MURRAY**FUTURES**

Lower Lakes & Coorong Recovery

The Coorong, Lower Lakes and Murray Mouth:

Managing for a Healthy Future

August 2009

Government of South Australia

WATER FOR GOOD

Have your say

This document outlines the proposed method for future management of the Coorong, Lower Lakes and Murray Mouth.

It builds on the framework outlined in the *Directions for a healthy future* document released for public consultation in early May 2009. Feedback from that consultation was generally in support of the proposed framework.

This document describes in more detail the climatic scenarios which the site faces and the actions needed to secure its future.

The consultation process for this document invites feedback on:

- the goal in managing the site;
- the proposed management actions;
- the impact of those management actions on the environmental, social, economic and cultural values of the site; and
- how the site should be managed and where communities could be involved.

This feedback will directly inform the Long-Term Plan for the Coorong, Lower Lakes and Murray Mouth and associated documentation - including a Business Case for the proposed actions to secure its long-term future. This suite of documents will be tabled with the Australian Government in the fourth quarter of 2009 to access the $200 million funding set aside as part of the *Murray Futures* program.

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The Coorong, Lower Lakes and Murray Mouth: Managing for a Healthy Future

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1. Summary

Situated at the end of the Murray-Darling Basin System, the Coorong, Lower Lakes and Murray Mouth (CLLMM) are recognised internationally[1] as one of Australia's most significant wetlands.

The Murray-Darling Basin is experiencing the worst drought since records began in 1891. Because the Coorong, Lower Lakes and Murray Mouth rely on flows from upstream in the Murray-Darling system, they are directly affected by the water that is delivered.

Years of basin over-allocation and the current severe drought have led to significant impacts upon the Coorong, Lower Lakes and Murray Mouth. Water levels in the Lakes have now dropped to unprecedented lows. As the water levels have fallen, serious land and water management issues have progressively emerged with the drying of wetlands, exposure of previously submerged sulfidic soils, and the disconnection of different elements of the system. There have been insufficient freshwater flows through the barrages and as a result the water quality of the system has declined markedly.

As water levels have not previously, in recorded history, fallen to such extremely low levels, there is no precedent for dealing with environmental impacts on this scale. Unlike natural disasters, where a step by step plan can be prepared to recover from specific events, planning for this unfolding situation will by necessity be reactive.

Changing climatic conditions will result in changes in freshwater availability and sea level rise. However, the precise timing and impacts are uncertain.

The goods and services that drive the regional economy and support local social systems largely depend on a healthy and functioning environment. It is therefore critical that our primary focus is to conserve the species, ecological communities and ecosystem services of the site. In doing so, our actions will contribute significantly to regional social and economic wellbeing in the long-term.

Our goal is to secure a future for the Coorong, Lower Lakes and Murray Mouth as a healthy, productive and resilient wetland system that maintains its international importance. Achieving this will directly support the local economy and communities.

Over the next 20 years, the long-term plan for the region will work towards keeping freshwater in the Coorong, Lower Lakes and Murray Mouth system. However, given the significant uncertainties we face because of the current extremely dry conditions, all proposed actions are being taken with a view to maximising potential management options in the future.

We cannot adopt a 'business as usual' approach.

We need to manage the site in a way which adapts to changing conditions. This means a substantial program of monitoring the site and research into the areas that we do not currently understand. As conditions change and our knowledge increases, our responses must also change to cope with the greater variability in salinity and availability of freshwater arising from changing climatic conditions.

Our approach to management must also be much more responsive to community guidance and oversight than at present. This will mean looking at new forms of governance of the site.

About this document

This draft document outlines the proposed method for the management of the Coorong, Lower Lakes and Murray Mouth. It builds on the framework outlined in the *Directions for a healthy future* document, released for public consultation in May 2009. All of the ideas and feedback that were received

[1] The Coorong, Lower Lakes and Murray Mouth (CLLMM) was designated a Wetland of International Importance under the Ramsar Convention on Wetlands in 1985.

through the first stage of consultation have been considered in producing this document. Feedback from the first stage of consultation was generally in support of the proposed framework.

Now in the second phase of developing the long-term plan for the region, this document presents a suite of possible management actions. These actions, framed within the context of the core elements are based on four different future climatic scenarios – wet, median, dry and extreme dry. A set of likely management actions is also presented.

Working together to get results

Community input is vital to ensure the best possible long-term plan for the region is developed. Whilst consultation is an ongoing process and people are encouraged to send in feedback throughout the year, specific feedback is now sought on this document including:

- The goal for the site – what is a realistic goal given a changing climate? (refer to section 6)
- The proposed management actions – what is supported? (refer to section 7 and appendix 6)
- The impact of those management actions – how will these impact on the social, economic, cultural and environmental values of the site? (refer to section 7)
- The management approach – how should the site be managed in future? (refer to section 7)

The answers to these questions will underpin the Long-Term Plan for the site and the Business Case for action to be tabled with the Australian Government in the fourth quarter of 2009.

2. What is at stake?

A wetland of international environmental standing

The Coorong, Lower Lakes and Murray Mouth comprise a system of shallow lakes, lagoons and wetlands at the end of the Murray-Darling Basin system. The Coorong, Lower Lakes and Murray Mouth site was designated as a Ramsar Wetland of International Importance in 1985 in recognition of its diverse range of wetland ecosystems, habitats and bird, fish and plant species (some of which are threatened or endangered). It is regarded as a biodiversity 'hot spot' in southern Australia[2].

The unique ecology within the Coorong and Lakes Alexandrina and Albert has been in decline. The speed of this decline has increased substantially since 2007 when it became evident that ecosystem processes were collapsing with the decreasing water levels within the Lakes. Several important ecological 'hot spots', such as the Currency Creek and Finniss River tributaries, have become dry and are experiencing significant soil acidification.

One of the largest freshwater ecosystems in Australia is at risk of collapse.

A prized local environment

The Coorong, Lower Lakes and Murray Mouth are popular areas for recreational activities such as sightseeing, bird-watching, camping, walking, picnicking, fishing, swimming, boating, canoeing, water skiing and 4-wheel driving. In 2008 the South Australian Tourism Commission estimated the visitation rates to the Coorong National Park to be around 138,000.

The region is one of the most popular tourism and recreational locations in South Australia. Local businesses such as cafes, restaurants and accommodation are significant employers in the region and are reliant on tourism and recreational activities. These retail and service industries are affected by any downturn in tourism. In addition, the flow-on effects from any downturn impact on employment in a range of other industries in the community.

A rich and diverse culture

Cultural and spiritual significance for the Ngarrindjeri people

At the request of the Ngarrindjeri, this section remains to be developed in consultation with Ngarrindjeri people. Working in partnership with Ngarrindjeri is critical to the successful development and implementation of this Long-Term Plan. To meaningfully incorporate Ngarrindjeri interests into the Long-Term Plan and future programs, the Department for Environment and Heritage has entered into a *Kungun Ngarrindjeri Yunnan* or 'Listening to Ngarrindjeri Talking' Agreement with the Ngarrindjeri. We are now working with the Ngarrindjeri Regional Authority to establish the process for working together to ensure that Ngarrindjeri interests and values are incorporated into the Long-Term Plan and addressed in future programs.

A regional community and economy

Many regional communities upstream of the Coorong, Lower Lakes and Murray Mouth are affected by the current conditions and decisions about the future management of the site. The River Murray and Lower Lakes, from Lock 1 at Blanchetown downstream to the barrages, comprise one weir pool. When Lake levels recede it follows that levels in the River Murray channel recede. It also follows that the quality of water in the Lakes has the potential to affect the quality of water in the upstream channel. Problems that have arisen upstream of the Lower Lakes include the drying of wetlands, the slumping of riverbanks and irrigation banks, disruption to the operation of ferries across the river, and the stranding of irrigation infrastructure. These issues are being addressed by the South Australian Government's drought contingency planning which is currently underway.

[2] An overview of the system is provided in Appendix One. The Ramsar criteria are presented in Appendix Two.

The gross regional product (GRP) of the Lower Murray/ Lakes and Coorong regional economy was estimated to be around $700 million in 2006-7[3]. Primary industries directly contributed about $145 million to this and directly employed around 2,000 people. Irrigated agriculture employed 1,000 people, contributing over $70 million to the GRP[4]. Anecdotal evidence suggests that drought conditions over the last few years have substantially reduced these numbers.

The restructuring of regional industries which has occurred in recent years can be expected to continue. There will be changes impacting on all industries in the region. Some changes have already occurred, with a reduction in the number of dairy farms and a reduction in livestock numbers. Wine production and the irrigation industry have also been affected by drought and water availability. Impacts are being detected in other agricultural industries as well as the fishing, tourism, and boating industries. Further research is being undertaken to quantify the effects of declining water availability and quality on industry in the region.

[3] Source: ABS (2007)
[4] A land use map for the region is provided in Appendix Four.

3. What are the problems?

The key driver of the site's health is the availability of freshwater. As the levels of freshwater have declined since 2007, several impacts have occurred:

- The system has gradually become disconnected – wetlands around the lakes are no longer connected to the main lakes. As water levels have declined further entire lakes have become disconnected from one another. There is insufficient water to keep the system going. What was a holistic system is, at the current time, a series of disconnected water bodies with not enough water to maintain their core Ecological Character.
- There is insufficient flow to maintain the basic functions of the site – the Murray Mouth now requires continual dredging, fish cannot readily move around the site, salt cannot be flushed out to sea from the Lakes, and the Coorong does not receive the flows to keep it fully alive.
- The low water level in itself means that formerly moist soils can no longer support the full array of vegetation and sulfur-rich sediments are exposed to air for the first time.

These constitute major problems for the site.

Due to the severe drought conditions and the over allocation of water across the Murray-Darling system the ecology of the site no longer functions effectively. Management actions are focussed on triage to stabilise the area and enhance future options.

A summary of the key issues and their current status is:

Issue	Current situation	Management challenges
Reduced freshwater inflows and levels as a result of drought, over-allocation and a changing climate	Low flows and unprecedented low water levels (below sea level) due to over-allocation upstream and reduced inflows resulting from drought and/or climate change, and continuing evaporation. However the forecast of future inflows indicates that planning should be for a freshwater future for the Lower Lakes.	The over-allocation of water resources across the entire Murray-Darling Basin will take considerable time and cost to resolve. There is limited opportunity to purchase water at the moment. This is a longer term management strategy which is underway.
Acid Sulfate Soils	Low water levels in the lakes and tributaries have uncovered large areas of previously saturated sulfidic sediments that are acidifying on drying, causing Acid Sulfate Soils. This has resulted in the potential for undesirable environmental, human and animal health and economic impacts. Nowhere else in the world has this situation occurred on such a large scale before.	Best management approach is to saturate with freshwater, which is impractical under current circumstances. Bioremediation, limestone dosing and infrastructure strategies are currently being employed.
Salinity[5]	Salinity levels increasing throughout the site, exceeding those suitable for human or livestock consumption, and for irrigation of horticultural crops. Significant impacts on biodiversity in the region.	Best management approach is to flush with freshwater, which is un viable under current circumstances.
Biodiversity loss	The combined impact of low flows past Wellington and reduced water quality is impacting upon the Ecological Character of the site.	Unless the critical water quantity and quality needs of the site are addressed, its Ecological Character will change dramatically.

[5] An indication of the ecological response to declining water levels and quality is provided in Appendix Five.

Socio-economic impacts	Irrigation and fishing industries are being affected and there are concerns about health implications, the future of local industries, associated effects on employment and a financially viable future.	There are challenges for the community to remain optimistic in finding and implementing the best solutions to this difficult and complex situation.
Sea level rise	Current predictions, based on International Panel for Climate Change projections, are for a rise of at least 0.3m by 2050 and 1.0m by 2100. There will be impacts on biodiversity and the barrage system. It is possible Lake Alexandrina will assume a more estuarine character as a result in the long term.	The longer term implications of sea level rise on the Coorong, Lower Lakes and Murray Mouth are currently being assessed. Given the constricted nature of the Coorong, Murray Mouth and low-lying islands, it is predicted that if the barrages were to be permanently opened during periods of low freshwater flow down the system, this would likely result in a further constriction, if not permanent closure, of the Murray Mouth. Rather than establishing an estuarine environment, this is likely to result in hypersaline conditions within the lower parts of Lake Alexandrina.

4. What is being done to manage the current problems and plan for the future?

Much has been done by all levels of Government working together with local communities, scientists, technical experts and engineers to respond to the immediate problems due to drought and over-allocation, plan for worst-case future climate scenarios and develop long-term sustainable solutions in a coordinated fashion.

A range of actions has been implemented in response to the current situation, while future planning continues to prepare for worst-case scenarios if triggers are reached. These actions include:

Initial response measures

- Dredging to keep the Murray Mouth open.
- The sealing of the barrages.
- South Australia has recovered its target share of 35GL of water through the Living Murray initiative. The first step of this national program, established in response to concerns about the declining health of the River Murray system, was the recovery of 500 gigalitres (GL) of water by 30th June 2009 which can be deployed for environmental purposes to six Icon Sites into the future, including the Coorong and Lower Lakes.

Emergency measures

- Implementation of the Goolwa Channel works including the ponding of freshwater within the Finniss River and Currency Creek area and the use of limestone to manage acidification of soils.
- Trials to assess the effectiveness of revegetation and bioremediation techniques to manage Acid Sulfate Soils.
- The purchase of water on the temporary water market

Preparing for the future

- The development of the 'Water for Good' plan, to secure water for South Australia's future.
- Investment in waste water recycling and storm water re-use and the commencement of construction of a $1.83 billion desalination plant for Adelaide.
- The establishment of the Murray Futures Program.
- The construction of pipelines and standpipes for the delivery of potable and irrigation water supplies as part of the Murray Futures Program.
- Investigations into the options available to reduce salinity in the Coorong's South Lagoon.
- A Goolwa to Wellington Local Action Planning Group initiative – the *Coorong and Lower Lakes Community Eco-Action Project* – to increase community involvement in helping the area adapt to a rapidly changing environment during the current extreme drought.
- Undertaking Water Allocation Planning for both the Eastern Mount Lofty Ranges and South Australian Murray-Darling Basin System to ensure that social, economic and environmental water needs are addressed.
- Pursuing a constitutional challenge to upstream States to protect South Australia's rights to water.
- Input into the preparation of the Murray-Darling Basin Plan to set more sustainable policies for the use of water and policies to manage risks to water resources across the entire Murray-Darling Basin.
- Improving efficiencies in irrigation practices.

Planning for a worst case situation

- Preparatory work for a temporary weir near Pomanda Island to protect South Australia's water supply below Lock 1, should this be required as a last resort measure.
- Technical investigations and the commencement of an Environmental Impact Statement on the environmental implications of the temporary wetting of the Lower Lakes with a minimal amount of seawater to address Acid Sulfate Soils. This is considered to be a last resort management response if trigger levels are reached.

Associated with these actions are a range of measures by the Australian Government including the investment of $3.1 billion in buying back water in the Murray-Darling Basin over 10 years, among other measures to protect and restore environmental assets as part of the Commonwealth *Water for the Future* strategy (2008). A component of *Water for the Future* is the Sustainable Rural Water Use and Infrastructure Program - a 10 year, $5.8 billion program.

5. What could the future look like?

A freshwater future is possible

The recent CSIRO *Sustainable Yields* project considered a number of future climatic scenarios, including the continuation of historic climatic conditions[6], the continuation of recent climatic conditions[7], and a range of global warming scenarios proposed by international climate change experts, from a 'wet' through to a 'dry' climate.

Based on these scenarios, the project predicted that the atypically low annual flows of 2007-08 would continue to occur only 1% of the time under a continuation of the 1997-2006 climate, and 4% of the time under a future 'dry' predicted climate. The succession of dry years we are currently experiencing is beyond what the science predicts to occur in the future.

Significantly, the CSIRO *Sustainable Yields* report makes the point that revised water management arrangements in the future could reduce the time the Lower Lakes were below sea level.

Sea level rise

The current South Australian projections are for at least a 0.3 metre rise by 2050 and a full 1.0 metre rise by 2100. However, more recent projections suggest that the global sea level could rise as much as 0.5 metre by 2050 and 1.5 metres by 2100.

Sea level rise is not seen as an immediate threat, but it is acknowledged that it may lead to a transition of the lower reaches of the Lower Lakes system to a more estuarine environment in the long-term.

What future climatic scenarios should we plan for?

We are planning for the three 2030 climate scenarios modelled by the CSIRO *Sustainable Yields* project[8]. These assume a current level of water resource development.

However, in addition to these scenarios, we have also allowed for an *extreme dry* climatic scenario. While this scenario goes beyond that which the science predicts to be common in the future, it is an extraordinary situation that is currently being faced by the Coorong, Lower Lakes and Murray Mouth[9]. Planning for this worst case situation is therefore necessary.

The final Long-Term Plan (in fourth quarter 2009) will develop an integrated action plan for funding and implementation which takes into account the range of possible climatic scenarios. A brief description of the four scenarios is as follows:

Climatic Scenario	Overview	Implications for the Coorong, Lower Lakes and Murray Mouth
Wet 2030 Model Scenario	mean total end of system flow = 5,550 GL/yr	117.3% of mean flow under current development and historic climate at Murray Mouth.
Median 2030 Model Scenario	mean total end of system flow = 3,482 GL/yr	• 73.6% of mean flow under current development and historic climate at Murray Mouth. • severe drought inflows to the Lower Lakes (i.e. < 1,500 GL) increase to 13% of years. • slight increase in the average period between flood events that flush the Murray Mouth.

[6] Historical climate = Mid 1895 to mid 2006.
[7] Recent Climate = 1997 to 2006.
[8] Further technical information relating to the *Sustainable Yields* modelling is available on the CSIRO website.
[9] These four climatic scenarios represent points on a continuous line of possible climatic conditions which could occur in the future, given current levels of water resource development. For ease of representation in this document, they are presented as four individual scenarios.

		• maximum period between flood events that flush the Murray Mouth increased to nearly 1 in 8 years. • average annual volumes of environmentally beneficial floods close to halved.
Dry 2030 Model Scenario	mean total end of system flow = 1,417 GL/yr	• 29.9% of mean flow under current development and historic climate at Murray Mouth. • increase in cease to flow frequency at Murray Mouth to 70% of time. • severe drought inflows to the Lower Lakes (i.e. < 1,500 GL) increase to 33% of years. • increase in the average period between flood events that flush the Murray Mouth to 1 in 3 years. • maximum period between flood events that flush the Murray Mouth increased to over 1 in 16 years.
CLLMM Extreme-Dry Scenario (based on the conditions currently being experienced)	mean total end of system flow = 336 GL/yr	• severe drought inflows to the Lower Lakes (i.e. < 1,500 GL) increase to 100% of years

6. What is our goal for the Coorong, Lower Lakes and Murray Mouth?

The goods and services that drive the regional economy and support local social systems stem largely from a healthy and functioning environment. It is therefore critical that our primary focus is to conserve the species, ecological communities and ecosystem services of the site. In doing so, our actions will contribute significantly to regional social and economic wellbeing in the long-term.

Our goal therefore is to secure a future for the Coorong, Lower Lakes and Murray Mouth as a healthy, productive and resilient wetland system of international importance.

How this goal translates to outcomes at the site will depend on the future climate, how the extent of freshwater availability affects the Ecological Character of the site, and what is realistic to achieve. A more precise goal for the site, based on the predicted climatic scenarios, will be developed through consultation with the community and scientists, and form part of the long-term plan.

The table below provides a preliminary description of the possible implications for the Ecological Character of the Coorong, Lower Lakes and Murray Mouth for each of the three CSIRO modelled future climatic scenarios (wet – median – dry) and the extreme dry situation currently being experienced.

Climatic Scenario	Overview	Possible implications to Ecological Character of the Coorong, Lower Lakes and Murray Mouth
Wet 2030 Model Scenario	mean total end of system flow = 5,550 GL/yr	• Water levels in Lake Alexandrina maintained between 0.3 and 0.85mAHD in most years. In some years water levels may be higher due to the sheer volume of water available. • Wetland systems (including Lakes Alexandrina and Albert, the Coorong, the Murray Mouth and Estuary, the Goolwa Channel and the Tributaries) connected, healthy, resilient and productive. • Ruppia species present in both the North Lagoon and South Lagoon of the Coorong. The salinity gradient present in the lagoons promotes the survival of the diversity of biota the Coorong is renowned for.
Median 2030 Models Scenario	mean total end of system flow = 3,482 GL/yr	• Water levels in Lake Alexandrina maintained between 0.3 and 0.85mAHD for more than 50% of the time. • Wetland systems (including Lakes Alexandrina and Albert, the Coorong, the Murray Mouth and Estuary, the Goolwa Channel and the Tributaries) connected during these periods. Outside of these times, the Coorong, Murray Mouth and Estuary could experience periods of disconnection. • Dredging required to maintain an open Murray Mouth sometimes. • Ruppia would start to disappear from the South Lagoon of the Coorong.
Dry 2030 Model Scenario	mean total end of system flow = 1,417 GL/yr	• Water level in Lake Albert dropped to levels close to the acidification trigger of -0.5mAHD, with water being pumped from Lake Alexandrina into Lake Albert to avert acidification of the latter. i.e. these wetland systems would be artificially connected. • Water levels in Lake Alexandrina dropping. • Flows over the barrages would occur approximately every three years in ten. • Dredging would be required to maintain an open Murray Mouth most of the time.

Climatic Scenario	Overview	Possible implications to Ecological Character of the Coorong, Lower Lakes and Murray Mouth
		• The ecology of the Coorong would be likely to be significantly altered, with Ruppia species almost absent from the South Lagoon and contracting from the North Lagoon.
CLLMM Extreme Dry Scenario (based on the conditions currently being experienced)	mean total end of system flow = 336 GL/yr	• Lake Albert disconnected from Lake Alexandrina. • Lake Alexandrina a shallow water body disconnected from Lake Albert, the Coorong, Murray Mouth and Estuary, the Goolwa Channel and the Tributaries. • Large areas of exposed Acid Sulfate Soils in Lakes Alexandrina and Albert, the Goolwa Channel and Tributaries. • No flows over the barrages most of the time. • Coorong becomes hypersaline, and the salinity gradient that supports the diversity of species characteristic of the Coorong non-existent in the South Lagoon and parts of the North Lagoon.

It should be noted that this table is based on the current water allocation arrangements and does not incorporate water recovery targets being achieved by South Australia through the Living Murray initiative or new arrangements to be influenced by South Australia through the development of the Murray-Darling Basin Plan. For example, it may be possible to improve Ecological Character outcomes by improving water allocation arrangements for the dry and/or median scenarios.

7. Taking action to secure a healthy future

Over the next 20 years, the long-term plan for the region will work towards freshwater driving the character of the site. The current situation is, however, more typical of an 'extreme dry' scenario with limited available freshwater.

Following consultation and review, a suite of possible management actions has been developed to best ensure the future of the site. These actions correspond to the four climatic scenarios (refer to Appendix Seven for the complete list). This suite will be further refined following completion of a number of scientific studies and community consultation which examine the impacts of these actions.

The following list outlines those activities that have emerged so far as likely candidates for the final suite of management actions. Generally, they are either 'no regrets' actions (i.e. no negative consequences) or are intended to limit major damage. They can be broadly grouped as:

- Emergency works and measures
- Building ecosystem resilience
- Community and Government management arrangements.

Emergency works and measures

Activities being implemented now

These activities are being implemented now to adjust to the current unprecedented situation of reduced inflows:

- Strategic purchase of the small amounts of available freshwater to protect high priority locations within the Coorong, Lower Lakes and Murray Mouth site (e.g. in the Finniss River and Currency Creek).
- Implementation of Acid Sulfate Soil hot spot treatments until sufficient freshwater flows return to saturate lake and creek bed sediments and stop Acid Sulfate Soil formation (e.g. in the Finniss River and Currency Creek).
- Implementation of broad-scale seeding trials to stabilise soils and provide a basis for revegetation and bioremediation of Acid Sulfate compounds.
- Commencement of a rehabilitation program of growing plants, fencing and weed removal to help the survival of existing vegetation.
- Maintenance of an open Murray Mouth by dredging until sufficient freshwater flows return.
- Installation of water regulators to pool water within the Finniss River and Currency Creek and in the Goolwa Channel to limit Acid Sulfate Soil formation and mobilisation until sufficient freshwater flows return to saturate lake and creek bed sediments.

Activities undergoing further assessment

Preparations for this activity are underway (including Environmental Impact Assessment) but no commitment has been made to deliver it, as it is considered to be a last resort measure:

- Introduce a minimal amount of seawater to mitigate against Acid Sulfate Soil formation.

Building ecosystem resilience

These activities are being considered as priority actions that provide flexible and adaptive management arrangements in the medium to longer term, consistent with the goal of securing this site as a healthy, productive and resilient wetland of international significance.

High Priority activities

- Input to the Murray-Darling Basin Authority's Basin Planning process to ensure that the environmental water requirements of the Coorong, Lower Lakes and Murray Mouth site are considered a priority.
- Ensuring that freshwater is available for the benefit of the entire Coorong, Lower Lakes and Murray Mouth site in the long-term.
- Considering the feasibility/appropriateness of water diverted from South East wetlands to benefit the Coorong.
- Reducing reliance upon the Lakes as a source of freshwater so that lake levels can be managed at more variable levels. This will enable, for example, fringing vegetation to re-establish and thus provide a buffer in times of low water levels.
- Pumping out hypersaline water from the South Lagoon of the Coorong to re-establish a more appropriate salinity regime (includes associated works such as the clearing of sills near Parnka Point).
- Extending the rehabilitation program of growing plants, fencing and weed removal to help the survival of existing vegetation.
- Preventing acid formation in sulfide-rich soils and managing the re-wetting phase.

Activities which have currently been rejected from further assessment are listed on the Coorong, Lower Lakes and Murray Mouth website:
http://environment.deh.sa.gov.au/cllmm/faqs-options-for-managing.html

Community and Government management arrangements

The experience in managing the site in the last three years in particular has highlighted the need to adopt a very different approach to management in the future. This will involve:

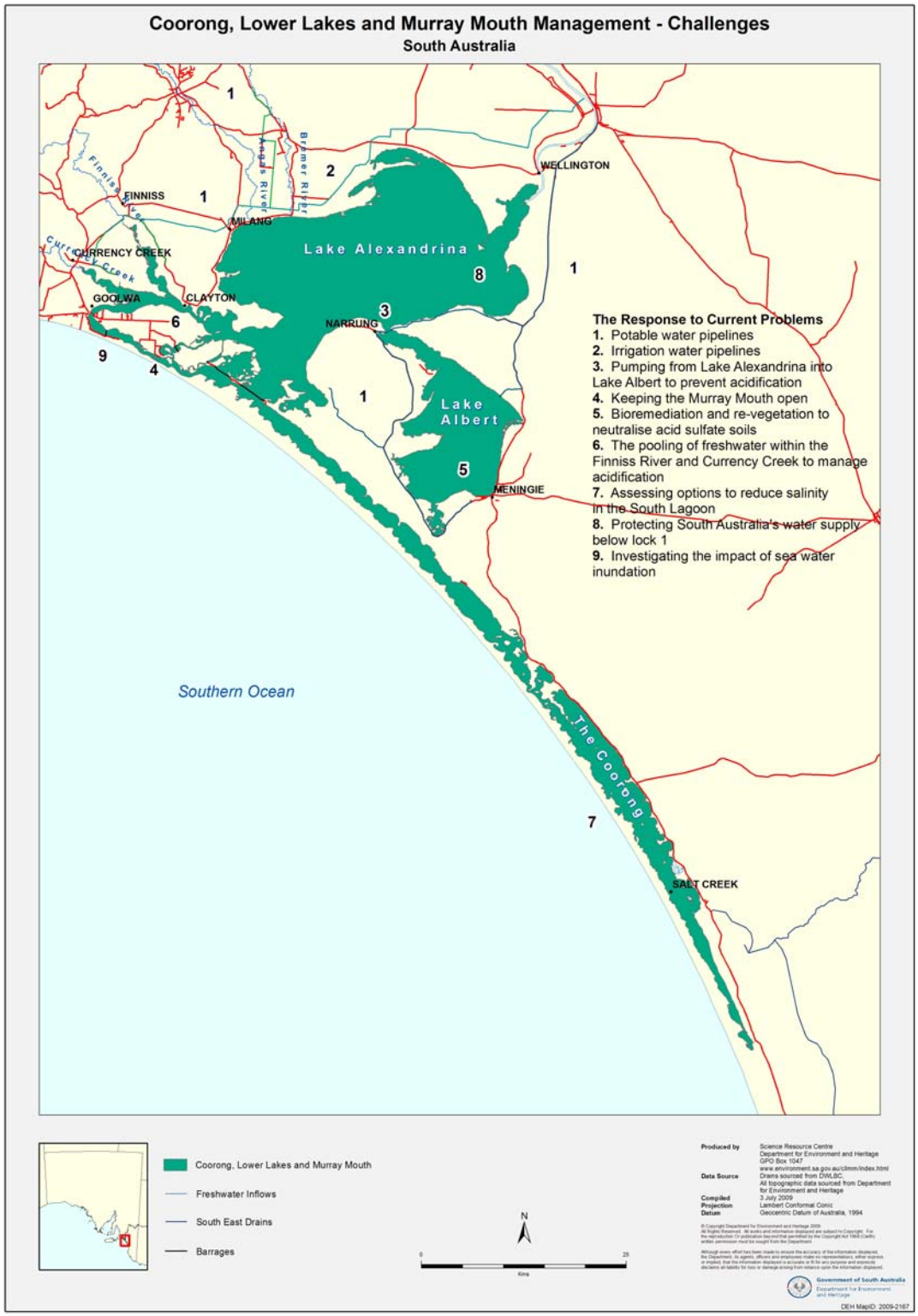
- Managing for change - Government will put in place a formal adaptive management regime. This includes a single monitoring framework – to check on the health of the site – and an operating cycle which links planning, action and monitoring in a feedback cycle.
- Involvement of the Ngarrindjeri – the traditional owners of the site (to be negotiated with the Ngarrindjeri).
- The community – to ensure that community-based understanding and knowledge is incorporated into the adaptive management approach.

The precise nature of these arrangements needs to be confirmed through discussion and negotiation with all parties concerned. Identifying abilities and capacity of each party will then enable an effective adaptive management approach to be proposed in the long-term plan.

Regardless of the future climatic scenario, we are committed to ensuring opportunities for community involvement. We acknowledge the vital work already being done by many community organisations in undertaking on-ground works and making an active contribution to the planning process.

Appendices

Appendix 1: Overview of the system - map



Overview of the system

The Coorong, Lower Lakes and Murray Mouth covers approximately 140,500 hectares (ha), with 23 different wetlands types existing as an interconnected mosaic of freshwater to estuarine and saline habitats.

Freshwater system units

Lake Alexandrina is the largest of the lakes – approximately 76,000 ha. This shallow lake receives the majority of its freshwater from the Murray, although local rainfall and runoff from the Mt Lofty Ranges also (potentially) contribute substantial inflows. The Murray passes through Lake Alexandrina to the sea. The water in the Lake has been predominantly fresh for the last 7,000 years. Currently it is relatively saline near the barrages and brackish in the centre.

Lake Albert is a smaller (about 16,800 ha) and shallower, freshwater lake to the south-east of Lake Alexandrina, to which it is connected via a narrow channel (Narrung Narrows) near Point Malcolm. It has no other significant inflows, except local rainfall and groundwater flows, and is not connected to the Coorong, the Murray Mouth or to the sea.

The **Tributary wetlands** are the lower reaches of three Mt Lofty Ranges streams: the Finniss River, Tookayerta Creek and Currency Creek. These also lie within the Ramsar site. They are considered to have 'permanent' flows, but flow may stop for periods in summer depending on local climatic conditions and extraction rates.

Estuarine-saline system units

The Murray Mouth and Estuary – this part of the Ramsar site includes the Murray Mouth from the Goolwa Barrage to Pelican Point, and includes the Goolwa, Coorong and Mundoo channels.

The **Murray Mouth** is the only site where water contaminants such as silt, salt and nutrients can exit the Murray-Darling Basin. Prior to European settlement, flows of water out of the Murray River were adequate to maintain an open Mouth. However, more recently, through-flow has been dependent on dredging and co-ordinated barrage releases from a system of five barrages which regulate flow, separating the freshwaters of the River Murray and Lake Alexandrina from the more saline waters of the Murray Mouth estuary and the Coorong lagoons.

The Coorong is a series of lagoons which stretch along the coast for approximately 140 kilometres (km). The aquatic environment usually ranges from estuarine-saline in its **North Lagoon** to hyper-saline in the far reaches of its **South Lagoon**.

Appendix 2: Ramsar criteria used to designate Wetlands of International Importance

In order to qualify a Wetland of International Importance, site must satisfy one or more of the following. The Coorong and Lakes site qualifies against criteria 1-8 (shown shaded) below.

Criterion 1	Contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate bioregion.
Criterion 2	Supports vulnerable, endangered or critically endangered species or threatened ecological communities.
Criterion 3	Supports populations of plant and/or animal species important for maintaining the biological diversity of the region.
Criterion 4	Supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
Criterion 5	Regularly supports 20,000 or more waterbirds.
Criterion 6	Regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.
Criterion 7	Supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.
Criterion 8	Is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.
Criterion 9*	Regularly supports 1% of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.

* It is not possible yet to confirm if the site qualifies against this recently added ninth criterion. It may be that it does so for some of the native fish species found there.

Appendix 3: Legislative and policy context

A range of international agreements and Commonwealth and state legislation and policies govern the management of the Coorong, Lower Lakes and Murray Mouth.

An overview of these is presented in the table following, and some of the most important ones are discussed briefly below.

Commonwealth Legislation	*Environment Protection and Biodiversity Conservation Act 1999* *Water Act 2007* *Water Amendment Bill 2008.*
Relevant Commonwealth strategies & plans	*Living Murray, 2002* *The Lower Lakes, Coorong, and Murray Mouth Icon Site Environmental Management Plan, 2006-2007* *The Murray-Darling Basin Authority's Basin Plan, 2007* *Commonwealth Wetlands Policy, 1997* *Water for the Future, 2008*
State Legislation	*Waterworks Act 1932* *National Parks and Wildlife Act 1972* *Coast Protection Act 1972* *Native Vegetation Act 1991* *Environment Protection Act 1993* *Development Act 1993* *Water Resources Act 1997* *Aboriginal Heritage Act 1988* *River Murray Act 2003* *Natural Resources Management Act 2004* *Fisheries Management Act 2007* *Marine Parks Act 2007* *Climate Change and Greenhouse Emissions Reduction Act 2007* *Water (Commonwealth Powers Bill) 2008.* *Murray-Darling Basin Act 2008*
Relevant State strategies and plans	*Coorong, and Lakes Alexandrina and Albert Ramsar Management Plan, 2000* *Wetlands Strategy for South Australia 2003* *Living Coast Strategy for South Australia 2004* *State Natural Resources Management (NRM) Plan 2006* *South Australia's Strategic Plan 2007* *No Species Loss 2007* *Tackling Climate Change: South Australia's Greenhouse Strategy 2007-2020* *Murray Futures, 2008* *South Australian Murray-Darling Basin Draft Regional Natural Resources Management Plan, 2008* *Water for Good, 2009*

Commonwealth legislation, initiatives and plans

One of the major Commonwealth pieces of legislation relevant to the Coorong, Lower Lakes and Murray Mouth is the *Environment Protection and Biodiversity Conservation Act 1999*. This Act provides a legal framework for ensuring that the Ecological Character of all Australian Ramsar sites is retained and that heritage sites and listed migratory and threatened species and communities are protected.

The Living Murray initiative was established in 2002 in response to concerns about the declining health of the River Murray system. A major focus of the *Living Murray* initiative is on improving the environment at six designated Icon sites. The program's first step is to recover 500 gigalitres (GL) of water by 30 June 2009 which can be deployed for environmental purposes at the six Icon sites into the future. (South Australia has achieved its target share by recovering its 35GL.)

The Living Murray Icon Site Environmental Management Plan for the Coorong, Lower Lakes and Murray Mouth has recognised that the site's social, cultural and economic values are under threat due to diminished flows. The Plan establishes three ecological objectives for the site:

- An open Murray Mouth
- Enhanced migratory water bird habitat in the Lower Lakes and Coorong
- More frequent estuarine fish spawning and recruitment.

The *Water Act 2007* established the Murray-Darling Basin Authority whose main function is to address over-allocation and protect, restore and provide for the ecological values and ecosystem services of the Murray-Darling Basin. This will be achieved through a Basin Plan, to commence in 2011. Among other things, it will specify: limits on the amount of water (both surface water and groundwater) that can be taken from Basin water resources on a sustainable basis; an environmental watering plan to optimise environmental outcomes for the Basin; and rules about trading of water rights in relation to Basin water resources.

The Commonwealth *Water for the Future* strategy (2008) is a national framework that integrates rural and urban water issues. Buying back water to restore the environment is one of the priorities of *Water for the Future*. The Australian Government is investing $3.1 billion in buying back water in the Murray-Darling Basin over 10 years. The water must be used to protect and restore environmental assets.

A component of *Water for the Future* is the Sustainable Rural Water Use and Infrastructure Program, a 10 year, $5.8 billion program. State Priority Murray Futures projects will be funded from the Program with South Australia receiving up to $610 million for a range of activities including the purchase of water entitlements from willing sellers, with water to be held by the Commonwealth Environmental Water Holder. As part of the South Australian Priority Project activities, the Australian Government is providing up to $200 million to South Australia to support an enduring response to the environmental problems facing the Lower Lakes, Murray Mouth and Coorong. This includes a $10 million feasibility study of the long-term options for the management of the site.

As part of the Australian Government's Nation Building and Jobs Plan, $10 million has been committed to the South Australian Department for Environment and Heritage for bioremediation and revegetation in newly identified suitable sites in and around the Lower Lakes. This initiative builds on the outcomes of smaller-scale bioremediation trials undertaken by the South Australian Government on the shores of Lake Albert and seeks to engage and involve the community.

State legislation, plans and strategies

Two particularly relevant state Acts are the *River Murray Act 2003* and the *Murray-Darling Basin Act 2008.* The *River Murray Act 2003* specifies a number of objectives for a healthy River Murray, which include:

- The protection of key habitat features, ecological processes, high value floodplains, wetlands of international and national significance and native species;
- Ecologically significant natural flow regimes, fish passage areas and connectivity between and within environments within the River Murray System;

- Overall improvement of water quality (including salinity, nutrient levels and pollutants) within the River Murray system to sustain ecological processes, environmental values and productive capacity; and
- Human dimensions such as community interests, community knowledge and the importance of a healthy river to the economic, social and cultural prosperity of communities.

The *Murray-Darling Basin Act 2008* specifies that the Murray-Darling Basin Authority must be informed of any proposal that may significantly affect the flow, use, control or quality of any water in the River Murray in South Australia. The Authority's approval is required in order to carry out any works (for example, a temporary weir) not already provided for under the agreement. In considering an authorisation, the MDBA must assess any possible effects on the water, land or other natural resources within the Murray-Darling Basin.

Murray Futures, 2008

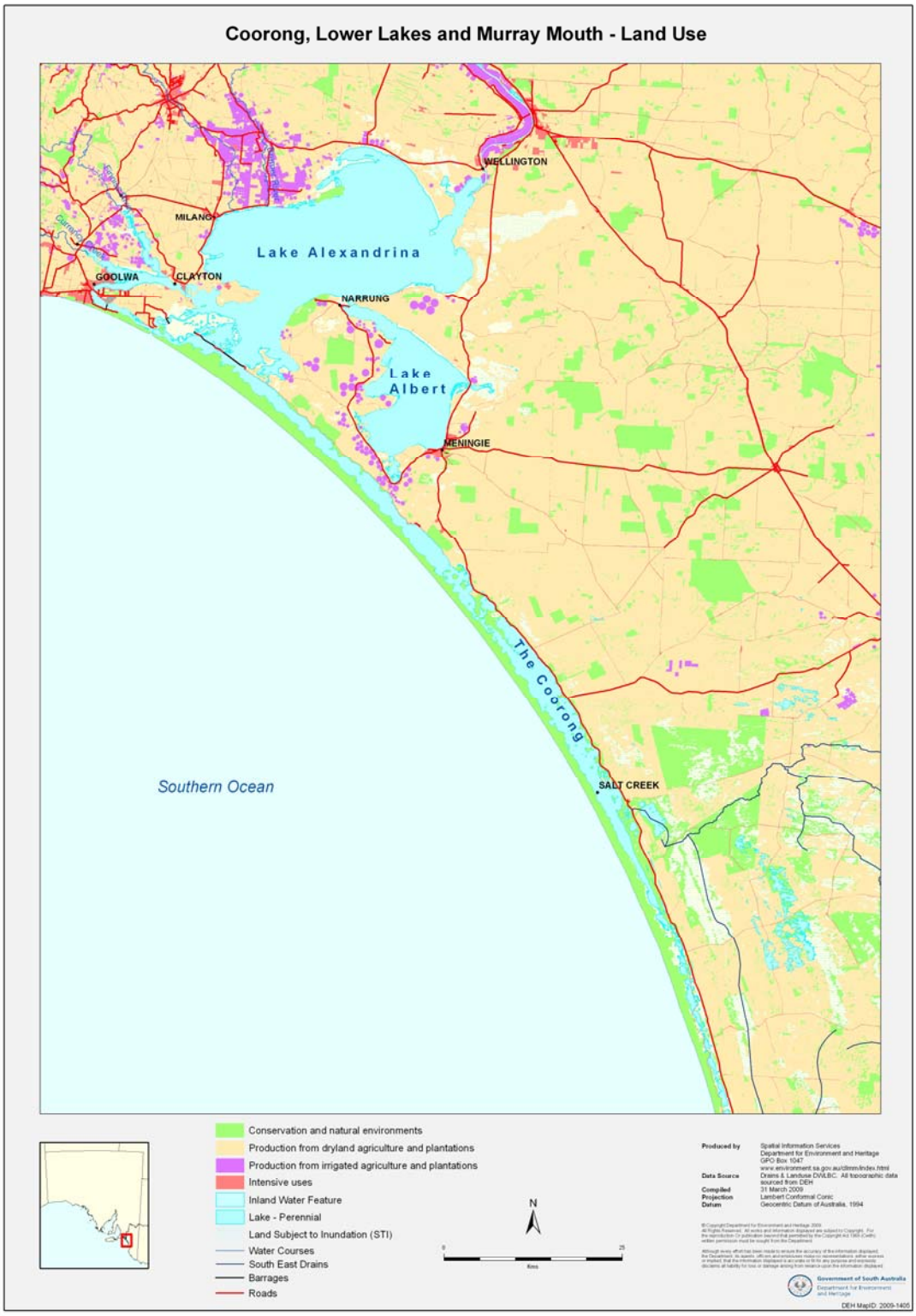
This is South Australia's priority project to secure the future for Murray-Darling Basin industries and communities reliant on the environment. *Murray Futures* positions South Australia to respond to the threats and challenges facing the River Murray in a future of reduced water availability and climate change.

The ten-year integrated package aims to ensure that South Australia will respond proactively to climate change by adopting flexible, adaptive environmental management practices to achieve long-term community, industry and environmental outcomes. It aims to maximise the use of existing environmental water and target water to key priority sites, while also providing environmental water savings. It is designed to ensure the river system and its communities are more 'climate ready'.

Importantly, *Murray Futures* also supports National and Murray-Darling Basin initiatives, in recognition of the shared responsibilities to:

- Address over-allocation
- Address the immediate and worsening crisis in the Lower Lakes and Coorong
- Develop a 'One River' approach, and
- Set and meet a sustainable target for end-of system flows into the future.

Appendix 4: Land use - map



Appendix 5: Indicative ecological response to declining water levels and quality

Lake Level (m AHD)	Total Volume (GL) (Lakes Alexandrina and Albert combined)	Total Surface Area (ha)	Average Annual Evaporative Loss (GL)	Measured / Modelled Lake Alexandrina Salinity (EC)	Ecological and Management Implications
0.8	1957	82177	803	400 - 2300	Lower Lakes surcharge level under pre-drought conditions.
0.75	1932	82057	802	400 - 2300	Lower Lakes full supply level.
0.7	1907	81938	800	400 - 2300	
0.6	1825	81753	799	400 - 2300	
0.5	1744	81131	793	400 - 2300	Lower Lakes preferred minimum level under pre-drought conditions. Barrage opening not possible below this level under current operational arrangements, therefore: fish that require both marine and freshwater habitats are unable to migrate between sea and Lower Lakes and are therefore unable to complete their life cycles; water level and salinity targets for the Coorong are not met due to inadequate freshwater flows, therefore all Coorong biota (aquatic plants, mudflat invertebrates, fish, shorebirds, fish-eating birds, waterfowl) are threatened; Dredging required to maintain an open mouth. Mouth closure leads to: salinisation of estuary and exacerbation of inappropriate salinity and water levels in Coorong; all Murray estuary biota threatened.
0.4	1662	80143	783	400 - 3000	
0.3	1582	79114	773	400 - 3000	Likely exposure of all fringing submerged and emergent aquatic vegetation around the shoreline of the Lower Lakes and tributary wetlands, therefore: loss of fringing vegetation, unless exposure is temporary; likely loss of many freshwater fish and waterbird species.
0.2	1503	78072	763	400 - 3000	
0.1	1425	76985	752	400 - 3000	
0	1348	75688	739	400 - 3000	
-0.1	1273	74262	725	3000	
-0.2	1198	72786	711		
-0.3	1126	71386	697	3250	Lakes Alexandrina and Albert become disconnected at this level, therefore: fish communities in each lake become isolated.
-0.4	1054	69960	683	3500	
-0.5	985	68498	669	4000	'Runaway' acidification of Lake Albert occurs at this level and lower, therefore: all biota in Lake Albert threatened.

Lake Level (m AHD)	Total Volume (GL) (Lakes Alexandrina and Albert combined)	Total Surface Area (ha)	Average Annual Evaporative Loss (GL)	Measured / Modelled Lake Alexandrina Salinity (EC)	Ecological and Management Implications
					Salinity in Lake Alexandrina exceeds threshold for most freshwater fish: likely loss of freshwater fish from Lake Alexandrina and tributary wetlands.
-0.6	917	66835	653		
-0.7	851	65067	636	4500	
-0.8	786	63238	618	5000	
-0.9	724	61537	601	5500	
-1	663	59622	582	5750	
-1.1	605	57236	559	6250	
-1.2	550	54024	528	6700	
-1.3	497	51304	501	7000	
-1.4	448	47948	468	7500	
-1.5	402	43753	427	7800	'Runaway' acidification of Lake Alexandrina occurs at this level and lower, therefore: all biota in Lake Alexandrina and tributary wetlands (estuarine fish, waterfowl, fish-eating birds) threatened.
-1.6	359	40435	395	8000	
-1.7	318	38649	378	8300	
-1.8	278	37000	361	8700	
-1.9	241	34833	340	8900	
-2	205	32678	319		
-3	3	2978	29		

Appendix 6: Management response to a 'wet, 'median', 'dry' and 'extreme dry' future climatic scenario

Presented below is a table of draft management actions that have been developed based on the best currently available scientific information and with the advice of local community members. The actions presented here do not represent a final management response, nor do they represent a formal South Australian Government position, rather they are provided as a prompt for further discussion with the community, scientists, industry groups and other government agencies (i.e. local government and the Australian Government).

Guided by the ideas put forward by scientists, the community and government agencies, the *Directions for a healthy future* document proposed core elements which need to be in place to ensure that the Coorong, Lowe Lakes and Murray Mouth can deal with any future climatic scenario. These Core Elements also retain, to the maximum extent practicable, the ecological values which make this area a wetland of international importance, and promote the intention to manage this site as one interconnected system.

For ease of presentation only, the actions listed here have also been grouped according to the components of the site (Coorong and Murray Mouth, Lake Albert, Lake Alexandrina, Tributaries-Finniss River and Currency Creek). This is so that those with an interest in a particular location can see which actions are proposed for these locations.

As a result of feedback received during public consultation on the *Directions for a healthy future* document in May 2009, the six Core Elements have been refined. These are reflected in the headings used in the table below.

Please note that we are currently experiencing an 'extreme dry' situation.

In the tables below, Y = Yes (the action would be undertaken under a particular scenario) and N = No (the action would not be undertaken under a particular scenario)

Actions	*WET*	*MEDIAN*	*DRY*	*EXTREME DRY*	*Rationale*
COORONG AND MURRAY MOUTH					
Freshwater provided to the Lakes and Coorong and managing variable lake levels					
• A1 Increase diversion of water from the South East Drainage system.	**N**	**Y**	**Y**	**Y**	Reduction of salinity in South Lagoon.
• A2 Increased freshwater provided from upstream in the MDB (Basin Plan, Water for the future, buy backs etc)	**Y**	**Y**	**Y**	**Y**	Short-term – Reduces salinity within the wetland system, including the Coorong. submerges Acid Sulfate Soils Long-term - Delivery of freshwater to the site is the preferred option for establishing a healthy, productive and resilient wetland of international importance. Re-establishes salinity gradient within the Coorong that makes it a productive estuarine system, Secures the future of communities and industries dependent on the wetland system.
• A3 Connect Lake Albert to the North Lagoon of the Coorong	Y	Y	N	N	High River Murray flows from Lake Alexandrina could be delivered directly to the North Lagoon via Lake Albert.
The Murray Mouth open and connecting the Coorong, River and Lakes to the sea					
• A4 Dredging – existing strategy	**N**	**Y**	**Y**	**Y**	Murray Mouth needs to be kept open when insufficient river flows are available to flush the Murray Mouth. This is to maintain system connectivity, which is critical for a healthy, productive and resilient wetland.
• A5 Dredging – increase channel dimensions	**N**	**Y**	**Y**	**Y**	Murray Mouth needs to be kept open when insufficient river flows are available to flush the Murray Mouth. This is to maintain system connectivity, which is critical for a healthy, productive and resilient wetland. Dredge the Murray Mouth to establish and maintain mouth channels that are larger in size, and to get greater penetration of tidal flows along the Coorong.
• A6 Dredging with sand fluidisation	**N**	**Y**	**Y**	**Y**	Murray Mouth needs to be kept open when insufficient river flows are available to flush the Murray Mouth. This is to maintain system connectivity, which is critical for a healthy, productive and resilient wetland. In addition to dredging, fluidise sand (by using pump and pipe infrastructure to inject water or air into the sand to cause re-suspension) to use the natural flow and enhance its capacity to move sand seawards
• A7 Channel dredging with River Mouth Training Walls	**N**	**Y**	**Y**	**Y**	Murray Mouth needs to be kept open when insufficient river flows are available to flush the Murray Mouth. This is to maintain system connectivity, which is critical for a healthy, productive and resilient wetland.

Actions	*WET*	*MEDIAN*	*DRY*	*EXTREME DRY*	*Rationale*
COORONG AND MURRAY MOUTH					
• A8 Sand bypassing with River Mouth Training walls	N	Y	Y	Y	Construct River mouth training walls to stabilise and maintain the entrance channel and improve navigability through the Murray Mouth. Dredge the Murray Mouth and inner channel to establish a good starting environment Murray Mouth needs to be kept open when insufficient river flows are available to flush the Murray Mouth. This is to maintain system connectivity, which is critical for a healthy, productive and resilient wetland. Construct River mouth training walls to stabilise and maintain the entrance channel and improve navigability through the Murray Mouth. As an addition, install infrastructure to bypass long term net sand transport.
Maintaining system connectivity and ecological function					
• A9 Fish passages through to the Coorong at Goolwa.	**Y**	**Y**	**Y**	**Y**	Fish passages are essential structures to enable fish to move between different parts of the Ramsar site that have been disconnected through barrages, regulators and other devices.
Managing localised threats, especially acidification					
• A10 Pumping out of the South Lagoon.	**N**	**N**	**Y**	**Y**	Will lead to a reduction of salinity in the South Lagoon of the Coorong - salinities are currently above the threshold for keystone species, such as Ruppia. Complementary action to A11.
• A11 Clearing of sills near Parnka Point.	**N**	**Y**	**Y**	**Y**	Complementary action to A10 – essential to increase mixing between the North and South Lagoons and enhance the salinity gradient within the South Lagoon and to ensure the success of A10.
• A12 Transplanting of Ruppia sp.	**Y**	**Y**	**Y**	**N**	Ruppia spp. are keystone species for the ecology of the Coorong Lagoons and are in extremely poor condition. Existing populations are not self-sustaining. Revegetation will increase their cover and thereby improve overall ecological health of the Coorong lagoons.

Actions	*WET*	*MEDIAN*	*DRY*	*EXTREME DRY*	*Rationale*
LAKE ALBERT					
Freshwater provided to the Lakes and Coorong and managing variable lake levels					
• B1 Increase freshwater provided from upstream in the MDB (Basin Plan, Water for the future, buy backs etc)	**Y**	**Y**	**Y**	**Y**	Short-term – Reduces salinity within the wetland system, including Lake Albert. Submerges Acid Sulfate Soils Long-term - Delivery of freshwater to the site is the preferred option for establishing a healthy, productive and resilient wetland of international importance. Secures the future of communities and industries dependent on the wetland system.
• B2 Pumping from Lake Alexandrina.	**N**	**N**	**Y**	**N**	The acidification trigger level for Lake Albert is -0.5mAHD. Pumping water from Lake Alexandrina to Lake Albert would avoid reaching this trigger point, thus avoiding acidification. However, funding for pumping ceased on 30 June 2009: the continuing low inflows to the Lower Lakes was also bringing Lake Alexandrina closer to its trigger point. Further modelling will be undertaken to better define acidification trigger levels once results from acidity flux research investigations are obtained.
• B3 Develop a framework to manage water most effectively within the site	**Y**	**Y**	**Y**	**Y**	Water levels within the Lakes have traditionally been managed to provide for take by irrigators from the water bodies. Managing water levels primarily for ecological outcomes will allow for greater variation in lake levels and should lead to improved wetland health.
• B4 Reduce reliance upon Lakes for extractive uses – i.e. installation of pipeline and/or rainwater tanks etc (note that this action does NOT include the irrigation pipeline to Langhorne Creek, which is an existing action)					Will remove reliance of all water users from the lakes and increase the reliability and quality of water supply to these users. Allows for greater flexibility in managing water levels in the lakes for wetland health.
The Murray Mouth open and connecting the Coorong, River and Lakes to the sea					
• The requirement to maintain an open Murray Mouth is addressed in the Coorong and Murray mouth section above.					
• The requirement to maintain the natural variable salinities in the Coorong in this future is addressed in the Coorong and Murray Mouth section above.					
Maintaining system connectivity and ecological function					
• B5 Narrung Narrows remedial works (applies to wetter	**Y**	**Y**	**N**	**N**	Improve connectivity between Lakes Alexandrina and Albert to improve the water

Actions	*WET*	*MEDIAN*	*DRY*	*EXTREME DRY*	*Rationale*
LAKE ALBERT					
scenarios only) – remove bund, dredge narrows, undertake remedial works including modifications to ferry causeway to provide for natural flows through The Narrows.					quality and water regime in Lake Albert.
• B6 Alternative to Narrung Narrows remedial works (applies to dry scenarios only) - Installation of a regulator at Narrung.	**N**	**N**	**Y**	**N**	Allows for greater flexibility in varying water levels in the two Lakes. This has the potential to result in better water quality in one or both Lakes. May provide water savings Provides the opportunity to implement actions in one of the Lakes without impacting on the other Lake.
Managing localised threats					Prevention is preferable to treatment.
• B7 Prevention of acidification	**N**	**N**	**Y**	**Y**	
• B8 Hot spot Acid Sulfate Soil mitigation (e.g. cracking clays, sands, Mono-sulfidic Black Oozes)	**N**	**N**	**Y**	**Y**	Application of finely ground limestone will neutralise acid that has been generated.
• B9 "Bioremediation basin".	**N**	**N**	**Y**	**Y**	Application of finely ground limestone will neutralise acid that has been generated. Bioremediation will help to manage the effects of acidification. Provides approximately 170GL per year of water savings, through ceasing to pump water from Lake Alexandrina. Lake Albert converted to an ephemeral wetland, which can facilitate bioremediation.
• B10 Revegetation for Acid Sulfate Soil remediation around Lake edges.	**N**	**N**	**Y**	**Y**	Revegetation using crops and native plants will help to promote conditions that do not encourage the formation of acid and will reduce mobilisation of heavy metals. This will prepare the Lake for other management options such as saturation of exposed soils with freshwater, native revegetation (reeds, rushes, trees).
• B11 Planting of annual crop type species on exposed areas to contain wind erosion.	**N**	**N**	**Y**	**Y**	Promotes resilience within the wetland system as it minimises the exposure of new acid sulfate soils to air.
• B12 "NRM" activities (weed control, fencing, rabbit control to ensure success of revegetation and cropping).	**Y**	**Y**	**Y**	**Y**	Pest plants and animals have the potential to significantly alter the Ecological Character of the site if not controlled. Uncontrolled stock access to the Lakes threatens some components of Ecological Character through processes such as disturbance of acid sulfate soils, trampling, grazing and pugging.

Actions	*WET*	*MEDIAN*	*DRY*	*EXTREME DRY*	*Rationale*
LAKE ALEXANDRINA					
Freshwater provided to the Lakes and Coorong and managing variable Lake levels					
• C1 Increased freshwater provided from upstream in the MDB (Basin Plan, Water for the future, buy backs etc)	**Y**	**Y**	**Y**	**Y**	Short-term – Reduces salinity within the wetland system, including Lake Alexandrina. Submerges Acid Sulfate Soils Long-term - Delivery of freshwater to the site is the preferred option for establishing a healthy, productive and resilient wetland of international importance. Secures the future of communities and industries dependent on the wetland system.
• C2 Develop a framework to manage water most effectively within the site	**Y**	**Y**	**Y**	**Y**	Water levels within the Lakes have traditionally been managed to provide for take by irrigators from the water bodies. Managing water levels primarily for ecological outcomes will allow for greater variation in lake levels and should lead to improved wetland health.
• C3 Reduce reliance upon Lakes for extractive uses – i.e. installation of pipeline and/or rainwater tanks etc	**Y**	**Y**	**Y**	**Y**	Will remove reliance of all water users from the lakes and increase the reliability and quality of water supply to these users. Allows for greater flexibility in managing water levels in the lakes for wetland health.
The Murray Mouth open and connecting the Coorong, River and Lakes to the sea					
• The requirement to maintain an open Murray Mouth is addressed in the Coorong and Murray mouth section above.					
• The requirement to maintain the natural variably salinities in the Coorong is addressed in the Coorong and Murray Mouth section above.					
Accepting variable water levels, yet maintaining system connectivity					
• The requirement to maintain ecological connectivity in this future is addressed in the Coorong and Murray Mouth and Lake Albert sections above.					
Managing localised threats, especially acidification					
• C4 Revegetation (native) for ecosystem rehabilitation around Lake edges.	**Y**	**Y**	**Y**	**Y**	Planting these areas will increase the connection between habitats within the Lake, including between aquatic and terrestrial habitats. Additional benefit of providing additional carbon and iron to the Lake system.
• C5 Cropping of annual species in exposed areas to	**N**	**N**	**Y**	**Y**	Promotes resilience within the wetland system as it minimises the exposure of acid

Actions	*WET*	*MEDIAN*	*DRY*	*EXTREME DRY*	*Rationale*
LAKE ALEXANDRINA					
contain wind erosion, to be followed by planting natives and increasing biodiversity.					sulfate soils to air.
• C6 "NRM" activities (weed control, fencing, rabbit control to ensure success of revegetation and cropping).	**Y**	**Y**	**Y**	**Y**	Pest plants and animals have the potential to significantly alter the Ecological Character of the site if not controlled. Uncontrolled stock access to the Lakes threatens some components of Ecological Character through processes such as disturbance of acid sulfate soils, trampling, grazing and pugging.
• C7 Bioremediation wetlands for areas that disconnect from main water body of Lake Alexandrina.	**N**	**N**	**Y**	**Y**	Application of finely ground limestone will neutralise acid that has been generated. Bioremediation will manage acidification risks and acid sulfate soils. Parts of Lake Alexandrina converted to ephemeral wetlands/swamp, which can function as Bioremediation Basins.
• C8 Prevention of acidification	**N**	**N**	**Y**	**Y**	Prevention is preferable to treatment
• C9 Hot spot Acid Sulfate Soil mitigation (e.g. cracking clays, sand, Mono-sulfidic Black Oozes).	**N**	**N**	**Y**	**Y**	Application of finely ground limestone will neutralise acid that has been generated. It will also help to promote conditions that do not encourage the formation of acid.
• C10 Introduction of minimal amounts of seawater to avert acidification of Lake Alexandrina	**N**	**N**	**N**	**Y**	May avoid acidification (although could make it worse)

Actions	*WET*	*MEDIAN*	*DRY*	*EXTREME DRY*	*Rationale*
TRIBUTARIES - FINNISS RIVER AND CURRENCY CREEK					
Freshwater provided to the Lakes and Coorong and managing variable lake levels					
• D1 Increased freshwater provided from upstream in the MDB (Basin Plan, Water for the future, buy backs etc)	**Y**	**Y**	**Y**	**Y**	Short-term – Reduces salinity within the wetland system. Submerges Acid Sulfate Soils. Long-term - Delivery of freshwater to the site is the preferred option for establishing a healthy, productive and resilient wetland of international importance. Secures the future of communities and industries dependent on the wetland system.
• D2 Reduce reliance upon Lakes for extractive uses – i.e. installation of pipeline and/or rainwater tanks etc					Will remove reliance of all water users from the lakes and increase the reliability and quality of water supply to these users. Allows for greater flexibility in managing water levels in the lakes for wetland health.
The Murray Mouth open connecting the Coorong, Lakes and the sea					
• The requirement to maintain an open Murray Mouth in this future is addressed in the Coorong and Murray mouth section above.					
• The requirement to maintain the natural variable salinities in the Coorong in this future is addressed in the Coorong and Murray Mouth section above.					
Maintaining system connectivity and ecological function					
• D3 Installation of fish passage into regulators					Fish passages are essential structures to enable fish to move between different parts of the Ramsar site that have been disconnected through barrages, regulators and other devices.
Managing localised threats, especially acidification					
• D4 Installation of regulators to achieve soil saturation in creeks to address Acid Sulfate Soils (& removal in Year 5).	**N**	**N**	**N**	**Y**	Installation of the regulators will mitigate the acidification risks within the tributaries by inundating acid sulfate soils and minimising formation/ mobilisation of acid and heavy metal salts. Creation of a freshwater refuge area subject to operation of the regulators, and a reduction in salinity.
• D5 Revegetation (native) for Ecosystem rehabilitation around the tributaries.	**N**	**N**	**Y**	**Y**	Provides an opportunity to increase the connection between habitats within the wetland system, including between aquatic and terrestrial habitats.
• D6 Cropping of annual species to contain wind	**N**	**N**	**Y**	**Y**	Promotes resilience within the wetland system as it minimises the exposure of acid

Actions	*WET*	*MEDIAN*	*DRY*	*EXTREME DRY*	*Rationale*
TRIBUTARIES - FINNISS RIVER AND CURRENCY CREEK					
erosion.					sulfate soils to air.
• D7 "NRM" activities (weed control, fencing, rabbit control to ensure success of revegetation and cropping).	**Y**	**Y**	**Y**	**Y**	Pest plants and animals have the potential to significantly alter the Ecological Character of the site if not controlled.
• D8 Hot spot Acid Sulfate Soil mitigation (e.g. cracking clays, sand, Mono-sulfidic Black Oozes).	**N**	**N**	**Y**	**Y**	Application of finely ground limestone will neutralise acid that has been generated. It will also help to promote conditions that do not encourage the formation of acid, and assist the re-establishment of key plant and animal species.

Actions	*WET*	*MEDIAN*	*DRY*	*EXTREME DRY*	*Rationale*
A RESPONSIVE MANAGEMENT APPROACH BASED ON ROBUST RESEARCH, ADEQUATE MONITORING AND EXTENSIVE COMMUNITY INVOLVEMENT - An adaptive management framework is under development. Community involvement aspects will be determined through consultation with communities.	**Y**	**Y**	**Y**	**Y**	Community engagement, project managers, finance, procurement, policy, governance. This is to include policy work such as water allocation planning and other mechanisms.
ENGAGEMENT OF THE TRADITIONAL OWNERS – THE NGARRINDJERI	**Y**	**Y**	**Y**	**Y**	At the request of the Ngarrindjeri, this section remains to be developed in consultation with Ngarrindjeri people. Working in partnership with Ngarrindjeri is critical to the successful development and implementation of this Long-Term Plan. The recently signed *Kungun Ngarrindjeri Yunnan* or 'Listening to Ngarrindjeri Talking' Agreement (see p.7 for further detail) will provide an opportunity to ensure that Ngarrindjeri interests and values are incorporated into the Long-Term Plan and addressed in future programs.

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