Department of Environment, Water and Natural Resources

Cost benefit analysis of proposed Lake Albert Management actions

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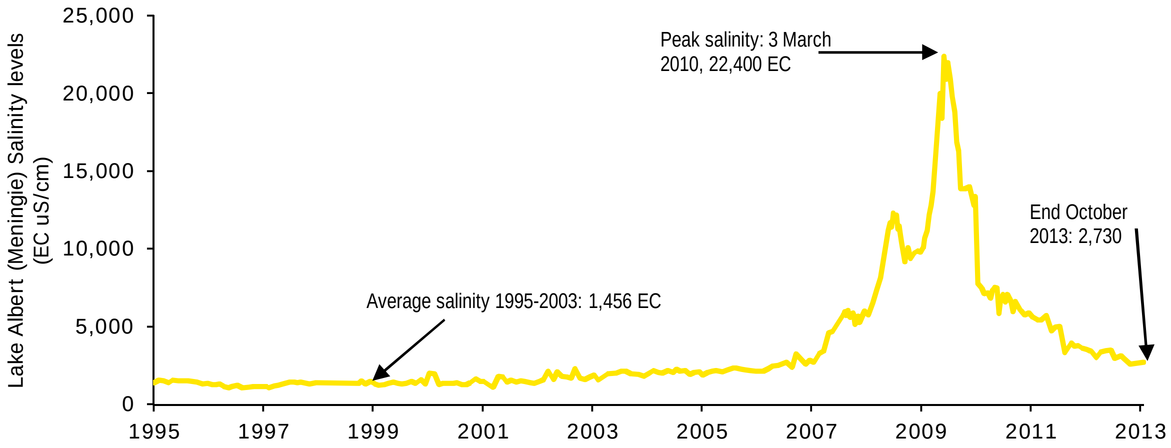
Executive summary

The environmental health of Lake Albert, and in particular its salinity, has been a concern to the South Australian government for a number of years. The severe 2005-10 drought resulted in an unprecedented increase in salinity in Lake Albert, which peaked in 2009-10 at 22,400 EC[1], and elevated salinity levels thereafter. This has renewed interest in addressing the salinity issue.

As at December 2013, Lake Albert salinity levels remain higher than long term historical levels, which results in poorer environmental, social, and economic outcomes. While salinity levels have been falling from their 2009-10 peak, hydrological modelling suggests that Lake Albert salinity levels will remain above long term average levels for the foreseeable future.

Figure 1: Historical recorded salinity levels in Lake Albert (Meningie), 1995-2013



Source: EPA, supplied via email from Karl Fradley, 17 December 2013.

To address the continued high salinity levels in Lake Albert, the Department of Environment, Water & Natural Resources (DEWNR) engaged EY to conduct an economic cost benefit analysis on proposed management actions aimed at reducing current salinity levels, and improving the long term sustainability of the region. For example, at long term average salinity levels the water in Lake Albert can be used for productive purposes (i.e. land use can return to irrigated agriculture), whereas at existing levels this is less likely to be the case.

This report sets out the findings of our work.

The management actions to be considered included:

- The base case or ‘Doing nothing’
- Dredging of the Narrung Narrows
- Removal or partial removal of the Narrung Causeway
- Modification of the Narrung Causeway (installation of culverts)
- Coorong Connector (pipe/channel between Lake Albert and the Coorong)
- Permanent water regulating structure in Narrung Narrows
- Lake level manipulation (lake cycling).

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[1] EC refers to units of Electrical Conductivity, a measure of salinity. For reference, drinking water is typically up to 1000 EC, and seawater is approximately 55,000.

Management actions were first considered in terms of their engineering feasibility and potential hydrological impacts. Actions which presented a limited hydrological benefit and/or were likely to be costly or technically difficult to implement are not considered in this cost benefit analysis.

The results of the hydrological modelling found that the option which presented the most substantial reduction in salinity, to approximately 1,000 EC on an average long term basis, was the construction of a channel discharging water from Lake Albert to the Coorong, referred to in this report as the Coorong Connector. Other options considered provided a limited benefit in most cases, with the exception of the permanent water regulating structure in Narrung Narrows, which resulted in an *increase* in projected salinity in Lake Albert.

Table 1 below provides the results of the modelling using two scenarios: a 'recovery' scenario (where the starting condition has elevated EC levels) and a 'current conditions' scenario (based broadly on the existing salinity levels at the time the work was undertaken). It is also important to note the modelling exercise was for comparative purposes only and the results are not absolute so should be read as a guide only.

Table 1: Results of hydrological modelling on possible management actions (average of all weather conditions, per cent change on commencement compared to base case)

	Starting condition (EC)	6 months (% change on start)	12 months (% change on start)	18 months (% change on start)	24 months (% change on start)	30 months (% change on start)	36 months (% change on start)
Base case	5,000	-14.62%	-19.82%	-28.60%	-26.31%	-38.45%	-33.42%
Incremental difference over base case							
Dredge Narrung & Remove Causeway	5,000	-0.67%	+0.55%	-1.12%	-1.66%	+0.46%	-1.39%
Lake cycling 1	5,000	-1.56%	-4.04%	-3.16%	-6.73%	-5.61%	-8.08%
Lake cycling 2	5,000	-1.30%	-1.95%	-2.84%	-3.33%	-4.38%	-4.08%
Coorong connector	5,000	-34.41%	-45.21%	-46.10%	-49.93%	-42.13%	-46.07%
Permanent Narrung Structure	5,000	+5.32%	+7.13%	+8.89%	+9.18%	+10.32%	+11.49%
Base case	2,000	-7.66%	+0.59%	-7.86%	+0.83%	-7.43%	+2.13%
Incremental difference over base case							
Dredge Narrung & Remove Causeway	2,000	+1.05%	-1.51%	+0.01%	-2.43%	-0.57%	-2.72%
Lake cycling 1	2,000	+1.08%	-3.40%	-1.57%	-5.70%	-3.50%	-7.59%
Lake cycling 2	2,000	-0.49%	-1.72%	-1.92%	-2.98%	-3.02%	-4.03%
Coorong connector	2,000	-26.48%	-39.50%	-42.36%	-48.64%	-46.29%	-52.30%
Permanent Narrung Structure	2,000	+3.50%	+4.43%	+7.32%	+8.22%	+10.23%	+11.18%

Source: BMT WBM 2013.

Note: Lake cycling 1 and lake cycling 2 refer to two different possible methods for cycling Lake Albert.

Engineering feasibility assessments noted the potential difficulties associated with several options (specifically, dredging), but no option was ruled out on a technical feasibility basis. Based on the results of the engineering studies and hydrological modelling, the Coorong Connector was considered to be potentially worth pursuing, and therefore is considered in this analysis.

The construction of the Coorong Connector would result in average salinity of 1,000 EC, which is below its long term average of approximately 1,670 EC prior to the 2005-10 drought. This additional reduction in salinity is a by-product on the proposed solution (BMT WBM 2013).

The construction of the Coorong Connector would result in a range of socio economic costs and benefits. The net economic impact of the Coorong connector is a function of:

- The capital and operating costs required
- The improved productivity of existing irrigated land under the base case
- The improved productive use of associated agricultural land - returning land use to irrigated agriculture, predominantly dairy (i.e. land that, prior to the drought, was used for irrigated agriculture and is now used for dryland grazing)
- The value of ecosystem services improved by the Connector (and reduction in salinity)
- The residual value of the asset (i.e. the Coorong Connector channel infrastructure).

Irrigated dairy produces a significantly higher economic output per hectare (measured by either cash farm income or land value) compared to dry land grazing, but requires lower salinity water for irrigation. In addition, lower salinity typically enables significantly higher levels of productivity. Just as importantly it requires greater certainty over the reliability of water quality.

If the installation of the Coorong Connector allows the reversion or conversion of a large area of land from dryland grazing to irrigated dairying, then it will result in an incremental increase in economic output and net benefits.

The irrigated land area is therefore a key variable which drives the potential benefits and their range, including whether the project as a whole delivers net quantitative costs or benefits.

Table 2: Socio economic costs and benefits of the project case

Item	Quantified impact	Net present value, $ millions
Direct costs		
Capital costs	Construction costs	$16.7 m
Operating costs	Operating costs	$1.6 m
Direct benefits		
Lower salinity water for irrigation	Increased value of agricultural output due to changes in land use from dryland grazing to irrigated dairy	$2.7-$4.7 m
Lower salinity water for irrigation	Increased productivity of existing irrigated land	$0.45 m
Residual value of assets	Benefits calculated over a 25 year period. The channel has a useful life of 100 years and therefore a residual value is included in the benefits	$2.3m
Qualitative benefits		
Increased community activity from growing agricultural sector and an improved environment	Improved community activity and potential growth in regional population related to increased agricultural output, tourism and employment.	Positive
Total direct and indirect benefits		*$5.5-$7.5 m*
Total qualitative impacts		*Positive*
Net project costs/benefits		*$12.8 – $10.8 m net project costs*
Cost benefit ratio		*0.30 – 0.41*

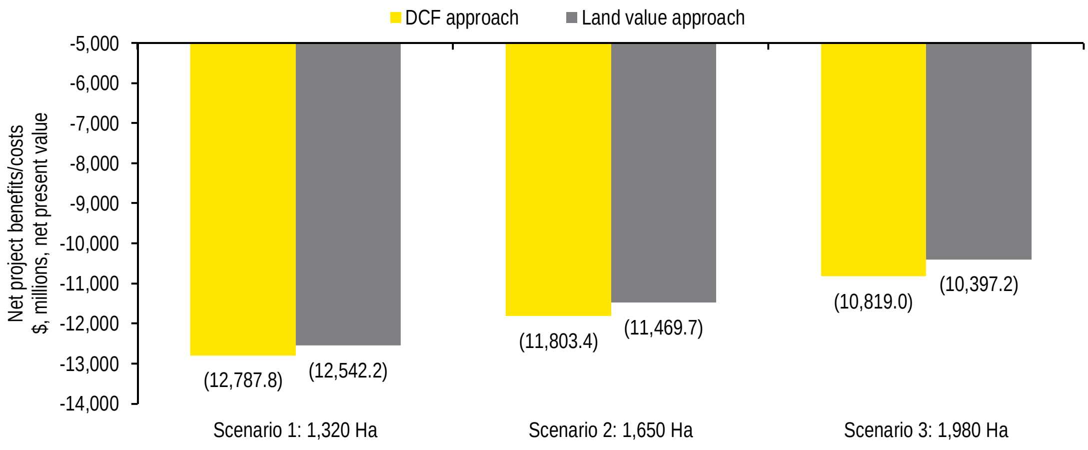
Source: Various.

Note: Present value is calculated at a 7 per cent real rate.

Figure 2 below illustrates the different net project cost or benefit under the three different irrigated area scenarios considered. It reflects the use of two different approaches to estimate the value created by these scenarios: the income approach (which takes the difference in the net present value of the income derived from the two land uses, using discounted cash flows), and the land value approach (which takes the difference in land values associated with the two land uses).

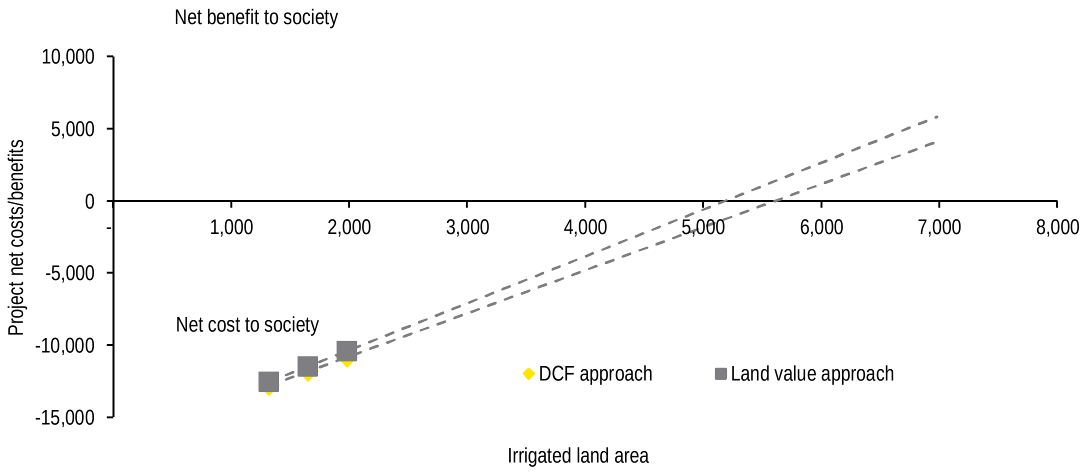
As shown in Figure 2, the project as a whole varies in net costs or benefits from a $12.8 million cost under the lowest irrigated land area scenario, to a $10.8 million cost to society under the highest irrigated land area scenario. The breakeven land area at which the projects’ costs equal its benefits is shown in the figure below, and is between 5,179 Ha and 5,607Ha.

Figure 2: Net costs and benefits of the Coorong Connector, under various scenarios



Source: Various.

Figure 3: Breakeven analysis on changes in irrigated land area



Source: Various.

Note: Data points from the scenarios considered are shown in the figure, with trend lines illustrating the linear relationship with the irrigated land area. Increases in the irrigated land area result in greater benefits to society (all else being equal). The breakeven points, the points at which the project represents a neither a cost nor a benefit to society, are shown as the trend line crosses the horizontal axis.

This breakeven analysis means suggests in order for the project to represent a benefit to society, the project case needs to result in a total irrigated land area of approximately 5,250 Ha or more, compared to a base case scenario of 400 Ha (as illustrated by the trend lines crossing the horizontal axis in Figure 3).[2] This is significantly greater than the historical peak level of 2,801 Ha, observed shortly before the onset of drought in the early 2000's, and more than ten times the current irrigated land area. Based on the observed historical land areas, the current irrigated land area, and the breakeven analysis shown above, it appears unlikely that the project would result in a net benefit to society.

To get back to historical levels of irrigated land area farmers and irrigators would need to develop a view that future salinity and water levels in Lake Albert will be supportive of changes from dry land to irrigation. Expanding dairying production requires investment in milking equipment, sheds, vehicles, irrigation equipment and supporting infrastructure, which must be paid off over a longer time horizon (based on a private, risk reflective cost of capital). Based on DEWNR consultations with landholders within the region, a step change of this magnitude in the irrigated land areas within the Lake Albert region appears unlikely. However, even a return to historical irrigated land areas would fall short of the required land areas for the project to deliver a net benefit to society.

A key benefit of the Coorong Connector option is, however, the reduction in recovery period from drought, and the narrower range of salinity levels in later time periods (outside of drought). The reduced time frame for a return to normalised salinity levels would encourage investment under the project case, as it would reduce the time period over which irrigated dairy farms operations might be under financial stress. For example, the 2005-10 drought and elevated salinity levels drove a substantial reduction in irrigated land area to almost nil, demonstrating the challenge of financially withstanding prolonged periods of financial stress. It would also result in environmental benefits, from shorter periods of lower quality water.

The Coorong Connector may also result in an environmental benefit to the Coorong, through the discharge of lower salinity water. However, further hydrological modelling and research is required to assess the actual benefit (or potential cost) from environmental changes to the Coorong as a result of the Coorong Connector. These have not been considered here for this reason. There may be some merit in considering alternative options which provide drought recovery benefits with lower capital costs (such as expanded or more formalised Lake Cycling, see Appendix).

1. Introduction

The environmental health of Lake Albert, and in particular its salinity, has been a concern to the South Australian government for a number of years. The severe 2005-10 drought resulted in an unprecedented increase in salinity in Lake Albert, which peaked in 2009-10 at 22,400 EC[3], and elevated salinity levels thereafter. This has renewed interest in addressing the salinity issue.

As part of a process to address the continued high salinity levels in Lake Albert, the Department of Environment, Water & Natural Resources (DEWNR) engaged EY to conduct an economic cost benefit analysis on a set of proposed management actions aimed at reducing current salinity levels, and improving the long term sustainability of the region. For example, at long term average salinity levels the water in Lake Albert can be used for productive purposes (i.e. land use can return to irrigated agriculture), whereas at existing levels this is less likely to be the case.

This report sets out the findings of our work.

1.1 Scope of this report

The scope of this report is to consider the economic costs and benefits of proposed management actions. This includes a consideration of:

- The economic costs of proposed management actions, such as through the capital or operating costs of proposed management actions
- The economic benefits of proposed management actions, to residents in the region, consumers and the community at large.

This economic cost benefit analysis uses a standard net present value approach, to determine the costs and benefits of a base case and project case, as per the Commonwealth Department of Finance Handbook of cost benefit analysis (2006).

Economic, social, and environmental costs and benefits, where possible, are quantified over a 25 year period. Costs and benefits which are unable to be quantified are treated on a qualitative basis.

The central discount rate assumption used is a 7 per cent real (not including inflation) discount rate. Sensitivities are used at 4 per cent and 10 per cent.

The scope of an *economic* cost benefit analysis is different to a *financial* cost benefit analysis. In an economic cost benefit analysis, the objective is to determine the costs and benefits from any given change to the economy, rather than to any one defined entity (e.g. in this case the party that might fund the investment). This necessarily includes a consideration of economic, environmental and social factors (though in practice, some of these issues may be difficult to quantify).

1.2 Structure of this report

This report is structured as follows:

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[3] EC refers to units of Electrical Conductivity, a measure of salinity. For reference, drinking water is typically up to 1,000 EC, and seawater is approximately 55,000 EC.

- Section 2 discusses the background to this report
- Section 3 discusses the proposed management actions considered
- Section 4 discusses the hydrological modelling and feasibility of the proposed actions
- Section 5 discusses the socio economic costs of the proposed actions
- Section 6 discusses the socio economic benefits of the proposed actions.

1.3 Disclaimer

This report is in response to EY's contract with the Department of Environment, Water and Natural Resources (DEWNR).

Restrictions on the Report Use

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We have not independently verified, or accept any responsibility or liability for independently verifying, any information provided to us by DEWNR, nor do we make any representation as to the accuracy or completeness of the information. As outlined in our offer dated 6 September 2013, the scope of this Report has not involved forecasting and/or verifying the forecast assumptions underpinning DEWNR's activities. To the extent that our conclusions are based on forecasts, we express no opinion on the achievability of those forecasts and thus they should not be relied upon by DEWNR.

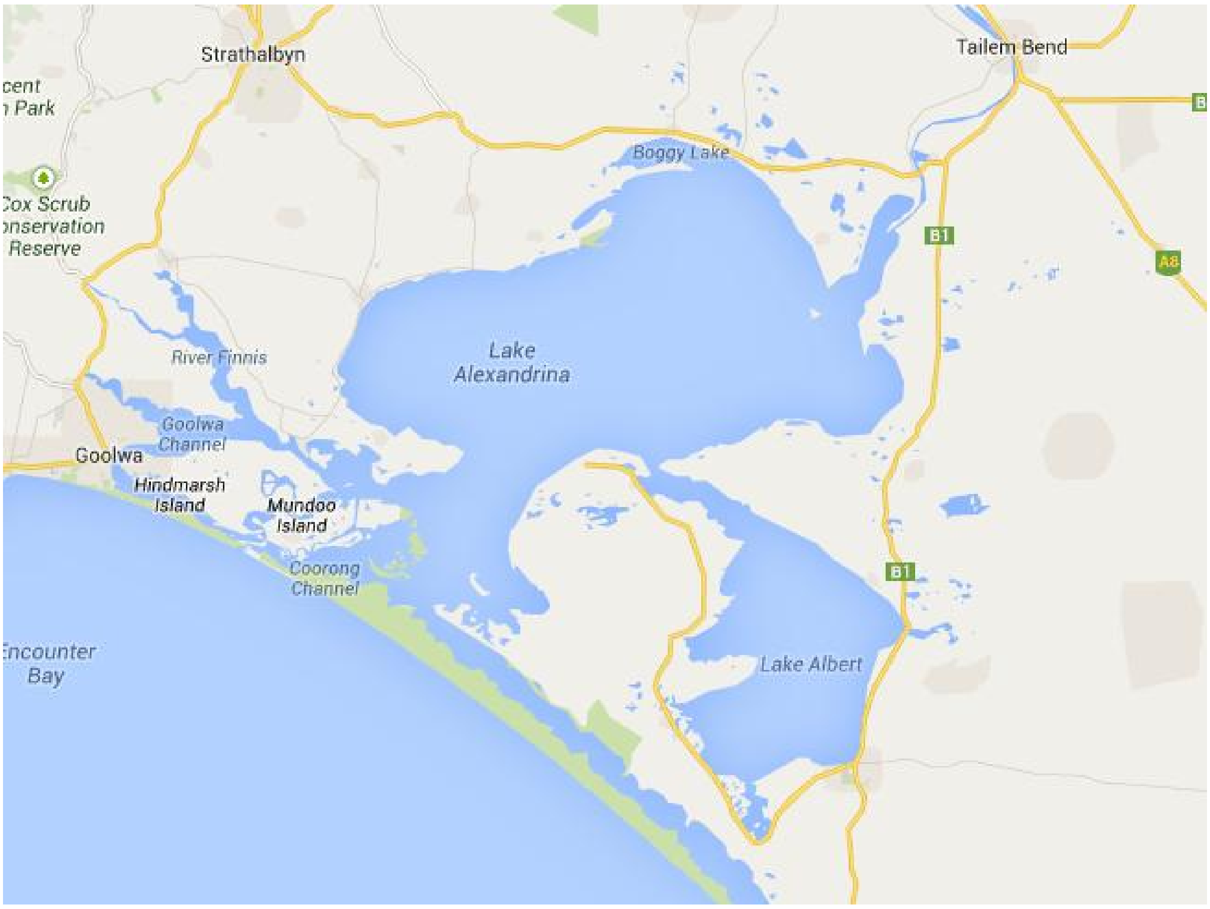
We accept no liability for any loss or damage which may result from your reliance on any research, analyses or information so supplied. This report provides the outcomes of our project analysis.

2. Background

2.1 The region

Lake Albert is one of the lakes within the Coorong, Lower Lakes and Murray Mouth region (CLLMM) in South Australia, approximately 100km South East of Adelaide. It is fed by the Murray Darling Basin catchment, via an entry at its northernmost point (the Narrung Narrows).

Figure 4: Map of the Coorong, Lower Lakes and Murray Mouth region.



Source: Google Maps.

Salinity and water quality levels in Lake Albert are dependent on the inflows into the CLLMM system, groundwater discharge, winds across the lake, and evaporation off the lake.

2.2 Historical condition

Salinity

The historical condition of the lower lakes has been generally relatively poor (based on the results of a 1998 EPA study), due to a range of factors:

- High turbidity in Lake Alexandrina
- Moderate nitrogen and phosphorous concentrations

- Concentrations of heavy metals exceeding national guidelines for the protection of aquatic ecosystems at some sites
- Salinity exceeding the guidelines for good quality drinking water at some sites.

Historical records show considerable variability in salinity levels over time. For example, some historical records note (post European settlement) the elevated salinity in the lower lakes before the installation of the barrages between the 1930's and 50's, which prevented the inflow of seawater into the lower lakes. Prior to European settlement and increased upstream extractions from the River Murray system it is understood that the condition of Lake Albert was, however, generally fresh and supported a range of extensive aquatic and wetland ecosystems.

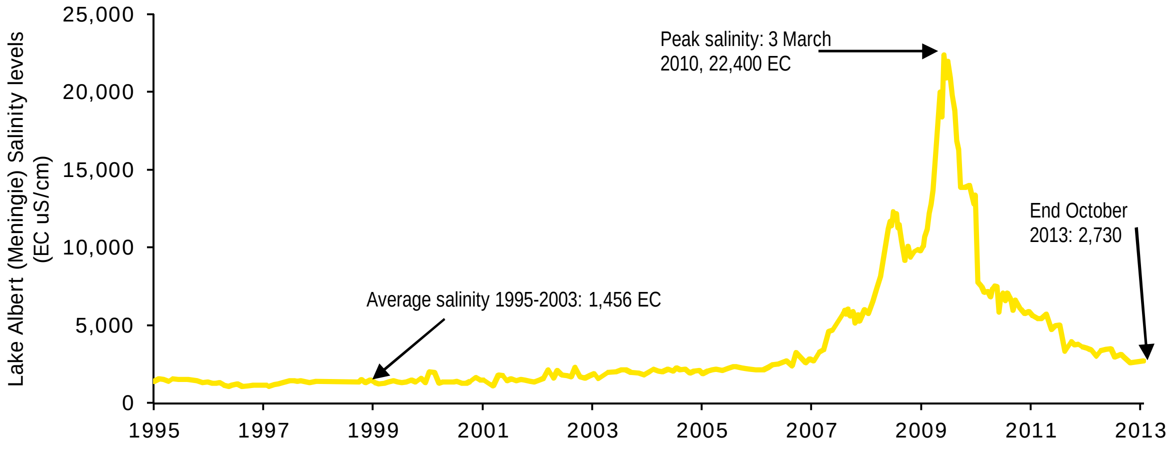
The lake intake at the north, in combination with the prevailing winds from the west, creates a salinity gradient from north to south. Winds driving fresher waters from the northern entry push towards the lakes eastern shores, resulting in the poorer quality water around the western and southern ends. Evaporation around the Lakes edges results in higher salinities.

The lake salinity levels fluctuate from year to year (across multi year periods) along with changes in inflows. Salinity levels also fluctuate within the year, due to higher evaporation in the summer months and the addition of rain during the winter months, as well as irrigation demands on the lake during the summer. Slight falls in the lake levels also result in groundwater discharge back to the lake, which can be slightly saline.

Continuously recorded historical salinity levels are available for only a relatively short period of time, from 1995 to 2013. Prior to the 2005-10 drought the salinity levels remain relatively flat, and averaged 1,456 EC between 1995 and 2003 (with a standard deviation of 256 units of EC).

We understand an average salinity level of 1,670 EC can be considered to be the approximate historical average under 'normal' conditions (BMT WBM 2013).

Figure 5: Historical recorded salinity levels in Lake Albert (Meningie), 1995-2013.

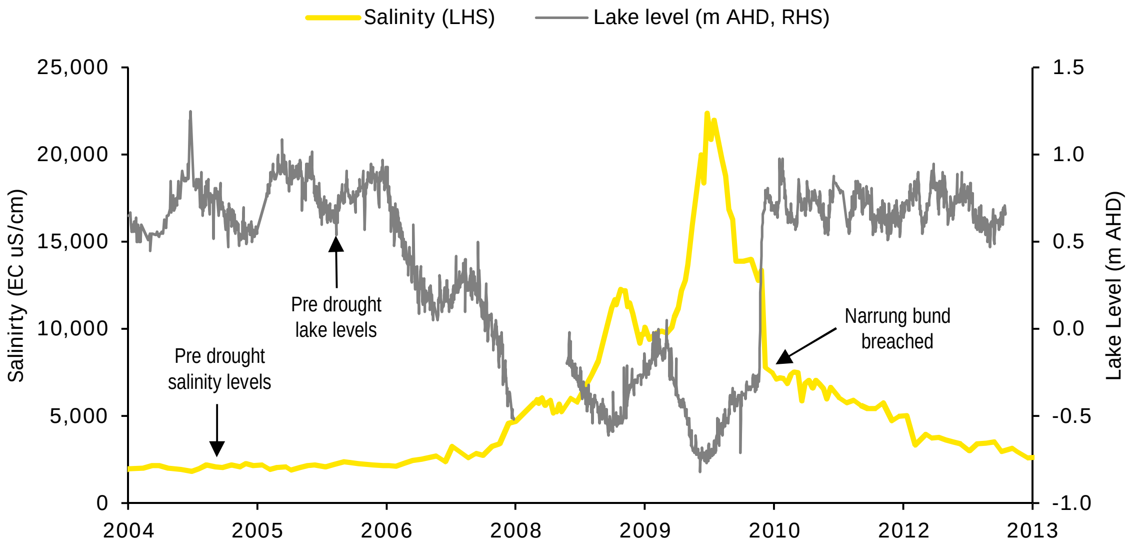


Source: EPA, supplied via email from Karl Fradley, 17 December 2013.

Between 2005 and 2010, salinity levels rose quickly, to reach a peak salinity level in 2010 of 22,400 EC. The climb in the level of salinity was primarily due to the lowering of lake levels (from reduced system inflows and continued high evaporation levels) during the 2005-10 period and the construction of Narrung Bund across Narrung Narrows which disconnected Lake Albert from Lake

Alexandrina. Pumping water from Lake Alexandrina to Lake Albert led to the importation of salt into Lake Albert. As the volume of water in the lake falls while the amount of salt remains unchanged, the salinity level rises almost exponentially (which can be observed in the figure below).

Figure 6: Level levels and salinity in Lake Albert, 2004-2013



Source: EPA, supplied via email from Karl Fradley, 17 December 2013, Waterconnect website (www.waterconnect.sa.gov.au), Meningie Sailing club jetty observation station.

The impact of the 2010-11 La Nina event can be observed in the rapid increase in lake levels, culminating in the breaching of the bund which temporarily separated Lake Albert from Lake Alexandrina in September 2010 (the bund was permanently removed in May 2011)[4]. Water levels rose from below 0.5 metres below sea level, to return to their approximate historical average level at approximately 0.75 m above sea level, and salinity levels fell quickly to a still elevated 7,000 EC due to dilution in the first instance.

At May 2013, salinity levels were approximately 3,000 EC. At November 2013 the level was approximately 2,700 EC, still substantially higher than the historical average level of 1,670 EC.

Ecosystem

Despite Lake Albert's water quality and salinity levels, the Lake has supported a wide diversity of flora and fauna both within the lake itself and around its fringes. Two assessments undertaken in 1988 summarised the historical condition of ecological habitats in Lake Albert, shown in the table below.

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[4] La Nina events, the reverse of El Nino events, are known to cause extensive wet weather during summer months in eastern Australia and are frequently known to result in flooding.

Table 3: Historical ecological condition of Lake Albert

Wetland	Species present	Thompson Valuation	Lloyd and Balla Valuation
Narrung	Samphire, abundant aquatic plants, many hundreds of waterbirds of many species and an abundance, but only a moderate diversity of aquatic invertebrates. (Thompson Survey, 1983-85)	High	21-30 (High)
Narrung Narrows	Extensive areas of bulrush and reeds. These wetlands provide important habitat for waterfowl and probably aquatic fauna. (Thompson Survey, 1983-85) Extensive areas of aquatic and large areas of open water, with small patches of lignum and a few willows. (RMWMC Comments, 1994)	High	21-30 (High)
Belancoe	Sedges, dense bulrush, dense aquatic plants, a few species of waterbirds, Mitchellian freshwater hardyheads, big-headed gudgeons and an abundance of aquatic invertebrates. (Thompson Survey, 1983-85)	High	21-30 (High)
West Kilbride	Sedges, reeds, several species of waterbirds, Mitchellian freshwater hardyheads, Australian smelt, blue-spotted goby and aquatic invertebrates. Black swans and purple swamphens bred on this weltand. European carp were present. (Thompson Survey, 1983-85)	High	21-30 (High)
Marnoo Complex	Sedges, reeds, aquatic plants, hundreds of waterbirds of many species, Mitchellian freshwater hardyheads, Australian smelt, redfin perch and a diversity of aquatic invertebrates. Fringing this wetland is a remnant stand of the formerly more widespread salt paperbark (*Melaleuca halmaturorum*). Black swans bred on this wetland. (Thompson Survey, 1983-85)	High	21-30 (High)
Waltowa Swamp	Reeds, samphire, sparse aquatic plants, hundreds of waterbirds of several species, Mitchellian freshwater hardyheads and a diversity and abundance of aquatic invertebrates. (Thompson Survey, 1983-85)	High	21-30 (High)

Source: DEWNR, Lake Albert Scoping Study.

Ecological condition reports undertaken since then note the significant deterioration of habitats in Lake Albert post drought. The rapid and widespread loss of water and deterioration in water quality led to the widespread loss of habitats suitable of supporting native fish and birdlife.

From 2010 onwards, the Lake Albert region witnessed a significant improvement in the abundance of birdlife and fish species which were notably absent during the drought. A survey undertaken in 2012 noted a doubling in birdlife numbers in the CLLMM, due to influxes from other wetlands (evidently to their preferred habitats). Similarly, fish species have been observed in wetlands in 2011/12 seasons which were absent in the previous two years due to poor water quality.

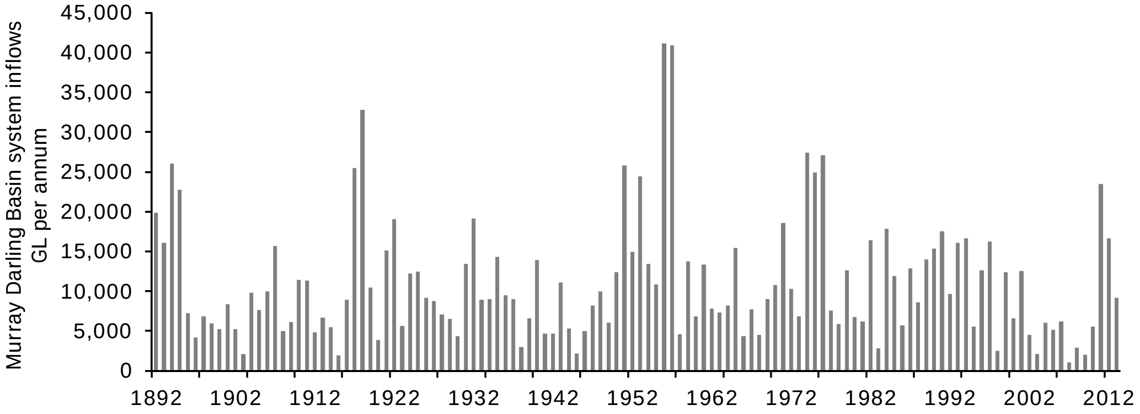
The requirement for the improvement, and maintenance, of the environmental and ecological condition is therefore the presence of low salinity water in the CLLMM region. Measures which can achieve this, over and above a base case scenario, are likely to generate environmental benefits.

2.2.1 System inflows

Lake Albert is fed through the Murray Darling Basin via Lake Alexandrina. Inflows into the Murray

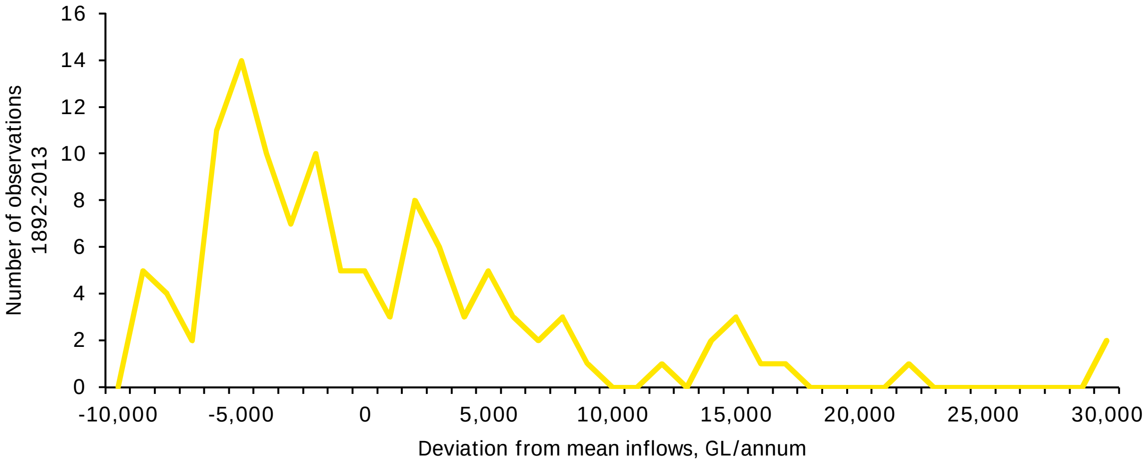
Darling Basin are characterised by an average inflow (from 1892 to 2010) of 11,043 GL per annum, but a median (i.e., the most commonly occurring event) of 9,033 GL per annum. This positive skew is a result of the contribution of a set of infrequent high inflow years, which can be three times the annual average inflows (such as the 1956 or 2011 flood years).

Figure 7: Murray Darling Basin system inflows, 1892-2013



Source: Murray Darling Basin Authority, data supplied via email.

Figure 8: Distribution of inflows to the Murray Darling Basin over time, 1892-2013



Source: Murray Darling Basin Authority, data supplied via email.

In practical terms, this can mean prolonged periods of lower than average inflow years, and low system inflows. This means that in the future, there are likely to be periods where Lake Albert will be faced with drought conditions again (and perhaps more frequently in future, depending on any potential impacts of climate change).

For irrigators and other lake users, the risk of drought, and the response period to recover from drought, is a major risk.

2.3 Current users of Lake Albert

The major economic uses of Lake Albert are for primary industries and recreation. In 2009, a potable water pipeline was installed which connects the major communities in the region to drinking, stock, and domestic water (sourced from higher up in the river system). This means that changes in the quality of water within Lake Albert itself are primarily an issue for irrigators and lake users.

The primary economic value generating use for Lake Albert is through irrigation primarily for dairy cattle. Provided that adequate high quality water can be found, the land is well adapted to use for irrigated dairy, due to constant temperate weather conditions and the soil types. Historically, farmers have used irrigated water from Lake Albert with moderately elevated salinity levels, but this requires the use of higher volumes of water to continue flushing the salt levels through the soil. Once irrigation is stopped, salt levels can rise and reduce the use of the soil.

The alternative primary industries land use (without available water) is dryland grazing.

In 2006-07 the Gross Regional Product (GRP) of the CLLMM Region was $686 million, including $124 million from primary industries, of which $43 million was for irrigated agriculture[5].

This region includes Lake Alexandrina, the Coorong, and Lake Albert. It would be expected that the primary contributor to the $145m of primary industries GRP would be the Lake Alexandrina region.

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[5] Econsearch, Economic Profile of the Lower Lakes Region of South Australia: 2006/07, December 2009

3. Proposed management actions

3.1 Management actions considered in 2013

The Department began considering a range of different management actions in 2013. These options included:

- Doing nothing
- Dredging of the Narrung Narrows
- Removal or partial removal of the Narrung Causeway
- Modification of the Narrung Causeway (installation of culverts)
- Coorong Connector (pipe/channel between Lake Albert and the Coorong)
- Permanent water regulating structure in Narrung Narrows
- Lake level manipulation (lake cycling).

These options were to be considered from a range of perspectives. Any potentially 'successful' option would need to satisfy all of the following conditions:

- Provide a significant hydrological improvement to water quality (primarily, salinity); to be assessed by the outcomes of hydrological modeling conducted via the MSM BigMod and TUFLOW FV modeling packages
- Provide a significant improvement in biological and environmental outcomes (as a result of the improvement in water quality),
- Present an acceptable capital and operating cost to deliver the required hydrological and biological outcomes.

The actions are described below.

3.1.1 Doing nothing (the base case)

The first option is the do nothing option (the base case). Under a base case scenario, Lake Albert would continue to experience elevated salinity levels particularly during prolonged drought periods. Post 2011, lake levels in the CLLMM region have returned to more normal levels, and this would be expected to continue to be the case in the future.

The costs of this option would be the continued degraded environmental, social, and ecological state in the region.

In the following sections, the costs and benefits of the do nothing option are more clearly defined.

3.1.2 Dredging of the Narrung Narrows

The connection point between Lake Alexandrina and Lake Albert is approximately 500m wide and 12 km long, stretching from the existing Narrung Causeway in the North West to the opening of Lake Albert in the south east.

This channel between the fresher Lake Alexandrina and the more saline Lake Albert is primarily wind driven. The channel is also shallow, varying between 4-5 metres at its deepest points to approximately 1 metre at wider points. Potentially, increasing the depth of the channel at its wider points may increase the wind driven fresher flow from Lake Alexandrina, and thereby improve the water quality and reduce the salinity in Lake Albert.

Figure 9: Narrung Narrows, showing the Narrung causeway in the North West, and the opening of Lake Albert in the south east

Source: Google Maps.

This would require the removal of some reeds in lower flow sections of the narrows. From an engineering perspective, this option would also require the removal of dredged materials. These dredged materials would need to be deposited at some distance to the narrows, either on land or further away in the body of Lake Albert or Lake Alexandrina.

3.1.3 Removal or partial removal of the Narrung Causeway

The Narrung Causeway was constructed during the 1960’s in repose to the 1956 flood to increase the ability of the ferry to operate in adverse weather conditions. This causeway crosses approximately half the width of the channel at its northern most point.

During the drought from 2005-10, the Department constructed a temporary bund to retain the water levels in Lake Albert, to prevent acidification on the edges of Lake Albert[6]. In October 2010 the bund was breached due to floodwaters, and removed, but the causeway remains in place.

Figure 10 shows the causeway (to the bottom left of the image) and the remains of the bund before its complete removal.

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[6] Lake Albert has extensive soil types referred to as acid sulphate soils. These soils, which are generally submersed at normal lake levels, may generate sulphuric acid crystals when dried out and exposed to air. The use of the bund was then intended to prevent acid sulphate mobilisation, and reduce the impact of any acid contamination in the region.

Figure 10: Narrung causeway and partial remains of the temporary bund, August 2010

Source: Murray Darling Basin Authority website, accessed 12 November 2013.

Some members of the community thought Narrung Causeway may be limiting the flow of fresher water from Lake Alexandrina to Lake Albert so therefore by removing the causeway, there would be an improvement to the water flow, and water quality in Lake Albert.

3.1.4 Modification of the Narrung Causeway

An alternative to the removal of the Narrung Causeway is the installation of flow permitting works to its structure, for example, culverts.

Complete removal of the Causeway would likely severely impact ferry operation, so this option is a compromise to retain the 24/7 ferry operation and allow for an increase in water passage.

3.1.5 Coorong Connector

2006 design and alignment

In 2006, URS prepared a report on behalf of the Department of Water, Land and Biodiversity Conservation containing a pre-feasibility concept design and cost estimate for a channel connecting Lake Albert to the Coorong. The aim of the management option was to reduce Lake Albert salinity. The report did not include an analysis of the ecological or water quality benefit or otherwise of this management option.

The 2006 Coorong Connector design and alignment would have involved the construction of a channel to hydraulically connect Lake Albert at its southern edge with the Coorong. The aim of this option was to permit the flow of semi-saline water from Lake Albert to the Coorong.

This option would have involved a channel approximately 3.5 km long and 50 metres wide at the channel base, and potentially 150 metres in width including side slopes. This option would also represent a permanent engineering alteration to the existing environment.

Figure 11: Potential channel design from a 2006 URS study on the Coorong Connector option

Source: URS, 2006.

2013 design and alignment

This is based on the selection of alignment 2 as the preferred alignment, which requires the construction of a 1,825 metre long channel, 13.3 metres wide at the base, from Lake Albert to the Coorong. Regulating structures would be installed at each end to prevent water flowing from the Coorong to Lake Albert (known as a reverse head event), which would be manually operable. It is expected that these gates would be operated only rarely (perhaps once a year). The regulators would also permit the movement of people and vehicles across the channel from the eastern to western sides along Narrung Road.

The costs of this option are discussed in more detail in Section 6.

3.1.6 Permanent water regulating structure in Narrung Narrows

The installation of a permanent water regulating structure could be used to manipulate the difference in lake levels between Lake Alexandrina and Lake Albert. This could permit the closure of the regulator during periods where there is lower quality water near the Narrows. It could also be used to build hydraulic head in Lake Albert when lake levels are low in Lake Alexandrina, to drain water from Lake Albert. Alternatively, lake levels could be manipulated lower in Lake Albert before the arrival of major flows into the lower lakes.

3.1.7 Lake level manipulation (lake cycling)

Lake cycling refers to changing the level of the lakes through the use of the barrages (dividing the Coorong from Lake Alexandrina). By lowering the lake levels across both Lake Alexandrina and Lake Albert, it is possible to drain some volume of water in Lake Albert prior to fresh water inflows from upstream.

By cycling the lake levels it is possible to export some of the salt which is kept in Lake Albert in normal conditions.

3.1.7.1 Enhanced lakes cycling

While the infrastructure to cycle Lake Alexandrina and Lake Albert is already in place, the process is labour and time intensive. The existing barrage at the Goolwa Channel which is used for lake cycling is manually operated through the use of ‘stop logs’: concrete barriers which are raised or lowered within the barrage structures. These stop logs must be raised or lowered using heavy vehicles, which takes time, and staffing requirements generally mean this is done during a normal working week, rather than at times which would optimise lake cycling benefits or prevent reverse head events.

The potential installation of hydraulic gates to the existing structures would permit the remote control operation of the barrages and cycling of lakes without the use of heavy vehicles. This option would improve the responsiveness and reduce the potential time required to cycle the lakes, though hydrological modelling suggests that it would result in minimal water quality improvements (all things being equal).

The use of remote control gates would also be of additional use only if adopted in isolation. If other options were pursued (such as the Coorong Connector), then the salinity levels may fall, and lake cycling would no longer be required to such an extent for Lake Albert but may still be used for other purposes such as replicating wetting/drying regimes in the Lower Lakes.

4. Hydrological modelling and feasibility of proposed actions

4.1 Scenarios and methodology

DEWNR undertook hydrological modelling to understand the potential impacts on salinity from the proposed management actions outlined in the previous section. This modelling process forecast the salinity (and water level) of the proposed actions against a series of environmental scenarios:

- Medium flow, medium evaporation
- Low flow, medium evaporation
- Low flow, high evaporation.

All three scenarios were considered for two wind conditions (which for scenario purposes, were repeated year on year):

- 2008-09 wind conditions
- 2010-11 wind conditions.

And for two different starting salinity conditions (Lake Alexandrina/Lake Albert respectively):

- 700/2000 EC (approximately reflecting current November 2013 conditions)
- 400/5000 EC (to reflect a reasonable drought level of salinity).

There are therefore 12 total scenarios considered. All scenarios were run with several daily data points over a three year period.

It is important to note that there is no central likely scenario. All the scenarios shown reflect a possible event.

It is also important to note the modelling exercise was for comparative purposes only and the results are not absolute so should be read as a guide only.

4.2 Results

The table below outlines the results of the hydrological modelling process.

The modelling scenarios illustrate the natural variability in salinity between the winter and summer months. There are clear annual cycles for each scenario and option considered, which trends around a mean salinity level.

Based on the results of the hydrological modelling below, the base case salinity level appears to remain higher than the historical level of approximately 1,670 EC. For the scenarios starting with a 5,000 EC level, the base case remains high and trending downwards, but does not reach the long term average level within the three year forecast window. For scenarios starting with a salinity of 2,000 EC ,the base case salinity level remained approximately unchanged (but varied with seasonal fluctuations)[7].

This would suggest that under a base case scenario, there will be no significant reduction below the current 2,000 EC level in the future. This may be because of the unprecedented spike in salinity during 2010, and retained elevated levels of salinity in the water tables and the water body itself. Alternatively, there may be a reduction in salinity over time, but beyond the three year period considered here.

For the other options considered, most measures achieve little appreciable difference in the salinity level in Lake Albert compared to the base case (see Table 5). For the 5,000 EC scenarios all options considered result in a reduction in salinity 36 months after the starting condition, but so does the base case. Most options considered, such as the lake cycling options, dredging and removing the causeway both achieved a marginal reduction in salinity across weather scenarios, but both remained within a 10% deviation from the base case. The permanent Narrung structure resulted in a significant *increase* in salinity levels in Lake Albert compared to the base case, of approximately 11% in all scenarios.

The Coorong Connector is the significant exception of the options considered. The connector results in a significant reduction in salinity levels in all scenarios, regardless of the starting salinity level. Under the connector scenarios, the salinity level also trends towards a stable level of approximately 1,000 EC, and reaches this level within 18-30 months of the commencement of the modelling period: suggesting that the connector is also effective at reducing the time to return to a stable and low salinity level.

Table 4: Results of hydrological modelling on possible management actions (average of all weather conditions)

	Starting condition (EC)	6 months (EC)	12 months (EC)	18 months (EC)	24 months (EC)	30 months (EC)	36 months (EC)
Base case	5,000	4,270	4,010	3,571	3,685	3,078	3,330
Dredge Narrung & Remove Causeway	5,000	4,236	4,037	3,515	3,602	3,101	3,260
Lake cycling 1	5,000	4,192	3,808	3,412	3,348	2,797	2,926
Lake cycling 2	5,000	4,205	3,912	3,428	3,519	2,859	3,126
Coorong connector	5,000	2,549	1,749	1,265	1,188	971	1,026
Permanent Narrung Structure	5,000	4,536	4,366	4,015	4,144	3,594	3,905
Base case	2,000	1,847	2,012	1,843	2,017	1,851	2,043
Dredge Narrung & Remove Causeway	2,000	1,868	1,982	1,843	1,968	1,840	1,988
Lake cycling 1	2,000	1,868	1,944	1,811	1,903	1,781	1,891
Lake cycling 2	2,000	1,837	1,977	1,804	1,957	1,791	1,962

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[7] Given the historical context, this would appear to be a strong conclusion. Historical salinity levels remained close to 1,670 EC, but under the scenarios considered, the consistent result was an elevated salinity during the forecast period. However, the hydrological modelling appears to be the most comprehensive and relevant source available for the likely future salinity level in Lake Albert.

	Starting condition (EC)	6 months (EC)	12 months (EC)	18 months (EC)	24 months (EC)	30 months (EC)	36 months (EC)
Coorong connector	2,000	1,317	1,222	996	1,044	926	997
Permanent Narrung Structure	2,000	1,917	2,100	1,989	2,181	2,056	2,266
Average Coorong connector salinity post commencement	n/a	1,933	1,485	1,131	1,116	948	1,011

Source: DEWNR, 2013.

Note: Lake cycling 1 and lake cycling 2 refer to two different possible methods for cycling Lake Albert, which have different salinity impacts.

Table 5: Results of hydrological modelling on possible management actions (average of all weather conditions, per cent change on commencement compared to base case)

	Starting condition (EC)	6 months (% change on start)	12 months (% change on start)	18 months (% change on start)	24 months (% change on start)	30 months (% change on start)	36 months (% change on start)
Base case	5,000	-14.62%	-19.82%	-28.60%	-26.31%	-38.45%	-33.42%
Incremental difference over base case							
Dredge Narrung & Remove Causeway	5,000	-0.67%	+0.55%	-1.12%	-1.66%	+0.46%	-1.39%
Lake cycling 1	5,000	-1.56%	-4.04%	-3.16%	-6.73%	-5.61%	-8.08%
Lake cycling 2	5,000	-1.30%	-1.95%	-2.84%	-3.33%	-4.38%	-4.08%
Coorong connector	5,000	-34.41%	-45.21%	-46.10%	-49.93%	-42.13%	-46.07%
Permanent Narrung Structure	5,000	+5.32%	+7.13%	+8.89%	+9.18%	+10.32%	+11.49%
Base case	2,000	-7.66%	+0.59%	-7.86%	+0.83%	-7.43%	+2.13%
Incremental difference over base case							
Dredge Narrung & Remove Causeway	2,000	+1.05%	-1.51%	+0.01%	-2.43%	-0.57%	-2.72%
Lake cycling 1	2,000	+1.08%	-3.40%	-1.57%	-5.70%	-3.50%	-7.59%
Lake cycling 2	2,000	-0.49%	-1.72%	-1.92%	-2.98%	-3.02%	-4.03%
Coorong connector	2,000	-26.48%	-39.50%	-42.36%	-48.64%	-46.29%	-52.30%
Permanent Narrung Structure	2,000	+3.50%	+4.43%	+7.32%	+8.22%	+10.23%	+11.18%

Source: DEWNR, 2013.

Note: Lake cycling 1 and lake cycling 2 refer to two different possible methods for cycling Lake Albert, which have different salinity impacts.

Figure 12: Example hydrological modelling output graph (high starting salinity level)

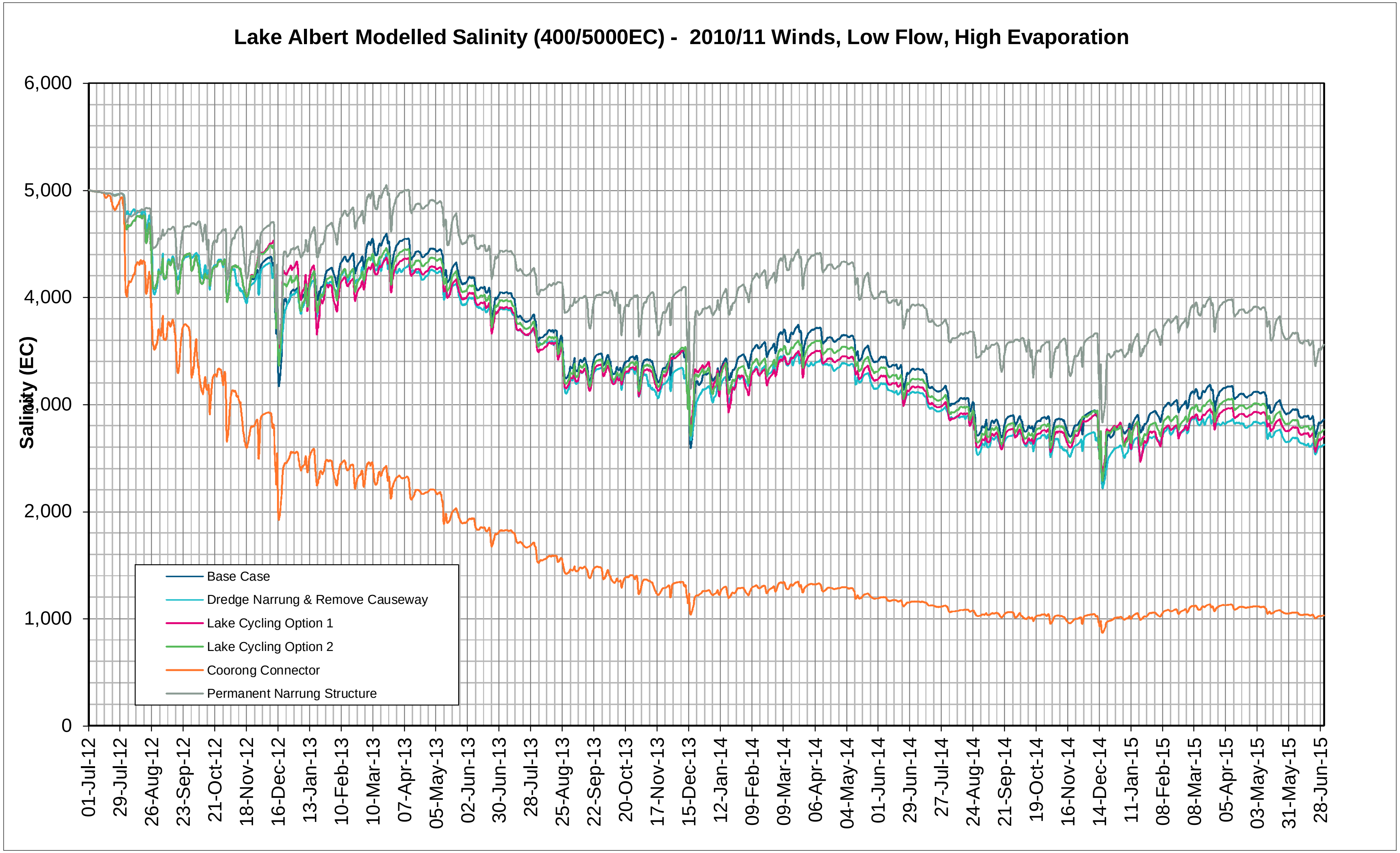
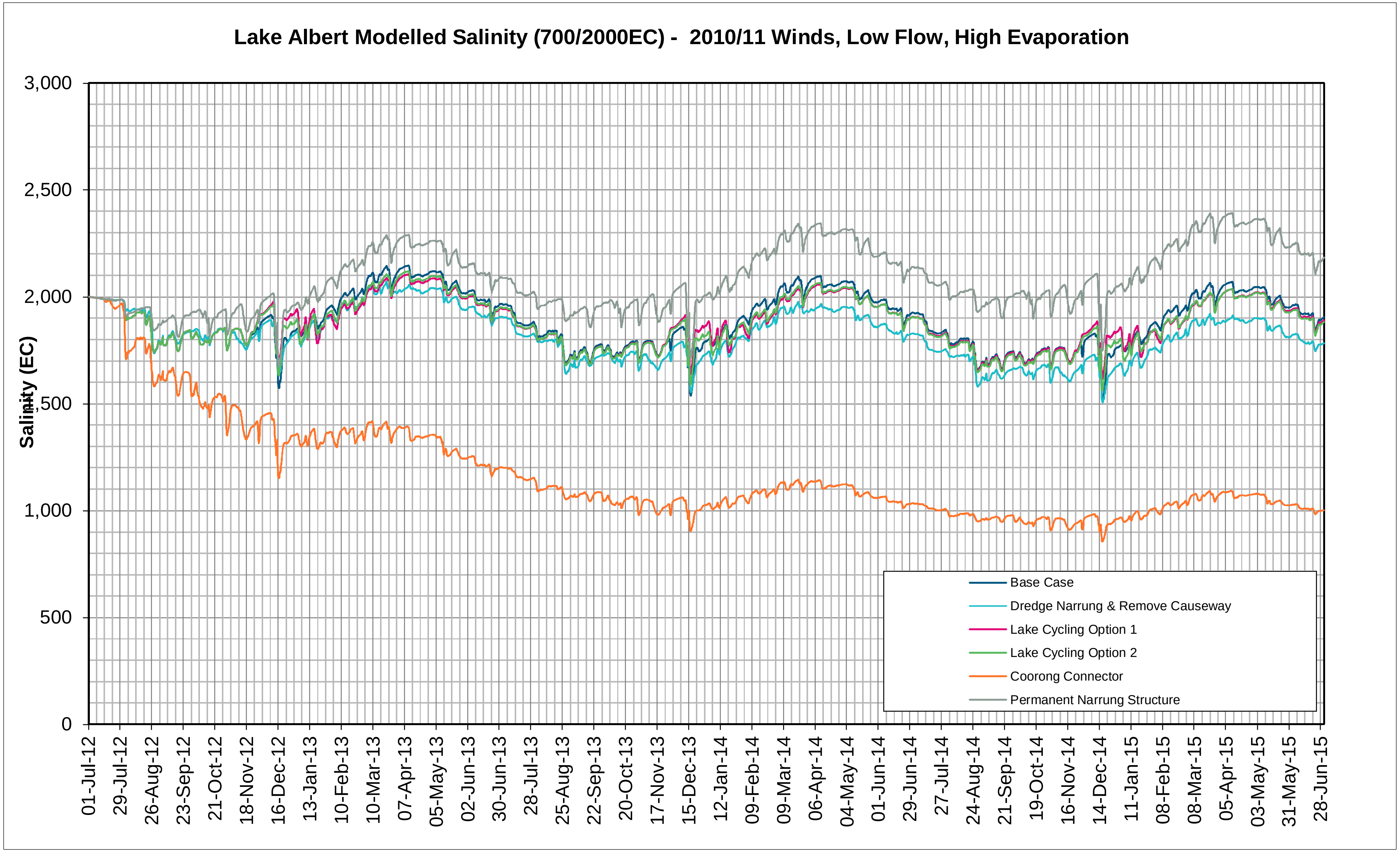


Figure 13: Example hydrological modelling output graph (low starting salinity level)



4.3 Multi criteria analysis of proposed actions

In July 2013, DEWNR undertook a multi criteria analysis (MCA) of the proposed options, from the perspective of engineering feasibility and potential hydrological and cost impacts[8]. The MCA analysis noted that for some options, the construction related issues may be significant. In particular:

- Dredging and the removal of the causeway would require the disposal of very large volumes of dredged materials, which could potentially be contaminated with acid sulfate soils (complicating potential disposal sites, and increasing possible costs)
- Ground conditions and geotechnical risks present an unknown risk to construction costs and timelines for the Coorong Connector and permanent regulating structure options
- The engineering complexity and design requirements for a permanent regulating structure would be challenging.

These issues would contribute to a risk assessment at a later date in the construction feasibility and the potential risk adjusted costs of any preferred option.

Based on the multi criteria analysis, all options may still be potentially deliverable.

4.4 Actions to consider in the economic cost benefit analysis

Based on the outcomes of the hydrological modelling and the feasibility analysis, only some of the options considered are suitable to be considered in the cost benefit analysis. Only the following options presented a reduction in salinity over the base case:

- Dredging the Narrung Narrows and removing the causeway
- Lake cycling (1 and 2)
- Coorong Connector.

However, dredging and removing the causeway presents several significant engineering challenges, with little material improvement in water quality. For this reason, it is not considered in a cost benefit analysis. The remaining options to be considered in the following section are:

- Lake cycling: an option which appears to deliver reliable (though small in magnitude) reductions in salinity over the base case for very low cost
- Coorong Connector: the option which delivers the largest reductions in salinity of all options considered, but which requires a large capital investment to deliver. Notably, the Coorong Connector option also appears to drive a permanent reduction in salinity in all weather conditions, as well as reducing the time required to return to a stable and low salinity level in Lake Albert.

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[8] The full engineering feasibility assessment is shown in SKM, Engineering feasibility of potential management actions, Lake Albert and Narrung Narrows, February 2014.

5. Socio economic costs of the proposed management actions

The costs of the proposed Coorong Connector option are outlined in the table below.

This is based on the selection of alignment 2 as the preferred alignment, which requires the construction of a 1,825 metre long channel, 13.3 metres wide at the base, from Lake Albert to the Coorong. Regulating structures would be installed at each end to prevent water flowing from the Coorong to Lake Albert (known as a reverse head event), which would be manually operable. It is expected that these gates would be operated only rarely (perhaps once a year). The regulators would also permit the movement of people and vehicles across the channel from the eastern to western sides.

Table 6: Proposed Coorong Connector capital costs (high level engineering cost estimates)

	$, 2013
DEWNR delivery fees	$[redacted]
Approvals, clearances, communications & land access agreements	$[redacted]
Preliminary investigations	$[redacted]
Other contractor managed works	$[redacted]
Channel earthworks	$[redacted]
Inlet and outlet works including dredging	$[redacted]
Civil works - upstream	$[redacted]
Concrete works - upstream	$[redacted]
Gates - upstream	$[redacted]
Miscellaneous items - upstream	$[redacted]
Civil works - downstream	$[redacted]
Concrete works - downstream	$[redacted]
Gates - downstream	$[redacted]
Miscellaneous items - downstream	$[redacted]
Total direct cost	$[redacted]
Project contingencies	$[redacted]
Contractor margins, preliminaries & profits	$[redacted]
Contract variation contingencies	$[redacted]
Anticipated total construction cost	$ 18,969,093
Present value of future capital costs	$16,653,094

Source: SKM, Engineering Feasibility study of potential management actions, Lake Albert and Narrung Narrows, February 2014.

Note: Present value is calculated at a 7 per cent real rate. Detailed design, approvals and investigations are assumed to occur in FY2015, with the remaining construction taking place in FY2016. Modelled costs are based on a $18.97 million capital cost.

Construction of the channel would also require periodic dredging at both ends of the channel. Sacrificial anodes would also be required (and replaced every six months) to prevent corrosion of the structure over time.

Table 7: Proposed Coorong Connector operating costs

	$ per annum, 2013
Estimated annual operating costs	$110,000
Periodic lifecycle costs every five years (dredging)	$257,500
Total annual lifecycle costs	$110,000 - $367,500
Present value of future operating costs	$1.6 million

Source: SKM, Engineering Feasibility study of potential management actions, Lake Albert and Narrung Narrows, February 2014.

Note: Present value is calculated at a 7 per cent real rate.

6. Socio economic benefits of proposed management actions

6.1 Summary of socio economic benefits

The base case and project case scenarios are summarised in the paragraphs below.

Base case scenario

Under a base case scenario, Lake Albert would be characterised as:

- Averaging lake levels close to the long term historical average, approximately 0.75m AHD
- Averaging salinity levels according to the hydrological modelling described in the previous section, approximately 2,000 EC and fluctuating with wind, season, and natural variation
- Experiencing uncommon periods of drought, with returns from drought lake levels to historical averages within 1-2 years and returns to average salinity levels in 4-5 years
- Providing an ecological habitat somewhat poorer than historical pre drought condition, but improving from its November 2013 state
- Providing a water quality which is generally suitable for its current agricultural uses (predominantly dry land grazing with isolated irrigated dairy).

Project case: the installation of the Coorong Connector

- Averaging lake levels close to the long term historical average, approximately 0.75m AHD
- Averaging salinity levels according to the hydrological modelling described in the previous section, approximately 1,000 EC and fluctuating with wind, season, and natural variation
- Experiencing uncommon periods of drought, with returns from drought lake levels to historical averages within 1-2 years and returns to average salinity levels in 1-2 years
- Providing an ecological habitat equivalent to the historical pre drought condition within a 5-10 year period
- Providing a water quality which is suitable for expanded irrigated agricultural uses.

The incremental environmental impacts of the project case are:

- Lower salinity levels (1,000 EC vs 2,000 EC)
- Improved environmental condition (within a 5-10 year period)
- Faster reductions in salinity in the event of drought in the future.

Summary of costs and benefits

The challenge in estimating the potential economic benefits should not be underestimated, and will be the result of complex interactions between a number of (often particularly uncertain) variables. In these circumstances we have used a range to indicate the potential likely benefits of the project case, as we believe this is a prudent and suitably conservative approach.

The table below summarises the socio economic benefits of the project, classified into direct and indirect benefits. Some of these are treated quantitatively, others qualitatively.

Table 8: Socio economic costs and benefits of the project case

Item	Quantified impact	Net present value, $ millions
Direct costs		
Capital costs	Construction costs	$16.7 m
Operating costs	Operating costs	$1.6 m
Direct benefits		
Lower salinity water for irrigation	Increased value of agricultural output due to changes in land use from dryland grazing to irrigated dairy	$2.7-$4.7 m
Lower salinity water for irrigation	Increased productivity of existing irrigated land	$0.45 m
Residual value of assets	Benefits calculated over a 25 year period. The channel has a useful life of 100 years and therefore a residual value is included in the benefits	$2.3m
Qualitative benefits		
Increased community activity from growing agricultural sector and an improved environment	Improved community activity and potential growth in regional population related to increased agricultural output, tourism and employment.	Positive
Total direct and indirect benefits		*$5.5-$7.5 m*
Total qualitative impacts		*Positive*
Net project costs/benefits		*$12.7 – $10.8m net project costs*
Cost benefit ratio		*0.30 – 0.41*

Source: Various.

Note: Present value is calculated at a 7 per cent real rate.

These benefits are discussed in more detail below.

6.2 Quantitative and qualitative benefits

There are several possible sources of benefits from the proposed management actions, which can be classified into the following categories:

- Quantifiable economic benefits related to productivity or output
- Environmental benefits
- Social and cultural benefits.

These are described in more detail below.

6.2.1 Quantifiable economic benefits

Quantifiable economic benefits refer to benefits derived from improvements to productivity or output, which result in changes to macroeconomic variables such as gross regional product, employment, wages and salaries, and/or economic value add. These types of benefits can be considered more easily quantifiable than other less tangible benefits (such as environmental or social), but it should be emphasised that they are not necessarily more important.

In this case, an example of these types of benefits would be increased employment or productivity (increased sales for the same inputs) due to lower salinity in Lake Albert.

There will also be direct costs to irrigators in re-establishing irrigation infrastructure and associated operating costs. These have not been separately assessed but are largely captured in the incremental analysis undertaken. The capital costs may in particular form a barrier for land reverting to irrigation use, particularly if prolonged droughts and elevated salinity levels cannot be avoided.

6.2.2 Environmental benefits

Environmental benefits refer to benefits derived from quantitative or qualitative increases in environmental condition. Changes to lake salinity may, for instance, result in appreciable improvements in biodiversity within the lake and its immediate surrounds, and/or increases in the size and durability of habitats to negative shocks.

There are a range of potential methods which can be applied to quantify these benefits. Environmental benefits often require the use of a benefits transfer approach (using figures developed from similar studies undertaken elsewhere or at other times). Generally, environmental benefits are more difficult to quantify, but once again, no less important in the consideration of the preferred option.

6.2.3 Social and cultural benefits

Social and cultural benefits refer to benefits derived from (generally qualitative) improvements in the social or cultural fabric. Communities can contribute to welfare through non priced, but still valuable services. This type of activity may be expressed through community events run by volunteers, sporting organisations, cultural organisations, and other identifiable organisations and events.

Some options may alter the social and cultural fabric in an affected region. This should be considered in the final selection of the preferred option.

These benefits potentially include the amenity benefits associated with having access to lower salinity water including, particularly for the town of Meningie, in respect of parks, amenities, golf club, football club and council. There may be some avoided costs in respect of these uses as well.

6.2.4 Weighing economic, environmental and social benefits

In some cases, economic objectives may conflict with environmental or social objectives. Rapid economic change may be desirable from a financial perspective, but if it comes at the cost of some negative environmental or social objectives, it is an open question as to whether it is on the whole, worth pursuing.

However, in many cases, economic objectives are aligned with environmental or social objectives. In this case, economic objectives are likely to be achieved through the improvement, not the degradation, of the environmental condition (in this case the salinity in Lake Albert). In this case, a positive cost benefit analysis derived from improved economic outcomes would result in a socio economic benefit to society overall.

Similarly, some economic objectives may have little or no impact on the environmental or social condition. In these cases, a positive cost benefit analysis based on improved quantifiable economic outcomes would also result in a socio economic benefit to society overall.

6.3 Economic benefits

6.3.1 Summary of economic benefits

There are a range of economic benefits from the Coorong Connector option:

- Moving to higher value land uses due to lower salinity water
- Increasing productivity of irrigated land due to lower salinity water
- Residual value of assets.

6.3.2 Moving to higher value land uses due to lower salinity water

Changes in salinity may drive a change in the possible uses, and therefore the economic value of the land and its output. Economic benefits will be generated if the following conditions can be satisfied:

- The management action causes a significant reduction in salinity compared to the base case
- The reduction permits a change in land use (e.g. from dryland grazing to irrigated dairy).

The quantifiable change in economic value can then be calculated by the following formula, using land values:

Increase in economic value	=	(land value of irrigated dairy minus land value of dryland grazing)	x	Area of land changed in use from dryland grazing to irrigated dairy

Or alternatively, comparing the net present value of discounted cashflows generated from the output in each year:

Increase in economic value	=	(income from irrigated dairy minus income from dryland grazing)	x	Area of land changed in use from dryland grazing to irrigated dairy

The use of these two different methods should provide a cross check for the actual potential economic benefits generated by any proposed action.

These calculations require inputs from the following variables:

- The acceptable salinity ranges for dryland grazing and irrigated dairy
- The different land values and incomes for dryland grazing and irrigated dairy
- The amount of land which may change in use from one to the other.

Inputs for these variables are documented below.

Acceptable salinity ranges for different users

Reductions in salinity, incremental to the base case scenario, will increase the number of possible uses for Lake Albert water as well as increase the potential agricultural yield. Significant reductions in salinity will permit the change in land use from existing uses (which are more tolerant of higher salinity water) to higher value uses requiring lower salinity water. The table below shows the salinity tolerances for animals. Salinity tolerances for pasture or crops may differ substantially from those shown here (we understand that the tolerances for crops such as Lucerne may be lower than current conditions).

Table 9: Salinity tolerances for different animals (EC)

	Maximum concentration for healthy growth	Maximum concentration to maintain condition	Maximum concentration tolerated
Sheep	6,000	13,000	*
Beef cattle	4,000	5,000	10,000
Dairy cattle	3,000	4,000	6,000
Horses	4,000	6,000	7,000
Pigs	2,000	3,000	4,000
Poultry	2,000	3,000	3,500

Source: PIRSA, Factsheet 2013.

The two potential land uses considered, depending on the salinity level in Lake Albert, are irrigated dairy and dryland grazing. Changes in salinity levels also result in different levels of productivity over and above the broad concentration tolerances shown above. This is discussed further below.

Land values and incomes of different uses

Table 10 below outlines the differences in land values and incomes from the land uses considered.

Table 10: Land values and income for different land uses

	Dryland grazing ($ per Ha)	Irrigated dairy ($ per Ha)
Land value approach		
Indicative land value	$750	$3,000-$3,750
Incremental land value	n/a	$2,250-$3,000
Income approach		
Cash farm income	$15.52	$496.55
Incremental cash farm income	n/a	$481.03
Cash farm income (after depreciation)	$15.52	$355.38
Incremental cash farm income (including depreciation)	n/a	$339.86

Source: Valuer General Estimates 2012; ABARES Australian Beef, financial performance of beef cattle producing farms, 2010-11 to 2012-13, pg 6 & 28; ABARES Australian Dairy, financial performance of dairy producing farms, 2010-11 to 2012-13, pg 8-9.

Note: Depreciation is sourced from ABARES data. Cash farm income after depreciation is used to provide a guidance for the estimated cashflows generated from irrigated dairy farming after the costs of additional equipment and assets.

Irrigated dairy contributes a much higher value per hectare (both in income and in land value) than dry land grazing.

The income measure used is derived from ABARES Cash farm income. This is similar to, but not equivalent, to an earnings before interest and tax accounting treatment. Cash farm income is the difference between cash farm costs (payment of external labour, purchase of stock, feed, professional services, consumables and lease payments), and farm cash income (sale of stock or crops, leases, royalties, hire, or other income). Farm cash income does not include the cash flows for investing purposes other than stock, and does not include the owner's wage.

On face value the return from irrigated dairy appears to be substantially higher than dry land grazing (based on land value vs cash farm income), but the reality is more complicated. Irrigated dairy land earns a much higher value per hectare than dryland grazing, but it also requires a higher amount of physical assets such as sheds, milking equipment, and other property, plant and equipment. That is, there is a higher investment required. This investment must also be paid for out of cash farm income.

Net of depreciation, as shown in Table 10, the incremental cash farm income remains significantly higher than that of dry land grazing.

Long term projections of irrigated land areas under a base case and alternative case

Any benefits which arise from *the change* in irrigated land area must therefore provide some guidance for two critical questions:

1. What would the irrigated land area be under a base case scenario?

   and:

2. What would the irrigated land area be under a project case scenario?

These questions are complicated in this case by the recent, and unprecedented change in irrigated land areas as a result of the 2005-10 drought (as shown in Figure 14). At the start of 2014, irrigated land areas are at their lowest levels by historical standards, lower than known levels in 1983 by a wide margin.

Any return to historical levels of any kind, would imply rapid growth on the existing irrigated land areas. This may be difficult to realise for a range of reasons:

- The reduction in irrigated land areas was in response to significantly lower water quality in Lake Albert (as a result of unprecedented low inflows). For any return to irrigated land use, farmers would need to be confident that this type of event would be unlikely to occur again. The drought response around Lake Albert caused farmers to change from irrigated dairying to dryland grazing, and farmers may be unwilling to change back because they feel that irrigated dairying is not viable anymore.
- The time which has transpired since the land was used for irrigated dairying has meant that returning to irrigated dairying would require significant investment in sheds, milking equipment, irrigation channels, and other plant and equipment. Farmers would need to consider that this

investment was likely to be repaid within the near future (according to a higher, private cost of capital, not a lower public cost of capital).

- There have been significant changes in ownership in the farmlands surrounding Lake Albert. Many aging irrigators who were looking for an exit before the drought may have decided to sell their farm and any water allocations and leave the land to a new owner, who is likely to have turned the property over to dryland grazing. There may be a loss of skills in irrigated dairying within the region which may take some time to recover.

Alternatively, there are a range of reasons which would suggest that the land will return to its former use as irrigated dairy:

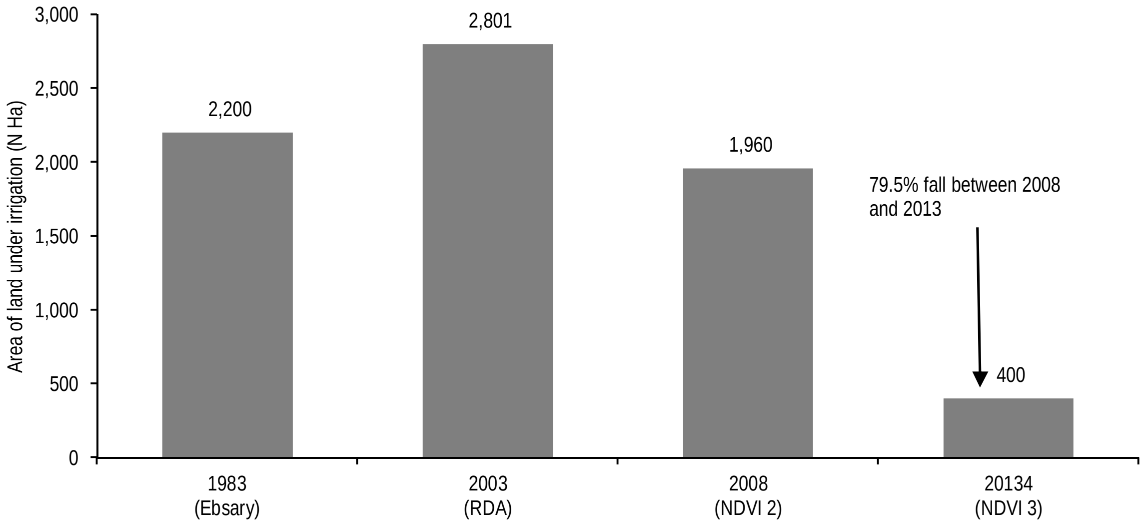
- In 2005, there was approximately 2,800 Ha of land irrigated, and it would be reasonable to assume that if that land area was irrigated in the past then it would be suitable to be returned to irrigated dairying (thought the transition period may take some time).
- In the longer term, the land should return to its highest value use. ABARES cash farm income estimates per hectare show that income per Ha is much higher (approximately 23 times greater even after depreciation) from irrigated dairy than from dry land grazing; which would suggest there is a strong financial incentive for farmers to turn dryland farms to irrigated dairy wherever possible.
- Changes to Commonwealth and State water policy in the Murray Darling Basin have increased water flows to the environment, primarily through the water holdings of the Commonwealth Environmental Water Holder and the Murray Darling Basin Plan. This would suggest that there is less probability of very low flows to the lower lakes, under either a base case or project case scenario.
- Water entitlements and allocations are freely traded commodities below Lock 1, and equally accessible in either Lake Alexandrina or Lake Albert. As with the land use, the use of water should return to its highest use. If this was irrigated dairy before the drought, unless there has been a step change in the cost of water for irrigation, then it would be reasonable to assume that it would be irrigated dairy after the drought.
- Changes in technology, in particular increased automation with dairying equipment may make it easier to convert land to irrigated dairy.
- The peak level of irrigated land areas witnessed in 2005 when water quality and quantity was high represents a potential irrigated land area given relatively recent technology and productivity levels. Irrigation technology has however improved since 2005. New dairying technology, including increasingly automated milking equipment in particular, may increase the productivity of existing and new farms (particularly any which establish in the Lake Albert region in the future). This would also be expected to increase the potential area which could be turned to irrigation in the future under both the base case and project case scenarios.

To resolve these issues (the base case and project case land areas), feedback was sought from community consultation with land owners within the region.

Areas of land to be converted from dryland grazing to irrigated dairy

This report uses a base case scenario of 400 Ha, and considers the alternative scenario to be between 1,320 Ha and 1,980 Ha around a mean of 1,650. This is consistent with other studies that have been recently undertaken into the potential irrigated land areas in the Lake Albert region, and based on consultations with land owners and irrigators within the region[9].

Figure 14: Historical land areas used for irrigation in the Lake Albert region



Source: DEWNR, NDVI Imagery studies; Lake Albert Scoping Study 2013, Neil Shillabeer pers com 4 February 2014.

Direct economic benefits from changes in land use

The potential economic benefits from changes in land use vary from $2.7 million to $4.7 million in present value benefits under a growth scenario which grows to 50 per cent larger than the 2005 peak. Changes in land area have been staged linearly over an 8 year transition period from 2015 to 2022[10]. The results of this analysis are illustrated in the table below.

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[9] Econsearch, Lake Albert Regional Development Australia Report, February 2014.

[10] An 8 year transition period was used to spread the time required for the investment in new equipment and new facilities. In order to convert an area of land to irrigation, farmers and investors will need to develop confidence in the new environmental condition, the predictability of future water quality under winter and summer months, and the potential yield from the land under irrigation. The use of an 8 year period is consistent with market forecasting practices used elsewhere (see GMO asset price forecasts at www.gmo.com).

Table 11: Direct economic benefits from changes in land use (discounted cash flow approach)

	Irrigated land area (N Ha)	Economic benefit (total, 25 years) $,000's	Economic benefit (Net present value) $,000's
Base case			
Remain at 400 Ha	400	0	0
Project case			
Scenario 1: 1,320 Ha	1,320	$6,722	$2,744
Scenario 2: 1,650 Ha	1,650	$9,134	$3,729
Scenario 3: 1,980 Ha	1,980	$11,545	$4,713
Actual potential range of economic benefits from changes in land use	$2.7 to $4.7 million		

Source: Valuer General Estimates 2012; ABARES Australian Beef, financial performance of beef cattle producing farms, 2010-11 to 2012-13, pg 6 & 28; ABARES Australian Dairy, financial performance of dairy producing farms, 2010-11 to 2012-13, pg 8-9; DEWNR NDVI land use studies.

Note: Present value is calculated at a 7 per cent real rate.

This method provides a cross check for the results of the discounted cash flow approach, and is shown in the table below. It is also possible to calculate the potential economic benefits from the change in land area using the change in land value (rather than the change in cash farm income).

Table 12: Direct economic benefits from changes in land use (land value approach)

	Irrigated land area (N Ha)	Economic benefit (total, 25 years) $,000's	Economic benefit (Net present value) $,000's
Base case			
Remain at 400 Ha	400	0	0
Project case			
Scenario 1: 1,320 Ha	1,320	$2,990	$2,990
Scenario 2: 1,650 Ha	1,650	$4,063	$4,063
Scenario 3: 1,980 Ha	1,980	$5,135	$5,135
Actual potential range of economic benefits from changes in land use	$2.9 – $5.1 million		

Source: Valuer General Estimates 2012; ABARES Australian Beef, financial performance of beef cattle producing farms, 2010-11 to 2012-13, pg 6 & 28; ABARES Australian Dairy, financial performance of dairy producing farms, 2010-11 to 2012-13, pg 8-9; DEWNR NDVI land use studies.

Note: Present value is calculated at a 7 per cent real rate.

These estimates provide a range to consider the actual potential economic benefits from any proposed reduction in salinity in Lake Albert due to changes in land use.

6.3.3 Increasing productivity of irrigated land

Agricultural productivity can be impaired by the application of higher salinity water. Higher salinity water can impair the growth of pasture, and increase the amount of water required in irrigation (in order to keep the water table from rising). The reduction in salinity levels caused by the Coorong

Connector will result in increased productivity of all irrigated land using Lake Albert water, compared to the base case.

Table 13: Changes in agricultural yield in dairy farming from changes in salinity levels

Salinity level (TDS)	Salinity level (EC)	Yield loss (%)
650	1,083	0%
700	1,167	10%
1010	1,683	15%
1320	2,200	25%

Source: URS Sustainable development, May 2003.

Applying these productivity estimates to the project case, we can calculate the value of the increase in productivity of irrigated land. This benefit applies to the land area which is irrigated under the base case scenario (400 Ha).

Table 14: Increased productivity of irrigated land

	Assumption	Economic benefit (total, 25 years) $,000's	Economic benefit (Net present value) $,000's
Base case salinity levels (EC)	2,000		
Project case salinity levels (approx.)	1,000		
Yield improvement on base case salinity levels (% change)	25%		
Scenario 1: 1,320	400*	$924	$450
Scenario 2: 1,650 Ha	400*	$924	$450
Scenario 3: 1,980 Ha	400*	$924	$450
Actual potential range of economic benefits from increased irrigated land productivity	$0.45 million		

Source: URS Sustainable development, May 2003.

*Note: *The irrigated land area of the base case (400 Ha) is shown for each scenario. The base case irrigated land area does not change between all three scenarios considered.*

Based on the increased productivity of irrigated land, there are potentially $0.45 million in benefits on a present value basis.

6.3.4 Residual value of assets

Due to the long lived nature of the proposed Coorong Connector, there are residual values in the asset which should be considered. These are illustrated in the table below.

Table 15: Residual value of assets at the end of the modelled period

	Irrigated land area (N Ha)
Capital costs (present value)	$16.65 million
Model period length	25 years
Useful life of assets	100 years
Percentage of asset value remaining at the end of the model period	75%
Undiscounted residual value of capital costs at the end of the model period	$12.50 million
Present value of residual value	$2.30 million

Source: SKM, Engineering Feasibility study of potential management actions, Lake Albert and Narrung Narrows, February 2014.

6.4 Environmental benefits of the proposed management action

The existence of environmental benefits to Lake Albert under a project case scenario depends on the flora and fauna located in the Lake Albert region, and their salinity tolerance. Under the project case, the Lake salinity would change from approximately 1,800 to 2,000 EC to approximately 1,000 EC.

Highly elevated salinity levels (in the order of 20,000 EC) during the drought between 2005 and 2010 resulted in significant environmental and ecological degradation. However, ecosystems in and around Lake Albert have adapted to the historical, base case, salinity level. This means that lowering the salinity level within the lake beyond the historical level would result in a fresher lake, but not necessarily improve the habitat conditions of the species in Lake Albert.

In comparing the base case and project case salinity levels, there are no material environmental benefits from the Coorong Connector.

There are two important caveats to this statement though:

1. During drought periods, the Coorong Connector reduces the time for salinity levels to fall from very high drought levels back to (or beyond) historical salinity levels. The Coorong Connector would therefore result in some environmental benefit in the event of major drought in future, by reducing the length of drought events.

2. The discharge of fresher water from Lake Albert to the Coorong may result in an environmental improvement in the Coorong (which is substantially more saline than Lake Albert at the proposed discharge point). This potential environmental benefit is complicated by several other factors which have not yet been fully investigated (in particular, such as the impact on the salinity profile in the Coorong, and the impact of turbidity and other discharged water from Lake Albert). This potential impact should be investigated in more detail at a later date.

These potential environmental benefits (the reduction in drought recovery times and the impact on the Coorong) have not been quantified here.

6.5 Social benefits of the proposed management action

The reduction of salinity which could be achieved with the installation of the Coorong Connector results in improved economic conditions and improved environmental conditions (as discussed above). It would also result in improved social conditions for the communities within the region.

Research into the community's perspective on the region noted that the social welfare of the region is tied to the environmental and economic performance of the region[11]. The reduction in salinity, and consequential expansion of the dairying economy, would result in increased employment, wages and salaries, and contribution to GDP within the region. This would also potentially result in an increase in population in the region as additional staff would be required to deliver an increased dairying output.

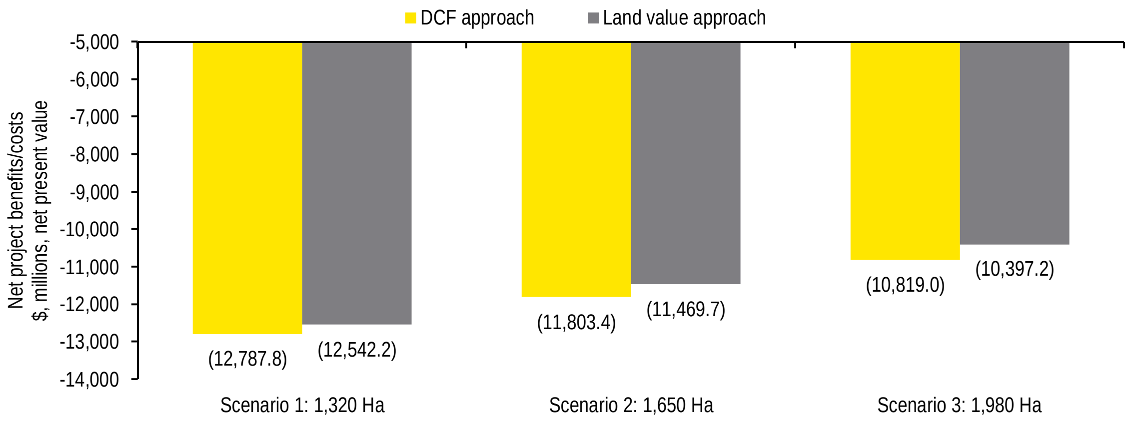
Improvements in the dairy related economy would also result in increased community participation activities, such as school attendance, community events, and maintaining and enhancing community connections. These factors are considered a qualitative benefit from the Coorong Connector.

6.6 Net costs and benefits from the proposed management action

The net costs and benefits of the Coorong connector are a function of the capital and operating costs, residual value, productivity improvements and the irrigated land area. The irrigated land area is the variable which results in the largest potential range of benefits ($2.7 to $4.7 million in present value terms). Whether the area is large or small will determine whether the project as a whole results in net costs or net benefits to society on a quantitative basis.

The figure below illustrates the different net project cost or benefit under the three different irrigated area scenarios considered. Under all circumstances, the project results in a net cost to society.

Figure 15: Net costs and benefits of the Coorong Connector, under various scenarios



Source: Various.

As shown in Figure 16, the project as a whole varies in net costs or benefits from a $12.8 million cost under the lowest irrigated land area scenario, to a $10.8 million cost to society under the highest irrigated land area scenario. The breakeven land area at which the projects' costs equal its benefits is shown in the figure below, and is between 5,179 Ha and 5,607 Ha.

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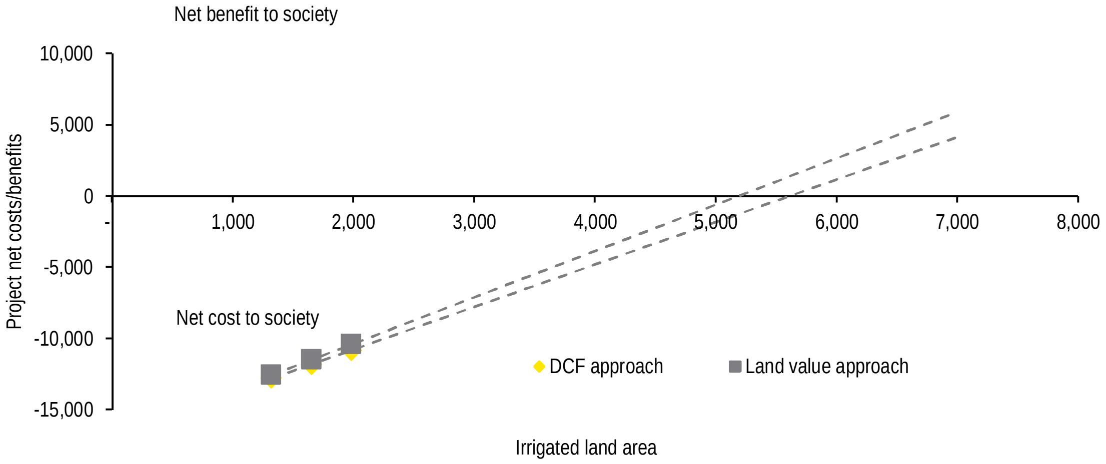
[11] Square Holes, Department of Environment, Water & Natural Resources, Lake Albert and Narrung Narrows: A community perspective, 2013.

Figure 16: Breakeven analysis on changes in irrigated land area



Source: Various.

Note: Data points from the scenarios considered are shown in the figure, with trend lines illustrating the linear relationship with the irrigated land area. Increases in the irrigated land area result in greater benefits to society (all else being equal). The breakeven points, the points at which the project represents a neither a cost nor a benefit to society, are shown as the trend line crosses the horizontal axis.

This means that in order for the project to represent a benefit to society, the project case needs to result in a total irrigated land area of approximately 5,250 Ha or more, compared to a base case scenario and current irrigated land area of 400 Ha (as illustrated by the trend lines in Figure 16). This is significantly greater than the historical peak level of 2,801 Ha, observed shortly before the onset of drought in the late 2000's. Based on the observed historical land areas, the current irrigated land area, and the breakeven analysis shown above, it appears unlikely that the project would result in a net benefit to society.

To get back to historical levels of irrigated land area farmers and irrigators would need to develop a view that future salinity and water levels in Lake Albert will be supportive of changes from dry land to irrigation. Expanding dairying production requires investment in milking equipment, sheds, vehicles, irrigation equipment and supporting infrastructure, which must be paid off over a longer time horizon (based on a private, risk reflective cost of capital). Based on DEWNR consultations with landholders within the region, a step change of this magnitude in the irrigated land areas within the Lake Albert region appears unlikely. However, even a return to historical irrigated land areas would fall short of the required land areas for the project to deliver a net benefit to society.

A key benefit of the Coorong Connector option is, however, the reduction in recovery period from drought, and the narrower range of salinity levels in later time periods (outside of drought). The reduced time frame for a return to normalised salinity levels will encourage investment under the project case, as it reduces the time period over which irrigated dairy farms operations might be under financial stress. For example, the 2005-10 drought and elevated salinity levels drove a substantial reduction in irrigated land area to almost nil, demonstrating the challenge of financially withstanding prolonged periods of financial stress.

The Coorong Connector may also result in an environmental benefit to the Coorong, through the discharge of lower salinity water. However, further hydrological modelling and research is required to assess the actual benefit (or potential cost) from environmental changes to the Coorong as a result of the Coorong Connector. These have not been considered here for this reason.

There may be some merit in considering alternative options which provide drought recovery benefits with lower capital costs (such as expanded or more formalised Lake Cycling, see Appendix).

6.7 Sensitivity analysis

Changes in the discount rate result in changes in the net benefits of the different scenarios considered. Reductions in the discount rate used to 4 per cent (from 7 per cent) result in significantly increased present values of economic benefits (between 64 per cent and 72 per cent), and smaller increases in the present values of costs (9 per cent). The net impact is an increase in net present benefits, and a lowering of the breakeven land area.

Conversely, increases in the discount rate result in lower net benefits for the same reasons. Costs incurred change only slightly due to their up front timing, but benefits are heavily discounted in the longer horizon. The net effect is a reduction of the net present benefits for each scenario considered, and an increase in the breakeven land area.

Changes to construction costs drive a similar change in the net costs or benefits from the project. Increases in construction costs result in lower net benefits under all scenarios considered, whereas decreases in construction costs result in higher net benefits under all scenarios.

The project case remains a net cost to society under all sensitivities considered.

Table 16: Net project costs and benefits (discounted cash flow approach)

	Scenario 1: 1,320 Ha		Scenario 2: 1,650 Ha		Scenario 3: 1,980 Ha		Breakeven	
	Total	Present value	Total	Present value	Total	Present value	Total	Present value
	$, 000's	$, 000's	$, 000's	$, 000's	$, 000's	$, 000's	$, 000's	$, 000's
Base case mature state irrigated land area	400	n/a	400	n/a	400	n/a	400	n/a
Project case mature state irrigated land area	1,320	n/a	1,650	n/a	1,980	n/a	5,607	n/a
Project costs								
Capital expenditure	18,970	16,653	18,970	16,653	18,970	16,653	18,970	16,653
Operating and lifecycle costs	3,890	1,630	3,890	1,630	3,890	1,630	3,890	1,630
Total project costs	22,860	18,283	22,860	18,283	22,860	18,283	22,860	18,283
Economic benefits								
Increased agricultural output from changes in land use	6,722	2,744	9,134	3,729	11,545	4,713	38,046	15,532
Increased productivity on irrigated land	924	450	924	450	924	450	924	450
Residual value	12,490	2,301	12,490	2,301	12,490	2,301	12,490	2,301
Total project benefits	20,136	5,495	22,548	6,480	24,959	7,464	51,460	18,283
Net project benefits/(costs)	- 2,724	- 12,788	- 312	- 11,803	2,099	- 10,819	28,600	-
Cost benefit ratio		0.30		0.35		0.41		1.00

Source: Various.

Table 17: Net project costs and benefits (land value approach)

	Scenario 1: return to 2005 levels		Scenario 2: grow to 25% beyond 2005 levels (4519 Ha)		Scenario 3: grow to 50% greater than 2005 levels (5423 Ha)		Breakeven	
	Total	Present value	Total	Present value	Total	Present value	Total	Present value
	$, 000’s	$, 000’s	$, 000’s	$, 000’s	$, 000’s	$, 000’s	$, 000’s	$, 000’s
Base case mature state irrigated land area	400	n/a	400	n/a	400	n/a	400	n/a
Project case mature state irrigated land area	1,320	n/a	1,650	n/a	1,980	n/a	3,688	n/a
Project costs								
Capital expenditure	18,970	16,653	18,970	16,653	18,970	16,653	18,970	16,653
Operating and lifecycle costs	3,890	1,630	3,890	1,630	3,890	1,630	3,890	1,630
Total project costs	22,860	18,283	22,860	18,283	22,860	18,283	22,860	18,283
Economic benefits								
Increased agricultural output from changes in land use	2,990	2,990	4,063	4,063	5,135	5,135	15,532	15,532
Increased productivity on irrigated land	924	450	924	450	924	450	924	450
Residual value	12,490	2,301	12,490	2,301	12,490	2,301	12,490	2,301
Total project benefits	16,404	5,741	17,476	6,813	18,549	7,886	28,946	18,283
Net project benefits/(costs)	- 6,456	- 12,542	- 5,384	- 11,470	- 4,311	- 10,397	6,086	-
Cost benefit ratio		0.31		0.37		0.43		1.00

Source: Various.

Table 18: Net project costs and benefits, sensitivity to changes in discount rate to 4%

	Scenario 1: 1,320 Ha		Scenario 2: 1,650 Ha		Scenario 3: 1,980 Ha		Breakeven	
	Present value	Change on 7% case	Present value	Change on 7% case	Present value	Change on 7% case	Present value	Change on 7% case
	$, 000s	%	$, 000s	%	$, 000s	%	$, 000s	%
Base case mature state irrigated land area	400	n/a	400	n/a	400	n/a	400	n/a
Project case mature state irrigated land area	1,320	n/a	1,650	n/a	1,980	n/a	7,536	- 33%
Project costs	-		-		-		-	
Capital expenditure	17,590	+ 6%	17,590	+ 6%	17,590	+ 6%	17,590	+ 6%
Operating and lifecycle costs	2,288	+ 40%	2,288	+ 40%	2,288	+ 40%	2,288	+ 40%
Total project costs	19,877	+ 9%	19,877	+ 9%	19,877	+ 9%	19,877	+ 9%
Economic benefits								
Increased agricultural output from changes in land use	3,909		5,312	+ 42%	6,714	+ 42%	14,338	- 8%
Increased productivity on irrigated land	591	+ 31%	591	+ 31%	591	+ 31%	591	+ 31%
Residual value	4,949	+ 115%	4,949	+ 115%	4,949	+ 115%	4,949	+ 115%
Total project benefits	9,449	+ 72%	10,851	+ 67%	12,253	+ 64%	19,877	+ 9%
Net project benefits/(costs)	- 10,429	- 18%	- 9,026	- 24%	- 7,624	- 30%	-	n/a
Cost benefit ratio	0.48		0.55		0.62		1.00	

Source: Various.

Table 19: Net project costs and benefits, sensitivity to changes in discount rate to 10%

	Scenario 1: 1,320 Ha		Scenario 2: 1,650 Ha		Scenario 3: 1,980 Ha		Breakeven	
	Present value	Change on 7% case	Present value	Change on 7% case	Present value	Change on 7% case	Present value	Change on 7% case
	$, 000s	%	$, 000s	%	$, 000s	%	$, 000s	%
Base case mature state irrigated land area	400	n/a	400	n/a	400	n/a	400	n/a
Project case mature state irrigated land area	1,320	n/a	1,650	n/a	1,980	n/a	3,688	+ 34%
Project costs								
Capital expenditure	15,791	- 5%	15,791	- 5%	15,791	- 5%	15,791	- 5%
Operating and lifecycle costs	1,213	- 26%	1,213	- 26%	1,213	- 26%	1,213	- 26%
Total project costs	17,004	- 7%	17,004	- 7%	17,004	- 7%	17,004	- 7%
Economic benefits								
Increased agricultural output from changes in land use	2,990		4,063	- 27%	5,135	- 27%	15,553	+ 0%
Increased productivity on irrigated land	358	- 20%	358	- 20%	358	- 20%	358	- 20%
Residual value	1,093	- 52%	1,093	- 52%	1,093	- 52%	1,093	- 52%
Total project benefits	4,441	- 37%	5,514	- 36%	6,586	- 34%	17,004	- 7%
Net project benefits/(costs)	- 12,563	+ 6%	- 11,490	+ 9%	- 10,418	+ 12%	0	n/a
Cost benefit ratio	0.26		0.32		0.39		1.00	

Source: Various.

Table 20: Net project costs and benefits, sensitivity to changes in construction costs (30% higher)

	Scenario 1: 1,320 Ha		Scenario 2: 1,650 Ha		Scenario 3: 1,980 Ha		Breakeven	
	Present value	Change on base case construction costs	Present value	Change on base case construction costs	Present value	Change on base case construction costs	Present value	Change on base case construction costs
	$, 000s	%	$, 000s	%	$, 000s	%	$, 000s	%
Base case mature state irrigated land area	400	n/a	400	n/a	400	n/a	400	n/a
Project case mature state irrigated land area	1,320	n/a	1,650	n/a	1,980	n/a	7,050	- 45%
Project costs								
Capital expenditure	21,649	+ 30%	21,649	+ 30%	21,649	+ 30%	21,649	+ 30%
Operating and lifecycle costs	1,630	-	1,630	-	1,630	-	1,630	-
Total project costs	23,279	+ 27%	23,279	+ 27%	23,279	+ 27%	23,279	+ 27%
Economic benefits								
Increased agricultural output from changes in land use	2,744		3,729	-	4,713	-	19,838	+ 28%
Increased productivity on irrigated land	450	-	450	-	450	-	450	-
Residual value	2,992	+ 30%	2,992	+ 30%	2,992	+ 30%	2,992	+ 30%
Total project benefits	6,186	+ 13%	7,170	+ 11%	8,155	+ 9%	23,279	+ 27%
Net project benefits/(costs)	- 17,093	+ 34%	- 16,109	+ 36%	- 15,125	+ 40%	-	n/a
Cost benefit ratio	0.27		0.31		0.35		1.00	

Source: Various.

Table 21: Net project costs and benefits, sensitivity to changes in construction costs (30% lower)

	Scenario 1: 1,320 Ha		Scenario 2: 1,650 Ha		Scenario 3: 1,980 Ha		Breakeven	
	Present value	Change on base case construction costs	Present value	Change on base case construction costs	Present value	Change on base case construction costs	Present value	Change on base case construction costs
	$, 000s	%	$, 000s	%	$, 000s	%	$, 000s	%
Base case mature state irrigated land area	400	n/a	400	n/a	400	n/a	400	n/a
Project case mature state irrigated land area	1,320	n/a	1,650	n/a	1,980	n/a	4,163	-
Project costs								
Capital expenditure	11,657	- 30%	11,657	- 30%	11,657	- 30%	11,657	- 30%
Operating and lifecycle costs	1,630	-	1,630	-	1,630	-	1,630	-
Total project costs	13,287	- 27%	13,287	- 27%	13,287	- 27%	13,287	- 27%
Economic benefits	-		-		-		-	
Increased agricultural output from changes in land use	2,744		3,729	-	4,713	-	11,227	
Increased productivity on irrigated land	450	-	450	-	450	-	450	-
Residual value	1,611	- 30%	1,611	- 30%	1,611	- 30%	1,611	- 30%
Total project benefits	4,805	- 13%	5,789	- 11%	6,774	- 9%	13,287	- 27%
Net project benefits/(costs)	- 8,482	- 34%	- 7,498	- 36%	- 6,513	- 40%	-	n/a
Cost benefit ratio	0.36		0.44		0.51		1.00	

Source: Various.

Appendix A References

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Appendix B Opportunities for expanded lake cycling

The hydrological modelling undertaken by DEWNR and described in section 4 identifies that lake cycling produces a noticeable reduction in salinity under all environmental conditions, though not as significant as the Coorong Connector. In particular, Lake Cycling can assist with reducing the time required to return Lake Albert salinity levels back to their historical average levels, and therefore provide an environmental benefit to the flora and fauna in the region.

There are several ways to achieve this benefit, which vary from the least expensive to the more expensive options.

Ad hoc lake cycling (the current scenario)

The lower lakes are currently cycled using locks at the Goolwa barrages to discharge water before upstream flows arrive to Lake Alexandrina on an ad hoc basis. The Goolwa barrages are operated using stop logs (heavy concrete blocks which are raised or lowered to permit flows when required using forklifts). The benefit of this approach is that it is the lowest cost option to realise benefits from Lake Cycling. The costs of this approach are:

- Stop Logs mean that the barrages can only be opened during daylight and normal working hours due to occupational health and safety requirements. This limits the operational flexibility, meaning that the times when the lakes are cycled is determined partly by the time of day or week, rather than when it is environmentally optimal to do so.
- Using stop logs is time and labour intensive, and while it is possible to operate the barrages intermittently, moving to a more frequent lake cycling program would require more staff and potentially more equipment.
- Lake cycling can also potentially cause “negative head” events, where the lake levels change on the saltwater side of the barrages, potentially resulting in an inflow of saltwater into the fresh inland side of the barrages. Stop logs can take time to operate, meaning that it can be difficult to quickly respond if a negative head event occurs. This means that the lake is only cycled when staff are available (a further restriction on operational flexibility), and the threat of negative head events remains.

Under the current operating structure, it is therefore possible to cycle the lakes intermittently, but not frequently. Secondly, the governance arrangements in place require decisions to be made by committee on an ad hoc basis, rather than according to a wider strategy for lake cycling during specific environmental conditions.

Proactive lake cycling (the alternative scenario)

Given the limitations of the current lake cycling approach, there is therefore potentially a benefit from moving to a more proactive program. The most obvious way to do this would be by constructing a remotely operated barrage system, which could be managed by an operator safely regardless of weather or light conditions, and quickly enough to respond to negative head events. The benefits of this approach would be:

- The ability to cycle the lakes according to the optimal environmental timing and conditions, rather than limited by the operational flexibility of staff availability, weather, light, or other factors
- The ability to prevent negative head events from occurring, and therefore allow for lake cycling more frequently and at shorter intervals
- Reduced cost of labour, where any current labour requirements would no longer be needed
- The ability to implement a proactive Lake Cycling strategy, which would be based on the medium term environmental outlook, rather than cycling the lakes on an ad hoc basis.

It would appear that there are benefits to moving from an ad hoc governance arrangement to a proactive, strategic lake cycling program regardless of whether there is any investment in remotely operated barrages. This option would appear to be effectively costless, while it would have some environmental benefits during drought response periods (such as the situation faced by Lake Albert in late 2013/early 2014).

There may be further benefits from the installation of remotely operated barrages, if this allows the operation of an expanded lake cycling strategy which isn’t possible with the current stop log system. If the economic, environmental and social benefits are greater than the incremental costs of the construction of remotely operated barrages, then this option should be pursued.

Appendix C Previous studies undertaken to date

Previous studies noted the possible costs and benefits of various options to improve water quality in Lake Albert. Generally, the options requiring major capital costs have shown insufficient benefits to offset the costs or risks of the option. This is summarised in the table below.

Table 22: Previous studies considering possible management actions

Option	Notes	Cost	Benefit/cost ratio
Dredging the Narrung Narrows	Considered by Ebsary in 1983 and McInerney in 2005, with options varying between dredging 300,000 m3 and 1.8 million m3 in material, which was considered to potentially increase channel flows by between 15% and 60%. Ebsary noted that the dredging might improve flow, but it may also improve flow back from Lake Albert, increasing the flow but not necessarily significantly changing Lake Albert salinity levels.	$1.1m - $4.1 m	0.52 - 0.67
Coorong Connector	Considered by Ebsary in 1983, Burton in 1988, URS in 2006, WBM Oceanics in 2006, PIRSA in 2006, Walter and Souter in 2006. Options considered a range of flow rates, from 15 GL/Month to 150 GL/Month in 1983. 2006 studies considered a required flow rate of approx. 3.5 GL/Day (or approx. 105 GL/Month). Studies considered that the option could achieve a significant reduction in EC (between 660 and 980 units of EC) over the base case. Studies noted the environmental implications of the option, from permanently altering the condition in the Coorong. This would necessitate a full consideration of the environmental impacts. Potential beneficiaries from the proposed option would include both environmental users, but also private irrigators.	$2.11m (in 1983) - $126 m (in 2006)	0.02 – 1.9
Permanent regulating structure at Narrung	Considered by Ebsary in 1983. Studies noted the potential to close the Narrung Narrows during periods of poor water quality, and then open the channel during periods if fresher inflows from upstream. The study noted that this would require the temporary lowering of the lake level to manage inflows selectively depending on incoming water quality.	$3.05 m in capital costs, $66k in operating costs (in 1983)	n/a
Variation of water levels in Lake Albert and Lake Alexandrina (Lake cycling)	This was considered by Ebsary in 1983, as well as BMT WBM in 2012. This option uses the barrages to lower the lake levels of both Lake Alexandrina and Lake Albert before major freshwater inflows from upstream, to reduce the salinity level in the CLLMM system. This option provides substantial benefits, for little to no cost.	Nil	n/a

	For this reason, it has been used in managing lake salinity levels in the past on an ad hoc basis.		

Source: DEWNR, Lake Albert Scoping Study, 2013.

The findings of previous studies vary widely. Inflation, changes in engineering requirements, changes in hydrological modelling approaches, and increased understanding of ecological and environmental conditions have all contributed to different results, both in terms of the expected capital costs as well as potential economic benefits.

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