Millewa Forest maintains its diverse array of fish fauna. The abundance of riverine species of conservation significance such as Murray cod, silver perch and Murray-Darling rainbowfish, persisted despite low in-flows. In some areas these species demonstrated distributional expansions throughout the riverine sites. There was also a dramatic increase in the number of young-of-year carp collected, despite the lack of flooding which is typically associated with carp spawning and recruitment. Murray crayfish were also collected and a large proportion of mature female Murray crayfish were not yet in berry. As the recreational fishing season was already opened, this suggests that a lot of these large females could have been removed from the system prior to their production of young.

Bird Condition:
The summer and autumn 2008 bird surveys were undertaken across survey sites at Barmah Millewa. Assessments were for both bushbirds and waterbirds.

During summer, waterbird surveys recorded a total of 13 species as present on the wetlands within Barmah-Millewa Forest. A total of 100 waterbirds were recorded during the summer surveys. The autumn surveys for waterbirds recorded a total of 8 species and 66 individuals on the 12 wetlands monitored within Barmah-Millewa Forest. Waterbirds were present on only two wetlands (Barmah Lake and Reed Beds South). All remaining wetlands were dry.

The summer 2008 surveys for bush birds recorded 29 species from the survey sites. An additional 13 species were recorded in the habitat adjoining the survey sites. The additional species were the Leaden Flycatcher *Myiagra rubecula* which was recorded in the habitat at the Fisherman's Bend plot in Millewa State Forest. The only threatened species recorded during the current round of monitoring was the Hooded Robin *Melanodryas cucullata*. A single individual was recorded from the River Murray Paddock (Millewa State Forest) and two birds were recorded from Rushy Swamp (Moira State Forest).

The autumn 2008 surveys for bush birds recorded 43 species from the survey sites. An additional 2 species were recorded in the habitat adjoining the survey sites. Three threatened species were recorded during the current round of monitoring. This included: Black-chinned Honeyeater *Melithreptis gularis* (a single individual in River Murray Paddock Millewa State Forest), Hooded Robin *Melanodryas cucullata* (one pair at Cherry Tree Yards Barmah State Forest), and Diamond Firetail *Stagonopleura guttata* (a single individual on Tongalong Ridge Barmah State Forest).

Vegetation Condition
Understorey vegetation: The understorey vegetation continues to exist as a relatively low diversity and abundance, despite no cattle grazing having occurred in Barmah Forest this year. The new Millewa Forest study sites supported this observation, although a number of new species were added to this project's species list due to a number of predominantly terrestrial grasses having been located at those sites. Overall, the Barmah-Millewa Forest continued to experience very dry conditions and some record hot temperatures in 2007/08. Sustained low river levels meant that nearly all creeks and wetlands throughout the forest are now dry, and the wetland sites monitored as part of this project were all dry and many deeply cracked.

Hattah Lakes

This information is quoted from a report by McCarthy, Tucker, Campbell, Henderson, Vilizzi, Wallace, and Walters –*The Living Murray Condition Monitoring of Hattah Lakes 2007/08* (June 2008). This work is funded by the Commission office under The Living Murray Program.

1. Introduction

The Hattah Lakes Icon Site encompasses the whole of the Hattah Lakes and adjoining floodplain system, which lie within Hattah-Kulkyne National Park (HKNP). These parks are located in Victoria, adjacent to the River Murray, in the triangle between the towns of Mildura, Robinvale and Ouyen, and to the east of the Calder Highway.

The Hattah Lakes are a system of perennial and intermittent freshwater lakes, most of which are filled from the River Murray via the Chalka Creek anabranch. The lakes only begin to fill when flows in the River Murray exceed the threshold flow rate of 36,700 megalitres/day (ML/day) at Euston Weir, though overland flooding of the River Red Gum floodplain does not commence until discharge is close to 50,000 ML/day. The hydrological regimes of the Hattah Lakes varies widely, ranging from lakes which used to hold some water almost constantly, to those with inflows averaging one year in four and with dry spells of four to twelve years.

2. Summary against Interim Ecological Objectives for the Icon Site

Restore healthy examples of all original wetland and floodplain communities

- Successful breeding events of colonial waterbirds to at least two years in every ten;
- Increase population size and breeding events of Hardyhead, Australian Smelt, Gudgeons and other wetland fish; and,

  Only four lakes had surface water in December 2007, and these each contained significant fish populations. Native fish dominated the fish community and comprised Carp gudgeon, Australian smelt, Flathead gudgeon and Golden perch. Only two Common carp and 20 Goldfish were sampled. These populations developed from the series of four pumping events from April 2005 to December 2006. The drying of the Hattah Lakes and their continual disconnection from the River Murray is a threat to the achievement sustainable native fish communities at Hattah Lakes

- Restoration of the aquatic vegetation zone in at least 50% of the lakes to increase native fish and bird breeding and survival.

  River Red Gum condition was very poor, with the majority of trees having only 1-20% of their estimated carrying capacity of foliage. Similarly, the condition of Black box was very poor with over 95% of trees classified as having only 1-20% of the carrying capacity of foliage. An absence of flood responsive species was noted across the vegetation communities. These responses are the result of the long period of time (7-12 years) since overbank flooding of these sites

3. Condition of Icon Site

Broadly the condition against the high level fish, birds and vegetation objectives of TLM are

Fish Condition
Only four lakes had surface water in December 2007, and these each contained significant fish populations. A total of 16,009 fish from six species (four native) were sampled with nets within the lakes. Native fish (>99.8%) dominated the fish community and comprised carp gudgeon, Australian smelt, Flathead gudgeon and Golden perch. For the exotic fish, only two Common carp and 20 Goldfish were sampled. These populations developed from the series of four pumping events from April 2005 to December 2006. Unless seasonal overbank flooding occurs, these fish populations will perish in 2008 as habitat availability decreases as the lakes dry. In the River Murray, 59 fish from six species (five native) were sampled with electrofishing. Native fish comprised 85% of the sample and included (in order of abundance) Golden perch, Bony herring, Murray cod, Silver perch and Australian smelt. Nine Common carp were sampled in the River Murray. The drying of the Hattah Lakes and their continual

disconnection from the River Murray is a threat to the achievement of TLM objectives relating to sustainable native fish communities at Hattah Lakes.

Birds Condition
No on ground monitoring was undertaken but aerial survey provided an insight into waterbird populations at this site

Vegetation Condition
River Red Gum: River Red Gum (RRG) at Hattah Lakes occur within the three water regime classes of Red Gum Forest(1,296 ha), Fringing Red Gum Woodland (3,611 ha) and Red Gum with Flood Tolerant Understorey(3,202 ha). The size class distributions of RRG were highly variable between sites. When pooled within water regime classes, these distributions followed an 'inverse J' curve providing evidence for relatively recent recruitment of RRG at Hattah Lakes. Of the 26 transects (each 1.5 ha) monitored in2007/08, approximately 4% of the trees surveyed were considered dead. However, the condition of RRG was very poor, with the majority of trees having only 1-20% of their estimated carrying capacity of foliage. This poor condition is attributed to the majority of RRG at Hattah Lakes not having been inundated with flood waters since 1996. The current condition of RRG is a threat to the achievement of the ecological objective for a sustainable population of river red gums at Hattah Lakes.

Black Box: Black Box (BB) at Hattah Lakes occur within the two ecological vegetation classes of Riverine Chenopod Woodland (8,249 ha) and Black Box Swampy Woodland (613 ha). The size class distributions of BB were highly variable between sites, but when pooled showed an 'inverse J' curve typical of populations that are being sustained. Of the six transects (each 1.5 ha) established in 2007/08, no dead BB were recorded. However, the condition of BB was very poor with over 95% of trees classified as having only 1-20% of the carrying capacity of foliage. The poor condition of BB is attributed to the long period since these trees received flood waters. The current condition of BB is a threat to the achievement of the ecological objective for a sustainable population of BB at Hattah Lakes.

*Lignum :*Lignum (Muehlenbeckia florulenta) condition was monitored at five sites established in 2006/07. Compared to 2006/07, Lignum viability in 2007/08 decreased at one site, increased at two sites, and remained unchanged at another two sites. Lignum colour decreased at all five sites. The viability and colour scores indicate that the populations sampled are in a reasonable condition, although the general decrease in colour scores from 2006/07 levels is of some concern. The importance of flooding for the survival of this species is well known and the long period since flooding of lignum areas is a threat to the achievement of the ecological objective for a healthy or sustainable Lignum community at Hattah Lakes.

Cumbungi: Cumbungi (Typha spp.) was detected in only two small stands during surveys of Hattah Lakes in 2007/08. However, the current near-absence of cumbungi appears typical for this area that continues to experience wetting and drying phases. Therefore, its near absence from Hattah Lakes is not considered a threat to the achievement of ecological objectives relating to sustainable vegetation communities.

Wetland vegetation: Wetland understorey vegetation was surveyed at nine wetlands (six dry, three with surface water) at Hattah Lakes in 2007/08. A total of 77 plant species (63 native, 14 exotic) were recorded during this first year of baseline monitoring. Wetland vegetation at Chalka Ck was different to the vegetation occurring at the lake sites. Also, vegetation communities at lakes that have not received recent environmental water through pumping were characterised by terrestrial species and were distinct from those that had received pumped water. Tangled Copperburr (Sclerolaena divaricata) was sampled and this species is listed as Poorly Known in Victoria.

Gunbower–Koondrook–Perricoota Forest

This information is compiled from various condition monitoring reports funded by the Commission office under The Living Murray Program.

1. Introduction

The River Red Gum forests of Koondrook-Perricoota (NSW) and Gunbower (Victoria) cover approximately 50,000 ha of River Murray floodplains to the west of the town of Echuca.

The site is characterised by high river banks, with high commence-to flow effluents. Naturally, water enters the forest from these effluents under high flow conditions (>18,000 ML/day on the Gunbower side and >30,000 ML/day on the Perricoota side) and flows parallel to the river, re-entering the river at Koondrook (Vic side) or entering the Wakool river system via a system of natural channels (NSW side). Flows above 30,000 ML/day are required to initiate overbank flooding.

2. Summary against Interim Ecological Objectives for the icon site

Maintain and restore a mosaic of healthy floodplain communities.

- 30% of River Red Gum forest in healthy condition;

  There was a Eucalypt canopy condition and cover and diversity of indigenous flora species in both the wooded and wetland water regime classes in Gunbower Forest from 2005 to 2008. The potential causes of the decline in the forest include first and foremost sustained lack of flooding (due to river regulation and drought), together with heavy grazing (caused by kangaroos and wallabies, cattle and rabbits) and logging. If the vegetation continues on the current trend, it is likely the Red Gum and Box woodlands will contract in area and simplify ecologically, and the wetlands will be displaced by trees
- successful breeding of thousands of colonial waterbirds in at least three years out of ten;

  No waterbirds recorded in summer 2008, as all wetland sites were dry. However prior to the autumn 2008, an environmental flow was placed into six wetlands within Gunbower Island SF. Two species of waterbirds (Australian Wood Duck Chenonetta jubata and Pacific Black Duck Anas superciliosa) were recorded on the wetlands receiving the environmental flow and further monitoring is underway to assess the impact of the watering.
- healthy populations of resident native fish in wetlands; and
- 80% of permanent and semi-permanent wetlands in healthy condition.

3. Condition of Icon Site

Broadly the condition against the high level fish, birds and vegetation objectives of TLM are:

Fish Condition
Information being collected

Bird Condition:
The summer and autumn 2008 bird surveys were undertaken across survey sites at Gunbower Koondrook Pericoota. Assessments were for both bushbirds and waterbirds.

During summer 2008 there were no waterbirds recorded as all wetland sites were dry. However prior to the autumn 2008 survey, an environmental flow was being placed into six wetlands within Gunbower Island SF. The remaining wetlands were dry during the autumn monitoring. Two species of waterbirds (Australian Wood Duck Chenonetta jubata and Pacific Black Duck Anas superciliosa) were recorded on the wetlands receiving the environmental flow. The low numbers of waterbirds on those wetlands being filled is not unexpected as the wetlands had only been receiving water for approximately a week when the surveys were undertaken.

The summer 2008 surveys for bush birds identified total of 31 species across the survey sites. An additional eight species were recorded in the habitat adjoining the survey sites. The only threatened species recorded during the current round of monitoring was the Black-chinned Honeyeater *Melithreptus gularis*. This species was recorded from Grey Box *Eucalyptus microcarpa* woodland adjoining site 15/3 (Perricoota SF) and River Red Gum *E. camaldulensis* forest adjoining site FDU-1 (Gunbower Island State Forest).

The autumn 2008 surveys for bush birds identified total of 32 species on the survey sites. An additional seven species were recorded in the habitat adjoining the survey sites. Three threatened species were recorded during the current round of monitoring: Black-chinned Honeyeater Melithreptus gularis recorded from Black Box Eucalyptus largiflorens (site BB-2) and from the habitat surrounding site GB-4 in Gunbower Island State Forest (SF); Hooded Robin Melanodryas cucullata recorded from Black Box woodland (16/3 Perricoota SF and BB2 Gunbower Island SF); Diamond Firetail Stagonopleura guttata recorded from River Red Gum (FTU-3) and Black Box (BB-2) in Gunbower Island SF.

Vegetation Condition:
Canopy Condition : All Eucalypt trees in Gunbower Forest have declined in crown condition from 2005 to 2008. River Red Gum (Eucalyptus camaldulensis) trees were recorded with the largest decrease and in the poorest condition in 2008, when compared to Black Box (E. largiflorens) and Grey Box (E. microcarpa). These results, coupled with observations of substantial River Red Gum death at the driest end of the spectrum, suggest the Red Gum forest is contracting and will continue to do so until the entire forest is adequately flooded and/or drought conditions break.

Permanent and Semi-permanent Wetlands: All fifteen wetlands surveyed in 2008 were dry, consequently, largely devoid of aquatic and mud flat flora (PFGs 1, 2, 3 4a and 4b) and dominated by bare ground, litter and/or coarse woody debris (PFG 0). Not only did the cover of wetland vegetation significantly reduce over time, so did the number of flora species (approximately 50% less in total). Target flora (threatened and high habitat value species) were also absent from the 2008 results, with the exception of a near negligible cover of River Swamp Wallaby-grass (Amphibromus fluitans) in two transects of Reedy Lagoon (RL2 and RL3). The main concerns with the 2008 wetland results is not the impact of prolonged dry conditions on the vegetation - as wetland flora is relatively tolerant to such - more the absence of aquatic and associated fauna habitat, and the establishment of River Red Gums in the Floodway Pond Herbland (deepest sections) due to reduced inundation frequency and duration

Wooded Water Regime Classes – as informed by the Understorey Quadrats: Understorey flora reduced in diversity and cover in almost all Plant Function Groups in the wooded water regime classes in Gunbower Forest between 2005 and 2008. These changes were more pronounced in the Red Gum vegetation than the Black Box and Grey Box. The probable causes of decline in understorey flora diversity and cover in the wooded vegetation, based on the bio-indicator investigation, are sustained lack of flooding of Red Gum vegetation (due to river regulation), and heavy grazing in the Box woodlands. The impact of drought during the four years of monitoring is also likely to have exacerbated these results. Furthermore these floristic changes would have added to losses associated with the commencement of mechanised logging in the forest, which resulted in soil compaction, disturbed ground flora and reduced soil moisture due to increased tree density and coppice regeneration.

Chowilla Floodplain, Lindsay-Wallpolla Islands

This information is compiled from various condition monitoring reports funded by the Commission office under The Living Murray Program.

1. Introduction

The Chowilla Floodplain and Lindsay-Wallpolla Islands Icon Site covers an area of 43,856 ha. The Icon site comprises several major floodplain areas.

The Chowilla floodplain straddles the SA and NSW border covering a total area of 17,700 ha. Some 74% of the Chowilla floodplain lies in SA, while the other 26% is in NSW, with the NSW portion known as Kulkurna. In addition to its status as an Icon Site the floodplain is part of the Riverland Wetland, listed under the Convention on Wetlands of International Importance (also known as the Ramsar Convention) and is incorporated into the Bookmark Biosphere Reserve, under the UNESCO Man and Biosphere program. In 1993 the area between the Old Wentworth Road and the River Murray was declared a Game Reserve, under the *National Parks and Wildlife Act*, 1972.

The other main floodplain areas are the Lindsay, Mulcra and Wallpolla islands in Victoria, which collectively cover 26,156 ha in northwest Victoria, downstream of Mildura. Wallpolla Island consists of

9,000 ha of land bounded by Wallpolla Creek, a Murray anabranch, and the Lock 9 weir pool on the River Murray. Lindsay Island (further downstream) consists of 15,000 ha of land bounded by the Lindsay River anabranch, and both the Lock 6 & Lock 7 weir pools. Mulcra Island covers approximately 2,156 ha of State Forest between Lindsay and Wallpolla Islands, and is formed by an anabranch of the River Murray, Potterwalkagee Creek.

2. Summary against Interim Ecological Objectives for the Icon Site

Maintain high biodiversity values of the Chowilla Floodplain

- Retain current area of River Red Gum and maintain at least 20% of the original area of Black Box vegetation;

Examination of the monitoring of 2550 River Red Gum at 22 sites on the Chowilla floodplain conducted between 2005 and 2008 reveals that: a) At sites where watering has been conducted on three occasions, the number of healthy trees (>75% original foliage) has remained stable, while the number of trees with no live foliage has increased by 5%. b) At sites that were watered on one or two occasions there was a 12 – 14% decrease in healthy trees and a 3 – 8% increase in trees with no live foliage and c)At sites along the permanent creeks there was a 24% decrease in the number of healthy trees.

At Lindsay Wallpolla, bark condition, foliage vigour and epicormic growth assessments indicate that the RRG are generally in poor condition. Bark condition and foliage vigour assessments of Black Box, indicate a high proportion on Lindsay Island had died recently or were near dead. On Mulcra Island, 7% had died recently or were near dead. Results from population age structure surveys indicate an overall lack of recruitment

- Maintain high value wetlands.

At Chowilla, fish species richness and distribution of most species were similar between years. The size distribution of three large bodied species, Golden perch, Common carp and Murray cod suggested a very low level of recruitment. However, the size distribution for small-bodied species including Australian smelt, Unspecked hardyhead and Bony herring suggests successfully recruitment of these species. Waterbird targets of successful breeding events at a frequency of not less than one in three years, have not been met.

At Lindsay Wallpolla, all fish species caught in 2006/07 were also caught in 2007/08 indicating no change in species richness between years. Length frequency distributions for Murray cod and golden perch also indicated recent recruitment

3. Condition of Icon Site

Broadly the condition against the high level fish, birds and vegetation objectives of TLM are

Fish condition - Chowilla

Overall, a total of 11,288 fish, representing 10 native and four exotic species, were sampled during the March/April 2008 condition monitoring sampling. Small to medium-bodied generalist species were the most abundant, namely Bony herring, Unspecked hardyhead and Australian smelt. The introduced Common carp and Goldfish were also abundant. The total number of fish sampled in 2008 was slightly higher than other years (2005, 8527 fish; 2006, 9493 fish, 2007, 9647 fish) largely due to greater numbers of Bony herring. All other species were collected in similar abundances each year with the exception of Murray rainbowfish, which has declined slightly each year since 2005.

Maintain the diversity and extent of distribution of native fish species throughout Chowilla: Species richness (number of species) and the distribution of most species were similar between years. Most species were widespread throughout available aquatic macrohabitats. Murray cod, however, were only captured from fast flowing sites (every year) and the River Murray (2007). Likewise, freshwater Catfish were only collected in fast flowing macrohabitats and in very low abundances (2 fish) in 2007. Dwarf flathead gudgeon also had a restricted distribution being collected in very low abundances (1-5 fish) in the River Murray in 2005 and in fast and slow flowing macrohabitats and the River Murray in 2008. Exotic Redfin perch were only present in low numbers during the 2007 and 2008 survey. In 2007 this species was collected in backwater and River Murray habitats whilst in 2008 it was collected in fast flowing macrohabitats and the River Murray.

Maintain successful recruitment of large bodied fish at least once every five years: The size distribution of the three large bodied species, namely Golden perch, Common carp, and the threatened Murray cod were examined as a non-destructive indicator of recruitment. In 2004 and 2005 the length frequency data for Murray cod consist of two modes, smaller fish ranging in size from 250 – 450 mm and larger fish 800 – 1250 mm. The number of fish < 400 mm, however, appears to decrease post 2005 suggesting a very low level of recruitment.

Golden perch length-frequency data indicate a low number of 0+ recruits in 2006 that later appear as a strong mode of 1+ fish in 2007. Also in 2006, a large number of small (80 – 150 mm) Common carp were captured. The abundance of small individuals for both of these species maybe attributed to increased discharge into South Australia during the spring/summer 2005. Nevertheless, the mechanisms involved in this increased recruitment are probably different for the two species. Golden perch are a flow-cued spawner thus the small within channel increase in discharge is likely to have facilitated some spawning and recruitment. Common carp, however, spawn every year and increased within channel flow is likely to have increased the number of suitable spawning sites and/or enhanced the survival of eggs and/or larvae.

Maintain successful recruitment of small-bodied native fish every year: The size distribution for small-bodied species namely Australian smelt, Unspecked hardyhead and Bony herring is consistent for all years and suggests that these species are successfully recruiting each year. The size distribution of the Murray rainbowfish, however, shifts from a single mode of fish 20 – 70 mm in length in 2005, to 35 – 80 mm in 2008 suggesting a low level of recruitment for this species.

An initial assessment of this monitoring suggests that all targets may have been met although there is some concern over the recruitment of large bodied fish.

Bird condition - Chowilla

Waterbird surveys have been conducted at Werta Wert and Lake Littra on a monthly basis since pumping commenced with hundreds of individuals being recorded at both sites. Birds from twenty-two species were identified feeding in and around the flooded areas at Werta Wert and fifteen species at Lake Littra, including state listed waterbirds such as the Australasian Shoveler and Musk Duck. In addition—despite the lateness of the season—there was a recorded nesting for an Australian Grebe at Werta Wert.

While this years environmental watering has made a substantial contribution to providing drought refuge for these significant species. These watering events did not make a contribution to the waterbird target in the draft Chowilla Monitoring Framework which states that conditions conducive for successful breeding of colonial waterbirds be provided in a minimum of three temporary wetland sites at a frequency of not less than one in three years. The last occasion in which large numbers of waterbirds were present on the Chowilla floodplain was during the 2006 – 07 environmental watering program (DEH 2007[b,c]).

Vegetation condition - Chowilla

River Red Gums and Black Box: The health of the River Red Gums across the Chowilla floodplain remains in decline owing to an extended period without flooding and the effects of elevated ground water.

A summary of the initial results show that between 2005 and 2008 there was a significant decrease in River Red Gums with greater than 75% of original foliage cover. This change was greatest at sites located along the permanent creek system (a decline of 24%) including areas such as Boat Creek and Pipeclay Creek that have been thought of as high quality areas. Declines of 12% and 14% were observed at sites that had been watered on one or two occasions, respectively. It was not possible to determine declines at sites, which had not been watered as no trees were recorded as having >75% foliage cover in the initial survey. There was no significant change (0%) at sites that had been watered three times.

Examination of the monitoring of 2550 River Red Gum at 22 sites on the Chowilla floodplain conducted between 2005 and 2008 reveals that:

- At sites where watering has been conducted on three occasions, the number of healthy trees (>75% original foliage) has remained stable, while the number of trees with no live foliage has increased by 5%.
- At sites that were watered on one or two occasions there was a 12 – 14% decrease in healthy trees and a 3 – 8% increase in trees with no live foliage.
- At sites along the permanent creeks there was a 24% decrease in the number of healthy trees.
-

Fish condition – Lindsay Wallpolla

Large-bodied fish were sampled using boat-mounted electrofishing in 2006/07 and again in 2007/08 at 12 sites comprising three macrohabitats (*i.e.* River Murray channel, no/slow flow anabranches, fast flow anabranches). All fish species caught in 2006/07 were also caught in 2007/08 indicating no change in species richness between years. Length frequency distributions for Murray cod and golden perch indicate recent recruitment. Both species were represented by multiple cohorts, indicating inter-annual recruitment and spawning potential. Silver perch were present in all macro-habitats, although in low numbers and represented by two cohorts. No mature silver perch were encountered. Similarly, freshwater catfish were not recorded in either year suggesting that this species is not present at robust levels. The exotic, common carp were present in robust numbers at all sites (24% of total catch), with numerous mature individuals recorded and recent recruitment evident.

The small-bodied fish community was specifically targeted separately to the large-bodied fish in 2007/08 using fyke and seine nets. This approach has provided a more in-depth assessment of the status of River Murray channel generalist and wetland/low flow specialist fish assemblages than with the previous electrofishing approach. All species listed in the OEF as River Murray generalists were present at LMW in 2007/08 and, based on length frequency distributions, exhibited robust populations with evidence of recruitment. Consequently, these populations are considered to be self sustaining. Similarly, all but one of the species listed in the OEF as wetland and low flow specialists were present and exhibited robust population structure and recent recruitment. The exception was *Galaxias rostratus* which is considered regionally extinct. The wetland and low flow specialists present at LMW are considered to be self sustaining.

Multivariate analysis of fish species composition and abundance at three macro habitats confirmed the importance of a varied range of habitat types in determining fish species diversity. Therefore, in order to increase diversity and extent of distribution of native fish it may be necessary to increase the range and spatial extent of habitat types. This could be achieved through a range of possible management interventions at wetlands and anabranches across the LMW floodplain.

Bird Condition– Lindsay Wallpolla

No on ground monitoring was undertaken however, the aerial survey of Icon Sites provided an insight into waterbird populations at this site.

Vegetation condition– Lindsay Wallpolla

River Red Gums: Bark condition, foliage vigour and epicormic growth assessments, conducted at 27 sites across LMW during 2007/08, indicate that the RRG at LMW are generally in poor condition. Additionally, based on bark condition and foliage vigour assessments, mortality rates amongst mature RRG was high, particularly at Lindsay Island where 20% of the trees surveyed were classed as either recently dead or near dead. Population structure surveys undertaken in2006/07 and 2007/08 indicate some episodic recruitment of RRG. However, the shape of size frequency distributions suggests these may not be sufficient to replicate historic recruitment levels. These observations indicate a general trend away from achieving objectives. A notable exception was the condition of RRG skirting Mulcra-horseshoe wetland. The good condition of trees at this location is attributed to *management* interventions that have delivered *c.* 1780 ML of water to the wetland via four pumping events between autumn 2005 and Spring 2006. In the absence of a natural flood event, further such management interventions of this type will be required throughout the LMW floodplain in order to meet the ecological objectives for RRG.

Black Box: Bark condition and foliage vigour assessments, conducted during 2007/08, indicate that a high proportion of BB (26% of those surveyed) in Riverine Chenopod Woodland (RCW) on Lindsay Island had died recently or were near dead. On Mulcra Island, 7% of the BB surveyed in RCW had died recently or were near dead. Population age structure surveys conducted in 2006/07 and 2007/08 reveal a general paucity of small trees (DBH ≤ 10 cm) on both islands, indicating an overall lack of BB recruitment at LMW. The high mortality rates coupled with low recruitment rates are attributed to river refgulation and ongoing drought conditions. There is no evidence to suggest that the condition or current area of BB at LMW is being maintained. On the contrary, observations indicate a general trend away from achieving the objectives. In the absence of a substantial natural flood event, the delivery of environmental water through management interventions is recommended in order to meet the objectives for BB at LMW.

Lignum: Fifteen permanent sites, each containing 30 lignum plants, were surveyed in 2006/07 and again in 2007/08. Assessments of viable biomass and colour indicate a general decline in the condition of lignum between years. This is attributed to the 14-year absence of a flood event of the magnitude required to inundate lignum communities and possibly to related changes in groundwater and salinity across the floodplain. Observations suggest the ecological objective for lignum at LMW is not currently being met and that, in the absence of a natural overbank flood event, the delivery of environmental water would be required to improve lignum condition.

Cumbungi: The spatial extent of this objective has been expanded to include Cumbungi in anabranches and adjacent River Murray reaches at LMW. The length of each Cumbungi stand was measured, in 2006/07 and again in 2007/08, along ten reaches (78km of waterway). Total stand length increased at all reaches by an average of 137%, between 2006/07 and 2007/08. Similarly, the total number of stands increased at all reaches with the exception of Dedmans Creek where it is likely stands had merged. Cumbungi forms dense mono-specific stands that are able to displace other aquatic macrophytes. Consequently, the objective for Cumbungi at LMW is not currently being met. The rapid expansion of Cumbungi is attributed to the current stable and permanent water regime, facilitated by the operation of a series of weirs, and by the absence of natural flooding and drying events.

Wetland and terrestrial vegetation assemblages: Wetland vegetation species assemblages were assessed during 2007/08 at 10 sites across LMW. In areas where environmental water had been pumped into wetlands, ephemeral plant assemblages were being maintained. As none of the wetlands held surface water at the time of the survey, there was no evidence that the objectives relating to maintainance of aquatic vegetation are currently being met. Repeat sampling in following years and continuation of watering events will allow for greater discussion of the predicted alteration of floristic composition and progress towards achieving the ecological objectives. Terrestrial vegetation was assessed by establishing transects at three different flood inundation frequency zones (*i.e.* often, sometimes, rarely) at each of six sites distributed across LMW. There was little difference between the 'sometimes' and 'rarely' vegetation assemblages. This is attributed to the 14-year time frame since these sites were last inundated. Plant species abundance was generally low and leaf litter accumulation was high, at 'often' sites. This is attributed to a lack of flooding required to create areas of bare ground into which flood responsive species could germinate. The scarcity of such species indicates that communities of floodplain plant assemblages are not currently being sustained. More frequent flooding is required to re-instate and maintain populations of flood responsive plant species.

Bird surveys across all sites

This information is quoted from a report by Kingsford and Porter – *Survey of waterbird communities of The Living Murray Icon sites* (May 2008). This work is funded by the Commission office under The Living Murray Program.

The Annual Aerial Waterbird Survey of Icon sites commenced in 2007. This links with the Annual East Australia Waterbird Survey and reports on the condition of Icon sites and compares to other locations across East Australia. Findings included:

- Waterbird abundance and breeding was concentrated in the Lower Lakes, Coorong and Murray Mouth Icon site which supported a mean total of 249,146 waterbirds (92% of survey total) with high species richness (42), including Freckled Duck, Cape Barren Geese, Banded Stilt, Australian Shelduck, Great Cormorant and migratory shorebirds. Breeding was also mostly confined to this icon site with 96% of the survey total.
- The northern Coorong supported high numbers of waterbirds (142,198), with significantly fewer birds in the southern Coorong (9,512). Lake Albert (30,276) and Alexandrina (67,169) also supported large numbers of waterbirds. Waterbird breeding abundance was low and restricted mainly to Lake Albert (3,951 mean breeding index), comprising two species (Straw-necked Ibis and Pied Cormorant).
- Water levels in the southern Coorong were low (<40 % full by area) while the northern Coorong and lower lakes held considerably more water (>90% full by area)
- Severe drought conditions continue to impact on waterbird communities and limit the availability of other wetland, floodplain and riverine habitats throughout the southern Murray-Darling basin.
- Most floodplain or shallow Icon sites were dry or almost dry and supported few waterbirds. The main river channel held water but relatively few birds and with low species richness.
- Wetland habitat in the Barmah-Millewa Forest icon site was mostly restricted to the main river channels and Moira Lake, and waterbird abundance was low.
- Most shallow floodplain wetland habitat in Gunbower Koondrook Perricoota system was dry and few waterbirds were present
- Hattah Lakes held water with high waterbird numbers recorded (16,097), comprising mainly Grey teal, Hardhead, Eurasian coot, Pacific black duck and Australasian shoveler. Within the icon wetland, two sites held most of the birds; Lake Lockie (12,200 mean total) and Lake Yerang (2,800 mean total),
- Wetland habitat in the Chowilla & Lindsay Wallpolla icon site was mostly restricted to the main channels although a small number of deeper billabongs still held water. Low numbers of waterbirds were recorded at this site.
- River Murray channel sites held water at all sections surveyed between Lake Hume and the Murray mouth but supported relatively low numbers and diversity of waterbirds.

References

Department for Environment & Heritage (2007b) Chowilla Floodplain Frog and Wetland Bird Monitoring Report 2006 – 2007. DEH, Berri, South Australia.

Department for Environment & Heritage (2007c) Ecological Response to Hydrological Management at Department for Environment & Heritage Managed Wetlands: 2005–2006. DEH Berri, South Australia.

Attachment 4: Lower Lakes Fact sheet

Lower Lakes Quick Figures – as at 31 July 2008

Normal Lower Lakes operating range: **0.3m to 0.75m AHD**	• At Full Supply Level (0.75m AHD) the Lakes hold approximately 2200 GL. • With few exceptions, the Lakes have fluctuated within this range since The Barrages were constructed in the 1930s. • The lowest recorded Lakes level prior to 2008 was approximately 0.1 m AHD during the drought in the late 1960s.
Current approximate Lower Lake levels: Albert: **-0.3m AHD** Alexandrina: **-0.4m AHD**	• The Lower Lakes are currently below sea level. • Sea water is kept out of the Lakes by the five barrages which separate the Lakes from the Coorong and Murray Mouth.
Estimated annual net evaporation and seepage from the Lakes (in dry years): **750 to 950 GL**	• Net evaporation is total evaporation minus local rainfall. • There are very large volumes of water lost through evaporation from the Lakes because of their large surface area. Evaporation rates are not significantly reduced at lower lake levels.
Water required to fill and maintain both Lakes to 0m AHD until July next year: **1050 - 1250 GL**	• A 300 GL volume of water, if delivered today, would fill the Lower Lakes from their July 2008 levels to 0m AHD. • However, if no additional water is delivered with this 300 GL, the Lakes would return to the current levels during summer (assuming dry conditions). • The total amount required to fill and maintain the Lakes from their July 2008 levels to 0m AHD, for one year, is 1050-1250 GL (300 GL plus one year of evaporation 750-950 GL).
Water that is planned to be delivered to the Lower Lakes in 2008/09: **350 GL**	• Under dry inflow contingency planning arrangements approximately 350 GL of dilution flows (needed to maintain River Murray water quality) should flow into the Lower Lakes (in 2008/09).
Estimated water in storages in the Murray-Darling Basin: (refer to MDB Water Availability Fact sheet)	• Under current dry inflow contingency planning arrangements, the water in public storages is already committed to meeting critical human needs, individual carry-over, and announced allocations. • The ability to extract water from private storages is limited and would incur significant transmission losses between the Northern Basin and the Murray System.
Losses incurred to deliver water from storages in the northern Murray-Darling Basin 2000 km to the Lower Lakes (in dry conditions): **About 70-80%** * * depends on amount, temperature, time of year and previous flow conditions	• At a low flow rate (to minimise transmission losses) several months would be required to deliver water.

- These figures are indicative, but agreed by all jurisdictions.
- AHD (Australian Height Datum) is the Australian standard altitude measurement.