Peak body for five landholder associations and 1600 irrigators in the Murray Valley

MURRAY DARLING BASIN PLAN

LOWER LAKES/COORONG

INDICATOR SITE

ADVICE TO

MURRAY DARLING BASIN AUTHORITY

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Contents

Murray Darling Basin River Catchments cover an area of 1.06 million km2 or 14% of Australia's land area. Annual economic output from the Basin is around AUD $23billion. AUD$10 billion of this is from Agriculture almost 1/3 of the value of Australia's total annual agricultural output.

Basin River Catchments - (extract:map/source MDBC)

1. New South Wales
2. Queensland
3. Victoria
4. South Australia

1. EXECUTIVE SUMMARY

The implications of the Water Act 2007 will have profound long term effects on Australia's economic production in the Murray Darling Basin. The 2007 Act seeks to reverse long term economic and social planning, that have resulted in the Murray Darling Basin producing 40% of Australia's total agricultural production.

The magnitude of potential change requires careful scrutiny of all aspects of the Murray Darling Basin Plan, particularly in relation to assessment of environmental needs and modelled scenarios, in relation to climate change.

The Murray Darling Basin Plan will set new sustainable diversion limits, which State Water Sharing Plans (WSPs) in 2014 (Victoria 2019) will be required to meet.

The Murray Darling Basin Authority has announced 18 indicator sites that will be used to determine the scale of change, resulting from water removed from productive purposes and returned to the environment.

Of the 18 indicator sites, 6 are listed under RAMSAR and thus are afforded additional status under the international agreement. The principles of protection under RAMSAR listing do not exclude human activity or management. RAMSAR enables 'wise use' of resources provided that the ecological status of the site is not jeopardised. Wise use of resources may include extractive actions for example, water extraction, fishing, harvesting of timber, or other productive purposes.

The Murray Darling Authority has indicated its intention to assess the ecological needs of the Murray Darling Basin RAMSAR sites based on the condition threshold at the time the sites were listed.

"The Living Murray Environmental Management plan for the Lower Lakes and Coorong (MDBC 2006)" included three ecological objectives:

1) An open Murray Mouth
2) Enhanced migratory water bird habitat in the Lower Lakes & Coorong
3) More frequent estuarine fish spawning and recruitment [9]

Since European settlement, much of Australia's landscape has been modified to meet settlement needs. Sites offered additional protection under RAMSAR, may also have a strong history of 'active management' (eg Barmah Millewa with timber production) or substantial hydrological modifications (eg Lower Lakes/Coorong).

Given the changing nature of Australia's landscapes, variable climatic conditions and historical influences of post European settlement, the Authority will need to consider successive Government policies that have substantially amended the 'indicator sites', when determining the ecological benchmark on which to base their future.

In its deliberations, the MDBA should also identify the inadequacies of the Water Act 2007. In particular, the exclusion of, internationally recognised principles of ecological sustainable development and the 2007 Water Act focus, on flow volumes alone, as a measurement, of environmental health.

[9] Living Murray

LOWER LAKES

In developing the Murray Darling Basin Plan, the Murray Darling Authority should give appropriate recognition to:

- The ecological conditions of the Lower Lakes and the Murray River between Mannum and Wellington, have been substantially modified by successive South Australian Government policies
- The construction and operation of the Barrages have had significant ecological impact on the Lower Lakes and Coorong
- The barrages location have reduced the natural estuarine tidal prism by 90%
- Land reclamation of the Lower reaches of the Murray River between Lock 1 (Mannum) and Wellington, have significantly altered the floodplain and wetland systems prior to Lake Alexandrina
- Under modelled scenarios for climate change, maintenance of the Lower Lakes and Lower reaches of the Murray River at an average flood height of 0.75m AHD is no longer feasible
- Re-designing interstate water sharing agreements to maintain evaporative losses of 750,000-950,000ML is not economically or socially feasible
- The ecological conditions of the Lower Lakes should not be a vehicle for South Australia to increase its share of basin resources above its current entitlement of 1850GL

Recommendations:

- The MDBA to instigate significant modifications to the management of the Lower Lakes and Barrage operations, in order to achieve ecological improvements.
    - Modernisation of Barrage operations and efficiencies
    - Enlargement of estuarine area through modification to specific barrages. Increase tidal prism and recreate natural sand scouring actions adjacent to the entrance to Southern Ocean
    - Investigate options to enable flexible operational water levels for the Lower Lakes below average flood height of 0.75m AHD, to meet modelled impacts of climate change and low inflows

- The MDBA to identify the need for operational efficiencies to be included as a Lower Lakes management option in years of low inflow or prolonged drought. These could include:
    - Reduction in evaporation and system losses in the Lower Lakes by building of a weir at Wellington
    - Investigate investments in pumping water from above Lock 1 to guarantee water quality and supply for downstream communities (including between Mannum and Wellington). Address financial support to local irrigators for installation of pumps to amend current gravity fed supplies from perched river.
    - The reestablishment of estuarine sections of the Lower Lakes by modifications to the Goolwa channel or Mundoo Barrages that could provide flexible management options and achieve beneficial water savings

- Existing State Sharing of water in the Murray Darling Basin should not be amended to maintain the Lower Lakes as a freshwater system at flood height.

A transparent process is required to identify any proposed modifications to water sharing impacts under the Basin Plan

- The MDBA needs to identify social and economic impacts of delivering environmental flows (Commonwealth Water Holder and environmental water achieved through SDLs) in peak demand periods. In particular, channel capacities and ability for existing entitlement holders to access their water rights

- A feasibility study and full cost benefit analysis is required to demonstrate true costs of maintaining Lower Lakes as an entirely freshwater system. This should cover impacts on other basin entitlement holders and should include An Environmental Flow Flood Risk Assessment for delivery of environmental flows. The delivery of flood flows via the Southern Connected systems to maintain 0.75mAHD flows through to the Lower Lakes , will require investigation of the full range of legal issues in relation to Crown infrastructure, Private Infrastructure, MDBA legal costs*(noting restrictions Hume – Yarrawonga 25,000ML, Barmah Choke 8,500ML, Flood capacities of Murray Channel)*

COORONG

In developing the Basin Plan, the Murray Darling Basin Authority should give appropriate recognition to:

- The ecological impacts of the South East of South Australia drainage schemes
- Estuarine changes that have resulted since 1940 from the construction and location of the barrages
- The environmental issues of the Coorong are primarily unrelated to flows from the Murray or Darling Rivers

Recommendations:

- Publicly acknowledge that the adverse environmental issues of the Coorong are primarily unrelated to Murray River Flows, to facilitate the development of ecologically sound solutions.

- Give consideration to the development of a Coorong Strategy that addresses the ecological impacts of the South East Drainage Schemes of South Australia and the location of the Barrages

- In developing a Coorong Strategy, investigate options for establishing sea water dilution flows to the Southern Lagoon to address hyper salinity. This option could be considered in the absence of substantially recreating freshwater flows from the South East of South Australia (impacted by drainage schemes)

- Identify further risks to restoring sub surface and surface flows to the Coorong in South East of South Australia. Review groundwater and flow impacts from current and proposed large scale timber plantations.

- Address the ecological impacts on the estuary of the Northern Lagoon of the Coorong from the location and operations of the Barrages

2. HISTORY OF BASIN WATER PLANNING (SUMMARY)

Following the drought of 1895-1903 which included the record drought of 1902, an agreement was reached between four State Governments to secure reliable water supplies and to expand irrigation.

The River Murray Waters Agreement was agreed by the States in 1915 and ratified by the Commonwealth Government in 1917. The Agreement was amended in 1987 with a new Murray Darling Basin Agreement being signed in 1992.

The Basic principles of the original and subsequent amendments, remain in place today.

The River Murray Waters Agreement also provided:

1. Flow at Albury is shared equally between New South Wales and Victoria
2. Victoria and New South Wales retain control of their tributaries below Albury
3. Victoria and New South Wales supply South Australia with a guaranteed minimum quantity of water or 'entitlement'

The River Murray Waters Agreement also provided:

1. A storage on the upper Murray (Hume Dam)
2. A storage on Lake Victoria
3. 26 locks and weirs extended up to Echuca (14 were constructed)
4. 9 locks and weirs on either the Murrumbidgee or Darling River (Murrumbidgee resulted)

Original State sharing arrangements were further amended with the completion of the Dartmouth Dam in 1979, when during negotiations, South Australia's entitlement was raised from 1500 GL to 1850 GL as a condition for the abandonment of the proposed Chowilla Storage dam due to salinity issues at the proposed site. Prior to these negotiations, South Australia had approximately $3/13^{th}$ share of the Basin resources, with New South Wales and Victoria sharing $5/13^{th}$ each. Despite South Australia being only 6.7% of the Basin, modifications to State sharing agreements, gave South Australia a new equal entitlement share of the Basin water resources, with a higher degree of reliability than other States.

It is worth noting prior to these negotiations (1979) and the resulting increase in share for SA to 1850GL, in 1968 the Lake Level had fallen to 0.1m AHD due to low inflows.

There is now widespread concern that the Water Management Act (2007), Basin Water Plan and associated environmental claims, will be a mechanism to further significantly amend the existing state water sharing arrangements, particularly where it relates to the Murray Southern connected systems.

Arguments to rewrite State water sharing arrangements, have been underpinned by environmental claims for the Coorong and Lower Lakes. The claims have extended

to, measuring the health of the entire Murray Darling Basin, by the flow volumes over the barrages in the Lower Lakes.

Water resource planning in 2010 should adequately reflect long term Government investment and achievements in water security for Australia and the substantive social and economic benefits that have occurred right throughout the Murray Darling Basin.

The Murray Darling Basin Authority will need to consider historical water sharing principles agreed to under the River Murray Water Agreement (Murray Darling Basin Agreement). In particular, during this current historically significant drought event, avoid permanent decision changes to the basic principles of State water sharing arrangements, when developing the new Murray Darling Basin Plan.

Murray Valley – Water Distributions

Year	**Total NSW Diversions GLs**	**Total Vic Diversions GLs**	**Total Flow to SA GLs**	**SA Evaporation Lower Lakes GLs**	**barrage flow**
2002/03	877	1775	1836.8		
2003/04	1329	1498	2068.9	1180	280
2004/05	1259	1502	1879.2	n/a	n/a
2005/06	1670	1637	2311.5	n/a	n/a
2006/07	Est<600	Est 1500(95%)	1440		
5 year total	**5735**	**7912**	**9536.4**		

Source: MDBC – River Murray Water Operational Monthly Account
Source: NSW State Water Annual Report 2003/04 (Ref evaporation Figs)

Until 2006/07, South Australian Murray River water supplies, have largely been protected from the extreme water supply shortages resulting from this current major drought. This is due to the tri state water sharing arrangements on the Southern connected systems, that guarantee supply reliability to South Australia, unless special drought contingencies are in place.

During this current major drought, South Australia continued to receive its entitlement share of 1850 or above, until 2006/07, when normal State water sharing arrangements were suspended due to concerns about continued drought conditions and risks to critical human water supplies .

In order to maintain the social and economic fabric of the entire Murray Darling Basin, the MDBA will need to determine in the new Basin Plan, whether during periods of protracted drought, the ability to maintain the Lower Lakes at flood height and as entirely freshwater system is feasible, particularly under predictions for climate change.

Since conversion of Lake Alexandrina and Lake Albert from estuarine conditions into permanent fresh water lakes in 1940, the average height of the Lower Lakes has been maintained on average, at flood height, 0.75m AHD in most years.

The Lower Lakes evaporate an annual average of between 750,000 and 950,000 million megalitres per year. This equates to 1/3rd of the total evaporation losses for the entire Murray Darling system.

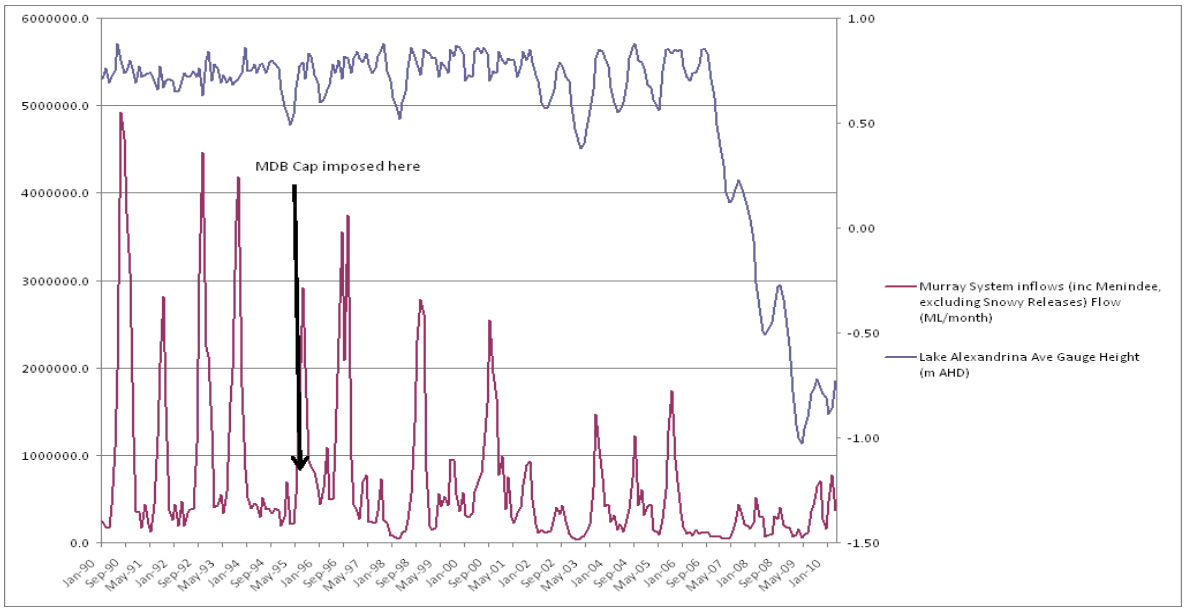
During this current drought, if flexible management operations had been in place for the Lower Lakes, it is estimated that the ability to conserve 1180 GL in evaporation losses from the Lower Lakes (2003/04) plus an additional 280GL that went over the Barrages into the sea (2003/04), would have delivered 100% water security for South Australia, plus given an estimated increase in water supplies of 25% - 30% for Victoria and New South Wales Murray Irrigation regions. The financial implications of this savings are almost immeasurable.

In developing the new Basin Plan, the MDBA should investigate opportunities to ensure that operational efficiencies can be in place to address critical water shortages during periods of protracted drought. In particular, during major droughts of similar magnitude to the 1895-1903, 1935-1945 and current 2000's drought, to ensure that scarce water resources are not squandered.

Extensive barrage modernisation, including consideration of enlarging the tidal estuary through relocation of one or more existing barrages, should enable responsive decisions to maximise ecological objectives and to minimise social and economic hardship to rural and regional communities in all three States, that directly source water from the main channel of the Murray River. This may require an operational weir at Wellington to enable drought contingency measures to be permanently available. Investigations could also consider modification to the estuarine area via Goolwa channel, or piping schemes to enable operational modifications to the entire lower reaches of the Murray river from lock 1.

On a scientific basis, the Basin Plan should also acknowledge the Coorong and Lower Lakes, as two separate management zones, requiring different options to achieve ecological objectives. In particular, acknowledging the ecological impacts on the Coorong, from Land reclamation and drainage schemes in South East of South Australia.

Murray System Inflows/Lake Alexandrina Ave Gauge Height Source: MDBC-River Murray Water Operations Monthly Account.Source: NSW State Water Annual Report 2003/04 (ref Evaporation Figs.)
Graph source: National Irrigator's Council



3. THE LOWER LAKES

Since the 1917 River Murray Water Agreement and resulting river regulation, Commonwealth and State Government decisions have all contributed to changes to the natural system of the Murray and Darling Rivers and tributaries.

"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 and Menindee) is approximately 9000GL and in all Basin storages, is approximately 23,000GL"[9]

The Lower reaches of the River Murray channel in South Australia represent the most modified river sections of the entire Murray. The River Murray distance of 2,200 kilometre, ends at Lake Alexandrina and Albert. There it historically divided into five main estuarine channels leading out to the Southern ocean. Estuarine water (saline/fresh) also interacted with the waters of the Northern Lagoon of the Coorong.

Prior to the River Murray waters entering the estuarine system of the Lower Lakes, it historically moved across the floodplain and wetland systems between Mannum and Wellington. Wetlands around the Wellington area were 'reclaimed' for agriculture from about 1880's onward. Between Mannum and Wellington, **large scale levee banks** were constructed either side of the main bed of the Murray River and by 1929, South Australian Government planning had reclaimed most of the wetland and low lying swamp areas for agriculture.[11]

This area today, is represented by a 'reclaimed' perched river system, where agricultural land lies below the main river channel. The Murray River water Levels don't fluctuate as in the NSW Section or upstream SA sections of the River. The River between Lock 1, Mannum and Wellington, is retained at the same static height levels as the Lower Lakes. Irrigation in this section, is gravity fed by opening individual farm access points to the river allowing water flows from the river, directly out below to the 'river flats'. In order to maintain the ability to have gravity fed flows (as opposed to pumping water), requires the Murray river and Lower Lakes levels to be maintained above 0.55m AHD.

While the current political climate, suggest the return of near natural conditions for the Murray Darling Basin and increased flows to the Lower Lakes, the reality is that the Federal and State Governments have invested considerable resources in securing reliable water supplies for most years. With the exception of prolonged historical drought scenarios, the system continues to provide social, economic and environmental benefits to the nation.

Given the reliability of the South Australian share of the Murray Darling Basin Agreement, the full impact of the drought was delayed. As a result it has been difficult for many people to understand the complexity and extremities of the drought in other States.

Since 2007/08, the South Australia share of entitlement flows as per the Murray Darling Basin Agreement, was temporarily adjusted to match the extreme drought

[9] MDBC
[11] MurrayUsers.SA.Gov.Au

conditions. Upstream states in the Southern connected Murray system were subject much earlier to water reductions, through reduced ‘allocation’ announcements on entitlements.

The severity of this current drought on the Basin Rivers and creeks has been substantial. This includes impacts on the Lower Lakes. Increasingly though, the blame for the demise of the Lower Lakes, is blamed on ‘over allocation’ of the Murray Darling Basin resources.

The reality is quite different. The Murray Darling system cannot store enough secure water supplies to meet normal yearly demands and store additional large excess supplies, to cover an extended drought period of ten years. Therefore the concept of ‘drought proofing the nation’ through reducing ‘over allocation’ is a myth.

There is growing concern that the Lower Lakes and Coorong have become an ‘icon’ issue to increase flows in excess of the 1850GL existing South Australian share of the Murray Darling Basin Reources. While the ecology of the Lower Lakes has suffered similarly to other upstream natural assets in this prolonged drought, it should be recognised that the Lower sections of the River and Lower Lakes, are a highly modified system, designed to provide static freshwater supplies.

While the issue of extractive uses of the water of the Murray Darling Basin has undergone a series of reforms and is now subject to further review under the Water Management Act 2007 and the new Basin Plan, the Murray Darling Authority should apply appropriate transparency when assessing information and claims in relation to the Lower Lakes.

Web – RiverMurray.com

Lower Lakes – Historical perspective (summary)

The Lower Lakes (Alexandrina & Albert) are relatively shallow and cover an area of 85,000 ha. Prior to building of the Barrages in 1935- 1940, the lakes were part of a tidal estuary, where the freshwater of the Murray River and local inflows, merged with the brackish water of the Lakes and saline waters of the Southern Ocean.

When the explorer Sturt first saw the Lower end of the Murray in SA in 1830, it was a period of low flows and a navigable estuarine system could not be imagined. In later

periods as European settlement developed, the options for navigation and irrigation saw the emergence of plans to build a system of barrages to keep the sea water out of the estuarine system and the conversion of the Lower Lakes into a freshwater system.

In pre European times of low flows, saline waters extended up to 250km upstream in the Murray as far as Mannum. Recording of sharks and other marine species within the lower reaches of the Murray, are typical of an estuarine environment.

Natural scouring by tidal flows regularly occurred keeping the entrance to the sea open. The opening to the sea has not been static and has periodically moved in a north or southerly direction determined by climatic or ocean events. The first survey of the passage way to the Southern Ocean from the Lower Lakes was in 1839 by W.J.S. Pullen. The booklet, South Coast Story by JC Tolley, identifies that a Captain Bloomfield Douglas, Naval Officer and Harbormaster further surveyed the mouth in 1857 and comparison between surveys (plans) identified the opening had moved south-east about 1600 feet. Further surveys in 1876 by W.N. Goalen identified that the entrance had moved another 1400 feet in a south westerly direction. “by 1940 , the opening, was much wider and was a further 1200 feet west, in a similar position to when Pullen surveyed it in 1839”. Today the entrance to the southern ocean remains variable.[7]

Historically, large quantities of sand regularly move with the influence of the sea and storm events affecting the opening to the Southern Ocean. The ‘South Coast Story’, identifies that “freshwater flowing through the several outlets from the lakes, does not affect the position of the channel to any great degree”.[5]

In earlier European settlement, the Murray Mouth was referred where the Murray entered the waters of Lake Alexandrina. Today it is referred to as the section where water passing from Lake Alexandrina pass through to the sea.

The difficulties of navigation remained a challenge to safe passage through to the sea and eventually to Adelaide. In 1889 the first notion of barrages to control outflows to the sea and prevent sea water from entering the river when flow was reduced was developed by the Engineer in Chief, Alexander B. Moncrief. In 1903 another alternative barrage scheme designed to prevent sea water intrusion into the Lower Lakes was suggested costing approximately 113,000 pounds.[7]

The Barrages at the Murray Mouth were eventually built in 1940 to ensure a fresh supply of water in the bottom reaches of the Murray and Lower Lakes. The five barrages have 593 independently operated gates. The design was to ensure the maintenance of high water levels to enable gravity fed irrigation systems on reclaimed land in the Lower reaches of the Murray River channel prior to waters entering Lake Alexandrina. (between Mannum & Wellington).[7]

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7 South Coast Story

Current operations

Prior to the onset of the 2000's prolonged drought, operations of the barrages maintained on average, the height of the Lower River Murray section and the Lower Lakes at 0.75m AHD. This in effect maintained a stable river height 274km upstream to the Blanchetown Lock.

When the lakes are full, approximately 2200GL of freshwater is stored.

The Lower Lakes account for net evaporation of approximately 700-950GL per year, almost a third of the total estimated evaporation".[3,9]

"The total net open water evaporation from major water bodies within the Basin is in the order of 3000GL/year. Of this, the Menindee lakes account for about 460GL/year (capacity), Lake Victoria 120GL/year, and Lake Hume accounts for about 60GL/year". [3]

In larger flows, water is released into the remaining Murray estuary and moves directly out to sea. If the wind is blowing from a northerly direction, fresh water flows will merge into the waters of the Coorong's northern lagoon.

In times of lower flow from the Murray River, evaporation from the Lakes exceeds inflows and in order to maintain 0.75 AHD levels, the barrages are closed and the lake level is raised to 0.85m AHD at the beginning of summer to allow for evaporation dropping the level to an average minimum of 0.60m AHD in autumn.[9,3]
"Current operating rules aim to maintain the water level within a narrow band of 0.6m- 0.85m ADH for the purposes of water supply, irrigation and bank stability."[9]

The construction of the Barrages in 1940, have significantly reduced the area of the tidal estuary and "disrupted the transition between fresh and salt conditions".[2]
The Lower Lakes are now 'hydrologically separated from the estuary" to ensure a freshwater system.

In 1914 it is estimated that 97.3km2 (75,000ha) of the Lakes were affected by the tidal prism, twice per day (est. 90% of its pre barrage size). The artificial barrages and conversion of the estuarine system of the Lower Lakes has reduced the estuarine system by 87%, thus reducing the overall effect of the tidal prism.[2]

To recreate the effects of this prism would require 20,000ML/day flow in excess of one month, to remove sedimentary sand build up and to retain an open entrance to the Southern Ocean. There is limited option for removing sand build up from storm surges[2]

In order to maintain an opening to the Southern Ocean, dredging is now required. It has been suggested that dredging in conjunction with barrage flows of a minimum

[3] Senate Inquiry
[9] MDBC
2 River Murray Barrages Environmental Flows

volume of 2,000 ML/day could maintain an open passage to the sea (Murray Mouth), preventing incoming tidal sand build up.[9] A reliance on flows through the barrages, is likely to limit operational and infrastructure investments that are necessary to address sustainable long term solutions. *(note barrage flows of 2000 ML/day = 730,000 ML per annum =/minimum estimates of Lower Lakes annual evaporation rates*)

The barrages have inefficient operating technology and a rapid response to mimic ecological needs cannot be achieved under the current regime. Some modifications have occurred with the Goolwa and Tauwitchere Barrages. The Mundoo Barrage full opening capacity, is limited to 20% of the natural channel and responding to various flow regimes is further constrained by 'cumbersome' operational features of the 1940's designed barrage. For the most part, the volumes of water released through the Mundoo Barrage is neglible.[2]

In pre barrage conditions, the Holmes Creek or Mundoo Channel would have delivered 10-20% of the total River Murray flows directly into the estuarine area adjacent to the opening of the Southern Ocean (now referred to as the mouth)[2]

Apart from supplying freshwater, the construction of the Barrages allows the Lower Lakes to operate as a safety valve during periods of moderate flooding. It is estimated that "the capacity of these two lakes (Lake Alexandrina and Albert) is equal to 60 days normal flow of the river and the lakes level out the water so that the rise at Goolwa is usually measured in inches. (7)

Lower Lakes Barrage
Web- photo

Local literature in South Australia, suggests that "during the great 1956 flood the maximum height above normal pool level was two feet six inches which contrasts with readings further upstream"[7]

Archival recordings of Jim Marsh (Harbor Master Goolwa) refer to Lake Alexandrina being approximately 55,000 acres and Lake Albert 20,000acres. "When a big flood hits it basically spreads out. The Goolwa barrages designed to pass 300,000 megalitres of water per day. In the 1956 flood, the water rose by 850ml, about 42inches, above pool, not by restriction of the barrages, but by the reduced the 'mouth' which didn't scour wide enough' (*to release sufficient flows)*[6]

Note: This is noteworthy for the MDBA, when pursuing goals to reinstate flood conditions to this RAMSAR listed site – certain adverse flood conditions in the lower reaches of the river can be mitigated against by the operation of the barrages. However, certain flood risks in SA Lower Lakes remain a risk. For NSW Southern connected systems, the concept of delivering

[9] MDBC Icon Site Management Plan

[2] River Murray Barrages Environmental Flow
[7] South Coast Story
[6] Lakeneedwater – history J Marsh

large parcels of environmental water, is likely to cause adverse impacts on upstream third parties, particularly in the regulated Southern Connected Systems.

The Murray Darling Basin Agreement and State Water Sharing arrangements, provides for water quality dilution and transmission loss flows. Approximately 1100GL is required in conveyance (transmission/dilution) flows to South Australia.

Above these base flow requirements, South Australia share of the Murray Darling Basin Water resource is 1850 GL. Each state can choose to consume its share or store a % of its resource.

Of South Australian share of the Basin water resources, (1850GL) approximately 200 GL is apportioned to Adelaide, 100GL industry and 450-500GL to Irrigation. The remainder may be as additional dilution, or for environmental or evaporative losses in the lower lakes.

Since the building of the barrages, in high resource years, South Australia has regularly received above the entitlement share of 1850GL. This has further allowed irrigation extractions to be relatively secure and for the Lower Lakes to be maintained at flood height of 0.75m AHD.

When Federal and Government policy Since Water Reforms were introduced in the Basin that separated Land and Water, water trade has triggered all entitlements and increased water usage in the Murray Darling Basin. This gave all entitlements a value and thus encouraged trade. Historically un-activated licenses (sleeper and dozer) or generally low utilisation of existing entitlements changed, as Governments encouraged the activation of entitlements through trade.

The promotion and activation of trade combined with low rainfall years, has reduced the ability for ‘above entitlement’ flows (>1850GL) to South Australia, which previously enabled the Lower Lakes to be maintained at flood height (0.75m AHD) for most years.

Water flows in the Murrumbidgee system are primarily managed by the major storages of Burrunjuck, Blowering, Eucumbene and Tantangara, while on the Murray System, Hume and Dartmouth Dams control flows.

In the Southern connected systems of the Murray, water delivery systems are highly regulated, with no provision (50Ml limit) for flood flow extractions or large scale on farm flood storages.

In contrast the Northern parts of the Basin extending into NSW and Queensland rely more on rainfall events and overland floodplain flows in many regions. Water management in the Northern system is not as regulated as in the South and features more large scale on farm storages to capture overland floodplain flows.

The two systems (North & South) contribute flows to South Australia but both have restrictive capacity depending on climatic events or geographic constraints (eg Barmah Choke & Murray River channel in NSW).

Water extraction in the Murray Darling Basin has undergone a series of reforms to date, particularly in the Southern connected systems. In 1997 a CAP was introduced based on extractions at 1993/1994 levels. This ceiling has been enforced in the

Southern Connected systems, but not in Queensland which had until early 2000s to implement changes. The Cap in Queensland has not been implemented across all water sharing plan regions but a moratorium on new developments has been in place since 2000. South Australia was not subject to the 1995 CAP on diversions.[9]

The onset of the current prolonged drought has seen a dramatic decline in water availability across the Basin. While Queensland, Northern NSW and the Southern connected systems of the Murray experienced severe drought conditions and low water availability, in contrast South Australia had relative water security under the terms of the basin water sharing arrangements until the last two operational years.

This perhaps has not been understood by many in South Australia, who continue to argue today that the decline in water availability in South Australia, is due to 'over extraction' in upstream states.

"The problems of the Lower Lakes are primarily the result of the current drought, and management scenarios are heavily influenced by how long it will be before there is enough rain to deliver adequate flows to the Lower Lakes".[3]

There are two main avenues for the MDBA to consider in future scenarios for the Basin, its resource and its human capital.

1. Permanent climatic and water yield changes under modelled assumptions for Climate Change
2. An evaluation of natural climatic variances and the current system of annual allocations that, provides a level of entitlement assurance within reasonable expectations based on availability of supply.

There is a growing tendency for political commentators, the media and environmental advocacy groups, to assume that there is an ability to 'drought proof the nation'. In essence for irrigation supplies, that sufficient water can be stored to meet annual demands, plus enough supplies to ensure 100% allocation even in prolonged drought events as currently experienced.

In addressing the ecological needs of the Murray Darling Basin, the Authority will need to be transparent in recognising the variety of changes impacting on the Basin Assets, particularly in relation to the 'icon sites' such as the Lower Lakes/Coorong.

Under climate change scenarios, achieving environmental flows to the Lower Lakes of the magnitude to maintain Lake height at 0.75m AHD in the future, is not achievable without compromising the productive capacity of the Basin and redesigning the economic basis of Murray Darling basin Communities.

[3] Senate Inquiry

Recreational & Urban Demands

The Murray Darling Basin and its water provide social and economic values to many communities. The operational expenditure for the system, is costed partly to Government and is applied on a full cost recovery basis to the Irrigation Industry.

Recreational uses of the regulated resources in the Murray Southern connected system, provide the basis for tourism and non industrial uses. Upstream of South Australia, fluctuating river levels create opportunities and negatives for the tourism industry. Tourism benefits are compatible with seasonal river levels, however in prolonged drought, low flows have had marked impacts on the tourism industry.

In general, the tourism industry in NSW (Southern Murray system) recognises seasonal opportunities and cooperative strategies can enable both Agriculture and Tourism benefits to be derived.

In South Australia, relatively stable river heights through the use of locks and weir and permanent Lower Lake Levels, have enabled the tourism industry to derive year long benefits. Stable river heights throughout the year, have however, had adverse impacts on the ecological health of the Murray River Channel and salinity management issues.

In determining the future of the Basin resources, the Murray Darling Basin Authority should recognise mutually beneficial arrangements from existing river regulation. In determining allocation of future basin resources, appropriate acknowledgement should be given to the irrigation industry which bears full cost recovery for river operations.

The prospect of retention of the Lower Lakes as a freshwater system has caused some division within South Australia. The ability to maintain the fresh water system, particularly in low rainfall periods, has led many to discuss the benefits of returning all, or a significant component of the Lower Lakes, to estuarine conditions.

Differing views may impact on urban and recreational values on Hindmarsh Island. . The location of this significant urban development in the Lower Lakes, is immediately upstream of the Goolwa barrage. This multi million dollar development bears resemblance to many of Queensland style of development, featuring secure water front views and a series of interconnecting canals. A major marina development is another feature of this project which provides boating access to Lake Alexandrina.

Initial planning potentially may not have foreseen lower inflows to the Murray Darling Basin as a result of prolonged drought and water reform changes under NWI (COAG) that led to activation of all basin entitlements.

The Murray Darling Authority will need to assess the practicalities of maintaining static water levels of the Lower Lakes at 0.75AHD for recreational purposes and balance this with other environmental or consumptive needs right across the Basin.

Photo L Burge: Hindmarsh Island 2009
Photo L Burge – Hindmarsh Island 2009

Photo L Burge – Marina Hindmarsh Island

Photo L Burge – Marina entrance – (distance -Goolwa barrage) 2009

Scientific Reports & Reviews - Lower Lakes

The Lower Lakes has been subject to a wide range of views and reports.

It is essential that the MDBA look objectively at the ecological impacts of the Barrages and the operational inefficiencies of the Lower Lakes.

There is increasing recognition that the MDBA should instigate a comprehensive independent analysis of the Lower Lakes and Coorong, to streamline Government investment and policies to maximise ecological objectives for the benefit of the entire Basin.

Given the strong desire to maintain the status quo of the Lower Lakes as freshwater systems at flood height in most years, even in periods of extreme low inflows experienced during prolonged drought, there is concern that only minimum modifications will be made to the operational efficiencies of the Lower Lake systems.

It is worth the MDBA including in its deliberations, aspects of the report titled 'River Murray Barrages Environmental Flows - produced with funding support from the Murray Darling Basin Commission. (Wetland Management Program, Department of Water Resources, SA) in June 2000.

This report identified a range of recommendations to address the environmental flow needs in the Lower Lakes and Coorong. The report funded by the MDBC (edited by Anne Jensen, Michael Good, Paul Harvey, Prudence Tucker and Martine Long)

The Scientific Panel identified four key issues driving serious degradation of environmental values in the Lower Lakes and Coorong. These are:

- Reduced area of estuary
- Changed water regimes of the lakes and river
- Freshening of brackish and saline habitats
- Reduced habitats for aquatic plants

The report's key report recommendations include:

- articulate detailed barrage operating guidelines to meet ecological needs
- automate barrage gates for more flexible operations and sensitivity to ecological needs
- investigate opportunities to manage lake levels over a greater range of levels
- modify Mundoo Barrage to increase flow capacity (scour capacity) and operate preferentially to limit sedimentation at the Murray mouth
- evaluate options for relocation and revised management of the barrages to enlarge estuarine area to increase the range of habitats
- undertake complimentary measures (eg lake short revegetation & stabilisation, carp control, regional revegetation)
- integrate flow management action with other regional planning and management activities for maximum effectiveness

The report also recommended:

- establish environmental monitoring program as a basis for adaptive management
- the most significant short to medium term recommendation is for automation of the barrages.
- Increase scour capacity of the Mundoo Channel in order to restrict sedimentation of mouth zone
- Longer term – feasibility of relocating the ageing barrages structures
- Changes should be based on adaptive management

The Scientific Panel referred to:

- significant decline in fish catches is believed to be due to rapid changes in flow and salinity caused by current barrage operations & reduced estuarine area
- changed tidal and river flow conditions are increasing the likelihood of river mouth closures
- the flow through the Mundoo channel has been significantly reduced from natural conditions which is causing siltation of the mouth
- primary source of sediments & nutrients is flow local catchments not river Murray

The Coorong is a narrow long body of water of approximately 140km in length. The Coorong is separated from the Southern Ocean by a narrow sand dune peninsula and is referred to as the Northern and Southern Lagoon.

The Coorong and Lower Lakes were recognised as an internationally recognised RAMSAR site in 1985. While this site is often referred to as the Lower Lakes and Coorong, in fact, it is two distinct water bodies, which operate independently. Particularly since significant developments have occurred since European settlement, primarily the South East drainage schemes and construction of the Barrages in the Lower Lakes. Regional salinity issues are referred to in zones; the remaining estuary on the Southern Ocean side of the Barrages, the North Lagoon and South Lagoon.

There are several key South Australian Government policies that have substantially caused the ecological decline of the Coorong.

Northern Lagoon
The ecological integrity of the Coorong (Northern Lagoon) has been impacted by the construction and location of the Barrages that resulted in the conversion of the natural tidal estuary of the Lower Lakes ecosystem, into permanent freshwater Lakes in 1940.

The most northern aspect of the Coorong is located directly adjacent, to the Tauwitchere Barrage, on Lake Alexandrina. Construction of the barrages changed the tidal interaction of the estuarine system, where the Lower Lakes and Coorong, join the Southern Ocean.

The Tauwitchere, Ewe Island and Mundoo Barrage would have the most profound impact, but in reality, all 5 barrages retain the freshwater flows in the Lower Lakes storage. Since construction of the barrages, most water releases from the Lower Lakes, now require both flows and strong wind forces, to drive freshwater flows into the Northern lagoon.

Tauwitchere Barrage (09) Coorong Northern lagoon (on left)(photo: L Burge)

Lake Alexandrina on right (Photo:L Burge)

NOTE: At the time of the Coorong/Lower Lakes listing under RAMSAR in 1985, the Coorong was already substantially modified by a range of historical processes. Listing included reference to, Saline and Hypersaline conditions (reverse estuary – more saline inland than at the mouth), despite sedimentary evidence identify brackish conditions for 7000 years. [8][4]

Photo L Burge 2008 – Coorong Northern Lagoon (Sand dune Peninsula separating Coorong from the Southern

Southern Lagoon

The historical ecological condition of the land locked Southern Lagoon, was defined by freshwater overland and sub surface flows from South East of South Australia and flow contributions from parts of Victoria.

Hyper saline conditions in the Southern end of the Lagoon, has been primarily caused by more than 125 years, of land drainage and reclamation schemes. The complex network of drains in the South East of South Australia, intercepts freshwater surface and sub surface flows and redirects the water, directly out to sea. Smaller intersecting drains, join to main arterial drains (eg Kingston drain) and divert these freshwater flows from a historical Northward flow to the Coorong, straight out to the Southern ocean.

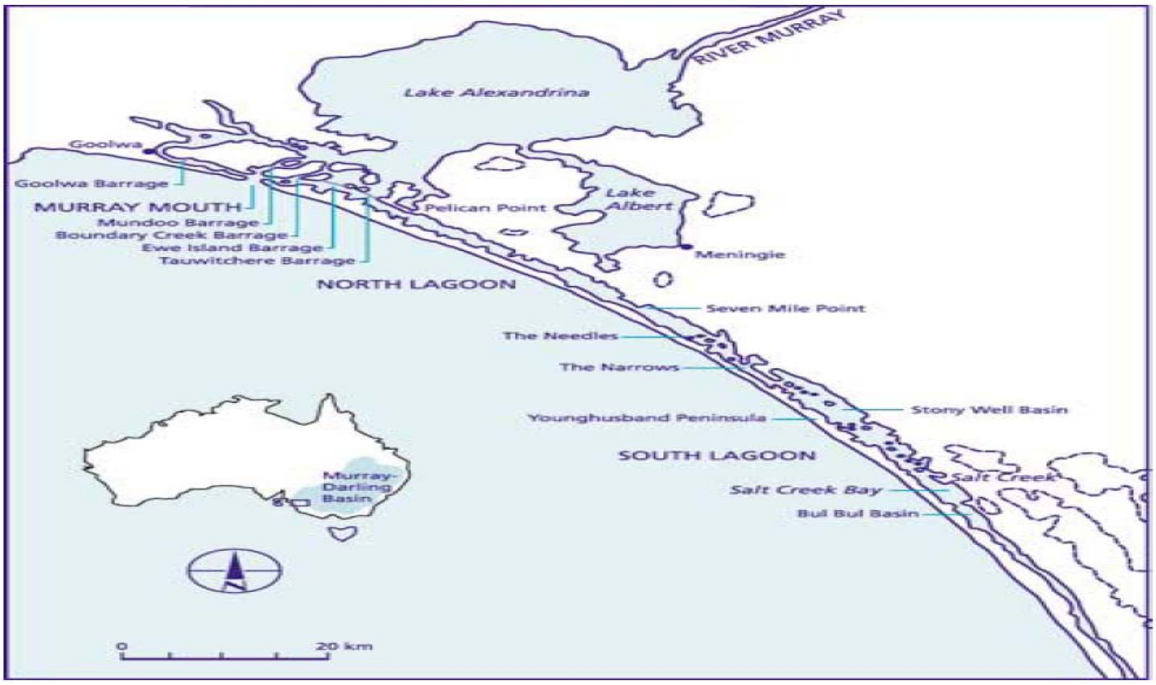
In 1993 the Upper South East Salinity Management and Floodplain Management Plan in South East of South Australia, saw further investments of $86M to address the risk of rising salinity, flood inundation and drainage issues.[4]

South East Drain (SA) (photo: L Burge)

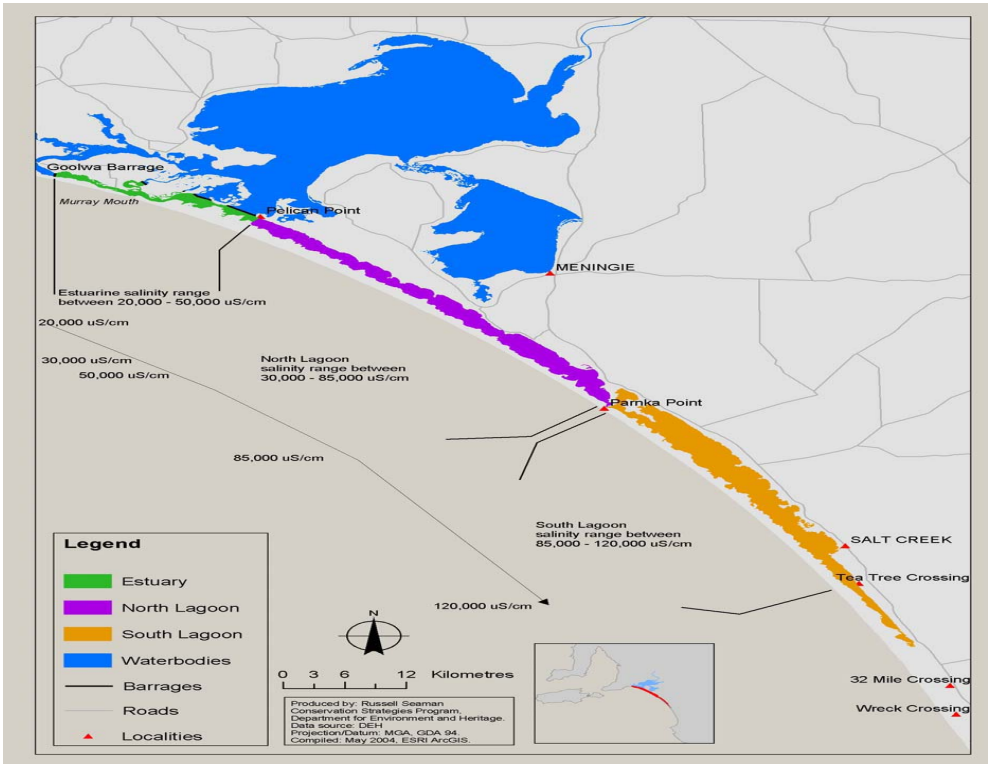
Drain discharge –Southern Ocean - Kingston South East (SA) Drains (photo L Burge)

4, [8] A brief history of upper SE Drains/ Gell P

FIGURE 1.1 LOWER MURRAY AND LAKES STUDY AREA (SOURCE: GEDDES AND HALL 1990)



Lower Murray & Lakes Study area (source: Geddes and Hall 1990) –Report MDBC – River Murray Barrages Environmental Flow



Salinity zones for the Coorong (estuary, North Lagoon, South Lagoon) MDBC Living Murray Icon Site Operational Management Plan –2006/07

The Coorong – History of the South East Drainage Schemes (South Australia)

The South East of South Australia was subject to large scale flooding and dryland salinity for thousands of years. The ABC (2006) described the area as being the "Kakadu of the South until a huge network of drains was carved throughout the region to improve arability of the land east of movement'. It is estimated that up to half of the land was seasonally flooded, with many areas permanently inundated. Prior to European settlement the area was dominated by wetlands, of which only about 8% remain (Gell et al (2002)).[4]

Historically the South East of South Australia was typified by low lying swamps and grasslands, interspersed with timber and ridges. This region is typified by 'a series of low ranges that separate the flats or valleys, and run parallel to the coast'. Land elevation naturally tilts from the South East to the North West draining the surface and sub surface water flows in conjunction with a series of 'ill defined water courses (Reedy and Avenue creeks and Bakers Range watercourse). Flows progressively end up in Tilley Swamp and Alf Flat.[1]

More defined watercourse consists of the Morambro, Naracoorte and the Mosquito Creeks that allow flows from Victoria to be forced also, in a north westerly flow within the eastern flats.[1]

Sub surface flows continuously move through the landscape in parallel with surface flows and in wet winter events, the groundwater may rise to the surface and contribute to surface flows.

These water flows slowly move to their natural discharge point into the Southern end of the Coorong at Salt Creek. The Southern Lagoon is landlocked and salts become concentrated as water is evaporated.[1]

The Survey General, George Woodroofe Goyder valued 'runs' in 1864 and an accompanying map that was included in M Williams "The Making of the South Australian Landscape' showed the valuations in the region based on Goyder's valuations. 'Williams estimated that: the amount of land under water in the western portion of the central flats, Biscuit and Avenue flats, rarely fell below half of the area of the run, and the cover was as much as two-thirds in Avenue Flat and up to three quarters in the northern or Blackford end of the flat. The absence of leases in the East Avenue and Bakers range flats was a measure of permanence of the water cover in the these two areas".[1]

Goyder refers to the region 'my opinion is that from Salt creek southward, the area of the South-East is equal to 7600 square miles and in every wet season half of that is under water. The depth of the water varies from 1 to 6 feet ad some of it is never dry. Some swamps extend from 4 to 6 miles'.[1]

" In July 1847, police commissioner, Alexander Tolmer, investigating a new mail route from Adelaide to Mount Gambier via Lake Mundy wrote….my course from the Salt Creek to Lake Mundy (which is near Kilbride) was south-east, and as the whole distance consists of alternate flats intersected by well-timbered ridges running north

[4] A brief history of Upper South East drains
[1] Down the Drain

and south, he (the reader) will at once perceive that to keep the said course necessitated travelling obliquely across the flats, which were all submerged, and the water so deep in many places that our horses had to swim. At night our camping-places were the ridges or slight elevations forming islands in the midst of these vast waters, and there dry our clothes. This was repeated from to day to day…."[2]

In contrast to this description, in other seasons such as in 1863, William Hanson (engineer and architect) stated ' the time of my visit to the district (January), coupled with an exceedingly dry spring, did not allow of seeing much water upon the swamps; in fact, where, in winter, in some places water had to be passed through consecutively for about 7 miles with intermission, the roads were perfectly dry in many instances…..in December 1860, after a series of dry winters, in passing from Penola to Guichen Bay (Robe), was described as having 40 miles of water out of the 70, it was necessary to go out of the way to find water for the horses to drink'[1]

From the mid 1840's, large pastoral runs and closer settlement around Mt Gambier meant that the issue of transport and mail delivery to Adelaide created discontent with the standard of transportation (roads & bridges). A petition was signed in 1860 to improve facilities.[1]

In January 1863, the whole South-eastern district was inspected by the commissioner of public works (W. Milne), the surveyor-general (Goyder) and the engineer and architect (Hanson).[2]

The concept of draining landscapes for agriculture and to enable unimpeded land passage began to take place. Goyder's vision 'the subject is of great importance to the residents in the South-east, and to the colony at large, as successful prosecution of the work would not only double the area at present available to the stockholder, and place at the disposal of the Crown a large extent of rich agricultural land, but it will also materially aid the general traffic of the country, and enable good roads to be formed at much less cost than must necessarily be expended if the country continues to be liable to inundations from inefficient means to carry off the ordinary winter's rain.

'Goyder, in his report, made the following recommendation to:

- Cut through the ridge that separated the north end of Tilley Swamp from Salt Creek
- Connect the swamp at Baker's Old Station (Blackford) with Maria Creek, and clear its channel to the sea
- Cut through the narrow ridges separating the waters of German Swamp and Mount Muirhead Flat from Glen's Creek and Lake Frome.

'Goyder recommended …..that a complete survey of the whole swamps and low ridges. This would….at once expose the practicability of the formation of drainage channels at right angles to the direction of the valleys', that is, in a direct course toward the sea.'.[1]

Over the next 125 years, successive South Australian Governments implemented a comprehensive system of drainage works and land reclamation activities in the South

[1] Down the Drain

East of South Australia, that diverted fresh water surface and sub surface flows from a north westerly direction to the Coorong, directly out to sea via a series of interconnecting drains.

In the history of the drainage schemes "Down the Drain, the story of events and personalities associated with 125 years of drainage in the South-east of South Australia (M Turner & D Carter), reference is made that 'without the drainage the Green Triangle would be decidedly blue. The removal of vast areas of surplus surface water has made land reclamation for agricultural and pastoral purposes, and for the construction of a network of communication and other facilities possible'.[1]

The South East of South Australia can be divided into two main drainage schemes systems.

The original South East Drainage Scheme which first commenced in the mid 1800's, enabled water logged or swamp land to be reclaimed for agriculture and to allow improve transport across the landscape. This larger section of drainage scheme and land reclamation area, extends to regions such as Millicent, Kalangadoo, Penola, Narracoorte, Lucindale, Kingston, Robe.

The Upper South East Salinity and Floodplain Management Plan (1993) is the more recent drainage scheme and is still being implemented. The project was financially supported from Natural Heritage Trust Funding.

In the early 1990's salinity was to dominate natural resource planning. 'A salinity map of the Upper South East identified about 223,000ha of land as being salt affected, with a further 27,000ha being natural saline land (Cann et al (1992)). The map was derived from assessment of vegetation health (not salinity) observed in aerial photography , backed up by field inspections."[1]

In 1993 the Upper South East Dryland Salinity and Flood Management Plan, proposed a number of objectives to manage salinity, with a network of 270km of deep drains, as key management options.

Despite strong community objections and assessment reports opposing the drainage scheme, in June 1995 the South Australian Cabinet endorsed the staged implementation of the drainage plan for the Upper South. In 1996 the plan was also endorsed by the Commonwealth Minister for Primary Industries and Energy and agreed funding was provided from the National Landcare Program. At the time there was strong community concern in relation to the depth of the proposed drains, as recorded in by the State Public Works Committee (PWC (1996)).[4]

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Indicative of Australia's approach to salinity risk at the time, predictions of rising water tables did not come to fruition. "A study of rainfall records in 1993 would have shown that the Upper South East's salinity and flooding problems were associated with a peak in an approximately 9-year cyclic pattern of winter rainfall, when most groundwater recharge normally occurs. Furthermore, the study would have shown that the Upper South East has been experiencing a decline in average annual rainfall of up to 20mm per decade since the mid 1900s".[1]

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[1] Down the Drain

[4] A Brief History of SE Drains

"In 1998 CSIRO produced a "True Salinity Map" of the Upper South East (Furby et al 1998)). The map was derived from the 1992 salinity map, information from a time sequence of four Landsat infrared images, digital terrain data, and field inspections. Vegetation status was noted to be a poor indicator of salinity status, because waterlogging can have similar effects to dryland salinity. The area affected by dryland salinity was recorded to be 195,240 ha (22% less than the 250,840 ha recorded in 1992), which is consistent with falling watertables in the region".[4]

"In 1999, the Program's Progress Report (SA State Government (1999)) contradicted the CSIRO 1998 reporting stating that "there had been a significant increase in degradation by salinisation in the area over the past decade" and the "current estimate of the area of land affected by salinity is 250,000ha … with a further 175,000ha at risk".[1]

During this period, environmental concerns in relation to the risk of land degradation through land salinisation, reached extreme levels. Salinity and land management became a highly politicised process.

In December 2005, the Australian Farm Institute identified that "many of the assumptions and models used in the Dryland Salinity audit of 2000 to estimate the future extent of dryland salinity have fundamental flaws that simply do not reflect what is actually observed on the ground. In particular, the methods used to calculate the much-touted '17 million hectare' figure, which is widely quoted as the official estimate of the potential future extent of dryland salinity, simply do not stand up to scrutiny'.[3]

Draining of the landscape in the region "Upper South East" continues today based on the assumption that draining landscape to reduce land salinisation risks is appropriate.

Although the original concept of the Upper South East Dryland Salinity and Flood Management Program (USEDS & FMP) was designed for salinity and flood mitigation, by early to mid 2000s, there was growing recognition about the impact of drainage schemes on the Coorong. Modifications to Morella Basin Wetland at Salt Creek have assisted small scale restoration flows to partially address Hyper Saline conditions in the Southern End of the Coorong.

The modifications have seen water releases to the Southern Lagoon of the Coorong at Salt Creek of 5,000-10,000 ML per year (Everingham, 2005). These flows were increased to 10,235 ML by 2005 (Everingham 2005). [4]

"*The Australian Government currently stipulates that the USEDS & FMP must limit releases to 40,000 ML per year on a ten year rolling average, to mitigate any impact of the less saline water (DWLBC, 2004b). This limit is currently being re-examined to ascertain if it is still applicable under the current hypersaline conditions (2–6 times seawater).*
The salinity of the water released from the upper south east is between 25,000 EC and 35,000EC (approximately half sea water). The releases currently have minimal mpact on the water level and salinity of the southern lagoon (Everingham, et al., 2005)".[4]

[4] A Brief History of SE Drains

[3] Australian Farm Institute

[4] A brief history of Upper SE Drains

In general though, there is little recognition in South Australia and Australia, of the ecological impacts on the Coorong, of the major drainage schemes in the South and Upper South East of South Australia.

The Murray Darling Basin Authority will need to appropriately recognise the causes of ecological changes to the Coorong and avoid the current political and advocacy claims, that Hyper Salinity in the Southern End is caused by river extractions in up stream States.

Plantation & Reafforestation Timber

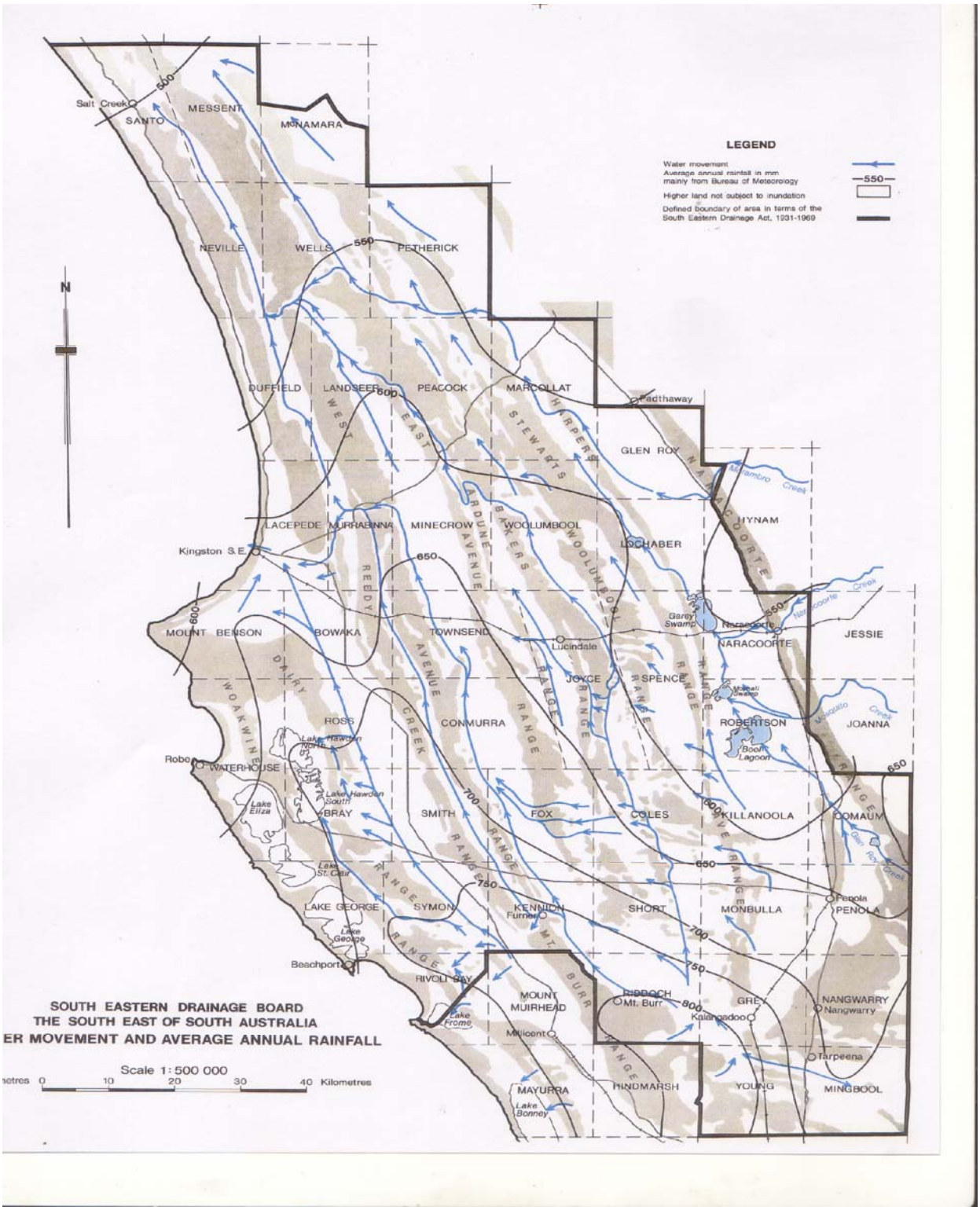
In determining the ability to restore a level of freshwater flow to the Southern end of the Coorong, the Authority would also need to review planning requirements for Managed Investment Schemes Timber Plantations. Currently it is estimated that there are approximately 50,000ha of timber plantations located in the centre of the South East Drainage Schemes. A further proposed area of an additional 50,000ha will further contribute to the decline in surface and subsurface flows that could be redirected north, eventually contributing to enhanced freshwater flows to the Southern end of the Coorong.

In the paper Trading Water for carbon with Biological Carbon Sequestration Science Volume 310 23.12.05) with contributions from the CSIRO, reference is made to "plantations decrease stream flow by 227 millimeters per year (globally (52%), with 13% of streams drying completely for at least 1 year)".[5]

This reference to the impact of Plantation Forestry, further highlights future conflicting public policy on Carbon Plantings, future Basin Wide flows and restorative action for the addressing the Hyper Salinity of the Coorong's Southern Lagoon.

[5] Trading Water for Carbon with Biological Carbon Sequestration


FIELD
GLYDE
COLEBATCH
RICHARDS
COOMBE
ARCHIBALD
MAKIN
McCALLUM
SHAUGH
Salt Creek
SANTO
MESSENT
McNAMARA
LAFFER
Keith
STIRLING
PENDLETON
CANNAWIGARA
SENIOR
NEVILLE
WELLS
PETHERICK
WILLALOOKA
WIRREGA
Bordertown
TATIARA
PARSONS
DUFFIELD
LANDSEER
PEACOCK
MARCOLAT
Padthaway
BEEAMMA
GEEGEELA
GLEN ROY
LACEPEDE
MINECROW
WOOLUMBOOL
HYNAM
BINNUM
Kingston S.E.
MURRABINNA
LOCHABER
MOUNT BENSON
BOWAKA
TOWNSEND
Lucindale
NARACOORTE
JESSIE
JOYCE
PENOLA
ROSS
COMMURRA
ROBERTSON
JOANNA
WATERHOUSE
Lake Hawdon South
BRAY
SMITH
FOX
COLES
KILLANOOLA
COMAUM
Lake St. Clair
SYMON
LAKE GEORGE
KENNION
MONBULLA
Beachport
RIVOLI BAY
MOUNT MUIRHEAD
RIDDOCH
Mt. Burr
GREY
NANGWARRY
Millicent
MAYURRA
HINDMARSH
YOUNG
MINGBOOL
BENARA
BLANCHE
GAMBIER
Mt. Gambier
KONGORONG
MacDONNELL
CAROLINE
Port MacDonnell
THE SOUTH EASTERN WATER CONSERVATION
AND DRAINAGE BOARD AREA
Kilometres 0 10 20 30 40 Kilometres


LEGEND
Water movement
Average annual rainfall in mm mainly from Bureau of Meteorology
Higher land not subject to inundation
Defined boundary of area in terms of the South Eastern Drainage Act, 1931-1969
550
N
Salt Creek
SANTO
MESSENT
McNAMARA
NEVILLE
WELLS
PETHERICK
DUFFIELD
LANDSEER
PEACOCK
MARCOLLAT
Padthaway
GLEN ROY
HYNAM
LACEPEDE
MURRABINNA
MINECROW
WOOLUMBOOL
LOCHABER
Kingston S.E.
MOUNT BENSON
BOWAKA
TOWNSEND
Lucindale
NARACOORTE
JESSIE
JOYCE
SPENCE
ROSS
CONMURRA
ROBERTSON
JOANNA
Robe
WATERHOUSE
Lake Hawdon South
BRAY
SMITH
FOX
COLES
KILLANOOLA
COMAUM
Lake St. Clair
LAKE GEORGE
SYMON
KENNION
SHORT
MONBULLA
PENOLA
Lake George
Beachport
RIVOLI BAY
MOUNT MUIRHEAD
RIDDOCH
Mt. Burr
GRE
NANGWARRY
Millicent
Tarpeena
MAYURRA
HINDMARSH
YOUNG
MINGBOOL
Lake Bonney
SOUTH EASTERN DRAINAGE BOARD
THE SOUTH EAST OF SOUTH AUSTRALIA
ER MOVEMENT AND AVERAGE ANNUAL RAINFALL
Scale 1:500 000
0 10 20 30 40 Kilometres

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