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Dear Dr Dickson

Submission to The Murray Darling Basin Authority on the Proposed Basin Plan

1. Summary

The Proposed Basin Plan is seriously flawed because it has been developed from false assumptions that there is always a shortage of water in the Murray Darling Basin, there is no potential for significant flooding within the Murray Darling Basin and that any change to natural flow regimes are detrimental to ecosystem health within the Murray Darling Basin.

The Proposed Basin Plan is ostensibly about the environment, yet there is no plan to restore the Murray River's estuary. A vast coastal lagoon, Lake Alexandrina, once dominated the estuary but since the building of 7.6 kilometres of sea dyke in the 1930s this area has been managed as an artificial freshwater reservoir to Lock 1. The reservoir is completely dependent on freshwater stored over 2,000 kilometres away in the upper Murray and Murrumbidgee catchments and is arguably the most degraded of all environments within the Murray Darling.

There are no plans to restore the estuary because the Murray Darling Basin Authority now claims Lake Alexandrina was never part of the Murray River's estuary and has always been a freshwater lake. This claim denies a significant scientific literature concerning not only the origin of Lake Alexandrina, but also similar Holocene formations around the southern Australian coastline. A consequence is that best practice management developed in other parts of Australia for other intermittently open and closed lagoons is ignored. The current political solution of using water worth several billion dollars to keep the

Murray's Mouth open would be dismissed as absurd if suggested for the management of any similar barrier estuary system.

2. Flaws in Assumptions, and Computer Model, Underpinning Proposed Basin Plan

The development of a Basin Plan is a requirement of the *Water Act 2007*. The Act and the Basin Plan are based on the assumption that current levels of water extraction within the Murray Darling Basin are unsustainable and that this is causing environmental degradation.

This assumption, that there is over-allocation of the water resource, is not questioned or proven in the Proposed Basin Plan. But this is central to the operation of the computer models that underpin the Basin Plan. For example, consider the following quote from a key paper that provides the rationale for contemporary government hydrological modelling including the modelling that underpins the Proposed Basin Plan[1]:

> *Not all the observed ecological impacts can be attributed to hydrological change alone; each catchment has also undergone extensive agricultural development and vegetation clearance, both of which may disturb riverine ecology. However, hydrological change is known to have an overriding and long lasting effect on ecological processes in large rivers. Thus, it would be fair to attribute a large proportion of the observed ecological change to changes in aspects of hydrology."*

This concept is then demonstrated by way of computer modelling, and then the output from the model is used as evidence that there is a problem with water infrastructure development that has caused the hydrological change. So the logic is circular.

This approach known as 'referencing', uses qualitative information to generate hypothetical relationships between changes in river flow and ecological condition. In other words, numbers are generated from questionable concepts. For example, ecological response curves are not based on the modelling of empirical data but as explained by Fran Sheldon and coworkers[2]:

> *"Ideas for the shape of the ecological response curves came from technical advisory panel discussions".*

[1] Sheldon et al. 2000. Using disaster to prevent catastrophe: Referencing the impacts of flow changes in large dryland rivers, Regulated Rivers: Research & Management 16: 403-420
[2] ibid

Mike Carberry, a cotton grower from the Namoi Valley, explained how he understood the process worked after meeting with computer modelers from the Murray Darling Basin Authority in January 2012:

> *"We questioned them about the 'key ecosystem function' points, that they have identified in the plan and have called them 'environmental assets', which one of them is at the Mollee gauge on my neighbors property no more than a couple of hundred meters from my house.*
>
> *This site, as well as the rivers health, is very familiar to us, as our family has been here for four generations and close to one hundred years. When asked what environmental indicators are they measuring to benchmark and check the rivers health (or to establish that if water is returned to the system what improvement has been made to the rivers health), the answer from the technical staff is they are only measuring [water] volume and occurrence.*
>
> *So [I asked them] you mean to say that you are not measuring water quality, sediment, turbidity, aquatic life or marine biota? The answer was, 'No'.*
>
> *It is unclear what assumptions are used in their models, when pressed they reverted to a standard answer which was "we just made a decision".*
>
> *The engineers … locked away in an office somewhere, were banging on keyboards running models and were mysteriously going to improve the health of the river without even seeing the river or monitoring of the river to actually evaluate what were the rivers problems and in detail what were the causes. Instead someone has created an agenda saying it is all about volumes water delivered downstream in the system."*

According to Mr Carberry one of the greatest threats to the long-term ecological health of the Namoi system is the introduced fish, European carp. The impact of this species is not assessed or considered in the Proposed Basin Plan because it is not possible to model any impact from European carp though a significant impact is not denied.

The Proposed Basin Plan is focused solely on quantities of water. In particular the Proposed Basin Plan identifies 10,873 gigalitres (GL) as the maximum amount of water that can be "sustainably" extracted from the Basin on average each year. In arriving at a single number of 10,873GL and then extrapolating to suggest that this means an additional 2,750 GL must be taken from irrigators, the draft plan reinforces the perception that irrigators always take a set volume of water from the system. In reality the amount of water diverted for

irrigation is highly variable with most irrigators receiving a small fraction of their licence entitlement during periods of drought.

The draft plan acknowledges the highly variable nature of the system in so much as Schedule 1 explains annual inflows to the Basin in the past 114 years have ranged from a high of 117,907 GL in 1956 to only 6,740 GL in 2006. The Proposed Basin Plan also notes this natural variability of flows is important to Murray Darling Basin ecology. Yet this variability is then ignored in arriving at a singe number: a sustainable diversion limit of 10,873 GL based on a calculated average inflow to the entire Murray Darling Basin of 31,599 GL.

The Proposed Basin Plan does not acknowledge a possible positive role for water storages through the provision of water that would otherwise be unavailable during periods of drought. For example, the two-year period to November 2007 recorded the lowest ever inflow to the Murray River with inflows during this period 43 percent lower than previous record lows. But during this period the river did not run dry and water quality did not deteriorate. Before the development of water infrastructure the Murray River was often reduced to a series of waterholes. For example, in Easter 1915 the Murray River ran dry in the vicinity of Koondrook, Central Murray Valley, Photograph 1.

Photograph 1. Murray River at Riversdale, Near Koondrook, Easter 1915

When the Millennium drought broke in the spring of 2010 there was very significant flooding along the Murray and Murrumbigee Rivers. Yet the Proposed Basin Plan, released after the devastating flooding of the 2010-2011 summer, claims that there is no-longer flooding in the Murray Darling:[3]

> *"Medium-to-large floods, which normally would flush through floodplains quite regularly, are now contained and regulated."*

In fact natural climate variability in the Murray Darling is so extreme that Andy Close, from the Murray Darling Basin Commission, wrote in 1990, before the recent Millennium drought and then flooding:

> *"It is not even possible to prove statistically that there has been a decreasing trend in the flow at the South Australian border over the last 80 years, despite the fact that diversions upstream are now greater than the current average annual flow to South Australia."*

It is the sheer magnitude of flow during flood years that make planning on the basis of averages as evident in the Proposed Basin Plan nonsense.

Because the Proposed Basin Plan has as its foundation a hydrological model based on circular reasoning that ignores key variables including variability of inflow (e.g. large flood events), and biological impacts (e.g. carp), any policy developed from this Plan will be of limited practical value and unlikely to return the Murray Darling Basin to ecological health.

3. Alternative Computer Model and Output

Computer modelling has a potentially important role in helping us understanding complex systems including how to optimize water allocation within the Murray Darling basin. But the modelling used by the Murray Darling Basin Authority and the inputted assumptions are far too simplistic to provide meaningful output. There are alternative approaches to modelling impacts of water extraction on ecosystems, for example multivariate time series analysis.

Li Wen from the NSW Department of Environment and Climate Change used such a model to reconstruct water flow in the Murrumbigee River system.[4] Wen concluded that the most marked impacts of river regulation are:

[3] See page 127 of Proposed Basin Plan.
[4] Wen, L. 2009. Reconstruction natural flow in a regulated system, the Murrumbidgee River, Australia, using time series analysis. Journal of Hydrology 364: 216-226

"1. Regulation upstream has increased the annual water availability at Wagga Wagga, especially during drought periods;

2. Dams upstream significantly reduced the peak flow during flooding; and

3. Diversions from Murrumbidgee downstream of Wagga Wagga have notably reduced river discharge at Hay and Balranald. The impacts are observable as early as 1925."

In summary this alternative type of computer modelling, when applied to a highly regulated system within the Murray Darling Basin, does not automatically conclude there has been a negative ecological impact from the changed flow regime associated with river regulation. Rather the conclusion is that there is more water during periods of drought and less water during periods of flooding.

4. Salinity Targets

The Proposed Basin Plan states that a minimum of 2 million tonnes of salt from the River Murray System be discharged to the Southern Ocean each water accounting period (Section 8.17).

This requirement appears to be based on nothing more than the popular perception that more freshwater needs to flow downstream and out the Murray's Mouth to 'flush salt' out of the system, to rid the Basin of salt. In reality since construction of the salt interception schemes and the implementation of the Salinity and Drainage Strategy in the 1980s the problem of increasing salinity in surface and river water, and rising saline ground water, both problems that once plagued the Murray Darling Basin are now manageable and salinity levels are no longer increasing.[5]

Mandating that a minimum amount of salt needs to be flushed from the system would mean that, for example, during the next drought, precious freshwater would be arbitrarily wasted on a non-existent salt problem. This is not to say there is not still a lot of salt within the Basin, indeed large areas of the Murray Darling Basin are underlain by marine strata[6], but as long as this salt is not mobilized it is not a problem.

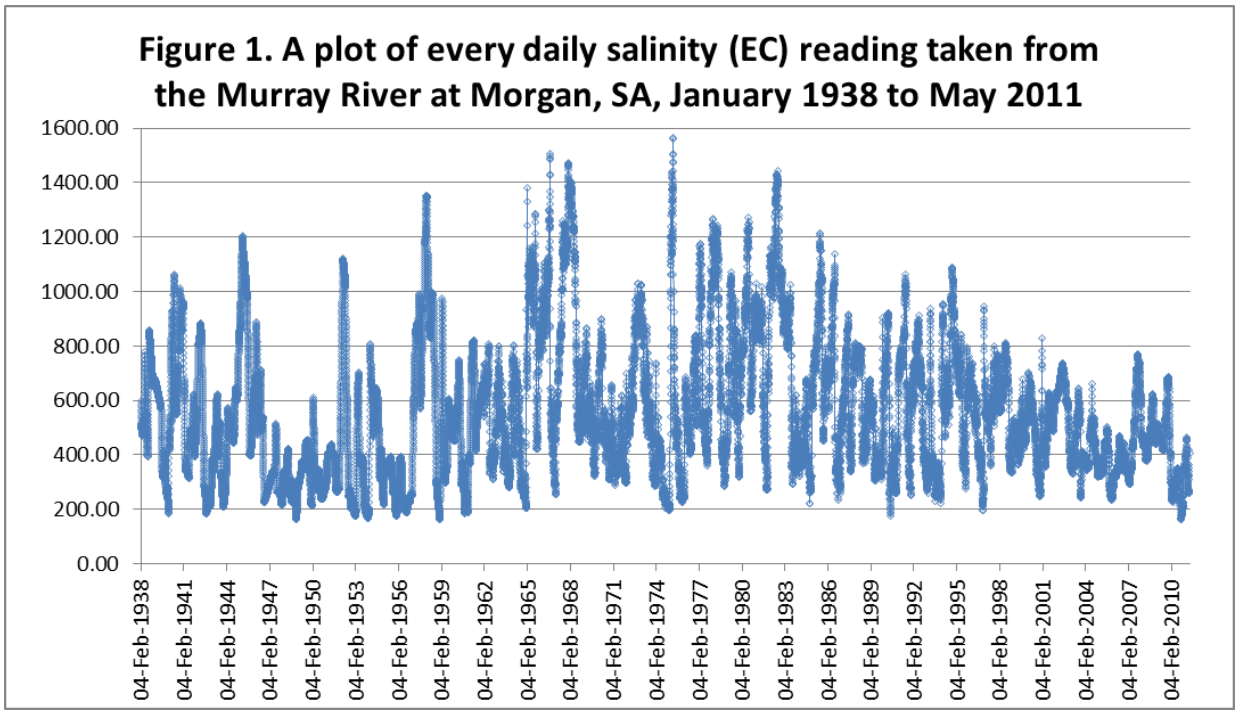
Low flow conditions associated with drought were once associated with higher river salinity levels.[7] During the drought of 1975 and 1982 levels were relatively high at 1,560 and 1,425 EC,

[5] Marohasy, J. 2003. Myth and the Murray: Measuring the Real State of the River Environment. IPA Backgrounder.

[6] See note on map 3, "oyster shells cover these hills" for the Murray banks north of Lake Alexandrina. This refers to known shallow marine deposits of Plio-Pleistocene age (say 5-2 Ma) that occur widely in this part of the basin. These oyster shellbeds are underlain by older marine strata back to early Miocene and older in age.

[7] Close A, 1990. River Salinity, In The Murray (Edited by Norman Mackay and David Eastburn), pages 127 to 146, Murray-Darling Basin Commission

Figure 1. However, during the recent drought river salinity levels continued to fall consistent with the trend of falling salinity since implementation of the comprehensive salinity strategy in the early 1980s.[8]

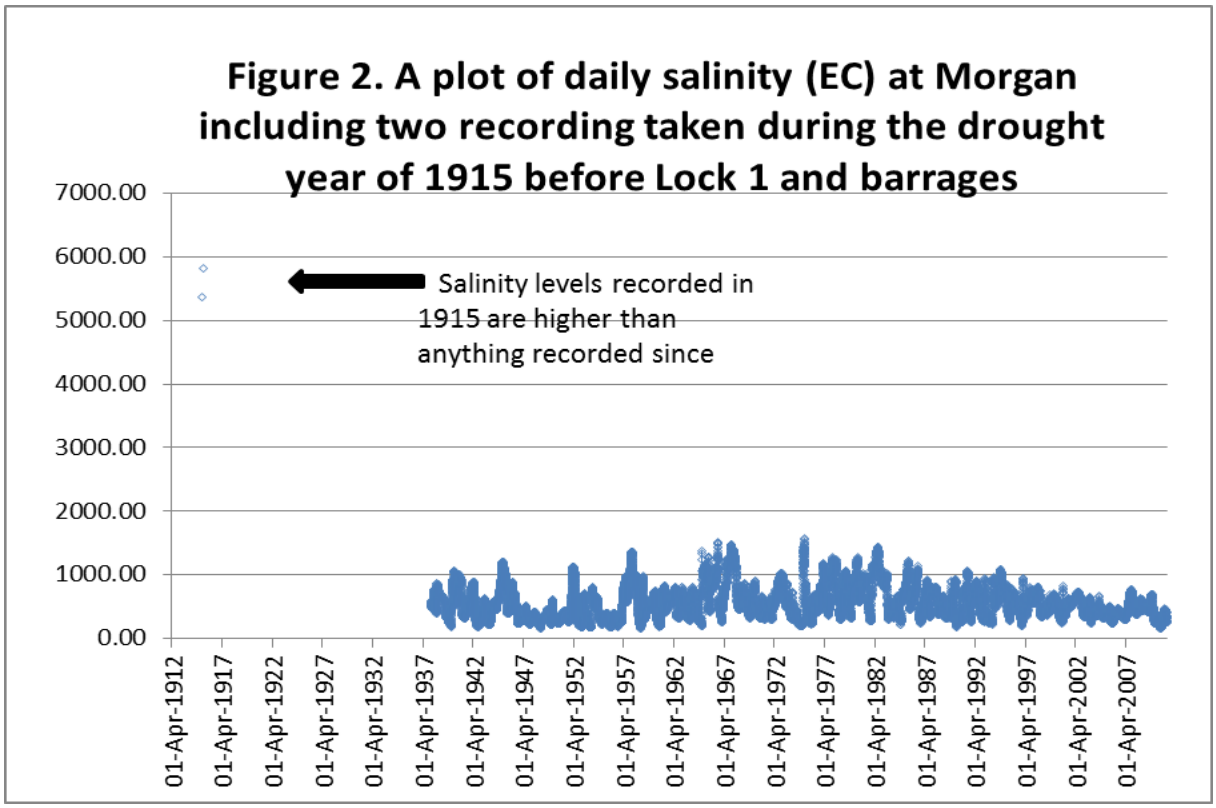


Two salinity readings were taken at Morgan during the drought of 1915 when the seawater penetrated far upstream.[9] Recorded concentrations at this time were 5,362 and 5,820 EC that is much higher than anything recorded since, Figure 2.

The available observational data clearly show that salinity levels at Morgan, which were once considered a reflection of river salinity impacts from all upstream water users, are not increasing and may now be reaching levels that could be considered artificially fresh given the natural state of the Murray Darling system. The available data is also inconsistent with popular claims that inflows to the Lower Lakes now contain elevated salt levels as a consequence of agricultural activity in the Murray Darling Basin.[10]

[8] Marohasy J, 2003. Myth & The Murray: Measuring the Real State of the River Environment, IPA Backgrounder,Vol 15/5.
[9] Data from Murray Darling Basin Authority.
[10] See 'Remove the barrages would turn Lower Lakes into a dead sea' by Kym McHugh, The Australian, September 17, 2011. http://www.theaustralian.com.au/national-affairs/opinion/removing-the-barrages-would-turn-lower-lakes-into-a-dead-sea/story-e6frgd0x-1226139320261 and Murray-Darling Basin Plan to push up River Murray salinity by Miles Kemp, Adelaide Advertiser, February 20, 2012. http://www.adelaidenow.com.au/news/south-australia/murray-darling-basin-plan-to-push-up-river-murrary-salinity/story-e6frea83-1226275165490 .

When the comprehensive strategy to reduce salinity was put in place the early 1980s, Morgan was chosen as the key indicator locality for the entire Basin.[11] Daily salinity readings are available from the Murray Darling Basin Authority for Morgan from January 1938 to the present.



5. Why the Lower Lakes are Important to the Proposed Basin Plan

Over the last decade, the Wentworth Group of Concerned Scientists, and other groups, have successfully lobbied for the environmental needs of Australia's river systems to have a guaranteed first priority call on water. This became reality with the *Water Act 2007* that not only gives environmental needs priority over industry and community, but within this category, environments listed under international conventions are given particular priority.

The *Water Act 2007* imposes a legal limit on the amount of water that can be diverted for non-environmental purposes and, through implementation of the Proposed Basin Plan, will result in a significant transfer of water from food production to the environment. The Proposed Basin Plan

[11] MDBC, Salinity and Drainage Strategy – Ten Years On, 1999

does not specify where the new environmental water recovered under the plan will be used i.e. which environments will benefit most. However, it is generally acknowledged that most of the water will be sent to the Lower Lakes in South Australia. This is because the legislation specifies that the new diversions limit must preserve the environmental values of key sites within the Murray Darling Basin in accordance with international conventions (i.e. these environments are first priority). The Lower Lakes are vast coastal lagoons at the termination of the Murray River that are listed as freshwater lakes under the international Ramsar convention. According to key reports[12] the lakes are currently suffering from inadequate freshwater flows.

According to the Proposed Basin Plan the Murray Darling Basin, presumably including the Lower Lakes, can be returned to ecological health if 2,750 GL is returned to the environment. But South Australian Premier Jay Weatherill has signalled that unless this figure is increased to somewhere between 3,500 and 4,000 GL South Australia will launch a High Court challenge because this is how much water is needed to preserve key environments just in South Australia.[13]

Such a legal challenge from South Australia would likely be prefaced on the Proposed Basin Plan failing to met the objectives of the *Water Act 2007*; in particular that the Basin Plan must be prepared to give effect to the relevant international conventions.[14]

Indeed, given current arrangements and despite relatively large volumes of water being channelled down to these lakes, including during the recent drought, they are generally considered an ecological disaster with many of the problems detailed in 'River Murray Barrages Environmental Flows: An Evaluation of Environmental Flow Needs in the Lower Lakes and Coorong'[15]. However, the solution is not more fresh water.

Because the Lower Lakes are Ramsar listed, the Australian government is obliged to report on their ecological health at regular intervals. In the last report the Australian government acknowledged that 'the site' had been in ecological decline for at least 20 to 30 years prior to listing in 1985, with the rate of

[12] See in particular 'The Murray Futures Lower Lakes and Coorong Recovery: Securing the Future: a long-term plan for the Coorong, Lower Lakes and Murray Mouth'. According to the plan ecological values of the Coorong, Lower Lakes and Murray Mouth can only be maintained if there are adequate freshwater end-of-system flows and thus the key long term management action is to secure adequate freshwater. The planning document does not specify the specific amount of water required but suggests a mean total end of system flow of 5,550 GL would result in improved management.
[13] South Australia to delay High Court challenge to Murray-Darling Basin plan, The Australian, November 29, 2011
[14] See Paul Kildea and George Williams, The Water Act and the Murray Darling Basin Plan. Public Law Review Update: March 2011 (Volume 22, Part 1)
[15] Jensen et al. 2000. River Murray Barrages Environmental Flows: An Evaluation of Environmental Flow Needs in the Lower Lakes and Coorong. A report for the Murray-Darling Basin Commission, ISBN 0 7308 5831 6

decline increasing since listing in part due to drought conditions. In particular the Australian government acknowledged that nearly half of 53 key functions were described as being 'of alarm' and a further third 'of serious concern'.

A key issue for the ecological health of the Lower Lakes is the sea dykes (the barrages), that have dammed the estuary. To quote Bob Bourman from the University of Adelaide and coworkers[16]:

> *"Originally a vibrant, highly productive estuarine ecosystem of 75,000 ha, characterised by mixing of brackish and fresh water with highly variable flows, barrage construction has transformed the lakes into freshwater bodies with permanently raised water levels; freshwater discharge has been reduced by 75% and the tidal prism by 90%."*

Peter Gell from the University of Ballarat writing in the recently published *The Sage Handbook of Environmental Change*[17] has commented that the natural state of the Lower Lakes was tidal, that the lakes have been incorrectly listed as freshwater in the International Ramsar Convention, and that until their natural estuarine character is recognised it will be difficult to reverse the long-term decline in their ecological health.

That the natural evolution of the Murray River's estuary from an intermittently open and closed lagoon to a fully tidal system was interrupted by the construction of the Murray Mouth sea dykes is the focus of a recent report by one of us *Plugging the Murray's Mouth: The Interrupted Evolution of a Barrier Estuary.*[18]

6. **Some Lower Lakes Geography**

Most water infrastructure development in Australia has occurred within the Murray Darling Basin. The basin covers approximately 14 per cent of the land area of Australia and is dominated by two large catchments: the Murray that is snow fed from the Australian Alps and the Darling that is dependent on highly variable rainfall. The Darling River flows into the Murray River near the township of Wentworth and then the Murray River flows into the vast, shallow, terminal coastal lagoon system known as the Lower Lakes near the township of Wellington. Lakes Albert and Alexandrina cover an area of 750

[16] *Marine Geology* 170:141-168
[17] Chapter 27. Human Impacts on Lacustrine Ecosystems, page 595
[18] Available online at http://jennifermarohasy.com/wp-content/uploads/2012/02/Plugging-the-Murray-Rivers-Mouth-120212.pdf

kilometres squared and evaporate between 878 and 1083 gigalitres of water in an average year.[19]

In 1844 William Wishart drew one of the first maps of the Lower Lakes for the South Australia Company, shown here with a recent Google Earth satellite overlap as Map 1. The map shows the water of the lake as brackish. Brackish water is a characteristic of estuaries and in particular the central lagoons of barrier estuaries and results from the mixing of seawater and river water.

Interestingly, this early map, as drawn in 1844, shows the mouth as where the Murray River enters Lake Alexandrina. The Murray's mouth is now officially at the sea end of the lake and is the shallow and narrow inlet between the sand dunes.

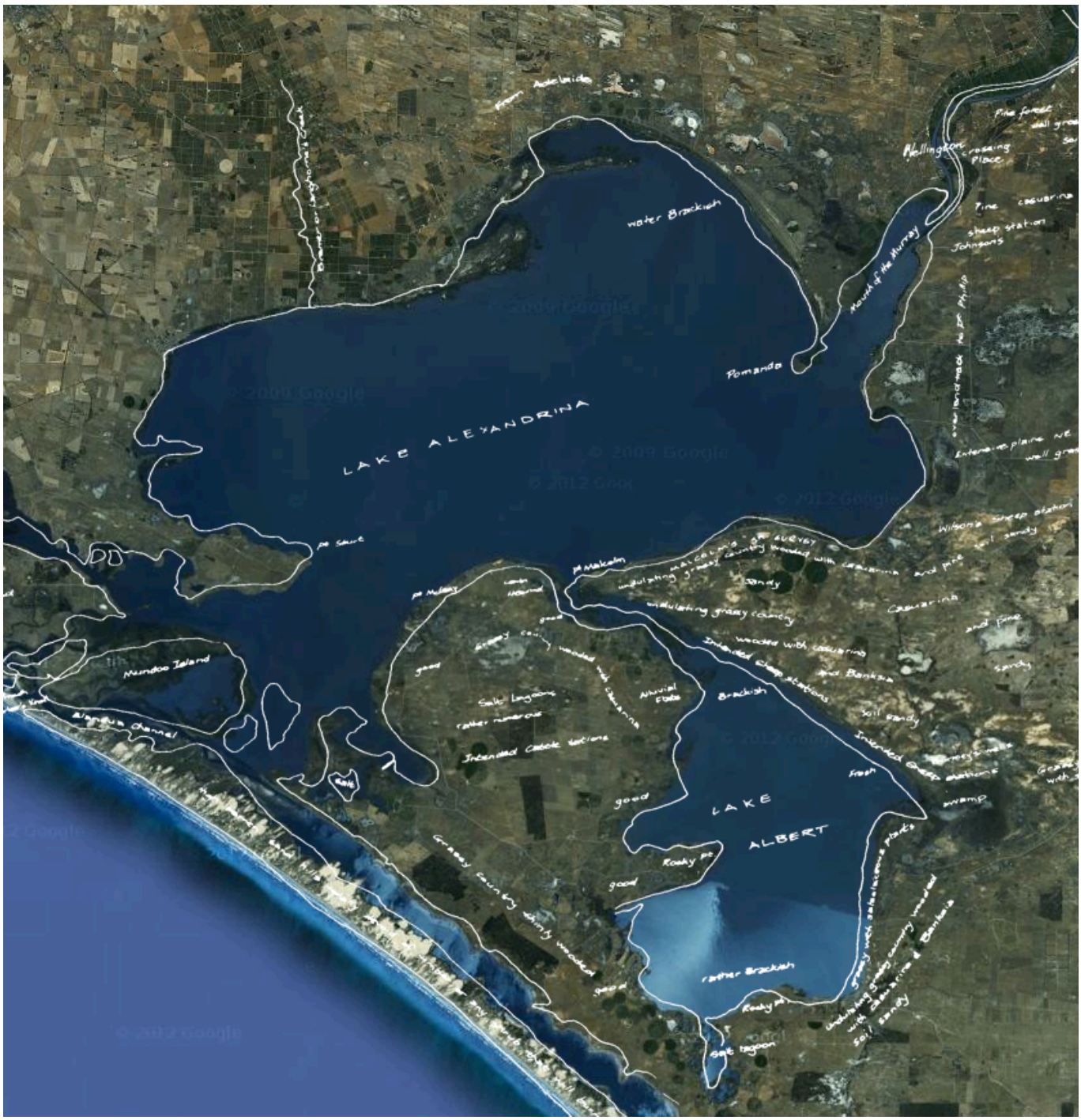
The modern Google overlap shows that most of the land now surrounding the Lower Lakes is intensively farmed. But the waters of Lake Alexandrina are now permanently fresh and used to irrigate the surrounding farmland. The waters changed permanently from brackish to fresh in 1940 when the gates in the Goolwa Barrage were shut to the Southern Ocean.[20]

The Murray Mouth barrages stretch for 7.6 kilometres across the five channels that converge on the Murray's sea mouth, which is a shallow and narrow inlet beyond Mundoo Island, Map 2.

An estuary is where freshwater from a river mixes with saltwater from the ocean. The barrages destroyed the Murray River's estuary by preventing the mixing of the waters. The barrages in effect dammed the estuary. Since construction of the barrages, the South Australian government has managed the Lower Lakes primarily as a freshwater reservoir. In particular, the barrages were designed to stop saltwater intrusions from the Southern Ocean and maintain the lakes and the Lower Murray River to Lock 1 at 0.75 metres above sea level to facilitate gravity fed irrigation.

[19] Marohasy, J. 2011. Calculating evaporation from the Lower Lakes. Available at http://www.mythandthemurray.org/calculating-evaporation-from-the-lower-lakes/

[20] The Murray Darling Basin Authority has measurements of salt levels in Lake Alexandrina (as measured from the Milang jetty) for the period immediately prior to the sealing of the barrages and since. This data shows that salinity levels exceeded 38 per cent seawater for a period of six months between October 1938 until May 1939. This data also shows that after the barrages were sealed Lake Alexandrina became permanently fresh.



Map 1. Lower Lakes as drawn in 1844 by William Wishart, South Australia Company, with a modern day Google satellite Map overlay. This map shows the 'mouth of the Murray' near Wellington. According to modern maps the mouth is the narrow and shallow inlet/outlet to the Southern Ocean beyond Mundoo Island. (from http://www.lakesneedwater.org/maps/Lower-Lakes-South-Australia-1844-Map)

Map 2. Map of the Lower Murray showing the barrages, Adelaide and Lock 1. (from http://www.lakesneedwater.org/maps)

During the Millennium drought water levels in Lake Alexandrina fell precipitously from 0.85 metres above sea level to -1.10 metres below. There was simply not enough water in upstream reservoirs to keep Lake Alexandrina and the adjacent Lake Albert supplied with adequate water notwithstanding the Snowy diversions and strictly limited allocations for irrigation during the drought.

The South Australian government could have opened the 593 gates within the five barrages. If the gates had been opened, the Southern Ocean would have flooded in as once happened naturally in autumn and for longer periods during drought. But instead the gates were shut tight. As soon as the floodwaters arrived in the spring of 2010, the gates were opened to let excess water out.

During the drought the federal government funded the construction of an irrigation pipeline that delivers water from Jervois (below Mannum) to the Langhorne and Currency Creek regions. The pipeline does not extent to Lake Albert. The total water entitlement for irrigated agriculture below Lock 1 is less than 133 Gl.

7. Lower Lakes Geological History

The Lower Lakes have a marine origin. Like most other estuaries around the Australian coastline, the Lower Lakes formed during a period of rapid sea level rise that marked the onset of the present geological period known as the Holocene. It is generally accepted that from about 10,000 to 7,000 years before present, the rate of sea-level rise in South Australia ranged between 9 and 24 mm per year.[21] It was during this period of rapid sea-level rise that the Murray River became progressively inundated with seawater; the southern ocean in effect drowning the river valley and spreading out over of an area of natural subsidence now known as Lake Alexandrina.

Sea level is thought to have peaked about 6,600 years before present and at about 3 metres above present sea level.[22] Beach building processes worked to deposit sand across the newly formed embayment, first as a sand-spit and latter as a sand barrier now known as the Younghusband Peninsula. Following establishment of the sand barrier, and until construction of the Murray Mouth barrages, Lake Alexandrina was the central basin of a wave-dominated barrier estuary with positive annual hydrodynamics.[23] In

[21] Barnett, E. J. 1993. Recent sedimentary history of Lake Alexandrina and the Murray Estuary, PhD Thesis, School of Earth Sciences, The Flinders University of South Australia, pp. 241
[22] ibid
[23] Ryan *et al.*, Conceptual Models of Australia's Estuaries and Coastal Waterways: Application for Coastal Resource Management, Geoscience Australia Record 2003/09. See appendix D.

"positive annual" estuaries evaporation, by definition, does not exceed the freshwater inflow. Although the volume of freshwater input varies regionally and temporally it is usually relatively high in these estuaries.

There are hundreds of similar Holocene formations around the southern Australian coastline. Indeed these barrier estuaries are a characteristic of the Victorian and New South Wales coastlines and include the Gippsland and Mallacoota Lakes, Lakes Illawarra, Macquarie, Burrill and Conjola. All these lakes, like Lake Alexandrana, are shallow and were plains or valleys near the sea with watercourses flowing through them until they became submerged with the dramatic rise in sea level that occurred at the beginning of the Holocene.

8. Denying the Natural History of the Lower Lakes

While anyone with a basic understanding of coastal processes and the recent geological history of Australia, examining, for example, a Google satellite image of the Lower Murray, would come to the conclusion that Lake Alexandrina is part of the Murray River's estuary, it is South Australian government policy that Lake Alexandrina be considered a freshwater lake and not part of the Murray River's estuary.

This story goes right back to the foundation myths associated with the settlement of South Australia and is now sustained by lobbying from special interest groups.

In the 1800s potential migrants were encouraged to buy land, sight unseen, on the basis that Lake Alexandrina was a fresh water lake and had a reliably navigable passage to the sea. In fact, Lake Alexandrina was never reliably fresh: in the early days of settlement saltwater used to often pour in through the Murray's Mouth in autumn and work its way across the Lake. And the Mouth was never reliably navigable with various plans proposed from the early days of settlement for widening and deepening this narrow and shallow inlet between sand dunes. But such is the power of politics this unproven myth has been adopted by Liberal, National and Labor parties and is federal government policy.

For example, when the federal government submitted its last report to Ramsar it reaffirmed the freshwater origin of the lakes with comment:

> *"Prior to European settlement, the Lower Lakes were predominantly fresh, with river water discharging to the sea and keeping the Murray Mouth clear. Saltwater intrusions into the Lake environment were not common until after 1900 when significant water resource*

development had occurred in the River Murray system (Sim & Muller 2004). Short-lived intrusions of saltwater would occur during periods of low flow down river resulting in a lower lake level; however it appears that only small areas of the Lakes, around the Mouth and channels, were affected."

It is interesting that the federal government, and many scientists associated with water reform in the Murray Darling, should cite Sim and Muller (2004) as evidence that the lakes should be managed as a freshwater system because this is their natural state. In making this claim and citing this particular report, government and government-scientists are in effect promoting the anecdote in a single report over a vast technical literature that details how, and when, barrier estuaries formed around the southern Australian coastline.[24]

But indeed the report 'A Fresh History of the Lakes: Wellington to the Murray Mouth, 1800s to 1935' by Terry Sim and Kerri Muller first published by the River Murray Catchment Water Management Board in 2004, and reprinted by the South Australian Murray-Darling Basin Natural Resources Management Board, is probably the most cited document in support of the notion that Lake Alexandrina has always been a predominately freshwater lake.[25]

The report is essentially a compilation of historical anecdote from early European visitors and settlers suggesting that the lakes contained fresh water. That the Lower Lakes were often full of freshwater is not disputed, but the much quoted Sim and Muller 2004 report omits information that shows the same lakes were often full of brackish water and occasionally seawater. In estuaries water quality is always changing: with the tides, with the seasons and with the climate in the upper catchment. To say that the lakes were predominately fresh and therefore must be always kept fresh is to suggest a steady state when none existed.

That the waters of Lake Alexandrina were often brackish during the early period of European settlement, but before the construction of the barrages, is evident from a study of newspaper reports from this period. Following are just four extracts:

[24] See for example Roy et al. 2001, Structure and function of south-east Australian estuaries, Estuarine, Coastal and Shelf Science 53: 351-384; Sloss et al. 2006, Holocene sea-level change on the southeast coast of Australia: a review, The Holocene 17: 1001-1016; Sloss et al. 2010, The Holocene infill of Lake Conjola, a narrow incised valley system on the southeast coast of Australia, Quarternay International 221: 23-35.

[25] See Mis-information vs. Evidence, by Trevor Harden at http://www.lakesneedwater.org/letters/eis-submission-t-harden/mis-information-vs-evidence .

"The third effect expected from this embankment cause is the supply of fresh water at the Goolwa, at least every ebb-tide. The want of permanent fresh water has been the greatest hindrance towards the advancement of this important township. Sometimes the river here is fresh for months, sometimes the reverse, particularly in dry seasons like that of last year; often it alternates from day to day. Numerous wells have been sunk with one result — salt, salt, salt. In 1855 the bulk of the Goolwa people were dependent on one well in Section 2207, some even travelling three and four miles to it. Latterly fresh water has been obtained in Section 2205, but whether the supply be copious or not has yet to be ascertained. Certainly a large sum of money has been spent in boring for fresh water in the Government township, but hitherto without success. The current running out at the Towadjeree channel has been frequently observed to be fresh, whilst at the Goolwa the water was salt." (June 11, 1856. South Australian Register)

"There is an immense body of fresh water lost in the Murray mouth during a year, and if this were dammed back and utilized properly by cultivators the 100000 acres or more in that locality could be made to support a very large and prosperous population. The effect upon the neighbouring townships could not but be beneficial, and might compensate fully for the loss of trade through the 'tapping' of the Murray by the railways above. The steamers upon the Murray could not be injured, provided there is a means allowed for escape through the mouth if they wish to leave the river. Certainly no residents upon the lakes or rivers could complain if the bitter, salt, and useless fluid of the lakes for nine months of the year were changed to a permanent and plentiful supply of fresh water fit for all purposes to which fresh water can be applied." (February 12, 1887. South Australian Register)

"The fishing at Goolwa being for salt water fish was different from that higher up the river, where the water was fresh. From December to January the fish were found with roe in them, the spawn being fully formed. He did not think that sea fish deposited their spawn in the still waters of the river and its estuaries, though they might resemble salmon in this respect. It was his opinion that these fish deposited at sea; where, he could not say. He thought that there were quite as many fish about now as three years ago, because though they might not have been caught they had been seen. For his own part he fished chiefly for butterfish and bream in the wide waters of the lake when the sea went up. When this was the case the cod went up stream, as they do not like salt water." (May 4, 1892. The Advertiser)

"Sir—It is clear from all the remarks made in Parliament regarding the Murray locks and settlement that this is a losing game. If engineering advice was wrong about conditions up river what reliance can be placed on the levels predicted at the mouth, where so many influences interfere with the natural flow? Low rivers are followed by high. During low rivers the mouth, by forces from the ocean, is sanded to a level to cope with that flow. This barrage of sand holds the high river back and floods all the lower levels, until there is force enough from the rising to wash the barrage to sea. If this barrage is held secure by heavy winds from the sea, the sea's pressure still causes higher flooding. No one can say just where the level is to stop. The proposed barrages must, under the best conditions, hold the level higher, to say nothing of what state they -will be in after five years' construction. It is known that the Murray and the Murrumbidgee have salty flats for hundreds of miles, and saline water must be flowing to the river bed at all stages. Little is noticed in times of high river, but at low levels it is sufficient to spoil the water. To say the flushing from the locks will overcome this is falsified by another statement, that saline water is prominent in deep holdings. Nothing will remedy these conditions but the natural flooding of the river. To stop this, and hold the water for what is claimed better uses will ruin the pioneers. They have every right to complain but I would ask them to think before they advocate what might prove a greater danger than the present one." (August 7, 1933. The Advertiser)

Aboriginal history is also often misleadingly quoted as evidence the lakes were always fresh. For example in a recent newspaper opinion piece the South Australian Water Minister Paul Caica asserted:

"Dr. Marohasy's claims also contradict the culture and wellbeing of the region's traditional owners, the Ngarrindjeri, which for thousands of years have been directly tied to the water in the Lower Lakes system being fresh."[26]

In fact the Ngarrindjeri language includes names for estuarine and marine fish species such as: malawi, naraingki (mulloway), kungguldhi (congolli), tinungari (bream), minmekutji (greenback flounder), kanmaindjeri, poronti (saltwater mullet), waltjeri (saltwater perch), kuratji (bony saltwater fish in Coorong), tarrawi, kuratji (salmon), ngrakami (gummy shark), taralgi (saltwater fish similar to callop) and pameri-kop (garfish).[27]. There are also words for freshwater species such as pondi (murray cod),

[26] See Adelaide Advertiser, March 31, 2012, by Paul Caica, SA Minister for the River Murray, 'Lakes flood plan defies the existing evidence'.
[27] See 'Ngarrindjerri – the first fishers of the Lower Lakes' at http://www.lakesneedwater.org/feature/ngarrindjerri-first-fishers-of-the-lower-lakes .

tyeri (golden perch), tji:ri (silver perch) and pomeri (cat fish).[28] But for every freshwater species mentioned in Mary-Anne Gale's Ngarrindjeri Dictionary there are two estuarine or marine species.[29] This suggests that the Ngarrindjeri ate a diversity of fish species, and were not particularly dependent, and did not particularly favor freshwater species.

Anthropologists Ronald and Catherine Berndt's book 'A World That Was: The Yaraldi of the Murray River and the Lakes' published in 1993 is considered an authoritative account of Ngarrindjeri traditional society and culture. Comment in this book suggests that at times the waters of the Lower Lakes were too salty too drink and that the seawater sometimes penetrated approximately 200 kilometres upstream. Following are relevant extracts:

> *"In this song he told of going up the Murray, almost as far as Mypolonga. Before the barrages were placed at the Murray Mouth near the sea coast, salt water came up the River to as far as the north of Mannum. At such times, fresh water was difficult to obtain close to the River, and in the adjacent swamps, salt-water mullet could be caught. In the song of Andrew's journey, he was watching the River dragging along trees as the salt water went up-stream. It gave him a strange feeling to see this and he was frightened. He could not drink the River water but had to dig a well about two feet deep to get suitable drinking water."* (page 221.)

> *"The country around Lake Albert has many patches of fine kangaroo grass, with scattered sheoak, banksia and ti-tree. Fresh water was obtained by digging wells, because apparently the Lake became brackish from the influence of the wind and tides and the intermingling of salt with fresh water."* (page 15.)

> *"Getting enough water was not an issue and when necessary, water was carried in skin receptacles, large haliotis shells or in skull containers. The people lived in well-known surroundings, hallowed by mythic associations and traditions, as familiar to them as their own close kin."* (page 17.)

But all this evidence is ignored, and the South Australian government, federal government and Murray Darling Basin Authority persist with claims that Lake Alexandrina and Albert have always been freshwater lakes.

[28] ibid
[29] ibid

According to the Murray Darling Basin Authority:

> *"Microscopic analysis of single-celled algae (Diatoms) provides evidence that in the 7,000 years since they were formed, the Lower Lakes would have been mainly fresh with rare seawater inflows."*[30]

Map 3. Map of Lake Alexandrina drawn in1838 based on the diaries of Charles Sturt showing Lake Alexandrina containing sea water, brackish water and also freshwater. (Available online at http://nla.gov.au/nla.map-rm2633)

And according to the South Australian government:

> *"The diatom record in lakebed sediments provides strong evidence that the Lower Lakes have been predominantly freshwater for the last 7,000 years and that seawater ingressions, when*

[30] Fact Sheet: All About the barrages. Available online at http://download.mdba.gov.au/proposed/FS_barrages.pdf

they did occur, did not extend north of Point Sturt."[31]

Yet the first official map of Lake Alexandrina, drawn in 1838 by John Arrowsmith, clearly shows seawater ingressions well beyond Point Sturt, Map 3.

While the South Australian government and Murray Darling Basin Authority claim the diatoms from the lakebed as proof that the lakes were fresh with rare seawater ingressions, this is but a narrow and selective interpretation from the executive summary of a report commissioned by the South Australian Department of Environment and Heritage[32]. In fact most of the diatoms found in the sediment cores from Lake Alexandrina are common in estuaries around the world and have broad salinity tolerance. Our reexamination of the diatom evidence[33] suggests that it is more likely that the lakes formed part of an estuary over the last 7,000 years with higher salinity particularly during the period from 2,000 to 7,000 years ago corresponding with higher sea levels.[34]

9. A Key Problem and The Obvious Solution

According to Water Minister Tony Burke, by taking 2,750 gigalitres of water from food producers and sending it down to the Lower Lakes the Murray's Mouth will be kept open 90 percent of the time.[35] But the very idea of using this volume of freshwater, worth between $3.4 and $5.5 billion[36], to keep this narrow and shallow channel open to the Southern Ocean is absurd particularly given a better job could be done with scouring by the tides of the Southern Ocean. Indeed the current political solution would be dismissed as extraordinarily wasteful and ineffective if suggested for the management of any similar barrier estuary in the world.

Blocking the channels that converge on the Murray's Mouth with sea dykes has reduced the potential for scouring of the Murray's Mouth by the tides. Back in 1856, South Australia's Surveyor General George Woodroffe Goyder recognised the potential of, in particular, the Mundoo channel to scour the Murray's Mouth. He suggested the natural process of deepening and widening the Murray's sea mouth be

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[31] Securing the Future: A Long-term plan for the Coorong, Lower Lakes and Murray Mouth, June 2010, Government of South Australia. (13mb pdf)
[32] Fluin *et al.*, 2009. An Environmental History of the Lower Lakes and Coorong. Report Commissioned by the South Australian Department of Environment and Heritage
[33] Abbot J. & Marohasy, J. What can diatoms tell us about the *7,000*-year history of Lake Alexandrina, South Australia? A re-examination of the evidence, In preparation
[34] Sloss et al. 2007. Holocene sea-level change on the south east coast of Australia: a review, The Holocene 17:999-1014
[35] Draft Murray Plan: Tony Burke, Radio National, Breakfast, April 12, 2012
http://www.abc.net.au/radionational/programs/breakfast/draft-murray-plan-tony-burke/3945288
[36] Values based on the approximate market value of water in August 2011 in the Murray Darling Basin. The value varies depending where the water is purchased in the Basin.

enhanced by cutting through the rock bar across this channel thus further concentrating tidal water inflow and river water outflow. The rock bar is of calcareous sandstone and a relic of sea level rise about 125,000 years ago. Instead over the last 156 years government policy has worked to stop the tide and block the channel; Photograph 2 shows the Mundoo barrage built immediately upstream of the rock bar.

Photograph 2. Aerial Image of Murray Mouth and Mundoo Channel, March 2003, Department of Environment and Heritage, South Australia

In their second submission to the Murray Darling Basin Authority on the Proposed Basin Plan Professors Bob Bourman and Nick Harvey from the University of Adelaide explain how the Mundoo channel barrage (sea dyke), in particular contributes to the Murray Mouth filling with sand:

> *" The existing Mundoo Barrage is seldom opened and only for short periods of time. The gates are cumbersome to operate, making it extremely difficult to respond to rapid changes in*

conditions induced by wind and storm. It takes two days to open and close the barrage as the roadway runs across it, which also cuts off vehicular access across Mundoo Channel when the barrage is open. The structure consists mostly of causeway with a small number of discharge gates. Even when the gates are fully open, there is a restriction of flow as the barrage gates only cover 20% of the natural channel width. As a result, potential flows through the Mundoo Channel have been greatly reduced in volume and frequency when compared with pre-barrage and pre-irrigation flows.

"The pattern of flow discharges through the estuary channels has been altered. Under natural conditions the Holmes Creek or Mundoo Channel accommodated ~10 % of the total flow of the River Murray. The Goolwa Channel has always been the major channel, carrying 60-70% of flows, with the balance of 10-20% of flows passing the remaining three openings (Oliver and Anderson 1940, McIntosh 1949, Johnston 1917). Today the main flow is still through the Goolwa Channel, but no water passes through the Mundoo and Boundary Creek Barrages.

"Before river regulation, flows through an active Mundoo Channel dispersed the sand plumes of the flood tidal deltaic sediments and inhibited vegetation growth. After regulation and extensive upstream abstractions, sand plumes of the flood tidal delta were protected from river flows by Mundoo Barrage, and later, protected from sea waves by the growth of Younghusband Peninsula to the northwest. The perfect setting had been established for the growth of a permanent, vegetated sand island at the outlet of Australia's largest river system. Without fluvial scouring, the mouth rapidly infills with coastal sediments, such as occurred during the recent drought, necessitating constant dredging to maintain an opening as between 250,000 and 1 million tonnes of sand are transported along the coast towards the mouth every year."

In the recent report by one of us, 'Plugging the Murray River's Mouth: The Interrupted Evolution of a Barrier Estuary' the obvious solution was proposed: removal of the Mundoo sea dyke and also the rock bar that Mr Goyder suggested be removed back in 1856. In this way tidal scouring of the Murray's Mouth could occur without the need for freshwater.

This solution is broadly consistent with best practice management of similar intermittently open and closed lagoons in other parts of southern Australia where local governments generally work to create biologically diverse and resilient systems by assisting their natural evolution through the development of

a clear channel for tidal inflows and river outflow.[37]

10. In Conclusion

The Proposed Draft Plan is not based on science. It may have been compiled with input from scientists, but it is essentially a political document that repeats false but popular myths while ignoring obvious and practical solutions.

Indeed if the Murray River's estuary was restored, and a different system of modelling employed to assess the current impacts of water extraction for irrigation on the environment, a reasonable conclusion could be that current diversions for food production are sustainable.

Yours sincerely

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[37] Ryan et al. 2003. Conceptual Models of Australia's Estuaries and Coastal Waterways: Application for Coastal Resource Management , Geoscience Australia Record 2003/09