
SOUTH AUSTRALIA'S 2009-10 REPORT TO THE BASIN SALINITY MANAGEMENT STRATEGY

Updated
4 February 2011

DFW 2010/04

DEPARTMENT FOR
WATER

This document aims to provide a summary of South Australia's implementation of the Basin Salinity Management Strategy in 2009-10.

The document has been prepared for the Government of South Australia by the Murray-Darling Basin Division, Department for Water.

DEPARTMENT FOR WATER

Murray-Darling Basin Division

25 Grenfell Street, Adelaide

GPO Box 2834, Adelaide, South Australia 5001

Telephone: National (08) 8463 6946
International +61 8 8463 6946

Fax: National (08) 8463 6999
International +61 8 8463 6999

Website: www.waterforgood.sa.gov.au

DISCLAIMER

The Department for Water, its employees and servants do not warrant or make any representation regarding the use, or results of use of the information contained herein as to its correctness, accuracy, currency or otherwise.

The Department for Water, its employees and servants expressly disclaim all liability or responsibility to any person using the information or advice contained herein.

© Government of South Australia, through the Department for Water, 2010

This work is Copyright. Apart from any use permitted under the Copyright Act 1968 (Cwlth), no part may be reproduced by any process without prior written permission obtained from the Department for Water.

Requests and enquiries concerning reproduction and rights should be directed to the Chief Executive, Department for Water, GPO Box 2834, Adelaide, South Australia 5001.

ISSN 1447-6843

Preferred way to cite this publication:

2010, *South Australia's 2009-10 Report to the Basin Salinity Management Strategy*, Department For Water Report DFW 2010/04, Government of South Australia.

Download this document at:

<http://www.waterconnect.sa.gov.au/TechnicalPublications/Pages/Default.aspx>

ACKNOWLEDGEMENTS

The Murray-Darling Basin Division of the Department for Water would like to acknowledge and thank the following agencies and organisations for their contribution to this report:

- South Australian Murray-Darling Basin Natural Resources Management Board;
- South Australian Research and Development Institute (SARDI);
- SA Water;
- CSIRO;
- Future Farm Industries Cooperative Research Centre;
- Department of Environment and Natural Resources (the former Department for Environment and Heritage); and
- Other divisions within the Department for Water (the former Department of Water, Land and Biodiversity Conservation).

CONTENTS

EXECUTIVE SUMMARY	10
1. INTRODUCTION.....	15
2. NINE ELEMENTS OF THE BASIN SALINITY MANAGEMENT STRATEGY	17
2.1 DEVELOPING CAPACITY TO IMPLEMENT THE STRATEGY	17
2.1.1 <i>Young Irrigator Group – Waikerie.....</i>	<i>17</i>
2.1.2 <i>Case Study Groups.....</i>	<i>18</i>
2.1.3 <i>How Efficient Are We? A Report on Water Use Efficiency.....</i>	<i>19</i>
2.1.4 <i>Irrigator Annual Reporting and Baseline Information for Irrigated Land.....</i>	<i>20</i>
2.1.5 <i>Goyder Institute.....</i>	<i>20</i>
2.1.6 <i>New Schedules to the Murray-Darling Basin Agreement.....</i>	<i>20</i>
2.1.7 <i>New Vessel Improves Capacity for Monitoring</i>	<i>21</i>
2.2 IDENTIFYING VALUES AND ASSETS AT RISK.....	22
2.2.1 <i>Salinity Horizons Project</i>	<i>22</i>
2.2.2 <i>Salinity Risks from Floodplains.....</i>	<i>23</i>
2.2.3 <i>Floodplain and Anabranche Management.....</i>	<i>25</i>
2.2.4 <i>Environmental Watering.....</i>	<i>26</i>
2.2.5 <i>Coordinating and Tracking Environmental Watering Actions.....</i>	<i>28</i>
2.2.6 <i>Chowilla Floodplain Icon Site.....</i>	<i>28</i>
2.2.7 <i>The Coorong, Lower Lakes and Murray Mouth (CLLMM).....</i>	<i>29</i>
2.3 SETTING SALINITY TARGETS	34
2.3.1 <i>Salinity Targets</i>	<i>34</i>
2.4 MANAGING TRADE-OFFS WITH THE AVAILABLE WITHIN VALLEY OPTIONS.....	38
2.4.1 <i>Emergency Response Projects.....</i>	<i>38</i>
2.4.2 <i>Reuse of Salt Interception Scheme Water</i>	<i>48</i>
2.4.3 <i>South Australian Weir Pool Manipulation Program.....</i>	<i>48</i>
2.4.4 <i>Water for the Future</i>	<i>49</i>
2.5 IMPLEMENTING SALINITY AND CATCHMENT MANAGEMENT PLANS	51
2.5.1 <i>State Plans and Strategies.....</i>	<i>51</i>
2.5.2 <i>Regional Plans and Strategies.....</i>	<i>53</i>
2.5.3 <i>Community Wetland Program</i>	<i>60</i>
2.5.4 <i>Review of Environmental Protection Policy.....</i>	<i>60</i>
2.6 REDESIGNING FARMING SYSTEMS	61
2.6.1 <i>Event-based Irrigation Monitoring</i>	<i>61</i>
2.6.2 <i>Climate Change Impacts on Irrigation Water Requirements.....</i>	<i>62</i>
2.6.3 <i>Water For The Future.....</i>	<i>62</i>
2.6.4 <i>On-Ground Support to Achieve Irrigation Efficiency.....</i>	<i>63</i>
2.6.5 <i>Future Farm Industries Cooperative Research Centre.....</i>	<i>63</i>
2.7 TARGETING REFORESTATION AND VEGETATION MANAGEMENT.....	65
2.7.1 <i>Revegetation and Restoration Activities.....</i>	<i>65</i>
2.7.2 <i>Sustainable Farming Vegetation Management.....</i>	<i>66</i>

2.7.3	<i>The River Murray Forest</i>	66
2.8	CONSTRUCTING SALT INTERCEPTION WORKS	67
2.8.1	<i>Waikerie SIS</i>	67
2.8.2	<i>Woolpunda SIS</i>	68
2.8.3	<i>Loxton SIS</i>	68
2.8.4	<i>Bookpurnong SIS</i>	69
2.8.5	<i>Qualco-Sunlands Groundwater Control Scheme</i>	69
2.8.6	<i>Murtho SIS</i>	69
2.8.7	<i>Pike SIS</i>	70
2.8.8	<i>Riverland Salt Disposal Management Plan</i>	70
2.9	ENSURING BASIN-WIDE ACCOUNTABILITY: MONITORING, EVALUATING AND REPORTING	72
2.9.1	<i>Monitoring</i>	72
2.9.2	<i>Evaluating</i>	84
2.9.3	<i>Reporting</i>	89
3.	VALLEY REPORTS	92
3.1	END OF VALLEY REPORT CARD	92
3.2	SUMMARY OF MONITORING SITES	94
3.2.1	<i>Border (A4261022)</i>	94
3.2.2	<i>Berri (A4260537)</i>	94
3.2.3	<i>Morgan (A4260554)</i>	94
3.2.4	<i>Murray Bridge (A4261162)</i>	94
4.	RESPONSE TO INDEPENDENT AUDIT GROUP	95
4.1	HIGH PRIORITY RECOMMENDATIONS	95
4.2	NORMAL PRIORITY RECOMMENDATIONS	98
5.	REFERENCES	100
6.	APPENDIX A	103
	<i>Reports delivered under the Riverine Recovery Project</i>	103

LIST OF FIGURES

Figure 1: South Australian Murray-Darling Basin.....	16
Figure 2: MVS Rosco.....	21
Figure 3: Aerial view of barrages, June 2009 (photo courtesy of DENR).....	30
Figure 4: Low water levels at Goolwa, June 2009 (photo courtesy of DENR).....	38
Figure 5: Temporary regulator at Clayton, October 2009.....	41
Figure 6: Mapped extent of fresh water plume entering Lake Alexandrina from River Murray.	42
Figure 7: Saline intrusion from Lake Alexandrina into the Lower River Murray, July 2009.....	42
Figure 8: Total salt in the lower River Murray between Woods Point and Lake Alexandrina.....	43
Figure 9: Saline plume from Lake Alexandrina into the Lower River Murray, November 2009..	44
Figure 10: Lake Albert revegetation trial, January-February 2009 (photo courtesy of DENR) ...	45
Figure 11: Ultra fine limestone placed across the mouth of Currency Creek, July 2009 (photo courtesy of DENR)	45
Figure 12: Levee bank cracking, Lower Murray, South Australia 2009.....	46
Figure 13: Riverbank collapse at Fred’s Landing near Tailem Bend.....	47
Figure 14: Riverbank collapse at Long Island Marina, Murray Bridge	47
Figure 15: Graph of South Australia’s salinity register balance	52
Figure 16: Grazing preference trials at Monarto research site (photo courtesy of SARDI).....	64
Figure 17: EC in South Australia during 2009-10.....	72
Figure 18: Total salt load at Morgan 2006-07, 2008-09 and 2009-10	73
Figure 19: A4261091, continuous flow site at Chowilla Creek	74
Figure 20: 3D EC mapping at Downstream Lock 6 looking upstream.....	75
Figure 21: Detail of 3D EC mapping at Downstream Lock 6 looking downstream at 616 km AMTD.....	76
Figure 22: 3D EC mapping at Pike River downstream of Lettons (A4260644).....	76
Figure 23: 3D EC mapping at Pike River – Murray river Junction	77
Figure 24: Track of surface salinity around the navigable edge of the Lower Lakes, March 2010 (imagery 2004).....	78
Figure 25: Track of surface salinity around the navigable edge of the Lower Lakes, July 2010 (imagery 2004).	78

Figure 26: EC downstream of Goolwa barrage, January 2010..... 79

Figure 27: Pre-European water table contours.....80

Figure 28: Pre-European water table contours and irrigated area..... 80

Figure 29: 2010 water table contours and irrigated area81

Figure 30: Estimated volumes stored in groundwater mounds81

Figure 31: Community monitoring for salinity (EC)82

Figure 32: Community stream sampling for salinity (EC) at selected sites.....83

Figure 33: Location of South Australia’s Numerical Groundwater Models 88

LIST OF TABLES

Table 1: Changes in the profile of irrigation application systems between 1996-1997 and 2006-2007 in the Bookpurnong LWMP Region..... 58

Table 2: Water Balance Efficiency Assessment undertaken in 1996-9758

Table 3: Field Application Efficiency Assessment 2006-07 58

Table 4: Successive Run of River salt loads, river kilometres 500 – 521 – DWLBC, 2009.....59

Table 5: SARMSS Monitoring Sites92

Table 6: End-of-valley Summary Report Card93

LIST OF ABBREVIATIONS

ABIMZ	Angas Bremer Irrigation Management Zone
ADCP	Acoustic Doppler Current Profiler
AHD	Australian Height Datum
BSMS	Basin Salinity Management Strategy
CLLMM	Coorong, Lower Lakes and Murray Mouth
CDS	Comprehensive Drainage Scheme
CEWH	Commonwealth Environmental Water Holder
COAG	Council of Australian Governments
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAFF	Department of Agriculture, Fisheries and Forestry
DEH	Department for Environment and Heritage
DENR	Department of Environment and Natural Resources (formerly DEH)
DFW	Department for Water (formerly DWLBC)
DWLBC	Department of Water, Land and Biodiversity Conservation
EC	Electrical Conductivity - $\mu\text{S cm}^{-1}$ EC
EIS	Environmental Impact Statement
ELMA	Environmental Land Management Allocation
EOI	Expressions of Interest
EPBC Act	Environment Protection and Biodiversity Conservation Act, 1999
EPP	Environmental Protection (Water Quality) Policy, 2003
FAE	Field Application Efficiency
FFI CRC	Future Farm Industries Cooperative Research Centre
GIS	Geographic Information System
GL	Gigalitre (1,000,000,000 litres)
IAG	Independent Audit Group
IGA	Inter-Governmental Agreement
IIEP	Improving Irrigation Efficiency Project
IIP	Improved Irrigation Practice
IRES	Irrigation Recording Evaluation System
LAPs	Local Action Planning Associations

LMIMZ	Lower Murray Irrigation Management Zone
LWMP	Land and Water Management Plan(ning)
MAD	Management Action Database
MAT	Management Action Target
MBI	Market Based Instruments
MDB	Murray-Darling Basin
MDBA	Murray-Darling Basin Authority
MERI	Monitoring, Evaluation, Reporting and Improvements
ML	Megalitre (1,000,000 litres)
NAP	National Action Plan for Salinity and Water Quality
NHT	Natural Heritage Trust
NRM	Natural Resources Management
OFIEP	On-Farm Irrigation Efficiency Program
PIP	Pike Implementation Project/Plan
PSR	Performance Story Reporting
RMIMZ	River Murray Irrigation Management Zone
RSDMP	Riverland Salt Disposal Management Plan
SAAE	South Australia Aquatic Ecosystems
SA MDB	South Australian Murray-Darling Basin
SA MDB NRM Board	South Australian Murray-Darling Basin Natural Resources Management Board
SARMSS	South Australian River Murray Salinity Strategy
SAMRIC	South Australian Murray-Darling Basin Resource Information Centre
SARDI	South Australian Research and Development Institute
SASP	South Australia's Strategic Plan
SIS	Salt Interception Scheme
SUTRA	Saturated Unsaturated TRANsport (finite element) model
TDS	Total Dissolved Solids
TLM	The Living Murray
USE	Upper South East
VI	Velocity Index
WAP	Water Allocation Plan for the Prescribed River Murray Watercourse
WQSMP	Water Quality and Salinity Management Plan
WUE	Water Use Efficiency

EXECUTIVE SUMMARY

Management of River Murray salinity remains a significant issue for South Australia due to its location on the lower reach of the River Murray; the natural geological structure of the Murray-Darling Basin (MDB) in which the River Murray acts as a drain for salt out of the landscape; the influence of human development in mobilising salt to the River, and the ultimate implications of salinity in terms of water quality for all uses, including critical human water needs.

South Australia is committed to delivering salinity management obligations under the Murray-Darling Basin Authority Basin Salinity Management Strategy (BSMS) (Schedule B, Schedule 1, *Water Act, 2007* (Cth)) and also recognises the importance of salinity management through key State level strategies and plans. These include:

- Water for Good (Action 56): Maintain a positive balance on the Murray-Darling Basin Authority's Salinity Register, and continue to implement strategies and actions to ensure the real time management of salinity in the lower reaches of the River Murray so that water quality remains at levels suitable for human consumption;
- South Australia's Strategic Plan (SASP) Target (T3.11): River Murray Salinity – South Australia maintains a positive balance on the Murray-Darling Basin Authority's Salinity Register;
- Objectives in the *River Murray Act 2003*; and
- Management Action Targets in the South Australian Murray-Darling Basin Natural Resources Management Plan.

Salinity management requires a continued investment from South Australia to manage the risk of increased salt loads to the River Murray into the future, partly due to past actions (the legacy of history) and continued irrigation development but also due to increased mobilisation of salt that may result from higher flows and environmental watering.

Development of a new Salinity Program for salinity management for South Australia has been initiated to ensure that South Australia can address these risks through focused investment, continue to meet its BSMS obligations, the SASP target and deliver against the related Action 56 in Water for Good. Importantly, the new program will be cognisant of requirements under the proposed Basin Plan. In terms of directions for managing salinity within this program, South Australia has been guided by previous recommendations of the Independent Audit Group – Salinity; the recommendations of the BSMS Mid-term Review and the outcomes of key projects recently completed, such as:

- a project examining future risk of South Australian entries on the BSMS Salinity Registers (Aquaterra, 2010); and
- a 'Salinity Horizons' project (Sinclair Knight Merz, 2010) to broadly quantify the long-term salinity risk of actions not already included on the salinity registers that will have a salinity effect; e.g. climate change, new diversion limits, environmental watering impacts has been completed. The outcomes will be used to ensure the Salinity Program being developed includes appropriate scale of investment in mitigating actions.

With the conclusion of the National Action Plan for Salinity and Water Quality, resourcing for the salinity program within South Australia has diminished. In terms of direct management of South Australia's input to the BSMS, South Australia's effort is now largely resourced through the South Australian Save the River Murray Levy. As the new Salinity Program is developed, risks will be highlighted to assist in building the case for further resources.

The ultimate aim is to ensure the State can continue to manage salinity within the River Murray system. In the meantime, South Australia is directing effort to the highest priority issues (such as addressing floodplain salinity risk) and working with Murray-Darling Basin Authority (MDBA) and other jurisdictions as appropriate to address such issues.

Context for 2009-10

Effects of Drought

Extremely low inflow conditions across the Basin severely impacted on the share of water resources available to South Australian users. A major priority for 2009-10 was the administration of water restrictions and water conservation programs which included increased compliance and monitoring of water use.

In support of these programs, quarterly consumption advice, water trading and water carryover continued in 2009-10 to meet the increasing demands from managers and users of the River Murray.

River Murray Water Allocations

Due to the exceptional drought conditions at the beginning of 2009-10, negotiations occurred with MDBA and partner jurisdictions to guarantee the delivery of water for critical human needs to South Australia and to provide a minimal volume of water for general allocations early in the year.

Decisions regarding available water allocations were made fortnightly, based on the assessments of water availability and by applying the River Murray Drought Water Allocation Decision Framework. This provided as much certainty to irrigators as possible.

The framework was amended during 2009-10 to ensure the Government of South Australia could meet its commitment to securing water for critical human needs (201 gigalitres) and for a Lower Lakes Environmental Reserve (170 gigalitres).

This water was secured through water purchase, resource improvements and reduced pumping from the River Murray as a result of improved inflows in the Mount Lofty Ranges watershed.

Access to floodwaters from Queensland and northern New South Wales also meant additional water could be allocated for irrigation and the environment late in the year. The final allocation level for irrigators was 62% of water access entitlement, a significant increase on 2007-08 (32%) and 2008-09 (18%).

Key Achievements

Key Department of Water, Land and Biodiversity (DWLBC) salinity management achievements in 2009-10 include:

- South Australia remains in positive balance on the BSMS Salinity Registers following MDB Ministerial Council endorsement of the November 2009 BSMS Salinity Registers (MDB Ministerial Council out-of-session #4 - June 2010);
- A review of water quality and salinity for the River Murray in South Australia was completed, with cross-government input. The review supported South Australia to provide advice and information on water quality and salinity management issues in South Australia to the MDBA, as information of interest in the development of the Water Quality and Salinity Management Plan as part of the Basin Plan;
- Completion of the project examining future risk of South Australia's entries on the BSMS Salinity Registers (Aquaterra, 2010);
- Completion of the 'Salinity Horizons' project (Sinclair Knight Merz, 2010);
- A South Australian specific project was initiated to quantify the local risk of floodplain salinity to the River Murray and identify specific mitigation strategies that could be driven from within South Australia (expected for completion October 2010) (Aquaterra, 2010);
- South Australia is working to conduct a full assessment of the salinity risk from the operation of the Chowilla environmental regulator (under construction). This will facilitate the future development of an appropriate operation strategy for the regulator to minimise these impacts;
- Work is progressing on the construction of the Murtho Salt Interception Scheme;
- An evaluation of Land and Water Management Plans in South Australia is currently underway;
- Initiation of development of the new Salinity Program for salinity management for South Australia;
- Preparation of long-term plan for the Coorong, Lower Lakes and Murray Mouth region;
- Redevelopment of the Natural Resource Information Management System portal for better functionality to access a range of natural resource data and information; and
- Completion of the Morgan to Wellington Numerical Groundwater Model, providing South Australia with a set of consistent groundwater models from the South Australian border to Wellington.

Significant Work

- Work continues on groundwater models to support the annual update of data entries on the BSMS Salinity Registers. South Australia is considering funding options for the next three years to enable ongoing modelling work to occur;
- Work has continued with the MDBA to initiate Stage 1 of the project "Flood Recession Salt Mobilisation from Floodplains of the River Murray" to investigate the basin scale risk of floodplain salt storages to both river salinity and the Salinity Registers balance;
- The project 'How efficient are we?' (documenting the historical improvement of water use efficiency in the South Australian Murray-Darling Basin) is nearing completion and is to be peer reviewed in late 2010;
- A final report for implementation of Codes of Practice for irrigation is nearing completion;
- Continued input to the implementation of the Pike, Bookpurnong and Pyap to Kingston Land and Water Management Plans;
- Substantial investment in emergency response projects to manage the impact of low water levels below Lock 1;
- Research into appropriate salinity and flow targets for the Lower Lakes and Coorong;

- Undertaking of a number of projects to deal with Lower Lakes water levels and address the recovery of that system, funded through the Murray Futures initiative; and
- Finalising supplementary documentation to respond to the concerns raised in the peer review of the Berri-Renmark and Pyap to Kingston Numerical Groundwater Models, to support model accreditation.

Future Work

Due to machinery of government changes, as of 1 July 2010 the South Australian Department of Water, Land and Biodiversity Conservation (DWLBC) ceased to exist. The new South Australian Department for Water assumes the functions of the former DWLBC in relation to Basin Salinity Management Strategy implementation.

Clearly, the forthcoming Water Quality and Salinity Management Plan within the Basin Plan will be a major focus for 2010-11. South Australia has been preparing for the release of the Basin Plan and will be formally responding to the Basin Plan documents during the corresponding consultation periods. It will be especially important for the Water Quality and Salinity Management Plan to build on the strength of the Basin Salinity Management Strategy successes and for effort to be directed to ensuring an appropriate interface between the new Plan and the existing Strategy.

In 2010-11, significant effort will also be directed towards:

- Finalising development of the new South Australian River Murray Salinity Program;
- Identification of strategies for securing investment in salinity mitigation actions into the future;
- Investigating opportunities to fund construction of the Pike Salt Interception Scheme;
- Developing a clear policy position on management of the salinity impacts of environmental watering;
- Addressing the management of real time salinity impacts including development of appropriate operational responses (such as additional water for dilution flows);
- Continued groundwater modelling support to underpin South Australia's entries on the BSMS Salinity Registers;
- Submission of the Morgan to Wellington Numerical Groundwater Model to MDBA for peer review to support accreditation and use of model data as input to BSMS Salinity Registers entries;
- Ensuring salinity provisions are retained within key State plans under review (e.g South Australia's Strategic Plan, River Murray Water Allocation Plan);
- Supporting Land and Water Management Plan implementation (including opportunities to further use event based irrigation monitoring) and improving the alignment of those plans with delivery of BSMS outcomes;
- Finalising the salinity assessment of the Chowilla environmental regulator and developing an operating strategy that is cognisant of salinity impacts; and
- Addressing the recommendations of the South Australian floodplain salinity project, particularly as they relate to data collection and monitoring to improve understanding of within floodplain salt mobilisation processes.

This effort will ensure South Australia can continue to address the highest salinity risks to the River Murray system, meet its salinity management obligations under Schedule B and be well

placed to manage against any new targets and objectives in the Water Quality and Salinity Management Plan.

Developments Since 2009-10

Although this report relates to the 2009-10 financial year, it needs to be recognised that there have been some significant developments since 30 June 2010 that provide some context for 2010-11. These changes will be highlighted to the Independent Audit Group – Salinity in November 2010. They relate mainly to improvements in system inflows. While these signify a significant improvement in water availability and the ability to manage water and salinity levels in the short-term, significant effort will still be required to address long-term salinity management issues below Lock 1 as highlighted within this report.

Water is also now flowing between Lake Alexandrina and Lake Albert for the first time in two years after the Government of South Australia made the decision to remove a 100 metre section of the Narrung bund (constructed in 2008 to assist in managing the emerging risk of acidification in Lake Albert as a direct result of unprecedented low water levels).

The need for the regulators at Clayton and Currency Creek has passed for a minimum of one year, and possibly two years. Partial removal of the Clayton regulator has been completed to allow up to 15 GL per day to pass through the regulator and the Goolwa Barrage. This provides an opportunity to once again export salt from the Basin to the sea via the Murray Mouth. With currently improving inflow conditions, it is likely that the triggers for full removal of the regulator will be reached in November 2010.

The proposal for a Temporary Weir near Pomanda Island (Wellington) has been deferred indefinitely due to recently improved system inflows enabling the restoration of water levels below Lock 1 and substantial improvements in Lake Alexandrina's salinity. The water quality of Lake Alexandrina is not considered to represent a threat to SA Water's pumping station offtakes at Taillem Bend and Murray Bridge for at least the next two years.

The proposal to allow seawater into the Lower Lakes has been deferred indefinitely due to the restoration of water levels below Lock 1. On this basis, it is considered that the threat of whole-of-waterbody acidification in Lakes Alexandrina and Albert has been mitigated for at least the next two years.

Investigations into the ability to maintain a virtual weir as an alternative to the proposal for a Temporary Weir near Pomanda Island (Wellington) have been completed. The Government of South Australia has concluded that a virtual weir could not be relied upon if River Murray flows past Wellington returned to base flow (only) conditions (350 GL per annum); and the water level in Lake Alexandrina was to fall to minus 1.5m AHD (or worse); or seawater was to be introduced to Lake Alexandrina.

With the restoration of water levels below Lock 1, the risk of further deterioration in Riverbank condition has largely been mitigated. However, the risk of Riverbank collapse events remains due to damage incurred during the period of low water levels.

The Goyder Institute has now been established and the Department for Water is enlisting support from the Institute in preparing South Australia's response to the MDBA's Basin Plan.

1. INTRODUCTION

This report documents South Australia’s accountability and delivery against the Murray-Darling Basin Authority Basin Salinity Management Strategy (BSMS) (Schedule B to Schedule 1, *Water Act, 2007* (Cth)).

The report is structured around a standard Table of Contents agreed to in 2008 by jurisdictions for BSMS reporting, as noted at Basin Salinity Management Advisory Panel Meeting #5, 13 July 2010.

Chapter two describes work undertaken in 2009-10, grouped against each of the nine elements of the BSMS, with an indication given to priority areas of focus for the coming year and beyond.

Chapter three provides a summary of flow and salinity observations and predictions at key locations within South Australia.

Chapter four summarises South Australia’s response to the recommendations of the Independent Audit Group – Salinity from their most recent report.

This report has been compiled by Department for Water with significant contributions from other agencies and organisations, as noted in the Acknowledgements section at the beginning of the report. This reflects that management of salinity in the South Australian Murray-Darling Basin (see Figure 1) involves a partnership approach across the community, State agencies, the Murray-Darling Basin Authority and other jurisdictions.

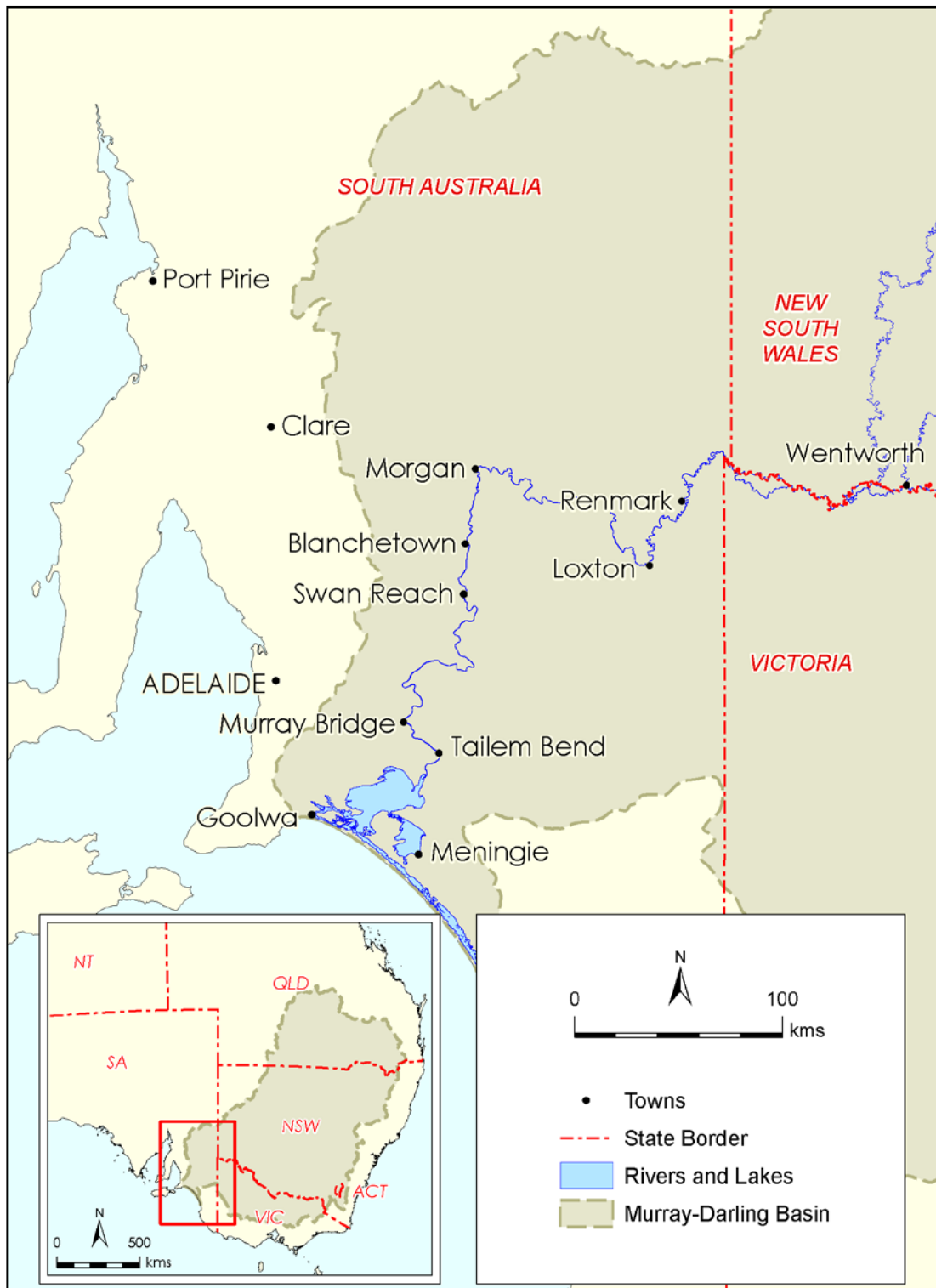


Figure 1: South Australian Murray-Darling Basin

2. NINE ELEMENTS OF THE BASIN SALINITY MANAGEMENT STRATEGY

The following sections highlight actions taken within South Australia in 2009-10 to implement each of the nine elements of the BSMS:

- 1. Developing capacity to implement the Strategy*
- 2. Identifying values and assets at risk*
- 3. Setting salinity targets*
- 4. Managing trade-offs with the available within-valley options*
- 5. Implementing salinity and catchment management plans*
- 6. Redesigning farming systems*
- 7. Targeting reforestation and vegetation management*
- 8. Constructing salt interception works*
- 9. Ensuring Basin-wide accountability: monitoring, evaluating and reporting*

2.1 DEVELOPING CAPACITY TO IMPLEMENT THE STRATEGY

The Commission and partner Governments will administer a comprehensive 'knowledge generation' program to support Basin and within valley planning and implementation.

The partner Governments will assist catchment communities to implement national, Basin and State initiatives by improving access to and use of the knowledge and decision tools generated by investigations and salinity research and development. This process will be supported by further capacity building for catchment planning, including communication and education.

(BSMS 2001–2015)

Various initiatives are undertaken in South Australia to develop and maintain capacity to implement the BSMS. Developing capacity occurs at different levels including within local communities and groups focussed towards on ground actions, within South Australian government departments and agencies, and in terms of the ongoing interface between South Australia, Commonwealth agencies such as the MDBA and other jurisdictions that are party to the Murray-Darling Basin Agreement. Initiatives such as the recently launched Goyder Institute are key to developing and maintaining linkages between State agencies, Universities and research organisations such as CSIRO. This ensures that government driven policy directions for salinity management are well linked to the latest scientific research.

2.1.1 Young Irrigator Group – Waikerie

During 2009-10 the Riverland West Local Action Planning has worked with the South Australian Murray-Darling Basin Natural Resources Management Board to deliver a Commonwealth Department of Agriculture, Fisheries and Forestry (DAFF) Next Generation grant aimed at Young Irrigators in the Riverland West Local Action Planning Area.

The major focus of the group operating under the Next Generation grant is to promote the development of more holistic appreciations of natural resource management, policy and decision making, industry development and on farm best management practice.

During the 2009-10 growing season the group participated in the following:

- training in the operation of drip irrigation systems;
- training in the utilisation of climatic and weather station data;
- training in the operation and analysis of soil water extraction data;
- use of six trial sites to demonstrate effective usage of soil water extractors (as a guide to soil salinity on farm), capacitance probes and logging gypsum blocks were established; and
- two tours, one to the Waite Campus to overview progress with State based horticultural research and development; and one to examine the progress with irrigation modernisation in Southern New South Wales and Northern Victoria, including meetings with the MDBA (Basin Planning process), DAFF (Engaging with Government) and State Water (NSW) – Hume Dam (Overview of Murray Darling system operations).

Throughout 2010-11, work will continue to build the second year of on farm irrigation and monitoring data from the existing trial sites. A further four trial sites will be established, with one site focussing on remediating water quality (organic loads). Results from the first year's work is still being collated and analysed. This will be featured in South Australia's 2010-11 report to the BSMS.

The Young Irrigator Group holds a lot of promise as a means of engaging with the next generation of landholders. Funding is being sought to support the development of the group further in 2010-11. Given the group's interest in policy and planning following the meetings with MDBA, DAFF, et al, the group would benefit by having further interaction with the BSMS or any successor to the BSMS that arises from the Basin Plan process. Effort will be directed in 2010-11 to address this.

2.1.2 Case Study Groups

Case study groups have been utilised to focus on capacity building in regions of interest for sustainable irrigation development and environmental management.

Bookpurnong to Lock 4 Case Study

The Bookpurnong to Lock 4 Case Study continued in 2009-10. A report on irrigation efficiency was completed for the region and a number of research and investigation projects were undertaken.

Irrigators within the region continued to utilise Irrigation Recording and Evaluation Software (IRES – refer section 2.6.1 for further information) to manage their irrigation scheduling. IRES was found to be particularly useful when used in combination with soil moisture monitoring devices to accurately forecast required future irrigation events, particularly in the context of the drought. Irrigators were able to maintain crop condition despite extreme temperatures.

Individual IRES records were also compiled to develop a district scale efficiency benchmark. IRES automatically calculates field application efficiency as irrigation records are entered. Field application efficiency (FAE) considers the efficiency of each irrigation event and requires a soil water balance to be calculated daily. The overall average FAE was 0.89 or 89% water use efficiency representing a high level of practice.

IRES technology also underpinned some research studies in the district including studies into maintaining levels of crop production in drought conditions and more accurately forecasting deep drainage events.

Irrigators within the district also participated in a major climate change project in the region, examining potential implications of climate change on their productivity.

All these initiatives assist in developing capacity in sustainable irrigation practice and minimising the salinity impacts from irrigation.

Pike River Case Study

The Pike River floodplain is an anabranch system located adjacent to Lock 5. The system is a priority area for rehabilitation, having significant ecological, social and economic value. The floodplain is degraded due to lack of flooding, salinisation, earlier use of some areas for irrigation (now abandoned), and grazing. Saline groundwater intrusion to the water bodies results in a significant discharge of salt from the Pike River system into the River Murray. In addition to the local impacts, this threatens water quality for all downstream water users, including Adelaide.

Since 2007 Pike River Land Managers, Renmark to the Border Local Action Planning Association (LAP), the (then) DWLBC and the (then) Department for Environment and Heritage (DEH) have been working cooperatively on the Pike Implementation Plan (PIP). The PIP is now completed and identifies a number of key priorities for the Pike system including: hydrological management and fish passage, sustainable extraction of water through the development of a sustainable diversion limit and irrigation infrastructure which allows for flexible water levels, removal of grazing and pest plants, animal control and salt interception. The PIP Reference Committee is currently seeking funding from the Commonwealth (via a broader State Business Case to Murray Futures) to implement the floodplain aspects of the PIP.

In conjunction with other measures, construction of a Pike Salt Interception Scheme (SIS) would provide considerable environmental benefits to the Pike area, as well as protecting downstream water quality.

2.1.3 How Efficient Are We? A Report on Water Use Efficiency

This project was initiated in March 2009. The primary objective is to document major drivers and enablers of changes in water use efficiency since 1960. The output is a report on water use efficiency in the South Australian Murray-Darling Basin identifying areas of high, medium and low performance. The draft report was completed in March 2010 and is scheduled for peer review in late 2010. Findings of the report support overall efficiency claims that are used as inputs to South Australia's ModFlow groundwater models. For example, some of the outcomes have been used to assist South Australia in responding to the peer review reports for the Berri-Renmark and Pyap-Kingston groundwater models (refer to section 2.9.2). This will support accreditation of the models and thus inform South Australia's future entries on the BSMS Salinity Registers.

However, due to some inconsistencies in the available datasets across districts, it is not currently possible to benchmark irrigation areas in the South-Australian Murray-Darling Basin using the method proposed in the report. An alternative suggested methodology (using surrogate measures) to progress benchmarking is currently under consideration.

2.1.4 Irrigator Annual Reporting and Baseline Information for Irrigated Land

In 2009-10, Irrigator Annual Reporting was undertaken along the River Murray Prescribed Watercourse to collect updated information based on the 2008-09 water use year. The irrigated crop survey project has traditionally provided the majority of updated information on irrigated land. However, due to resourcing limitations it was necessary to have licence holders complete Irrigation Annual Reports for the 2008-09 water use year. Information collected through the Irrigation Annual Reporting process was also used to calculate water use efficiency indices (based on the methodology within the River Murray Water Allocation Plan) which indicated very high levels of efficiency. This result was expected given irrigation allocations were only 18% in 2008-09.

A similar process will be undertaken to collect updated information on irrigated land for the 2009-10 water use year with Irrigation Annual Reports sent to all Site Use Approval holders where the water is being used for irrigation in either the River Murray Irrigation Management Zone (RMIMZ) or the Lower Murray Irrigation Management Zone (LMIMZ).

Irrigator Annual Reporting was also undertaken in the Angas-Bremer Irrigation Management Zone (ABIMZ) to collect updated data based on the 2008-09 water use year. The requirement to complete an Irrigation Annual Report in the ABIMZ is part of the Angas-Bremer Irrigation Code of Practice. In the Angas-Bremer region, 110 irrigators received 'Accredited Irrigator' status for the 2008-09 water use year as a result of successfully satisfying the accreditation requirements contained in the Angas Bremer Irrigation Code of Practice.

2.1.5 Goyder Institute

On 27 May 2010 it was announced that a new water research institute will be established in South Australia to help secure and manage the State's water supply.

The institute will provide independent scientific advice on South Australia's water system, improving the Government of South Australia's ability to forecast threats to water security and develop an integrated approach to water management. The institute is a partnership between the Government of South Australia, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the University of South Australia, the University of Adelaide, Flinders University, the South Australian Research and Development Institute (SARDI) and the Australian Water Quality Centre of SA Water.

Possible linkages to support implementation of BSMS will be explored in 2010-11. The Department for Water is likely to enlist support from the Goyder Institute in preparing South Australia's response to the forthcoming MDBA Basin Plan, including the Water Quality and Salinity Management Plan.

2.1.6 New Schedules to the Murray-Darling Basin Agreement

Clauses 130 and 135 of the Murray-Darling Basin Agreement require the MDBA to prepare a draft Schedule to account for South Australia's Storage Right (Schedule G) and a draft Schedule for Water Sharing (Schedule H) respectively. Basin jurisdictions, through the River Murray System Operations Review Steering Committee and the Operations Review Working Group, are currently engaged in the preparation of the Schedules. These Schedules supplement existing arrangements in the Agreement and aim to improve these arrangements, particularly under extreme dry conditions.

Schedule G (the storage schedule) in particular will be an important management tool to assist South Australia to store water in relatively wet times to manage during dry inflows and drought conditions (which are likely to become more prevalent in future). This may be of particular benefit in terms of providing opportunities for South Australia to manage critical human water need requirements and local salinity impacts within the State by having access to water in the upstream storages for release during periods of low water availability. This Schedule does not increase the volume of water available to South Australia; rather, it changes the timing of delivery of a small proportion of the total water balance.

2.1.7 New Vessel Improves Capacity for Monitoring

A new, state-of-the-art vessel to monitor salinity levels along the South Australian reach of the River Murray, MVS Rosco, was officially launched on 16 October 2009.

The vessel will be used by DFW staff to conduct scientific surveys in the River Murray, Lower Lakes and freshwater environments – covering up to 200 kilometres a day. The six-metre aluminium vessel (Figure 2) has been custom-built in South Australia, and features high-tech sensors, water sampling systems, and a fully-enclosed cabin for staff and equipment storage. The vessel is specifically designed and equipped to collect data while providing a high degree of safety, particularly in adverse weather conditions.

The boat has been named in memory of well-known DFW Berri staff member Ross ‘Rosco’ Stockdale, who sadly passed away in 2008. Ross had served in the water resources area in many capacities for 40 years and was known across the Riverland for his expertise and friendly nature. It’s fitting to have the MVS Rosco honouring a Riverland local who has been such a valuable member of DFW and his community.

MVS Rosco will enable salinity surveys to be undertaken and provide an improved platform for other types of surveys, for compliance, bank erosion, nutrients, sediment sampling, and algal bloom monitoring.



Figure 2: MVS Rosco

2.2 IDENTIFYING VALUES AND ASSETS AT RISK

The partner Governments will work with catchment communities to identify important values and assets throughout the Basin at risk of salinity, and the nature and timeframe of risk. This Strategy emphasises the triple-bottom-line approach, requiring a balance between economic, environmental and social values. It necessarily recognizes that living with salinity is the only choice in some situations.

(BSMS 2001–2015)

Considerable effort has been directed to identifying values and assets at risk in 2009-10.

The Salinity Horizons project (Sinclair Knight Merz, 2010) has been valuable in providing an ‘over-the-horizon’ perspective on factors that will influence the long-term salinity outcomes in South Australia. Ongoing work will be required to be directed to the issue of floodplain salinity.

The study South Australia has engaged Aquaterra to complete in 2010 will provide a valuable initial insight into this issue, by identifying the priority floodplains of salinity risk in South Australia. It is expected that the outcomes will be of great relevance to the broader basin wide study the MDBA is currently undertaking on this issue. Preliminary findings from the South Australian study highlight the importance of effective river management (including dilution flows management) to deal with post flood salt impacts.

Related to this issue, South Australia recognises that managing environmental watering at a Basin scale is a balancing act and that management and approval of environmental watering events will require a coordinated whole-of-Basin approach. This is to take into account the need to meet environmental water requirements for system assets and remove salt from floodplains while maintaining river salinity within acceptable salinity levels for all water users, including other downstream assets such as the Coorong and Lower Lakes. In assessing which sites to water, the potential scale of the cumulative salinity impacts and in-stream flow and salinity conditions, both current and future (i.e. future water availability for dilution) need to be considered.

2.2.1 Salinity Horizons Project

At this time, South Australia remains in positive balance on the BSMS Salinity Registers but it is noted that the overall register balance is predicted to decline over time due to increasing impacts from irrigation and South Australia’s limited access to salinity credits generated by salt interception schemes.

In light of this, a new Salinity Program is to be developed, building on the success of the existing program and addressing the emerging issues. As a first step, a project has recently been completed, Future Risks to South Australian BSMS Salinity Registers project, (Aquaterra, 2010) highlighting a number of risks to South Australia in terms of its credit balance on the BSMS Registers (the known/existing documented actions) and a series of recommendations have been made in relation to specific actions and the overall program. (Refer to section 2.9.2 for further information). These actions are aimed at reducing the uncertainty in the existing Salinity Registers entries, including improving the robustness of the groundwater models that underpin the entries.

As a second step to developing the Salinity Program and looking beyond the actions documented on the registers, a project was completed that analysed the likely salinity outcomes for River Murray in South Australia (the “salinity horizons”) taking into account those

factors not already considered in the BSMS Salinity Registers predictive entries (the actions not yet quantified) (Sinclair Knight Merz, 2010). This involved developing an assumed future position based on a range of agreed scenarios.

Key directions recommended to South Australia as a result of this study are:

1. To develop preferred real time salinity outcomes necessary to maintain beneficial uses/environmental values within South Australia, and establish the overall flow regime (including entitlement flows and environmental flows) that would be necessary to achieve preferred salinity outcomes.
2. To formulate a formal response to the Basin Plan, with specific attention given to:
 - the Water Quality and Salinity Management Plan objectives and targets;
 - the flow regime likely to arise from the proposed SDLs; and
 - long-term salinity accountabilities arising from the changed flow regime and Environmental Watering Management Plans and Buyback.
3. Upon approval of the Basin Plan (anticipated in 2011), the issues and findings raised in the Salinity Horizons report should be reviewed so as to better understand salinity horizons within the boundaries determined by future water sharing arrangements and consequential flow regimes. In light of improved understanding of the future flow regime, this review should establish a work program including:
 - review predictions on trends in irrigation footprint so as to better understand future obligations to maintain a balance on the Salinity Registers; and
 - develop a position on the role of the market in specifically acquiring dilution flows in addition to flows reserved for dilution under the established SDLs.
4. In light of the low confidence in the large credit associated the “improved irrigation efficiency” Salinity Registers entry, South Australia should (with support from BSMS partners), initiate studies to capture appropriate data sets, and develop an agreed methodology leading to improved confidence in the next rolling five year review of that entry.

The outcomes of this project are being considered with the outcomes of the work already completed in the Risk to Registers entries project, recommendations of the Independent Audit Group – Salinity, and other knowledge of River Murray salinity management to shape the future River Murray salinity management program for South Australia. In the coming period, particular attention will be directed to preparing South Australia’s response to the Basin Plan and the Water Quality and Salinity Management Plan. Effort is also being directed to updating the improved irrigation efficiency entry (refer section 2.9.3).

2.2.2 Salinity Risks from Floodplains

Floodplain salinity poses one of the single biggest risks to meeting River Murray salinity management objectives in South Australia. About 2 million tonnes of salt per year reaches the sea via the River. River regulation and greatly reduced flows, particularly in the last decade, have resulted in little discharge of salt to the sea. Much of this salt remains in the floodplains along the lower parts of the River Murray.

There is significant concern that the salt will become mobilised when these floodplains are watered as a result of natural flooding and/or through planned environmental watering events

(e.g. utilising infrastructure such as the Chowilla environmental regulator currently under construction).

Indeed, floodplain salinity has regularly been identified as an issue requiring further investigation, both within South Australia and the Murray-Darling Basin more broadly. The 2007 Mid-Term Review of the BSMS (under recommendation 6) identified a broad need to develop better understanding of the process of salt accumulation within the floodplain, in terms of its potential impact on river water quality if/when mobilised and the development of suitable management actions. In their recent reports (January 2009 and January 2010), the Independent Audit Group – Salinity recommend that work on this issue be progressed as a high priority.

South Australia has recognised that it needs to act now to address this issue. As a first step, a project was initiated in 2009-10 to:

- assess what tools are available to quantify floodplain salt loads;
- conduct a broad assessment of the risk;
- explore River system operational response options to mitigate the salinity affects following a flood; and
- identify areas for further work.

The project was in its last stages at June 2010. Some of the draft findings are provided below. It should be noted that this is only an excerpt from the full report that remains in-draft.

Draft conclusions from the broad risk assessment for during flood impacts include:

- During flood, salt loads are much higher than post flood, but are influenced by dilution effects;
- EC increased downstream with EC generally higher for larger events;
- Of the floods analysed, for smaller to medium events up to 60,000 ML/day, during flood impacts were small, with a 'step increase' from 0 to 5 t/day/km to 5-10 t/day/km above flows of 60,000ML/day. This flow threshold is related to the substantial increase in floodplain inundation above this flow;
- Salt wash-off processes and bank storage effects are dependent on a complex range of factors and not simply on inundated area (or time since previous flood). These processes are likely to be dependent on the prevailing conditions and the sequence of flood events; and
- During flood impacts appears to fall within similar ranges for all reaches with no clear reach of higher risk.

Draft conclusions from the broad risk assessment for post flood impacts include:

- For the floods considered, EC increased downstream and in some cases exceeded 1,000 EC;
- Post flood salinity impact was small or less than pre-flood salt loads for flows below 60,000 ML/day;
- Largest post flood impacts occurred for flood between 60,000 and 100,000 ML/day, reducing for flows above this value, making this flow range the highest risk;
- The occurrence of broad-scale floodplain flooding is particularly important in determining a high post flood salinity impact, although the actual area of inundation is less important. Further investigation and modelling is considered warranted to improve the understanding of these processes and impacts; and

- Within South Australia, the reaches of largest post flood impacts and therefore of highest risk appear to be the Chowilla and Pike floodplains.

Other draft conclusions include:

- A primary consideration for policy makers is whether disposal of salt to river will be permitted. The river is the natural disposal path for salt out of the Murray-Darling Basin, however there are many users dependent on low EC conditions;
- Overall, dilution flow is likely to be the most effective mitigation option (noting that other mitigation options considered require intentional disposal of salt to the river, either through direct disposal via pumping or indirect via manipulating floodplain salt discharge processes);
- Flood salinity risk and potential mitigation options need to be analysed with a higher level of detail. In order to make this evaluation, a range of tools and data are required to inform policy, to better understand the system and to determine benefit/costs of mitigation options;
- There is currently no singular tool that simulates all of these processes, and the assessment of flood salinity impacts is likely to require a range of tools, or possibly the development of an integrated tool;
- Further analysis of the possible flood salinity impact entering South Australia from upstream catchments is needed; and
- Significant gaps in data and the need for further monitoring work to address this.

One key recommendation that could be achieved with existing data is determining the sensitivity of floodplain salinity risks to the averaging period (i.e. changing the length of time of the pre and post flood periods).

A full report on the findings will be provided in South Australia's 2010-11 report to the BSMS. In undertaking this work, South Australia is aware that MDBA are also progressing work on the same issue. However, South Australia bears significant risk in relation to this issue and on this basis saw a need to undertake a separate, preliminary study. The complete outcomes of this project will be provided to the MDBA in due course (the report is expected to be finalised in September 2010) and will complement and inform the work being undertaken by the MDBA on the same issue. This should assist in shaping the floodplain salinity management policy directions for South Australia and the Basin more broadly.

2.2.3 Floodplain and Anabranche Management

A number of processes may compromise the ecological integrity of floodplain and anabranche systems. The key threats include altered flow regimes, highly saline groundwater, obstructions to fish passage, and pest plants and animals. Projects are underway at both the Pike and Katarapko floodplain and anabranche systems to improve the ecological health of the sites.

Significant investigations have occurred at both sites to determine potential works to improve the hydraulic connectivity of the creeks and wetlands with the river. At each site there are considerable works required to remove barriers to flow and improve structures to enable suitable fish passage. Additionally, at each of the sites consideration is being given to construction of environmental regulators to enable the flooding of significant areas of the floodplain at low river flows. Funding options for these projects are being investigated and the salinity implications of altered management at Pike and Katarapko are being considered.

2.2.4 Environmental Watering

During 2009-10 the Environmental Water Management Group successfully sought and received 93,125 ML of environmental water for South Australia's River Murray wetlands, floodplains and the Lower Lakes. The water received from each of the water sources includes:

- The Living Murray (52,969 ML);
- The Commonwealth Environmental Water Holder (29,917 ML);
- Private donations (54 ML);
- Environmental Land Management Allocation (ELMA) (185 ML); and
- South Australian River Murray Drought Water Allocation Decision Framework (10,000 ML).

This water was delivered to the following high priority locations along the length of the River:

- Lake Albert (68,300 ML);
- 3 Lower Lakes wetlands (285 ML);
- 10 Chowilla wetlands (13,690 ML); and
- 19 other wetlands (10,850 ML).

In addition, the following sites received additional water:

- Lake Bonney (26,000 ML) – through the South Australian River Murray Drought Water Allocation Decision Framework; and
- Lake Alexandrina (170,000 ML) – through the Lower Lakes Environmental Reserve.

Twenty-seven managed wetlands connected to the River Murray at pool level were closed in late 2006 to save water for critical human needs. Six other large wetlands were also blocked for the same purpose. Some of these sites have received environmental water through the South Australian River Murray Drought Water Allocation Decision Framework over the last two years to prevent irreversible damage. However, some sites remain closed and all managed wetlands are not being managed according to their accredited management plans that describe a wetting and drying regime.

Over the past few years, the Lower Lakes reached extremely low water levels and have been managed to prevent the threats of acidification and salinisation. In 2009-10 the Government of South Australia set aside 170,000 ML for the Lower Lakes to keep them above the critical acidification levels.

Environmental water delivery has ensured the maintenance of critical refuge sites along the River Murray for key species. Water was delivered to Boggy Creek (9 ML) and Turvey's Drain (26 ML) to preserve remnant populations of two threatened native fish. The Murray Hardyhead species is listed as nationally vulnerable under the *Environment Protection and Biodiversity Conservation Act, 1999*, whilst Southern Pygmy Perch are listed under the *Fisheries Management Act, 2007*. Monitoring has shown that populations are recruiting; hence the watering has been a success. Narrung wetland also received environmental water in spring 2009, with 250 ML delivered to preserve the seed bank of submerged aquatic plants. Monitoring has determined that there has been a net increase in seed density in the wetland sediments, resulting in the objectives of the watering being achieved.

Lake Limbra and Coombool Swamp at Chowilla received environmental water for the first time since the floods of 2000 and 1996 respectively. Evidence from other watered sites indicates that multiple watering will be required to restore these sites to good health.

Monitoring at sites receiving environmental water has shown important ecological benefits such as improved health of native vegetation and native frog and bird breeding at watered sites. The health of the rest of the river floodplain in general is in decline due to the lack of flooding events.

South Australia recognises that as well as benefits, environmental watering can have some costs, including salinity impacts. Addressing these impacts will require consideration of the issue in a broader context. Water quality needs to be maintained while recognising the river has a key function as a conduit for removing salt from the landscape to the sea. Both the long-term salinity impacts and the short-term salinity impacts will need to be considered. This approach recognises that the BSMS has a broader focus than salinity cost impacts at Morgan and keeping the Salinity Registers in balance. This is reflected in the BSMS objectives, especially:

- maintaining the water quality of shared water resources of the Murray and Darling Rivers for all beneficial uses — agricultural, environmental, urban, industrial and recreational; and
- controlling the rise in salt loads in all tributary rivers of the Murray–Darling Basin, and through that control, protect their water resources and aquatic ecosystems at agreed levels.

In progressing resolution of this issue, South Australia has raised the following points for consideration by MDBA and partner jurisdictions:

- the BSMS accountability framework (the Salinity Registers) has been effective in documenting the relative impact of actions that have a long-term in-river salinity impact, such as those resulting from irrigated agriculture. While they are effective in accounting for long-term salinity impacts, they may not adequately reflect the significance of short-term or “real time” in-river impacts, as the impacts tend to be minimal when modelled as a long-term average;
- whether environmental watering actions are subject to the same “rules” as other actions given the need to undertake intervention actions to improve the health of the system for all users. Environmental watering as an action, if well managed, ultimately can provide a whole-of-system health benefit by enabling salt to be removed from floodplains (thereby protecting ecological assets);
- the short-term impacts may be manageable when in-river flow and salinity conditions allow for dilution; at other times additional water for dilution benefit may be required to protect water quality for all water users, including Critical Human Water Needs; and
- it will be important for there to be effort across programs within the MDBA (e.g. BSMS, River Operations, Environmental Watering Plan and Risks) to ensure the short-term salinity impacts can be predicted, addressed and managed through measures such as provision of additional water for dilution benefit.

South Australia will work with the Basin Salinity Management Advisory Panel, other relevant programs within MDBA and partner jurisdictions to progress dealing with these issues in 2010-11 and beyond. Draft principles for the management of environmental watering events have been developed by South Australia to aid in these discussions. A key point is the need to consider all potential actions collectively and balance the need for environmental watering against prevailing in-river flow and salinity conditions, and availability of water for dilution benefit so as not to result in excessive salinity levels for other users.

2.2.5 Coordinating and Tracking Environmental Watering Actions

To assist in the coordination and management of environmental watering activities, a Management Action Database (MAD) is being established. The MAD will provide a repository for information that supports all the environmental water monitoring and management activities within the River Murray system in South Australia.

At present the software for the MAD has been developed and the first module established. Once fully developed, the database will provide a web-based Geographic Information System (GIS) and tabular interface to allow for the storage, manipulation and querying of geographical layers, environmental water accounting, tracking of wetland and floodplain management activities and to provide a central location for the storage, manipulation and querying of ecological monitoring data.

Further funding is being sourced to continue developing the required modules for the MAD including ecological response monitoring, management logs, water accounting, assessments (including salinity) and reporting capabilities.

2.2.6 Chowilla Floodplain Icon Site

The Chowilla Floodplain Icon Site contains a high diversity of both terrestrial and aquatic habitats, supporting populations of rare, endangered and nationally threatened species, and has many sites of cultural significance. The Chowilla Icon Site Management Plan is currently being implemented by DFW. The plan outlines the operation of the Chowilla Creek environmental regulator and identifies the range of benefits and risks associated with watering the floodplain.

Construction of the environmental regulator commenced in January 2010 and is scheduled for completion in 2012. Once operational, the environmental regulator will enable flooding of up to 50% of the floodplain and ensure the protection of significant areas of Red Gum and Black Box vegetation. However, the Chowilla floodplain is underlain by a shallow, highly saline aquifer, which is a well documented source of saline groundwater discharge into the River Murray.

Approval to construct the regulator does not constitute approval to operate the works. Such approval will be considered following a declaration that the works are effective under Clause 64 of the MDB Agreement. The construction approval also highlighted that significant work remains to fully assess both short and long-term salinity impacts of regulator operation. The MDBA also acknowledged that further effort is required on its part to progress issues relating to salinity and that the further work needs to be conducted as a priority.

Salinity impact assessments completed to date (using the existing Chowilla ModFlow groundwater model) have been independently peer reviewed for the MDBA. The review identified a number of model deficiencies and recommended further model development and assessment. Subsequent evaluation of the model by DFW has confirmed the models calibration and accuracy in predicting groundwater levels and indicates a likely conservative estimate of impact. A long-term salinity impact assessment has been completed and an interim BSMS Salinity Registers entry of 4.6 EC has been identified. Further modelling and model upgrade is required for a formal entry on the BSMS Salinity Registers. DFW is currently working with the MDBA to address this.

In light of the peer review findings and recognition of the need for a full salinity assessment of the potential impact of operation of the Chowilla environmental regulator, in April 2010 South Australia engaged Aquaterra to conduct a further independent assessment of the suitability of the existing Chowilla ModFlow model for calculating real time salinity impacts. Specific tasks included:

- Providing a definition of real time salinity against which the assessment can be made;
- Documenting what the existing model is designed to do, accredited to do and any gaps;
- Assessing the models suitability for real time and long-term impacts; and
- Documenting any changes required to address the gaps and estimated costs.

From this study, the model was validated as a sound predictive tool to estimate real time and long-term salt load impacts downstream of Chowilla Creek, but not (yet) within the Chowilla complex itself. However, it was noted that it is a sound platform on which to build that capability. The model has not been designed to estimate the salinity concentrations within creeks and rivers (real time or long-term), but it can produce outputs that would be suitable as inputs to other methods of estimating in-stream EC. Essentially, the conclusion was that while the model is suitable for use in predicting post flood salt loads, further development would improve confidence in the output. South Australia will pursue opportunities to fund upgrades to the model.

On the basis of these findings, real time salinity assessment work is in progress using the current version of the groundwater model. The focus of this work is to assess real time salinity increases associated with three potential initial operations. The results of this work will be available in 2010-11. It is anticipated that local salinity increases will be between 50 and 100 EC (assuming low flow conditions) under these scenarios. This impact will vary depending on the duration of operation, the rate of drawdown, and the availability of dilution flows. Future work will involve using the findings to develop an environmental regulator operating strategy.

2.2.7 The Coorong, Lower Lakes and Murray Mouth (CLLMM)

The Coorong, Lower Lakes and Murray Mouth (CLLMM) region is one of Australia's largest wetland systems. The region is of international ecological significance and is one of the MDBA's Living Murray Icon sites. The region hosts an economy based on agriculture, fisheries and tourism, and is the traditional country of the Ngarrindjeri nation. Modifications to the flow regime, lack of inflows from the Murray-Darling Basin and rising salinity have degraded the wetlands (see Figure 3 – note the dry lake bed to the right of the photo) and significantly changed the ecological character of the region. Indeed, salinity management is one of the key issues for this region. Until recently, ecological response to these changes and to management interventions was largely unknown.



Figure 3: Aerial view of barrages, June 2009 (photo courtesy of DENR)

CLLAMMecology Research Cluster

To address the lack of knowledge in this region, CSIRO's Water for a Healthy Country National Research Flagship established the Coorong Lower Lakes and Murray Mouth ecology Cluster (CLLAMMecology) in late 2006. It was the region's first comprehensive research program, and one of the first Clusters supported by the National Research Flagship Collaboration Fund, a \$97 million federal government initiative to support collaboration within the national innovation system. The three-year \$5.3 million initiative was tasked with developing better information and tools to support management initiatives to halt and reverse the degradation of the Coorong and Murray Mouth. It brought together researchers from key institutions, including the University of Adelaide, Flinders University, and the South Australian Research and Development Institute (SARDI) Aquatic Sciences.

In what was to become the largest research project examining the response of estuarine species to environmental flows in the region, CLLAMMecology brought together

hydrodynamics, spatial analysis and bird and fish ecology specialists to provide a whole-of-system approach to water management tools for ecological outcomes.

The key outcomes of the Cluster centre on the delivery of ecological knowledge of the region and the development of a comprehensive framework to evaluate the potential outcomes of management interventions on the ecological character of the Coorong and Murray Mouth region. The framework allows managers to evaluate how to best use the available management levers, such as environmental flows and dredging the Murray Mouth, to maximise environmental outcomes. The framework and has been instrumental in the development of “Securing the future: A long-term plan for the Coorong, Lower Lakes and Murray Mouth” under the Murray Futures, Lower Lakes and Coorong Recovery project, as described in the following section.

Securing The Future: A Long-Term Plan for the Coorong, Lower Lakes and Murray Mouth

In response to these issues, the Government of South Australia has prepared a Long-Term Plan for the CLLMM region to provide clear direction for the future management of the site as a healthy, productive and resilient wetland system that maintains its international importance. Achieving this will also directly support the local economy and all its communities. The Lower Lakes and Coorong Recovery is part of the Government of South Australia’s Murray Futures program, funded by the Australian Government's Water for the Future initiative (refer to section 2.4.4 for details of other initiatives under the Murray Futures program).

The Long-Term Plan was developed in consultation with the local community, scientists and technical experts and was publicly released on 4 June 2010. The Department of Environment and Natural Resources (formerly the Department for Environment and Heritage) is currently implementing the proposed management actions within the Plan. The development of the Plan has been supported financially by the Australian Government, through the *Murray Futures* program, as part of its commitment of up to \$200 million to address the problems facing the CLLMM region.

Achievements within the CLLMM region in 2009-10 most relevant to salinity impact management include:

- Release in June of Securing The Future: A Long-Term Plan for the Coorong, Lower Lakes and Murray Mouth;
- Development of a Business Case associated with the Long-Term Plan providing a whole-of-system adaptive management approach to the CLLMM site, seeking up to \$200 million in funding from the Australian Government for Lower Lakes and Coorong Recovery;
- Securing \$21 million funding from the Australian Government to implement early works actions for the CLLMM site, including bioremediation and revegetation, acid sulfate soil management, Lake Albert water level management, Coorong South Lagoon pumping, and lakefront habitat restoration at Meningie;
- 90 GL of water pumped from Lake Alexandrina into Lake Albert as part of the Lake Albert Water Level Management Project - to maintain the lake at -0.5m AHD and prevent widespread acidification (see also section 2.4.1 – Emergency Response Projects);
- Treatment of acidification in Boggy Lake with ultra-fine grained limestone; continuing monitoring of acidification “hot spots” throughout the CLLMM region;

- Continuing extensive research into acid sulfate soil processes and impacts to better understand and manage the acidification risks in the CLLMM region and continuing ecological monitoring of the CLLMM region;
- Coorong South Lagoon pumping project – continuing work to finalise State and Federal approvals and design work including significant engagement with the community to ensure residents are fully informed; and
- Construction of two temporary structures built as an emergency response to prevent the impacts of acid sulfate soils on the Goolwa Channel and its tributaries, regulate the flow of water and raise water levels (refer to section 2.4.1 – Emergency Response Projects).

Murray Mouth Sand Pumping Project

It is well recognised that an open Murray Mouth and adequate river flows are critical to salt export from the Murray-Darling Basin. Dredging of the Murray Mouth continued in 2009-10 in order to keep the Murray Mouth open due to the historically low river flows. The project pumped about one million cubic metres of sand per year and about 1,000 cubic metres of material per day.

Without the continued sand pumping operation, the Murray Mouth would close and likely result in catastrophic failure of the unique ecosystems of the Coorong. Dredging was assessed as the most effective method for keeping the mouth open, in terms of both cost and the environmental criteria, compared with a range of structural and other methods considered.

In November 2009, the Government of South Australia also endorsed continued dredging up until 2014 if required, with funding of up to \$24.5 million being made available through the MDBA. The Murray Mouth has been dredged to prevent closure since October 2002.

South Australian Aquatic Ecosystems Classification Project

DFW provided technical support to the MDBA to develop a classification and regionalisation for aquatic ecosystems in the Murray-Darling Basin and assess whether the MDBA's current register of key environmental assets represents the full range of aquatic habitats in the Basin.

It was found that South Australia was well positioned in terms of aquatic ecosystem classification in the Basin. It is the only State in the Basin which has applied the same classification across both rivers and wetlands; and aggregated wetlands into management units (Floodplain Inundation Response Units).

Vegetation Condition Monitoring

Numerous vegetation condition monitoring projects have been undertaken in the region downstream of Lock 1, in the Lower Lakes, Goolwa Channel and Coorong. For example, the Aquatic and Littoral vegetation monitoring of Goolwa Channel aimed to assess the impact of the major project 'Goolwa Channel Water Level Management Project' on the aquatic and littoral plant communities of the Goolwa weir pool. These results show that higher water levels have resulted in a change from terrestrial species to aquatic species in the Goolwa Channel and continued low water levels in Lake Alexandrina have resulted in colonisation by terrestrial species of the exposed lakebed. Results from this study and the seed bank assessment show that the system is resilient and the aquatic plant community has the capacity to recover when historical water levels are reinstated.

Meanwhile, a literature review on Aquatic and Littoral Vegetation of the Murray River Downstream of Lock 1, the Lower Lakes, Murray Estuary and Coorong provided background information for understanding drivers of the system, key knowledge gaps and the potential recovery of the system when freshwater flows return to contribute towards acid sulphate soil remediation. Findings included that, despite being highly modified, the SA MDB region is important because it is an aquatic system in an otherwise dry environment and contributes to regional and state biodiversity because a completely different suite of species is often present compared to the adjacent highland.

The River Murray downstream of Lock 1, Lower Lakes, Murray Estuary and Coorong has undergone further changes in recent years due to the combination of drought and water abstraction with changes to more salt tolerant fringing species and loss of submergent species and amphibious species.

Nevertheless, the system has showed that it is resilient and currently has capacity for recovery. Water level rises as part of Goolwa Channel Water Level Management Project have resulted in recolonisation of submergents and growth of fringing species in Goolwa Channel. How long the system can remain resilient is unknown.

2.3 SETTING SALINITY TARGETS

The Ministerial Council will adopt end-of-valley targets to protect values and assets while providing for targets to be revised, as new information becomes available. The partner Governments will empower catchment management organisations to advise on end-of valley targets and determine within-valley targets and monitoring arrangements, under salinity and catchment management plans.

(BSMS 2001–2015)

In light of the Water Act, 2007 (Cth) requirements for salinity objectives and targets in the Basin Plan, South Australia has directed effort in 2009-10 to research potential salinity targets for the lower River Murray to complement the existing Basin Salinity Target.

2.3.1 Salinity Targets

The BSMS has focused on managing salinity in reaches and catchments above Morgan, as this is where the Basin Salinity Target is located. However, maintaining salinity levels in the River Murray below Morgan is also important for water supplies for metropolitan Adelaide, towns, irrigation, industry, tourism, the Lower Lakes, Murray Mouth and the Coorong (as reported in the previous section). This has again been highlighted in 2009-10. Although flows have been actively managed as far as possible to provide dilution benefits, salinity levels have increased in the lower River Murray and the Lower Lakes as a result of the overall reduced flows, evaporation and lack of export of salt to sea via the Murray Mouth.

In the 2008-09 report the Independent Audit Group – Salinity recommended:

“that salinity targets below Morgan be developed to protect the significant assets and populations that may be affected by high salinity below Morgan”.

The development of the Basin Plan and the Water Quality and Salinity Management Plan presents a key opportunity to address this recommendation. Setting salinity targets below Morgan will aid in directing management actions that assist in maintaining water quality for critical human needs.

Indeed, within the *Water Act*, the need to provide for water for Critical Human Needs as far as Wellington in South Australia is recognised. Section 86A (Clause 1) states that critical human water needs to be taken into account in developing Basin Plan, having regard to the fact that the Commonwealth and the Basin States have agreed:

- “(a) that critical human water needs are the highest priority water use for communities who are dependent on Basin water resources; and*
- (b) in particular that, to give effect to this priority in the River Murray System, conveyance water will receive first priority from the water available in the system.”*

Conveyance water is defined as (Section 86A, Clause 4):

“water in the River Murray System required to deliver water to meet critical human water needs as far downstream as Wellington in South Australia.”

Within the Act, it is also stated that the MDBA must include salinity objectives and targets in the Basin Plan (*Water Act, 2007* (Cth), Part 2, Division 1, Section 25 (1)(b)). These targets, together with other water quality targets, are part of the mandatory content of the Plan and will be used to monitor the condition of key environmental assets and the health of the Basin system overall. In undertaking this function, the MDBA must have regard to the National Water Quality Management Strategy.

As mentioned in the preceding sections, South Australia is keen for the Basin Plan to include targets for the lower River and Lower Lakes, to protect environmental values.

Water Quality and Salinity Management Plan

In light of the Water Act requirements for salinity objectives and targets in the Basin Plan, South Australia has undertaken some preliminary analysis for water quality and salinity targets in South Australia. This was undertaken as part of a Review of Water Quality and Salinity for the River Murray in South Australia. A consultant was engaged (John Cugley Environmental) to prepare a report covering:

- causes of water quality degradation and trends;
- key water quality and salinity concerns including risks;
- potential water quality targets and objectives for the River Murray in South Australia; and
- knowledge and data gaps.

The findings of this analysis were provided to MDBA in January 2010 as information of interest to the MDBA in developing their Basin Plan.

The main water quality and salinity concerns identified include:

- salinity impacts on the aquatic ecosystems in the Lower Lakes and the Coorong, on drinking water supplies and water used for agriculture (irrigation and stock watering), as well as increased costs to households and industry;
- the predicted increased frequency of severe drought inflows, and the predicted reduced end-of-system flows compared with historical climate conditions for median and dry extreme 2030 climates - water quality impacts are likely to be severe;
- the impact of falling water levels and exposure of acid sulfate soils with generation of acidity and release of contaminants from sediments;
- impacts from nutrients released from major river stratification events during periods of low flow and when disconnected wetlands are reconnected to the main river channel;
- the risk of cyanobacterial blooms to drinking water supplies, recreational and agricultural uses; and
- high turbidity and the impact on water treatment costs and risks posed by poor water clarity on recreational use of the river.

Arising from these concerns, the following specific objectives emerged:

- maintain flows in the River Murray such that the Murray Mouth is permanently opened to the sea and that the water level in the Lower Lakes does not drop below sea-level;
- water quality entering South Australia must meet National Water Quality Management Strategy criteria to ensure that environmental values are protected;
- return the Coorong Ramsar site, to conditions that support a diverse and healthy range of estuarine, marine and hyper-marine ecological communities;

- achieve and maintain a healthy and diverse freshwater aquatic ecosystem in the river and Lower Lakes;
- no significant cyanobacterial blooms of public health concern;
- river water quality must be acceptable as a raw drinking water source for drinking water supplies; and
- water quality in the river and the Lower Lakes must be suitable for agricultural uses (irrigation and livestock).

The findings of the report relating to the setting of targets suggested that:

- the existing Basin Salinity Target at Morgan of 800EC should be retained as part of the Basin Salinity Management Strategy accountability framework;
- new operational salinity targets should be specified including:
 - a target of less than 400 EC for 99.7% of the time at the South Australian border to ensure that environmental values downstream are protected;
 - targets of less than 900 EC for 99.7% of the time at Murray Bridge and Wellington (this reflects the Australian Drinking Water Guidelines that state that total Dissolved Solids (TDS) should not exceed 500 mg/L which equates to between 800 and 900 EC depending on the conversion factor applied);
 - a target of less than 1,000 EC for 95% of the time, with an upper limit of less than 1,500 EC for 99.7% of the time, should be specified in Lake Alexandrina to protect agriculture and aquatic ecosystems. (The upper limit of 1,500 EC in Lake Alexandrina equates to a salinity of about 1,800 EC in Lake Albert). (Refer to the following section on salinity targets for Coorong and Lower Lakes for more information).

South Australia is currently undertaking further work to explore the achievability of these targets under different river operating scenarios and will use this information to assist in providing input to the Water Quality and Salinity Management Plan (Basin Plan) during the Basin Plan consultation phase. However, the key message is that targets for the lower River and Lower Lakes will be a desirable component of the plan, in that they would assist in directing management actions to maintaining salinities within acceptable levels.

In the review report, it was noted that a primary cause of water quality degradation is inadequate river flow. This is especially relevant to the lower reaches of the River Murray below Morgan. Ensuring adequate flow will assist in ensuring that levels of nutrients and toxicants are kept low, as well as assisting in managing salinity. In identifying conveyance water requirements and setting sustainable diversion limits, regard needs to be given to the need to better manage salinity and water quality below Morgan and ensure that any targets set are achievable under likely flow scenarios.

Salinity Targets for the Coorong and Lower Lakes

Research during the CLLAMMecology Research Cluster resulted in the development of an ecosystem state model for the Coorong that is able to predict the species and assemblages (including birds, fish, benthic invertebrates and aquatic plants) present in the Coorong under a variety of water availability scenarios (Lester and Fairweather, 2009; Lester et al., 2009). This has since been used to identify environmental conditions in the Coorong that are associated with ecological degradation, such as has occurred in recent years (Fairweather and Lester in press).

The ecosystem states model identified very close linkages between very high annual salinities in the South Lagoon and degraded ecosystem states. A threshold of 117 g L^{-1} for the South Lagoon was associated with the appearance of degraded ecosystem states in upcoming years (Fairweather and Lester in press). Other, non-salinity thresholds were also important in predicting upcoming ecological degradation, including barrage flows and water depths. (Fairweather and Lester in press). However, it should be noted that the level of degradation associated with degraded ecosystem states, and the salinity threshold, in particular, are both quite high. This means that ecological degradation is likely to already be occurring as these thresholds are approached. Therefore, a cautious approach is recommended with respect to these thresholds and that they be set as absolute maxima, rather than management targets.

Following the development of these thresholds, substantial research effort has been invested developing a salinity target for Lake Alexandrina. There were several intentions for this. These included allowing for salt export from the Basin, maintaining the Ramsar-listed ecological character of Lake Alexandrina itself, but also Lake Albert and the Coorong, and to keep the Murray Mouth open. Owing to the hydrology of the Lakes and Coorong, meeting a salinity target for Lake Alexandrina is likely to address these other issues as well (Heneker, 2009). Targets of 700, 1,000 and 1,500 EC were investigated. The target of 1,500 EC was insufficient to maintain the ecological character of the Coorong during dry periods and was likely to result in sub-lethal impacts of salinity on Lake Albert biota. Therefore, recommendations were made to maintain a maximum salinity of 1,000 EC in 95% of years, never exceeding 1,500 EC in Lake Alexandrina (and with the caveat that the 5% of years where the target was exceeded were not sequential), but that average annual salinity of 700 EC should be the target in most years, as this is the long-term average for Lake Alexandrina, and is most likely to support the regions ecological character.

Modelling showed that meeting the targets set for Lake Alexandrina (i.e. the long-term average of 700 EC with a maximum of 1,000 EC in 95% of years) was sufficient to also meet the salinity target of a maximum of 117 g L^{-1} in the South Lagoon of the Coorong, suggesting that these targets are compatible (Lester et al., 2010).

2.4 MANAGING TRADE-OFFS WITH THE AVAILABLE WITHIN VALLEY OPTIONS

The States will analyse and review the best mix of land management, engineering, river flow, and living with salt options to achieve salinity targets while meeting other catchment health targets and social and economic needs. The States will assist communities to understand and agree the options with affected groups, industries and people through best practice planning processes.
(BSMS 2001-2015)

The Government of South Australia is working with local communities and scientists, technical experts and engineers to:

- *address immediate drought response issues;*
- *plan for worst-case scenarios; and*
- *develop long-term sustainable solutions.*

2.4.1 Emergency Response Projects

As mentioned elsewhere in this report, the combined effects of the prolonged drought together with past management practices throughout the Murray-Darling Basin have resulted in water levels in the River Murray and Lower Lakes falling to critically low levels (see Figure 4).



Figure 4: Low water levels at Goolwa, June 2009 (photo courtesy of DENR)

If the situation returns and it is not possible to increase the flow of freshwater entering the Lower Lakes, salinities will continue to increase. Perhaps of more significance, acid sulfate soils and acidic water may cause serious damage to the Lower Lakes' ecosystem.

A number of agencies within the Government of South Australia have been working to address immediate drought response issues and plan for worst-case scenarios. Projects are dealing with the urgent issues of low water levels; reduced flows, rising salinities and acidification of exposed soils and waters.

The implementation of these projects will be dependent on flow of water entering the Lower Lakes. The projects may be unnecessary if flows increase and are sustained over the long-term. However, South Australia prefers to take a precautionary approach and address every realistic possibility.

Environmental Impact Statements (EIS) are a requirement of the *Environment Protection and Biodiversity Conservation Act, 1999 (EPBC Act)* where projects which have the potential to impact on areas of National Environmental Significance. Accordingly, the Government of South Australia is undertaking Environmental Impact Statements for four proposals that are being considered as part of its emergency management response strategy. These are as follows.

Temporary Weir near Pomanda Island

The Lower Lakes' levels have dropped well below sea level and soils that have been under water for centuries have now been exposed. This can cause acidification, resulting in ecological damage and rendering the water unsuitable for any purpose. The movement of acidic water upstream, as well as increased salinity in the Lower Lakes, caused by low river flows could put drinking water supplies at risk.

Construction of a temporary weir near Pomanda Island (below Wellington) is being considered by the Government of South Australia to protect water supplies. A temporary weir would secure the fresh water between Wellington and Blanchetown and protect the quality and volume of water at the main pump off-takes below Lock 1 by creating a physical barrier between the Lakes and the main river channel. A temporary weir remains a last resort, emergency measure to ensure that drinking water is protected for 1.2 million South Australians who receive supply from below Lock 1.

Proposal to allow sea water into the Lower Lakes

In November 2008, the Murray-Darling Basin Ministerial Council agreed on a management strategy to prevent acidification in the Lower Lakes. This included agreement to lodge a referral to the Australian Government to introduce seawater into the Lower Lakes if water levels were to continue to decline and there are no other options to prevent acidification. Allowing a minimal amount of seawater to enter the Lower Lakes will only be considered if water quality and water levels decline to a critical level where the lakes would turn acidic and if other measures to find a solution are not adequate.

Before a decision can be made to introduce sea water in to the Lower Lakes approval from the Australian Minister for the Environment, Heritage and the Arts is needed under the *EPBC Act*. Although the intent is to maintain freshwater in the Lower Lakes, if water levels and water quality drop below a critical point and acidification is imminent then allowing seawater into the Lower Lakes will need to be considered.

This would not involve flooding the Lower Lakes with seawater, but allowing just enough water through the barrages to maintain the level of Lake Alexandrina above the trigger level of 1.5 metres below sea level. As directed by the Murray-Darling Ministerial Council, the Government of South Australia has lodged a referral with the Australian Minister for the Environment, Heritage and the Arts to open the barrage network if necessary. Approval must be gained under the *Environment Protection and Biodiversity Conservation Act, 1999*.

An extensive modeling effort was undertaken to inform the Government of South Australia of the potential impacts of letting seawater into Lake Alexandrina. The goal was to answer questions about the feasibility of such an endeavour and to assess the water quality and water level impact. Modeling included:

- an assessment of the barrages condition and feasibility to let seawater in at the required rates;
- an assessment of impacts of the seawater option and other potential options on the water level and water quality in Lakes Albert and Alexandrina and the Coorong.;
- impact assessment of morphology around the Murray Mouth under the seawater option; and
- timeframes for refilling the lakes during a natural recovery of River Murray flows.

The hydrodynamic and water quality modeling effort incorporated research results from the acid sulfate soil research effort in the Lower Lakes area, completed in 2010.

The final report of these results is in preparation and will inform an initial ecological risk assessment for the area, under the different acidification mitigation options. Initial results indicate that the barrages system can effectively deliver seawater to Lake Alexandrina at the required rates, with minimal impact on the morphology of the Murray Mouth (compared to current). It also indicates that broad scale acidification is likely to occur if Lake Alexandrina is allowed to naturally draw down below a critical trigger level, but can effectively be avoided if fresh or seawater are introduced before this level is reached. Seawater introduction appears to have additional effects on water quality, with seasonal spikes in acidification events and the release of metals.

Goolwa Channel temporary flow regulators

As an emergency response to prevent the impacts of acid sulfate soils on the Goolwa Channel and its tributaries, the Government of South Australia has built two temporary structures to regulate the flow of water and raise water levels. These are:

- a temporary flow regulator in the Goolwa Channel (completed in early August 2009, see Figure 5); and
- a temporary low-level flow regulator at the mouth of Currency Creek (completed in September 2009).

They are temporary structures and will be removed once freshwater flows improve and the Lower Lakes recover. The temporary flow regulators have already proven successful in providing a freshwater refuge for native plants and animals, with sightings of the vulnerable Southern Bell Frog in Clayton Bay. Construction of a third temporary low-level flow regulator at the Mouth of the Finniss River has been deferred.



Figure 5: Temporary regulator at Clayton, October 2009

Proposal to pump hypersaline water out of the South Lagoon of the Coorong

At June 2010, salinity in the South Lagoon was five times that of seawater. A referral has been submitted to the Australian Government under the EPBC Act for a proposal to pump hypersaline water out of the South Lagoon of the Coorong in to the sea. Reducing salinity in the South Lagoon could improve the habitat for such bird species as sharp-tailed sandpipers and Caspian terns, important vegetation such as *Ruppia*, and restore fish populations in the Coorong. Assessments have shown that this project is feasible, and detailed designs and construction drawings are nearing completion. Current plans indicate that if all approvals are given, on ground works would start in November 2010 and pumping would begin in autumn 2011. Access to the beach would be maintained throughout the project.

Virtual weir

South Australia investigated the “virtual weir” concept as part of the draft EIS on the proposed temporary weir. Some key further work has been undertaken by MDBA, building on those studies initiated by the Government of South Australia. The study focussed on operating a Virtual Weir downstream of Lock 1, utilising freshwater flow from upstream to prevent the backflow of salt from the Lakes reaching urban supply off-takes.

Modelling for the virtual weir demonstrates that flows leaving the river and entering the lakes produce a natural fresh water plume (see Figure 6). If this plume extends far enough it acts as a virtual barrier or weir, with only fresh water pushed upstream during back-flow events. The study revealed that to achieve a virtual weir, there needs to be sufficient River Murray flow to maintain a buffer of fresh water in the Pomanda Embayment. Modelling indicates at least an additional 1-2 GL per day is needed past Wellington (during the high risk periods) to enable a virtual weir to work.

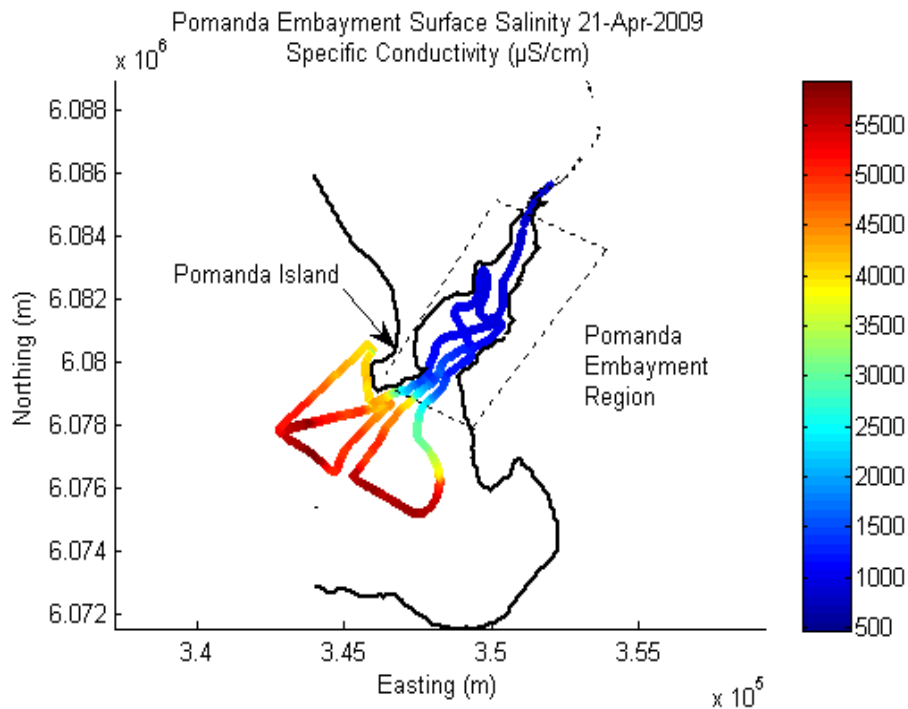


Figure 6: Mapped extent of fresh water plume entering Lake Alexandrina from River Murray

The study also considered saline wedges in the river channel (wind induced wave seiches that create back-flow events that push saline water from Lake Alexandrina into the river channel, which settles on the bottom). These are represented by red areas in Figure 7 (Pomanda Island is at left of image travelling upstream to Swanport Bridge at right of image). This ‘salt wedge’ remains in the channel and can move upstream unless conditions occur to flush the salt back into the Lake. Monitoring has confirmed that back-flow events with elevated salinity levels on the bed of the river have occurred as far upstream as Monteith (just downstream of Murray Bridge). Modelling has shown that salinity levels at Taillem Bend Pump Stations may exceed 1,400 EC for extended periods of time in the future (assuming continued low flows and increasing lake salinity).

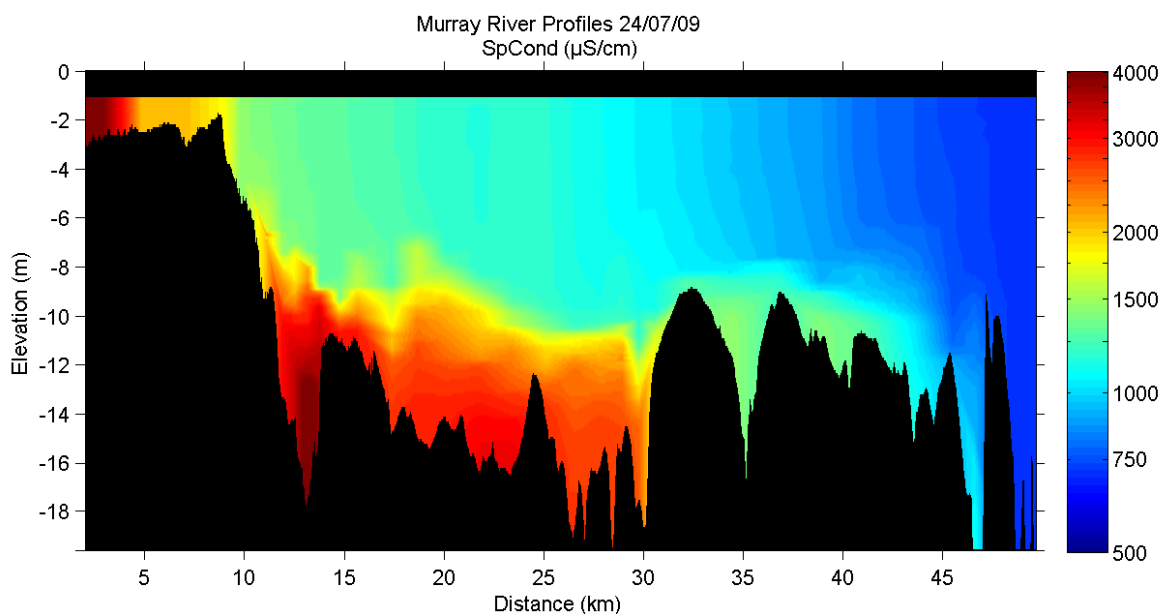


Figure 7: Saline intrusion from Lake Alexandrina into the Lower River Murray, July 2009

During the period May-September 2009 the total salt loading in the stretch of river between Lake Alexandrina and Tailem Bend doubled as a result of numerous back flow events¹ (see Figure 8).

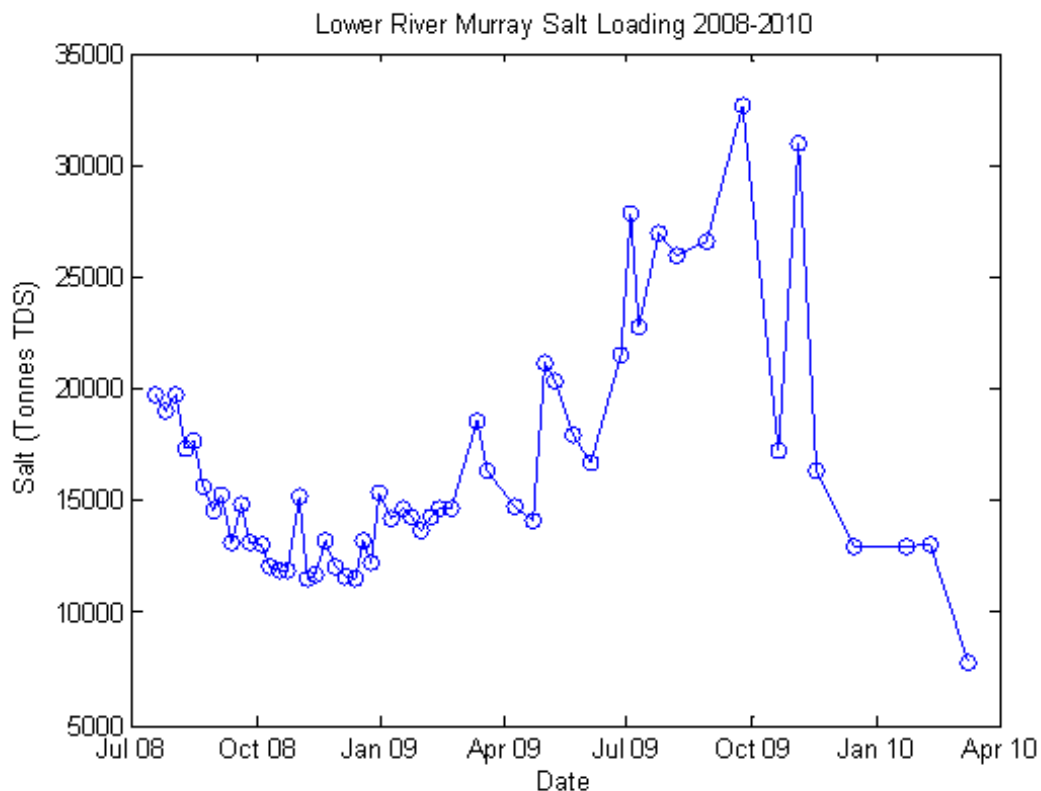


Figure 8: Total salt in the lower River Murray between Woods Point and Lake Alexandrina

The largest observed saline layer filled the river bottom to a level of approximately -8.5 m AHD and extended up stream to 104km AMTD. During this low flow period, the basin between Wellington and Tailem Bend (10km – 32km) was filled with saline water such that it began to spill over the upstream sill and flow further upstream. Figure 8 shows the maximum extent with the leading edge adjacent to the town of Monteith.

Since the flow in the river was low, and the salt extended 45km upstream, the flushing rate was insufficient to quickly remove the salt mixed into the surface layer. As a consequence of this the salinity in the surface layer showed an increasing trend. A series of wind events served to mix existing saline layers to the surface while simultaneously causing new ones to form. This combined with the low flushing rate caused a “ratcheting up” of salinity levels in the surface layer. Near Tailem Bend salinity increased to levels approaching Australian drinking water guideline limits for palatability because of this effect.

The increase in salinity during November was due to a two week “heat wave” that caused the temperature of the lake to increase relative to the river. This offsets the density gain caused by higher salinity and allowed the salty water to float upstream over the top of cooler river water. This heat wave effect has been observed on other occasions during long periods of 40°C weather. In this instance the leading edge of the salt plume extended beyond Tailem Bend,

¹ Estimated from salinity profiles at 20 sites, source Rob Daly, SA Water.

visible in Figure 9 as the lighter blue region travelling from Lake Alexandrina at the left of image into the Lower River Murray at right.

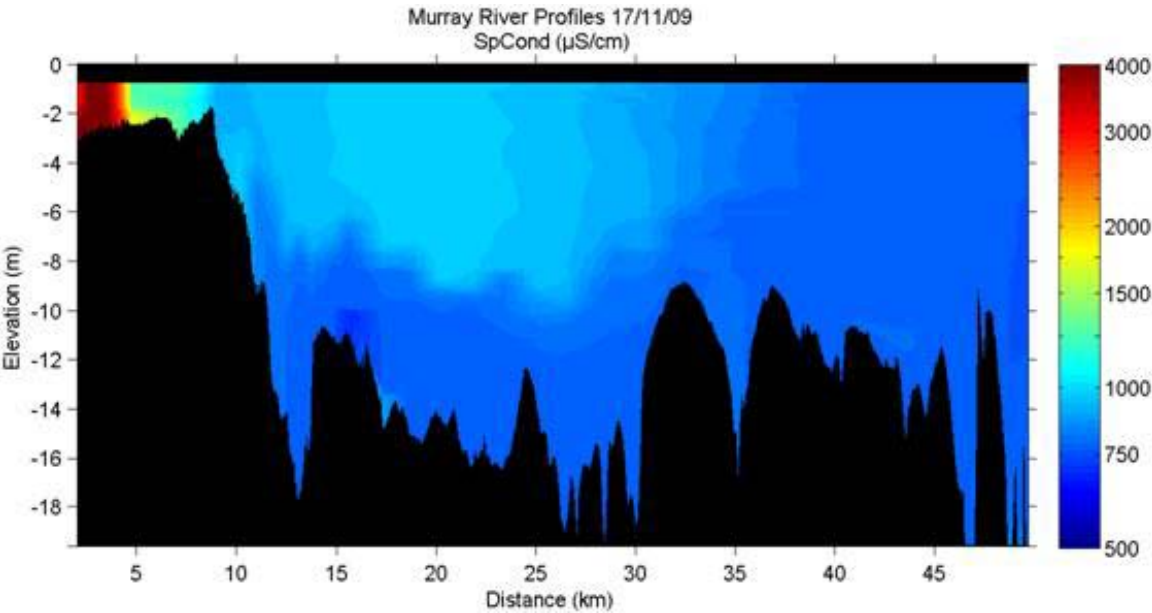


Figure 9: Saline plume from Lake Alexandrina into the Lower River Murray, November 2009

From this study, South Australia concluded the results have shown that the introduction of seawater to the Lower Lakes under the current low flow conditions would require a physical barrier at Wellington to prevent an unacceptable risk to urban water supply off-takes at Tailem Bend and Murray Bridge. For the conditions and mitigation measures modelled in the MDBA study (low inflows, no sea water), a virtual weir at Tailem Bend may be possible. An extensive process was run that examined the potential to maintain a Virtual Weir at Tailem Bend, which would utilise freshwater flows from upstream to prevent the movement of salt water from Lake Alexandrina to urban water supply off-takes.

While the model performs reasonably well in simulating the hydrodynamic behaviour of the lower River Murray and Lake Alexandrina, because it is being applied beyond its range of calibration and validation, sources of uncertainty are introduced. The conclusions are specific to the circumstances modelled and hence do not consider other associated impacts from continued low flows such as bank slumping.

Emergency interventions in Lower Lakes to address acidification

As well as the Goolwa Channel temporary flow regulators referred to in the preceding sections, other emergency interventions have been implemented in the Lower Lakes in order to protect the remaining ecological character of the site. This has included aerial seeding of 6,000 hectares of exposed lakebed and on-ground planting of more than 1.1 million plants (see Figure 10). This will generate vegetation cover which will reduce wind erosion, incorporate organic carbon into the soil and counter acidification. In addition, ultra fine limestone was placed across the mouth of Currency Creek and at locations in the lower Finniss River to neutralise acidifying water bodies (see Figure 11).



Figure 10: Lake Albert revegetation trial, January-February 2009 (photo courtesy of DENR)



Figure 11: Ultra fine limestone placed across the mouth of Currency Creek, July 2009 (photo courtesy of DENR)

Levee Bank Cracking Investigation Project

The project investigated issues required for more effectively managing the levee bank cracking (see Figure 12) caused by the current drought, such as length and location of levee bank system, connection of levee banks to the River Murray (elevation metres AHD), potential sites of cracking and soil absorbing capacity of floodplain soils.

This information will assist in the development of a remediation plan for both the Government of South Australia owned and private levee banks. This will assist in ensuring that flooding of the adjacent floodplains is prevented which if occurred would lead to a loss of primary production. It will also ensure that water remains in the River Murray channel and is used for dilution flow/ecological purposes.



Figure 12: Levee bank cracking, Lower Murray, South Australia 2009

Riverbank Collapse

A major program has been implemented since February 2009 to manage riverbank collapse in the River Murray below Lock 1. Unprecedented low river water levels between 2008 and early 2010 below Lock 1 have created river bank collapse and slumping. The program is focusing on managing the risk and minimizing the impact on the community.

During 2009 Riverbank Collapse was classified as a State Hazard. DFW was identified as the Hazard Leader and responsible for coordinating a hazard management program. A Riverbank Collapse Hazard Plan was also developed to identify relevant roles and responsibilities within in a framework of mitigation, prevention, preparedness, response and recovery activities.

A Communications Plan has been prepared to provide information to the public. This includes the establishment of a 24-hour, seven days a week, hotline number (1800 751970), for the public to report incidents, and to also receive information about Riverbank Collapse Hazard. A Safe Work Guide has also been developed and distributed to a range of stakeholders and groups. Training has been delivered to several agencies, including Councils, Police and the emergency services.

In 2010 there have been 6 reports of bank collapse, 17 reports of bank/road cracking and 22 reports of tree related hazards due to riverbank instability. A further 30 hotline calls have been received requesting further information on riverbank collapse. A total of 127 reports (35 collapses, 56 cracking and 36 tree related) have been received since February 2009.

The Riverbank Collapse Hazard Program is working closely with the DFW’s Development Planning Group and other agencies managing Development Approvals under the *River Murray Act, 2003*, considering appropriate development and safe working procedures. The main challenges ahead will focus on accurate and timely communication to the general public about incidents, mitigation and risk management at a time when water levels and conditions may be dynamic.

Figure 13 shows a case of riverbank collapse at Fred’s Landing (note that trees underwater in foreground previously denoted the edge of the bank); Figure 14 shows another example of riverland collapse at Murray Bridge (three cars were lost in this event).



Figure 13: Riverbank collapse at Fred’s Landing near Tailern Bend



Figure 14: Riverbank collapse at Long Island Marina, Murray Bridge

2.4.2 Reuse of Salt Interception Scheme Water

An Information Memorandum seeking expressions of interest (EOI) to access and use saline water from the Woolpunda Salt Interception Scheme (SIS) for commercial use was released on 15 February 2010 through advertisements in *The Australian* and *The Advertiser* and by way of direct contact with those who had expressed an interest in utilising the SIS water in the past.

Applicants were required to submit an initial EOI by March 2010. An Assessment Panel with relevant technical expertise was convened to consider the EOIs. Enquiries were received with interests in aquaculture, desalination and electricity production. Only one EOI was submitted by the due date, but was formally withdrawn on 1 April 2010.

The EOI process is now closed however the South Australian Government has agreed that the opportunity to access the SIS water will remain open. The MDBA, who currently receive enquiries about the use of SIS water from across the Basin, will be the first point of contact for any future enquiries related to the use of SIS water. The MDBA will maintain close contact with relevant Government of South Australia agencies in relation to such enquiries.

2.4.3 South Australian Weir Pool Manipulation Program

No weir manipulation events were undertaken during 2009-10 due to the continuing low flow and drought conditions across the MDB system. The continuing drought conditions meant that the significant ongoing drawdown of the weir pool below Lock 1 continued.

A South Australian River Murray Weir Operating Strategy has been developed to guide the implementation of weir pool manipulation events aimed at maximising potential ecological outcomes within the existing constraints. Opportunities to implement elements of this strategy will be pursued when conditions improve.

Work undertaken within the Weir Pool Manipulation program up to 2009 has been reviewed and summarised within the South Australian Weir Pool Manipulation Compilation Report (Aquaterra, 2009). This report includes summaries of work assessing the potential salinity impacts of weir pool manipulation.

A project undertaken during 2009-10 sought to identify potential “worst case” salinity impacts of weir pool raising within each South Australian River reach. A range of modelling methods and platforms were used including the South Australian ModFlow groundwater models and the Floodplain Inundation Model (FIM). The project also included use of the SWET model to determine water use associated with the weir pool raising scenarios. To complement these models, the consultants Aquaterra, have further developed tools including a Salt load calculator and EC converter to help process the modelled results and quantify the ranges of impacts due to weir pool manipulation.

In summary, the model outputs for the identified weir pool manipulation scenarios exhibit salt load peaks that can be initially large, but dramatically reduce in size usually within a month after the return to pool level has taken place. Reaches also exhibit a reduced salt load during the initial weir raising period due to the suppression of groundwater inflows.

The current South Australian groundwater models were initially designed to predict long term salt load impacts to the River Murray due to irrigation development and dryland clearing. They have been calibrated to historical hydrographs and measured Run-of-River data using the

MDBC Modelling Guidelines. However, other than the Chowilla model, floodplain processes have not been incorporated and thus the models are not calibrated to a flooding response.

The Aquaterra project highlighted the limitations of the existing models given that they were initially designed to predict long term salt load impacts due to irrigation development and dryland clearing and thus floodplain processes have not been incorporated. As a result the models are not calibrated to a flooding response and do not incorporate near bank salinity information or hydraulic model data. The models therefore have their limitations when used to investigate impacts on the River due to weir pool manipulations. These findings were echoed in the other work Aquaterra completed for South Australia on floodplain salinity impacts.

Given these and other limitations the report stresses that the results should be regarded as “preliminary” (Aquaterra, 2010) and substantially more work is required for greater accuracy. Consideration is being given to improving the confidence in the modelled outputs provided by Aquaterra through the use of Nanotem data to determine more reliable estimates of near river groundwater salinities for incorporation into the model.

2.4.4 Water for the Future

At the 3 July 2008 meeting of the Council of Australian Governments (COAG), Basin States signed an Inter-Governmental Agreement (IGA) on Murray-Darling Basin Reform that established new governance arrangements for the Basin.

The IGA also provides for Commonwealth/State Water Management Partnership arrangements whereby the Australian Government has agreed, in principle, to make available some \$3.8 billion in Water for the Future funds for priority projects in Basin States.

The IGA includes \$530 million for South Australia’s priority project, Murray Futures – an integrated package to sustain, support and reinvigorate communities and industries within the Murray-Darling Basin in South Australia. A further \$80 million has been made available for the purchase of water entitlements from willing sellers, with water to be held by the Commonwealth Environmental Water Holder (CEWH).

Murray Futures

Funded by the Australian Government’s Water for the Future program and a key component of the Government of South Australia’s Water for Good plan, the Murray Futures program aims to secure future water supplies, renew irrigation industries and communities and secure improvements to the river's health by providing flexibility in how the system is managed in the future.

The 10-year \$610 million Murray Futures program includes:

- \$120M Lower Lakes Pipelines to secure a quality water supply to the townships, communities and irrigators who draw water from the Lower Lakes.
- \$200M Lower Lakes and Coorong Recovery to undertake a series of medium to long-term projects around the Lower Lakes and Coorong to help protect this valuable Ramsar site and to sustain the communities reliant on it. This is detailed further in section 2.2.7 (“Securing the Future: A Long-Term Plan for the Coorong, Lower Lakes and Murray Mouth”).
- \$110M River Industry Renewal to encourage more efficient irrigation communities through the uptake of newer and smarter irrigation technology funded by the Private Irrigation Infrastructure Program managed by the Australian Government. From the South Australian

border to the Murray Mouth, communities all along the river are benefiting from the Government's support over the next 10 years, to help ensure their industries remain sustainable in a future challenged by increased climate variability and reduced water availability.

- \$100M Riverine Recovery to improve management of river wetlands and floodplains from the South Australian border to Wellington. The project aims include achieving measurable long-term improvements in the health of the riverine environment between Wellington and the South Australian border. A key outcome is contributing to establishment of a New Functional River that can be scaled according to the volume of water available. When water is scarce, the river will be scaled down whilst protecting critical elements of the ecosystem (for example, maintaining high value refuge areas); as more water becomes available, the river system will be scaled up and managed to rebuild resilience in the system. The Riverine Recovery Project will position South Australia to effectively implement the Basin Plan, in partnership with the MDBA and build on the Living Murray First Step Decision, to maximise environmental outcomes. Refer to Appendix A for the list of reports delivered under the Riverine Recovery Project to date.
- \$80M Water Buy Back to purchase water entitlements from willing sellers, with water to be held by the Commonwealth Environmental Water Holder.

2.5 IMPLEMENTING SALINITY AND CATCHMENT MANAGEMENT PLANS

This Strategy acknowledges gains made by existing plans, but requires that actions in existing and new plans, or the plans themselves, will need to be assessed and reported against the end of-valley and Basin targets and recorded on Salinity Registers.

The partner Governments will continue and enhance support for land and water management plans (LWMPs) in irrigation regions.

The partner Governments will enhance support for development and implementation of ICM Policy-compliant salinity and catchment management plans in dryland regions.

(BSMS, 2001-2015)

The significance of River Murray salinity as an issue for South Australia is reflected in it being recognised through key State level strategies and plans. The aim is to facilitate management action within the State that contributes to improved salinity outcomes locally and thus assists in meeting BSMS objectives.

2.5.1 State Plans and Strategies

South Australia's Strategic Plan

River Murray salinity management is recognised as a high level State objective within South Australia's Strategic Plan (SASP). The plan includes a specific salinity target (Target (T3.11): River Murray Salinity – South Australia maintains a positive balance on the Murray-Darling Basin Authority's Salinity Register).

An implementation plan and fact sheet for this target were released in 2007-08. The graph from this fact sheet is updated annually to reflect updates to South Australia's balance on the Salinity Registers and project the State's salinity credit balance over time. Due to the delayed salinity impacts of past actions, South Australia's balance is predicted to ultimately reach zero. The graph provides forward estimate of the timeframe for that to occur; this informs future policy directions and guides further investment and management actions to delay this. Reporting of progress against this target occurs in April and October each year and must be based on published data (as the graph and fact sheet become public information).

The graph from this fact sheet was last updated in 2008-09 to reflect the approved 2008 Salinity Register. Since the November 2009 BSMS Salinity Registers had not been approved by Ministerial Council in April 2010, South Australia has not yet updated the graph on the published fact sheet. However, the updated graph has been drafted to reflect the November 2009 data and is included in this report at Figure 15. The graph will be included in an updated SASP fact sheet for the October 2010 reporting period.

The Premier of South Australia launched the 2010 SASP update on 28 July. The Government of South Australia has committed to an extensive community and stakeholder engagement program for the update, to ensure the vision embodied in the Plan remains current and shared

by all South Australians. A key difference from the 2006 update will be the much stronger initial focus on developing consensus around medium term (thematic) aspirations for the state in 2020 and beyond. This will be the focus of a series of regional and metropolitan community forums scheduled for August-September 2010 and is expected to lead to a different “look and feel” for the Plan and generate even stronger community engagement and ownership.

The more concentrated focus on the content of particular Plan targets will take place with selected stakeholders later in the update process. This will start in the final quarter of 2010 after the state budget. Input from community members and stakeholders will be combined into a report from the Community Engagement Board to the State Government early in 2011. This input will be considered alongside advice from agencies for the purpose of preparing a revised Plan, which will be considered by State Government.

The DFW Salinity Program have provided consistent advice to those updating the Plan regarding the need to continue to recognise salinity within the Plan. DFW is of the view that South Australia needs to continue to recognise River Murray salinity as a priority issue in its own right within high level State plans like SASP to facilitate ongoing investment in management actions. In implementing SASP, the BSMS Salinity Registers provide an existing framework for quantifying long-term salinity impacts, thereby supporting ongoing SASP salinity target reporting.

For more information about SASP, please refer to: <http://www.saplan.org.au/>

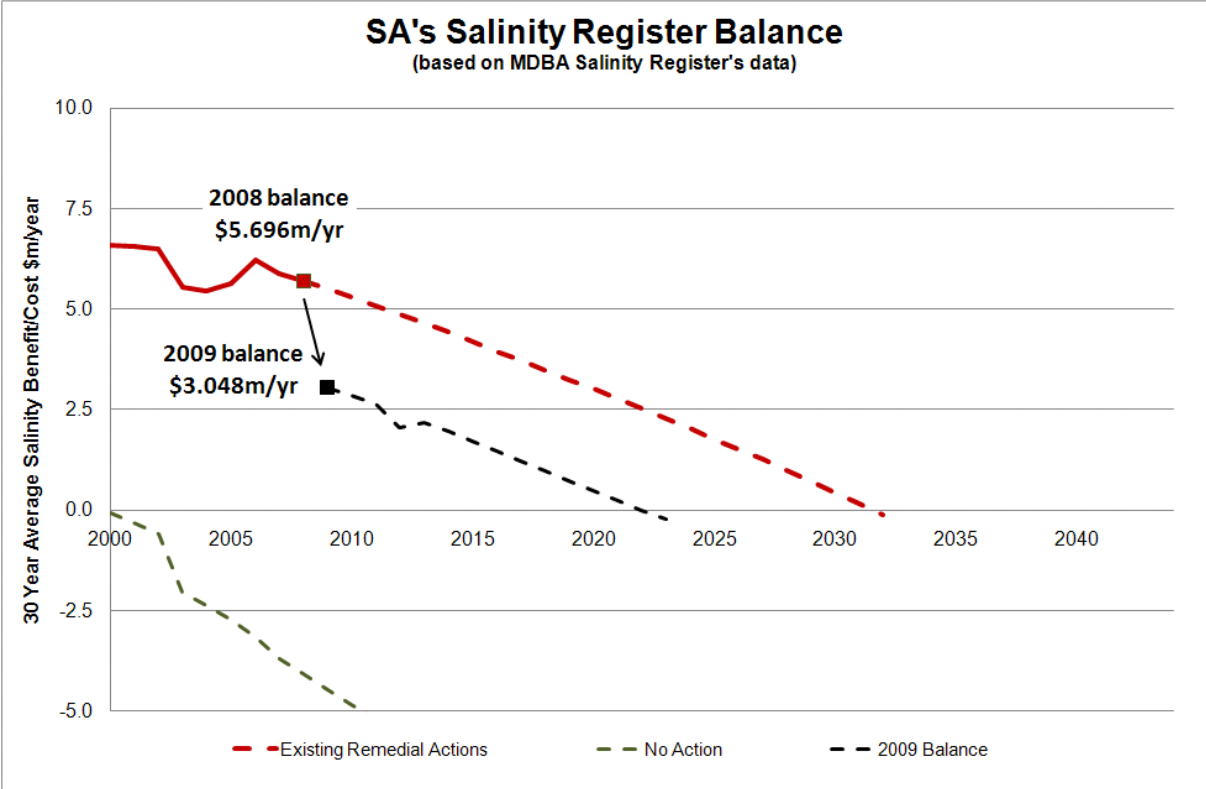


Figure 15: Graph of South Australia’s salinity register balance

Water for Good

South Australia has also adopted the essence of the objective to remain in credit on the BSMS Salinity Registers within a key State level strategy, Water for Good.

As mentioned elsewhere in this document, the relevant Water for Good Strategy (Action 56) is to “Maintain a positive balance on the Murray-Darling Basin Authority’s Salinity Register, and continue to implement strategies and actions to ensure the real time management of salinity in the lower reaches of the River Murray so that water quality remains at levels suitable for human consumption”.

South Australia reports quarterly in terms of progress against this action.

South Australian River Murray Salinity Strategy

The fifteen-year vision of this Strategy is to maintain salinity in the River Murray in South Australia at current levels (i.e. when the Strategy commenced in 2001). The long-term vision is to reverse the trend and restore a sustainable balance to ensure economic, social and environmental well being of current and future generations of South Australians.

As reported in 2008-09, the Strategy is now somewhat dated. It has been identified that the Strategy will need to be revised and updated to reflect current and future salinity management priorities. It is intended that this will occur when the Water Quality and Salinity Management Plan of the Basin Plan has been finalised, to ensure that the Strategy is aligned with that Plan.

2.5.2 Regional Plans and Strategies

Water Allocation Plan for the River Murray Prescribed Watercourse

The South Australian Murray-Darling Basin Natural Resources Management Board (SA MDB NRM Board), in accordance with the *Natural Resources Management Act, 2004*, is responsible for developing Water Allocation Plans for the SA MDB region in partnership with DFW. A concept statement has been prepared which outlines the proposed content of the plan and the relevant consultation required. A Community Advisory committee has also been established to assist formulating the WAP with members drawn from the local community including industry.

The existing WAP includes principles directed at protecting the River from adverse salinity impacts of water use. Principles 19 and 20 of the WAP allow the use of water for irrigation in the River Murray Irrigation Management Zone notwithstanding that such use may detrimentally affect the quality of water in the River by increasing salinity, provided:

“the increase in salinity is offset by an agreement, undertaking or obligation for works, actions or practices to prevent increases in salinity (including drainage management infrastructure, salinity mitigation infrastructure or revegetation to control irrigation recharge)”.

To give effect to this, within the WAP it is also stated that:

“Water shall only be transferred for irrigation where the use of that water will be required to achieve a water use efficiency of no less than 85%”

It will be important for salinity management provisions to be retained within the new WAP.

A cross agency project is currently underway to develop a detailed systems understanding of the environmental watering requirements of the ecological assets of the River Murray. It will also examine the best way to provide for these requirements through the WAP. The WAP will be released in 2014 after release of the Basin Plan to ensure that it is consistent with that Plan. It will also require accreditation by the MDBA.

South Australian Murray-Darling Basin Natural Resources Management Plan

As detailed in South Australia's 2008-09 Report to the BSMS, the SA MDB NRM Board launched the South Australian Murray-Darling Basin Natural Resources Management Plan (the Regional NRM plan) in June 2009. The Regional NRM Plan builds upon previous plans and strategies and provides a plan to protect and improve the condition of the natural resources of the SA MDB NRM region. The plan came into full operation on 1 July 2009.

The Regional NRM Plan establishes a consolidated set of targets which provide for a much stronger foundation for associated Monitoring, Evaluation, Reporting and Improvement (MERI) activities. As mentioned in South Australia's 2009-10 Report to the BSMS, the plan includes key targets associated with irrigation efficiency and salinity management, including:

- W1: All water resources are managed sustainably by 2018; and
- W2: Improve water quality to achieve the regionally endorsed environmental values by 2030.

A number of related management action targets are also identified. In regard to W1, these relate mainly to managing the salinity impacts of irrigation and include:

- W1.4: Minimise impacts of irrigation induced saline groundwater flows to water or ecosystem assets;
- W1.5: Complete a Basin wide prioritisation process for the development of land and water management plans by 2012; and
- W1.6: 90% of the irrigated area achieving WUE as prescribed by the relevant WAP by 2014.

In regard to W2 the key management action target is:

- W2.1: Maintain South Australia's position on MDB Authority Salinity Register in balance by 2014.

The SA MDB NRM Board is currently preparing a Regional Outcomes Report to assess progress against these targets (refer following sections).

Monitoring, Evaluation, Reporting and Improvement Achievements

In 2009, the Regional Monitoring, Evaluation, Reporting and Improvement Plan (MERI Plan) was completed for the South Australian Murray Darling Basin Natural Resources Management Board. The MERI Plan placed a strong emphasis on having a staged approach to MERI implementation, utilising participatory evaluation processes to increase evaluation capacity, ensuring evaluations support business planning and setting a direction for long-term development of MERI in the region.

One of the main features of the MERI Plan is a Schedule of Evaluation and Reports, ranging from monthly to five years. This schedule has been endorsed by the Board and supports key decision making needs. The schedule includes two important annual evaluations and reports: the Regional Outcomes Report and Hotspot Evaluations, which both commenced in the first half of 2010.

Regional Outcomes Report

The purpose of the 2010 Regional Outcomes Report is to provide strategic direction for the Board's Business Unit Managers to scope projects and develop budget forecasts for the 2011-

12 Business Plan. It also supports the Board's decision making in regard to funding allocations for the Business Plan. The process to develop the report was an opportunity to reflect on the first year of implementation of the SA MDB Regional NRM Plan: to assess progress against the NRM Plan performance measures and to check that the rationale behind the NRM Plan remains sound and is continually improved. More specifically, the focus of the 2010 Regional Outcomes Report was to assess progress against the 3-5 year Management Action Targets (MATs) and undertake a brief review of the logic and relationships between MATs and Board projects.

The process to develop the report included the collection of data and information, which constituted lines of evidence and context relating to each MAT. A number of facilitated natural resource-themed workshops were held (e.g. sustainable irrigation, water quality, Water Allocation Planning and aquatic biodiversity). These brought experts together to add their expert local knowledge to the lines of evidence and allocate an achievement 'score', explanatory statement and confidence rating for the assessment of each MAT.

The workshops and Regional Outcomes Report process were well received by participants. The majority viewed the workshops as an effective process to evaluate MAT progress and believed the workshop helped them understand progress toward the MATs, the logic behind the MATs and the types of evidence available to evaluate progress. The SA MDB NRM Board's Planning Team, as coordinators of the process, were pleased with the breadth and active participation of SA MDB NRM Board staff and partners, the positive feedback received about the value of reflecting on both the first year of implementation of the SA MDB NRM Plan and the strategic direction encapsulated within the Management Action Targets. At the time of preparing this report, the Regional Outcomes Report was being finalised.

It is understood that the findings of the Regional Outcomes Report will be presented to the SA MDB NRM Board in the second half of 2010 as part of their Annual Review and development of the 2011-12 Business Plan. The 2010 Regional Outcomes Report is the first evaluation of MAT progress and SA MDB Regional NRM Plan logic review. The learning's from the report development process will be used to further improve the SA MDB NRM Board's Schedule of Evaluation and Reports. An update on the outcomes of this assessment as they relate to salinity targets will be provided in South Australia's 2010-11 Report to the BSMS.

Hotspot Evaluations

Hotspot Evaluations are a new annual initiative of the SA MDB NRM Board and their Planning Team. The purpose is to enable the Board and staff to take a more in-depth look at a particular component of the Board's business and activities. The intent, as with the Regional Outcomes Report is to build staff understanding and capacity to undertake evaluations.

The focus of the two 2010 Hotspot Evaluations were the Board's 'NRM Education Program' and 'Improving Irrigation Efficiency Program'. These are both important programs that have been operating for more than five years. The Board was interested to explore the achievements and contributions of these programs, what aspects are working well and where improvements could be made.

The 'Improving Irrigation Efficiency Program' supports irrigators across the region to adopt best management practices and improve irrigation water use efficiency. These improvements, in turn, link to the desire to improve industry sustainability and reduce salinity impacts. To help achieve these immediate and longer-term objectives, the program has provided for:

- irrigation training workshops;

- on farm support for individual landholders; and
- establishment of an automatic weather station monitoring network.

The evaluation process has included the collation of existing data and the gathering of additional qualitative information (through interviews and case studies) to bring together a picture of the achievements of the program. The summary results of the evaluation include a Statement of Achievement and substantiating evidence matched with the main objectives of the Program. Early indications of the evaluation suggest that the program has been beneficial to the local community and:

- made a contribution to increased water use efficiency;
- assisted with some reduction in irrigation induced salinity across the region;
- increased awareness of water use efficiency including knowledge, skills and confidence of irrigators to manage water and salinity impacts; and
- contributed to on farm practice change.

The evaluation findings will undergo further interpretation and analysis to determine where improvements can be made to the program, particularly in regard to supporting achievement of the longer-term objectives and performance measures of the SA MDB Regional NRM Plan. The evaluations will also be considered in the context of where ongoing improvements can be made to the Hotspot Evaluation process as part of regional MERI Plan.

Updating Land and Water Management Plans

Rigorous planning processes at both regional and local levels are required to prevent further salinity rises and to mitigate ongoing impacts. Such planning will also aid in districts contributing to meeting any new salinity objectives within the Basin Plan (Water Quality and Salinity Management Plan) and compliance with new Sustainable Diversion Limits. Land and Water Management Plans (LWMPs) have been developed for priority districts of the South Australian Murray-Darling Basin (high salinity impact locations) and have received much community input and backing. However, they have:

- not been clearly linked to BSMS objectives; and
- suffered in the face of changing investment priorities.

In terms of the first issue, projects have been scoped to streamline the LWMP process to focus on key actions required in each priority district to address River Murray salinity over the next five years. The intention is to investigate linking LWMPs more directly to the BSMS objectives, specifically by incorporating actions in LWMPs that relate to BSMS Salinity Registers entries and ensuring that the related groundwater models are accredited to quantify salt loads for those entries. This will ensure that on-ground LWMP activities are clearly linked to BSMS outcomes. For example, data collection could be geared to improving datasets that form inputs to groundwater models. The concept has the full support from partners such as the SA MDB NRM Board who are keen to integrate their programs into the framework. There may also be future opportunities to report against the BSMS Salinity Registers as net impacts by LWMP area rather than as net impacts by type of action. This would bring South Australia into line with New South Wales and Victoria's method of reporting Salinity Registers entries.

It is intended that through these projects, the LWMPs would be upgraded to contain appropriate monitoring and evaluation strategies to ensure that actions can be substantiated and outcomes improved. By developing a more rigorous framework the community will have

greater certainty and can focus on outcomes. After development of the plans and accreditation through the BSMS process the projects would involve supporting the implementation of the plans through distributing seed funding to each region. In this way, projects would facilitate project development, cost sharing and maintenance of core programs. Funding options for this project are currently being pursued.

In terms of the second issue, difficulties have arisen in relation to completing the upgrades and implementing the plans in the Taylorville, Pyap to Kingston and Lower Murray Reclaimed Irrigation areas due to funding availability. The key problem is inadequate resources to enable finalisation of the plans and an absence of funding to support any resultant implementation activities. While the community groups that support these activities remain active, they are becoming increasingly unwilling to participate in any implementation activities, given that there is no investment or drive underpinning any potential implementation activities. This is a serious threat to completing LWMP upgrades and consequently, improved NRM and salinity outcomes within these regions. The IAG recognised these and other resourcing issues in their most recent report with Recommendation 2 (Financial and human resources for BSMS implementation) stating:

“That all Contracting Governments recognise the importance of continuing to manage salinity risks in the MDB, and ensure that human and financial resources are restored to levels that will allow the MDBA, in conjunction with the States and regional bodies, to successfully prepare and implement the Basin Plan; and that, in recognition of this, an injection of bridging funds be provided immediately for salinity and water quality until the financing of Basin Plan implementation is under way.”

Given very limited state funding opportunities, South Australia is currently seeking alternative funding support for the development and implementation of LWMPs and has submitted a funding bid to this effect to the MDBA for funding in 2011-12. If successful, the funds will be used for the projects outlined above.

In terms of other progress in 2009-10, upgrading the Bookpurnong to Lock 4 LWMP was completed in late 2009 with a Ministerial launch occurring in early 2010. Analysis undertaken during the development of the LWMP provided the results shown in tables below.

Table 1 shows changes in the profile of irrigation application systems between 1996-1997 and 2006-2007 in the Bookpurnong LWMP Region. The 30% increase in the use of drip systems is significant, conversely the use of overhead sprinklers has decreased almost 4 fold (SAMRIC, 2009).

Table 1: Changes in the profile of irrigation application systems between 1996-1997 and 2006-2007 in the Bookpurnong LWMP Region

Irrigation Type 1996-97	Hectares	% of irrigated area
Drip System	466.8	41.5%
Unknown/Other	16.3	1.4%
Overhead Sprinkler	241.8	21.5%
Under Canopy	398.7	35.4%
Total irrigated area	1123.6	100%

Irrigation Type 2007-08	Hectares	% of irrigated area
Drip System	1470.0	76.8%
Other, including removed system	17.8	1%
Overhead Sprinkler	113.3	6%
Under Canopy	311.8	16%
Total irrigated area	1912.9	100%

Table 2 displays the Water Balance Efficiency Assessment undertaken in 1996-97. This was used as baseline information in the development of the 1999 Bookpurnong LWMP.

Table 2: Water Balance Efficiency Assessment undertaken in 1996-97

Water Balance Efficiency Assessment 1996-97		
Total Irrigated Area 1,103 hectares	Volume in ML	Depth per ha. in mm
Total Application	11,138	1,010
Total water use	8,074	732
Crop deficit*	58	5
Drainage/loss	3,064	278
72% Water Balance Efficiency		
*Crop Deficit = (i.e. where annual Water use (CWR + Evap) exceeded Total application (Irr + Rain). These were at 3 of the 22 properties surveyed and annual water balance efficiencies for those 3 properties were found to exceed 100%. The summation of deficit volumes for these three properties provides the deficit volume appearing in the table.		

Table 3: Field Application Efficiency Assessment 2006-07

Field Application Efficiency Assessment 2006-07		
Irrigated Area (IRES) 1,419 hectares	Volume in ML	Depth per ha. in mm
Total Application	9,286	654
Total water use (est. 91% FAE)	8,450	595
Drainage/loss	836	59
91% Field Application Efficiency		

Tables 2 and 3 illustrate a comparison of monitored hectares (albeit via two different calculation methods) show major differences in rates of drainage in the Bookpurnong Irrigation area between the two periods. Whilst the latter analysis only covered an estimated 80% of the irrigation area the IRES calculation is a daily water balance approach, meaning that in

comparison to the annually calculated Water Balance Efficiency calculated in Table 2 a much more rigorous efficiency level has been attained in more recent times.

In terms of monitored salt loads entering the River at Bookpurnong (Table 4) substantial reductions were also noted between 1997 (71 tonnes/day - pre SIS) and 2009 (1.3 tonnes/day – 3 years into full SIS operation).

Table 4: Successive Run of River salt loads, river kilometres 500 – 521 – DWLBC, 2009

Run of River Survey Collated Results 1997 to 2008 Bookpurnong - River Kilometres 500 - 521		
Date	Tonnes day	Tonnes per year
August 1997	71 tonnes day	25,915
May 1998	55 tonnes day	20,075
June 2001	81 tonnes day	29,565
June 2002	69 tonnes day	25,185
June 2003	40 tonnes day	14,600
June 2004	75 tonnes day	27,375
June 2005	31 tonnes day	11,315
June 2006	34 tonnes day	12,410
August 2007	8 tonnes day	2,920
July 2008	3 tonnes day	1,095
June 2009	1.3 tonnes day	475

An analysis of perched groundwater occurrence and the status of regional groundwater was also undertaken and can be reviewed in the upgraded Bookpurnong LWMP. It was found that whilst the occurrence of on farm perched ground water (essentially drainage) had reduced over the intervening period between the development of the first LWMP in 1999 and 2009, major drainage issues are still occurring in the vicinity of Salena Estate/Solara Citrus at Bookpurnong (~190 Ml/annum in 2005). The Bookpurnong region has achieved many good outcomes however there is an ongoing drainage issue of considerable magnitude that could be remediated through extension and negotiation, which under the present reduced funding arrangement will not occur. This is just one irrigation region in the SA MDB, there are numerous other regions that would benefit from a similar approach.

Essentially Land and Water Management Planning has ground to a halt in South Australia in the last year of 2009-10. Limited funding and a high Federal Government focus on water buy back and on farm irrigation infrastructure upgrades has taken investment from extension and research focussed activities, making it extremely difficult for the LWMP program to keep building on its previous successes.

The severity of this situation needs to be recognised, for the communities, natural resource managers and the risks to delivering BSMS objectives. There is great potential for LWMPs to provide the link between on-ground management and assessment of accountable actions for entries on the BSMS Salinity Registers.

Sustainable Irrigation Code of Practice

Efficient on farm water use practices are important for reducing salinity risk through minimising deep drainage events, particularly given that the capacity to expand salt interception schemes

in South Australia is limited. To support such efficiencies, a draft code of practice for sustainable irrigation has been formulated. This work has been undertaken by DFW in conjunction with Rural Solutions - Irrigated Crop Management Services and the SA MDB NRM Board.

The code of practice is based on accrediting irrigators at a range of levels of irrigation efficiency practice, from meeting a minimum level of competency to a high level of competency. The code was formulated by identifying the key points of risk in the irrigation enterprise in relation to creating a deep drainage event and identifying and implementing control actions to minimise these risks. The code incorporates many of the current approaches that are known to assist in sustainable irrigation including crop surveys, soil moisture monitoring and computer based recording, scheduling and analysis. The code, if implemented, will provide an opportunity for irrigators to clearly demonstrate their standard of practice and contribution to salinity impacts. Uptake of the code will also ensure irrigators remain competitive within a low water use environment.

In this way, it provides a suitable framework for the collection of a range of key data for underpinning key policy processes such as Water Allocation Planning, the South Australian River Murray Salinity Zoning Policy and ultimately the BSMS. The code could also support South Australia in implementing future policy frameworks such as the Water Quality and Salinity Management Plan within the forthcoming Basin Plan.

South Australia strongly advocates trialling implementation of the code. A training program for each level of the code is being developed in conjunction with the code. Funding for trialling implementation of the code is currently being pursued through the Commonwealth with a proposal being submitted to MDBA for funding in the 2011-12 financial year.

2.5.3 Community Wetland Program

The SA MDB NRM Board supports community groups and Local Action Planning Groups (LAPs) to develop and implement wetland management plans for high value wetlands within the SA MDB NRM Boards' region.

In 2009-10 seven wetland management plans were completed and 25 community groups actively participated in wetland management. On-ground works funded to improve wetland hydrology included water control structures, box culvert structures and carp screens. Technical advice was also provided on best management practices for wetlands. Community monitoring programs were also developed with assistance and training provided in monitoring techniques, analysis, interpretation of data, and data storage requirements.

2.5.4 Review of Environmental Protection Policy

A major review is underway of the Environmental Protection (Water Quality) Policy, 2003 (EPP). The review is examining how to better equip the EPP to achieve specific environmental values including potentially lowering the water quality (including salinity) thresholds to bring them in line with National Water Quality standards. The review also examines processes for dealing with both point and diffuse sources of pollution and protecting against the accumulative impacts of pollution. The review will be released for community consultation by the end of 2010 with aim of implementation in 2011.

2.6 REDESIGNING FARMING SYSTEMS

The partner Governments will coordinate and enhance research and development into new farming and forestry systems that deliver improved control of groundwater recharge in the high rainfall grazing, winter rainfall cropping, and summer rainfall cropping zones. Over and above current programs the Commission will enhance research and development into new industries based on salinised resources, such as broadacre saltland agronomy, saline aquaculture, and salt harvesting.

(BSMS, 2001-2015)

Minimising the salinity impact of irrigation actions remains of critical importance. By applying the latest irrigation technology on farm, the long-term sustainability of irrigation developments is enhanced while minimising discharge of saline groundwater to the river, thus having significant salinity benefits for the River Murray.

Current BSMS Salinity Register projections indicate that salinity levels are likely to rise in the medium to long-term and that within South Australia there are limited opportunities for salt interception capacity to be increased. Improvements in irrigation water use efficiency are therefore essential for maximising the benefits from salt interception schemes and minimising salinity impacts of irrigation. Such improvements will also contribute towards meeting any new salinity objectives within the Basin Plan (Water Quality and Salinity Management Plan) as well as expected new Sustainable Diversion Limits for water extraction from the River Murray system.

2.6.1 Event-based Irrigation Monitoring

There has been extensive research effort in last 40 years to understand groundwater and salt movement processes in South Australia. This has led to a significant improvement in irrigation water use efficiency in the irrigation areas of the South Australian Riverland.

While major improvements have already been made in South Australia in relation to water use efficiency through on farm and infrastructure upgrade, the deployment of event-based irrigation monitoring tools such as Irrigation Recording and Evaluation Software (IRES) can yield further gains. Event based irrigation monitoring has multiple benefits such as enabling efficient management of available water resources, reduction of deep drainage and identification and management of the risk of root zone salinisation. When integrated with appropriate soil and climate monitoring, such tools enable irrigators to accurately forecast required irrigation events to optimise water use efficiency and reduce off-site salinity impacts. Through partnerships with the SA MDB NRM Board, Rural Solutions SA and private irrigators, on farm trials of event based irrigation monitoring and analysis have occurred. Application of such tools has clearly demonstrated the benefits of event based irrigation tools for minimising levels of deep drainage and improving capacity to water budget under a regime of low water availability. Currently, IRES is being utilised in the Loxton, Bookpurnong, Pike and Taylorville districts.

Some impediments do exist such as the complexity of the software used and the extensive time commitment required to keep and enter accurate records. These may represent a hurdle for some irrigators. Work has been undertaken in 2009-10 to simplify the use of the software

through an easier data entry screen. This will help to maintain the current use of the software and will be released to communities next year. Effort is also being directed to enabling automatic upload of metering data via telemetry.

A project has also been scoped to support the deployment of event based irrigation tools across the region. The project would involve identifying and utilising regional champions to work with software developers to further refine event based irrigation tools to improve system capability, examine barriers to further uptake and to facilitate the roll out of tools. The project will also provide nominal support to irrigators so that the capacity to develop district scale reports from the information can be maintained. The data gathered from the project will facilitate benchmarking of relevant indicators to optimise irrigation production and development of district scale reports. The project will improve South Australia's capacity to account for its salinity impacts. A funding proposal has been sent to MDBA for funding for the 2011-12 financial year.

2.6.2 Climate Change Impacts on Irrigation Water Requirements

During 2009-10 the SA MDB NRM Board commissioned a report to assess what future climate change scenarios would mean in terms of irrigated crop water requirements across the SA MDB region. The report was completed by CSIRO Land and Water Researchers working through the Cooperative Research Centre for Irrigation Futures.

The report used three climate periods: 1990-1999; 2000-2009 and the projected 2030 climate under a medium emissions scenario to assess irrigation water requirements and presented the results for dominant crop types at six key irrigation locations across the SA MDB region. The report confirmed the recent drought sequence, 2000-2009 to be more severe than the projected 2030 climate in terms of irrigation water requirements; however, other issues such as the impact that climate change will have on crop phenology also needed to be considered.

The climate change report contributes to the Atmosphere related Management Action Target in the SA MDB NRM Regional Plan which seeks to have 25% of natural resource managers incorporating climate change adaptation into their forward planning or management by 2014.

2.6.3 Water For The Future

The Water for the Future program is covered at Section 2.4.4 above. Two projects relating to improving on farm irrigation efficiency will be implemented by the SA MDB NRM Board and are therefore reported here.

On Farm Irrigation Efficiency Program

During 2009-10 the SA MDB NRM Board received in-principle funding approval from the Commonwealth Government as part of Round 1 of the \$300 million On-Farm Irrigation Efficiency Program (OFIEP). The Program aims to assist irrigators in the Lachlan and southern connected system of the Murray-Darling Basin to modernise their on-farm irrigation infrastructure and return water to the environment.

The funding received by the Board will be used to implement a number of on farm irrigation efficiency projects in the Riverland with the bulk of the works expected to occur during 2010-11. It is anticipated that Round 2 of the program will open late in 2010 and the Board will again be actively seeking to partner with irrigators interested in participating in the program.

Private Irrigation Infrastructure Program

The Commonwealth Government has committed up to \$110 million to fund irrigation infrastructure efficiency improvements for Murray Darling Basin operators in South Australia, with a share of the water savings to be used for environmental water purposes. The Private Irrigation Infrastructure Program will fund projects that improve the efficiency and environmental benefits of irrigation water use and management in the South Australian Murray-Darling Basin. In exchange for funding, successful applicants will transfer water entitlements to the Commonwealth Environmental Water Holder to use for environmental watering purposes.

The SA MDB NRM Board acted as a Delivery Partner in Round 1 of the Private Irrigation Infrastructure Program and at the time of writing is awaiting the outcome of its Round 1 application. The projects submitted by the Board are focused on upgrading off-farm delivery infrastructure to achieve efficiency gains and reduce on farm water use.

2.6.4 On-Ground Support to Achieve Irrigation Efficiency

The Improving Irrigation Efficiency Project (IIEP) continued to be implemented across the SA MDB region during 2009-10 albeit in a reduced capacity as a result of funding constraints. A series of irrigation management training workshops covering a wide range of topics was again delivered across the region and were well attended by irrigators. A total of 20 workshops were conducted in 2009-10 with over 260 irrigators participating in the training. The Salinity in Irrigated Horticulture workshop (delivered by the SA MDB NRM Board and SARDI) again proved popular.

A number of on farm salinity management trials continued to be supported by the SA MDB NRM Board during 2009-10 with root zone salinity management being a key issue for irrigators across the region following the prolonged period of reduced water availability. This work will continue in the 2010-11 irrigation season.

The SA MDB NRM Board upgraded seven regional rainfall monitoring sites in 2009-10 with funding provided by the Commonwealth Government through the Bureau of Meteorology administered Modernisation and Extension of Hydrologic Monitoring Networks program. The upgraded sites are part of the Board's broader automatic weather monitoring network that was established to assist the region's irrigators to optimise irrigation scheduling practices. The upgraded sites will report localised rainfall in 'real time' instead of the previous monthly web uploads meaning the data can be more effectively incorporated into irrigation management decision making.

2.6.5 Future Farm Industries Cooperative Research Centre

In 2009-10, the South Australian Government continued to be involved in the Future Farm Industries Cooperative Research Centre (FFI CRC) through DEH (now DENR), DWLBC (now DFW), SARDI, CSIRO and The University of Adelaide. The aim of the FFI CRC is to develop innovative farming systems and new regional industries based on productive perennial plants. These can reduce salinity impacts and provide other natural resource management benefits.

DEH was involved in a series of investigations to improve estimates of carbon sequestration rates from mature woodlots and environmental plantings in low to medium rainfall regions of South Australia. (Hobbs *et al.* 2010). Analysis of survey data from across the Murray-Darling

Basin and neighbouring regions have facilitated the development of preliminary models of carbon sequestration for the refinement of the National Carbon Accounting Toolbox, in a collaborative project with the federal Department of Climate Change and Energy Efficiency and CSIRO.

Other FFI CRC projects (Enrich, Evercrop and Oldman Saltbush Improvement) are focussed on the development of viable options for the lower rainfall livestock/cropping zone of southern Australia such as the SA MDB region. Research in this region is being led by SARDI, with support from DFW and CSIRO at its Monarto field site (Figure 16). The research focuses on developing the most promising species, selected for a range of traits including palatability, nutritive value and productive biomass. Earlier evaluation of improved Oldman saltbush strains has identified superior plants which have been cloned and planted during 2009, for advanced evaluation and selection of elite lines which will be commercialised in the near future. Varieties more readily established from seed are also being developed. Also at Monarto, research is being undertaken into strategies for the best grazing management of these species. In July 2009, a further forage shrub species evaluation trial was established at the Waikerie Mallee Sustainable Farming site to investigate the species local adaptation.

DENR continued its work on the biodiversity benefits of planted woody perennials and, based on a study of 15 sites in the SA Murray Mallee, has demonstrated that bird species richness was higher in saltbush plantings than in adjacent pasture sites, but lower than in Mallee remnants.

SARDI continues the delivery of dryland salinity information through the Saltland Knowledge Exchange project, which is the last major national extension project addressing dryland salinity management. As well as managing and updating the Saltland Genie and National Dryland Salinity Program websites, the project has developed salinity concepts and salinity management training courses that could be delivered to extension specialists in the Murray-Darling Basin.

Saltland Genie website: <http://www.saltlandgenie.org.au/>



Figure 16: Grazing preference trials at Monarto research site (photo courtesy of SARDI)

2.7 TARGETING REFORESTATION AND VEGETATION MANAGEMENT

The partner Governments recognise the necessity for landscape change specifically targeted at salinity control. In order to facilitate such targeted change, where changed farming systems are not adequate, the Commission will further develop the concept of a vegetation bank to have the capacity to finance extension of forestry outside of traditional forestry areas.

The partner Governments will further consider the financing of native vegetation management, rehabilitation and land stewardship, and the commercialisation of short rotation tree crops, particularly for the wheatbelt.

(BSMS, 2001-2015)

Reforestation and vegetation management activities are significant in promoting overall catchment health and land management. Reforestation can also provide long-term benefits in terms of stabilising groundwater movement and thus discharge of saline groundwater to the river.

2.7.1 Revegetation and Restoration Activities

Large scale landscape programs such as Woodland BushBids, the Woorinen Recovery Project and the South Australian Multiple Ecological Communities Environmental Stewardship project are dramatically increasing the area of private land targeted for conservation management. The SA MDB NRM Board manages these projects and has been using market based approaches to target key areas, be they geographical or based on priority species.

Woodland BushBids has recently contracted private land managers to improve the condition of approximately 6800 hectares of remnant vegetation. Contracts run for a period of 5 years with a range of conservation activities including pest animal and plant control, revegetation, regeneration and grazing pressure reduction. This was funded by the Native Vegetation Council.

The Woorinen Recovery Project (funded by the Native Vegetation Council) completed 54 hectares of revegetation and 121 hectares of remnant protection targeted at restoring and expanding the Triodia shrubby dunes of the Northern Murray Mallee, critical habitat for threatened Mallee birds. This project aims to double the target to revegetate 100 hectares in 2010-11 with increased protection.

The South Australian Multiple Ecological Communities Project (part of the Australian Government's Environmental Stewardships program) has been developed for areas of the SA MDB and will be rolled out in 2010-11. The aim of this project is to provide funded 10 or 15 year contracts to landholders to improve and protect the threatened ecological communities of the Peppermint Box grassy woodlands and the Iron-grass temperate grasslands.

Community groups and non-government organisations are important contributors to revegetation and conservation within the SA MDB. During the 2009-10 period Eastern Hills and Murray Plains Catchment Group, Goolwa to Wellington Local Action Planning Group, Murray Mallee Local Action Planning Association and the Coorong District Local Action Planning Association were responsible for the implementation of 189 hectares of revegetation.

Other groups such as the Threatened Plant Action Group, other Local Action Planning Groups, Conservation Volunteers Australia, Trees for Life, Greening Australia, Monarto Zoo, Aboriginal Learning of Country crews and local government have also undertaken revegetation works across the SA MDB during 2009-10.

2.7.2 Sustainable Farming Vegetation Management

The SA MDB NRM Board funded 2,180 hectares perennial pastures to be implemented by the Coorong District Local Action Planning Association, Murray Mallee Local Action Planning Association and the Eastern Hills and Murray Plains Catchment Group.

2.7.3 The River Murray Forest

The River Murray Forest project aims to plant regionally native species along the River Murray in order to improve biodiversity and ensure carbon sequestration outcomes. An expansion has aligned the project with the River Murray-Coorong Naturelinks Corridor. Expansion provides opportunities for planting in higher rainfall environments, with reduced establishment risk, while addressing important ecological needs throughout the corridor.

Public tenders were called for plantings on private land in each year from 2007 to 2009. A total of 2,450 hectares have been offered by landholders for planting through the tender process. These areas are now under contract. Plantings will be staged over several years to allow for seasonal conditions and seed supply. To date 300 hectares of the contracted area has been planted. However, due to seasonal conditions, success rates on revegetation activities have been poor. To minimize seasonal risks in the future the contractors will undertake the planting over several years to spread the risks, allow for site preparation work such as weed and rabbit control, and to ensure availability of seed. This project is managed by DENR and funded by the Government of South Australia.

Due to limited success over a period of years predominantly due to seasonal conditions, the SA MDB NRM Board in partnerships with the Native Vegetation Council is funding a three year project into trialling different methods to improve revegetation success. The first year of these trials began in 2009-10.

2.8 CONSTRUCTING SALT INTERCEPTION WORKS

The Commission will construct and operate new joint (partner Government funded) salt interception works to protect Basin-wide assets and values, including the shared water resources of the Murray and Darling Rivers. This will provide protection beyond the benefits from simply meeting end-of valley targets, based upon agreed cost sharing and benefit allocation principles. The benefits will continue to include salt disposal entitlements to offset the impacts of future actions that aggravate salinity.

(BSMS, 2001-2015)

Salt interception remains a key salinity impact mitigation strategy, having proven valuable in providing a reduction of saline groundwater flows into the River Murray, thereby reducing in-river salinity and protecting water quality for all water users.

Within South Australia, most schemes have been jointly funded in partnership with jurisdictions that are party to the MDB Agreement. Existing schemes in South Australia include Woolpunda, Qualco-Sunlands, Waikerie, Bookpurnong and Loxton. A Salt Interception Scheme (SIS) is currently under construction at Murtho. An SIS has been proposed for construction at Pike but is not funded under the Murray-Darling Basin Authority (MDBA) joint works funding program.

Saline water intercepted by SISs is disposed of to evaporation basins located at Noora (20km east of Loxton – for water from the Loxton, Bookpurnong, Murtho and proposed Pike SISs) and Stockyard Plain (15km southwest of Waikerie – for water from the Woolpunda, Waikerie SISs and the Qualco-Sunlands Groundwater Control Scheme).

There is an opportunity in future for investigations into options for using salt interception infrastructure for other benefits. A current investigation is using previous ecological and hydrogeological data gathered at Bookpurnong to further investigate the options of using SIS infrastructure to deliver multiple benefits, such as improved floodplain vegetation health.

2.8.1 Waikerie SIS

- Developed in 2 stages - Waikerie 1 (1992) and Waikerie 11A (2003).
- Both stages were constructed as a joint works under the Murray-Darling Basin Commission Salinity and Drainage Strategy.
- Waikerie Stage 1 intercepts approximately 74 tonnes of salt per day and stage 11A an estimated 23 tonnes of salt per day.
- Provides a 12.8 EC benefit at Morgan.
- The Waikerie Lock 2 extension was approved by the MDBC BSMS in September 2007 and became operational in October 2009.
- The scheme was designed to intercept a total of 39 tonnes of salt per day from entering the River Murray over a 30 year time period.

In 2009-10, the Waikerie SIS continued to operate effectively with few operational problems. An optimisation study has enabled the flows from some bores to be reduced to save pumping costs while still maintaining the interception targets.

Construction and commissioning of the \$4.3 million Waikerie Lock 2 SIS was completed and preliminary indications are that it is well on the way to delivering its design benefit of 9.4 EC.

The scheme consists of an additional seven bores downstream of the original Waikerie SIS, in between and either side of the three Qualco Scheme bores that are adjacent the river.

2.8.2 Woolpunda SIS

- Constructed as a joint works under the Murray-Darling Basin Commission Salinity and Drainage Strategy
- First section was commissioned in 1990; the balance in 1992.
- Intercepts a total of 150 tonnes of salt per day with a benefit of 47.4 EC, based on pre and post 1988 irrigation development
- An extension of the current scheme is being investigated to intercept an estimated 10 tonnes of salt which has been monitored entering the river from in river EC monitoring.

In 2009-10, this scheme continued to operate effectively as evidenced by the Run of River salinity surveys. The considerable effort made in recent years to rehabilitate bores partially clogged by iron bacteria deposits has been worthwhile with most bores treated being restored to close to as-new condition. Encouragingly, the condition of the bores post-recovery has been largely sustained for over two years after treatment with few signs yet of deterioration becoming evident which would be the trigger for further maintenance treatments.

2.8.3 Loxton SIS

- Designed to intercept a total of 70 tonnes of salt per day from entering the River Murray with a 19 EC benefit at Morgan.
- Being constructed in two stages – floodplain and highland.
- The Floodplain section of the scheme became operational at the start of 2009 and is currently intercepting a total of 50 tonnes of salt per day.
- The Highland component is currently under construction.
- Currently only the Floodplain component has been put on the BSMS Salinity Registers, the highland component will be added once the scheme is commissioned in 2010-11.

In 2009-10, all twenty seven floodplain bores and the Cliff Toe Drain operated satisfactorily. Work completed this year includes the installation of one additional floodplain bore and the Cliff Toe Drain was extended a further 80 metres to further improve the scheme's effectiveness. Also completed were the investigations in the highland areas and the feasibility of using conventional bore pumps in selected areas. Twenty one highland production bores were drilled along with associated observation bores to complement five bores that were drilled the previous year. The twenty six new highland production bores scheme will be operational by early September 2010 and this will complete the Loxton SIS.

By the end of 2009-10 a total of \$19.7 million of the allocated \$20.0 million had been spent on the construction of Loxton SIS with the remaining \$311,000 to be spent in 2010-11.

2.8.4 Bookpurnong SIS

- Constructed as a shared works under the Murray-Darling Basin Commission Basin Salinity Management Strategy and commissioned in September 2006.
- Intercepts an estimated 50 tonnes of salt per day
- Benefit of 21.8EC at Morgan over a 30 year time period

In 2009-10, the fifteen floodplain bores generally operated satisfactorily with no significant issues and with groundwater levels being held below their target levels. The seven highland bores likewise generally maintained groundwater levels below their target levels although some are suffering chemical clogging problems that are being addressed through some trial rehabilitation techniques.

A detailed investigation program was commenced to better understand the aluminium oxide clogging problem in part of the area that has to date precluded extension of the scheme into the affected zone. The key objective of this study is to assess and understand the processes leading to the dissolution and re-precipitation of aluminium. Ongoing data analysis is occurring and will be completed in 2010-11.

2.8.5 Qualco-Sunlands Groundwater Control Scheme

- Commissioned in 2001.
- Reduces salt load to the river by 19 tonnes of salt per day with a 4.8EC benefit at Morgan.
- Operated by local irrigators through the Qualco-Sunlands Groundwater Control Trust, which was established under the *Groundwater (Qualco-Sunlands) Control act 2000*

The drought and severe restrictions on irrigation allocations has resulted in a considerable reduction in drainage to the groundwater mound. Under these conditions groundwater levels have basically stabilised with the scheme being operated on a care and maintenance basis with most pumps running for only two hours per day with the exception of three bores adjacent the river that provide salinity protection.

As in the previous year, at the request of the Qualco-Sunlands Groundwater Control Trust, the Government of South Australia fully funded the operating and maintenance costs of the scheme for 2009-10.

2.8.6 Murtho SIS

- Approved for construction as a shared works by the MDBC BSMS at the end of 2007.
- Construction of the scheme is still underway and is expected to be completed by 2011-12.
- Conceptually designed to intercept a total of 99.4 tonnes of salt per day or a 20.2EC benefit at Morgan

Construction has progressed on schedule and to budget in 2009-10. The river crossing between Remark and Paringa is complete, the collection and disposal main pipeline has been installed and hydro-dynamically tested and the drilling of all production and observation bores has been completed.

The next stage of works to be undertaken in 2010-11 is to complete the climate sequence and solute transit modelling, let two tenders for the final stages of work; one for the civil works at Disher Creek and the other for the mechanical and electrical components of the scheme.

2.8.7 Pike SIS

- Conceptually designed as a 59 highland SIS bore scheme with 28.5km of pipeline to intercept a total of 167 tonnes of salt per day or an EC benefit at Morgan of 35.4EC over the 30 year time period
- Existing disposal infrastructure such as the Lyrup Surge vessel and the Disher Creek and Noora Gravity main pipelines will transfer the intercepted groundwater from the Pike SIS to the Noora Basin.
- The scheme has been conceptually costed at \$25.321M

The Pike SIS has not been adopted as an MDBA Joint Works Program. A Phase 2 Joint Works Program under the BSMS has been identified as a potential requirement under the 2007 BSMS Mid-Term Review, however no resolution on the scope of this program has yet been reached. The scheme will be critical in enabling irrigation development to continue to be offset into the future. It will also provide a means for offsetting other salinity impacts to be recorded on the BSMS Salinity Registers, such as the impacts of environmental watering actions. This includes future actions by the Commonwealth to apply environmental water to The Living Murray Icon Sites.

Funds were made available by the MDBA to progress detailed design work of the Pike SIS, to consolidate all available data and to undertake investigative drilling. South Australia is investing funds available from the National Action Plan for Salinity and Water Quality to construct a component of the Pike SIS. Construction works will commence in 2010-11.

The long-term benefits from completion of the Pike SIS are such that South Australia will pursue to progress the scheme as a Joint Works program with the MDBA.

2.8.8 Riverland Salt Disposal Management Plan

Stockyard Plains Disposal Basin

- Located 15km southwest of Waikerie;
- Encompasses a number of natural shallow depressions with floor elevations as low as 24mAHD and has a design top water level of 31mAHD;
- The maximum available pond area is about 7km² and with the basin operated at 31mAHD the current design capacity is 300L/sec;
- Owned and operated by the Murray-Darling Basin Authority;
- Schemes that dispose to the basin: Woolpunda – 165L/sec; Waikerie 103L/sec; Qualco-Sunlands – 35L/sec.

Noora Disposal Basin

- Located 20km east of Loxton and commissioned in 1982 with an estimated land size of 3600ha;

- Established to dispose of irrigation drainage water from the Comprehensive Drainage Schemes (CDS) stored at Berri Disher Creek Disposal, over time due to improved irrigation practices and prolonged drought conditions the volume of water disposed from the CDS has reduced from an estimated 119L/sec to 40L/sec;
- Receives water from the CDS and also from the Salt Interception Schemes;
- The current design capacity of the basin operating at 19.0m AHD is 435L/sec comprising a 100 year long-term average of 395L/sec from the SIS's and 40L/sec from the CDS;
- Owned and operated by the Government of South Australia;
- Schemes disposing to the Noora Basin are: Bookpurnong – currently 43L/sec, by 2100 54L/sec; Loxton – currently 57L/sec, by 2100 63L/sec; Murtho – proposed 50L/sec; Pike – proposed 93L/sec.

In 2009-10, work under the Riverland Salt Disposal Management Plan (RSDMP) continued to focus on the Noora Basin. A significant amount of work was focused on ensuring that when the basin is operated at maximum capacity, the intercepted saline disposal water will be contained within the boundary of the Basin.

To ensure this occurs, additional land is required to create a 'buffer zone'. An agreement has been reached for the land and the contracts will be finalised in 2010-11. Another focus has been on the sustainable management of the Basin and various land management practices have been planned and or undertaken within the Basin.

2.9 ENSURING BASIN-WIDE ACCOUNTABILITY: MONITORING, EVALUATING AND REPORTING

The partner Governments will demonstrate accountability by reporting to the Commission and Council through State end-of-valley Report Cards and Commission Salinity Registers that record the salinity effects of actions, including salt interception schemes and salinity and catchment management plans. The Council will receive audits every five years for each valley and Commission Register entry, assessing impacts on river salinity and progress towards targets, with the provision to require further action as necessary.

(BSMS, 2001-2015)

South Australia undertakes programs of monitoring, evaluating and reporting for salinity at different organisational levels and for different purposes. These programs are of great value in enabling South Australia to meet long-term accountability requirements under Schedule B (BSMS Salinity Registers entries) as well as providing a basis for understanding the short-term variations in-river salinity to guide real-time management actions.

2.9.1 Monitoring

The availability and accuracy of South Australia's salinity and flow data has increased dramatically with the telemetering and publishing of this data on the internet on a daily basis. All sites are checked on a daily basis by Department for Water staff to ensure any problems with equipment or data can be remedied in a timely manner.

During 2009-10 salinities in South Australia have generally remained low with decreased accessions due to local drought conditions and higher flows from upstream diluting the salt in the system (with the exception of the Lakes) (Figure 17).

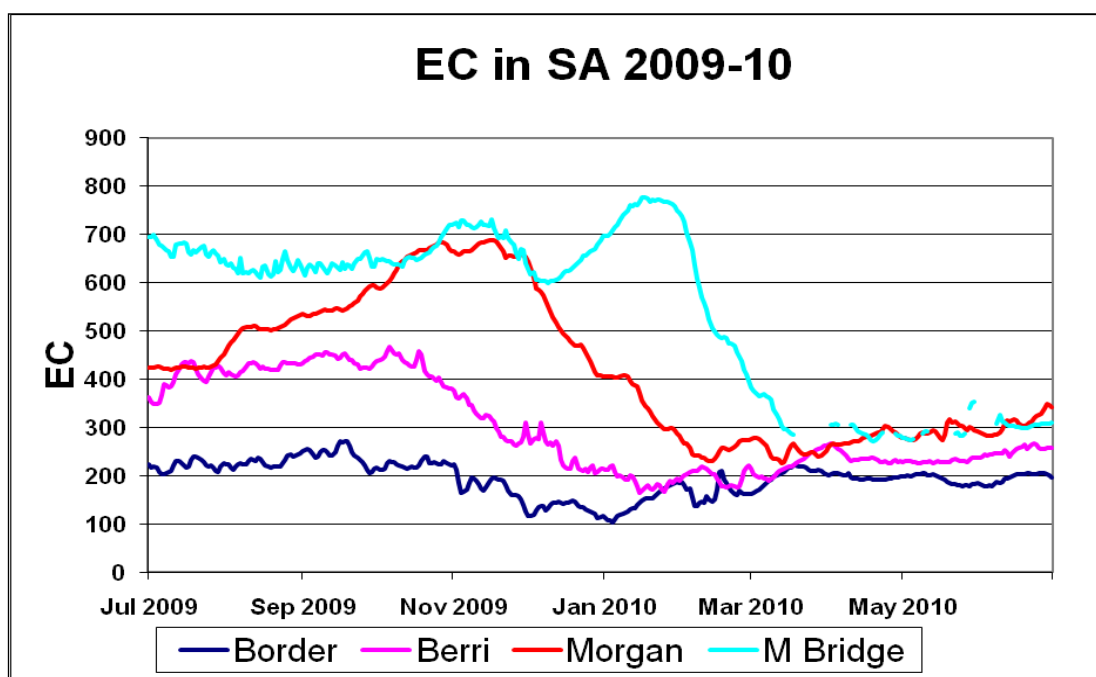


Figure 17: EC in South Australia during 2009-10

Both the Border and Morgan total salt loads increased in 2009-10 due to the increased flows to South Australia as can be seen in Figure 18. The Border increased from 161,000 tonnes to 178,000 tonnes and the Morgan load increased to 241,000 tonnes.

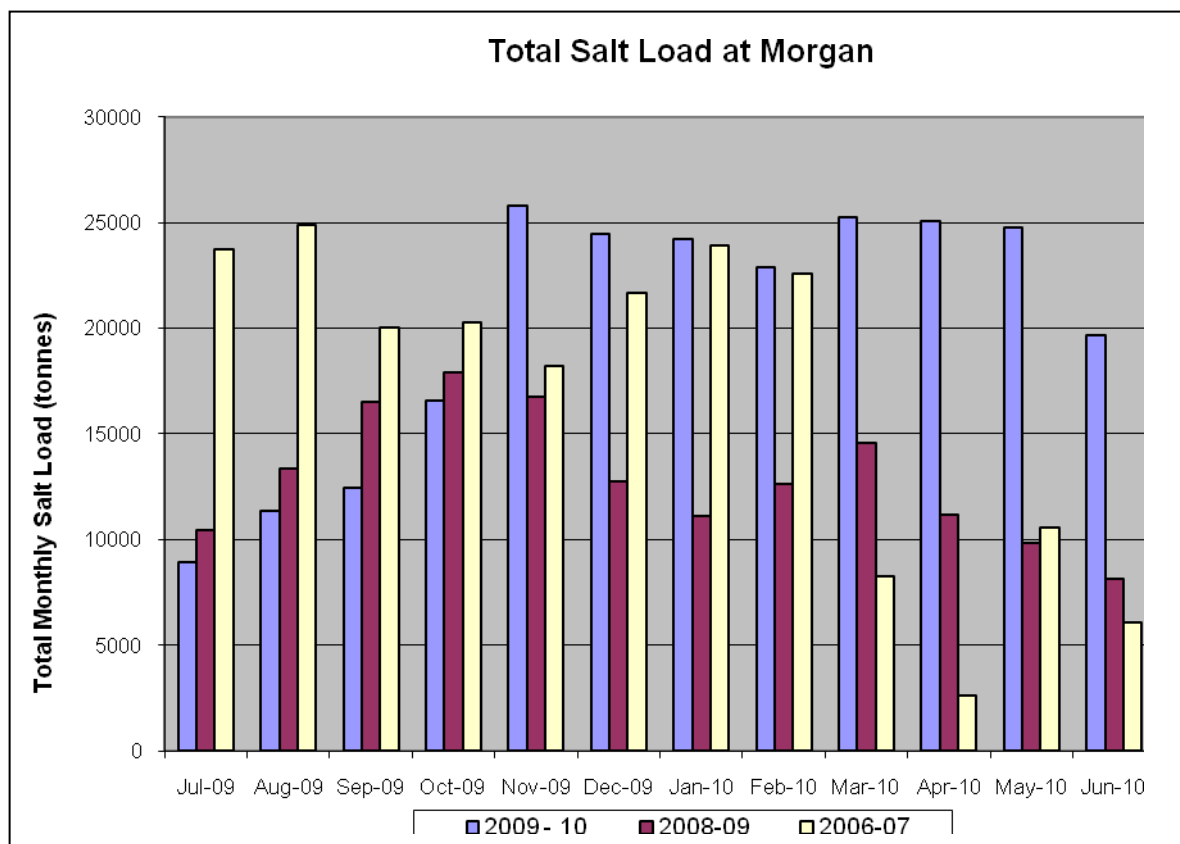


Figure 18: Total salt load at Morgan 2006-07, 2008-09 and 2009-10

Acoustic Flow Monitoring

Increased flows in the River Murray in 2009-10 have helped to improve the operation of Acoustic Doppler-based flow monitoring throughout the system.

In 2009-10 a project which verifies the rated flows over each lock in South Australia with Acoustic Doppler Current Profiler (ADCP) gaugings continued. Gaugings were conducted on average every 4 months, decreased from previous years due to the increased flows. General indications are that rated flow over Lock 1 is underestimating actual flow due to leakage through the lock not being sufficiently accounted for, while other locks show reasonable correlation with gaugings. Further gaugings are required at elevated flows (>3,000 ML/day) to improve confidence of the comparisons between gauged and rated flows.

Continuous flow monitoring in the Chowilla Anabranch has shown particular improvement in results in 2009-10 from previous years. The greater flows through the system have had a flushing effect at the majority of flow sites, reducing the occurrence of weed-affected data that has been prevalent under lower flow conditions. Calibration of some sites in the system has been affected by changing conditions caused by factors such as rock weir construction, channel obstructions from falling trees, and changes in cross-sectional geometry from channel scouring at higher velocities. These changing conditions require new velocity-index (VI) ratings to be developed, which are required to convert instrument-measured velocity to actual mean

velocity. Data records have also been interrupted at two sites and due to instrument malfunctions. The main Chowilla Creek flow site (Figure 19) however has continued to operate well, and a valid VI rating has been developed, accurate to ± 0.006 m/s and valid between flows of 815 to 4,200 ML/day.



Figure 19: A4261091, continuous flow site at Chowilla Creek

The flow site at Rufus River, which measures outflow from Lake Victoria, has continued to operate without loss of data in 2009-10. A VI rating has been developed for the site, accurate to ± 0.016 m/second and valid between flows of 400 to 4,000 ML/day. However, the last two gaugings have shown a significant deviation from the rating, which appears to be a result of a recent change in channel shape from deposition on the instrument side of the section. Further investigation is required to determine remedial measures for addressing this issue.

The continuous flow monitoring site at Morgan has produced a continuous 12-month flow record that has been used to perform salt load calculations at Morgan for 2009-10. Extensive ADCP calibration measurements were undertaken at the site during 2009-10, resulting in the production of a viable VI rating for the site with an accuracy of ± 0.007 m/s and validity over the flow range of 500 to 6,600 ML/day. The site has proved successful in demonstrating the dynamic behaviour of flow at Morgan, particularly at low velocity conditions (i.e. less than 0.05 m/second) where wind can significantly influence flow patterns.

Close Interval EC Surveys

Surface salinity mapping surveys have continued in Lake Alexandrina and 3D mapping surveys and cross sections were conducted at downstream Lock 6 (Figures 20 and 21) and in the Pike River anabranch system (Figures 22 and 23). A survey was also carried out both upstream and downstream of the Goolwa barrage to map any fresh water losses through or under the barrage after filling the Goolwa channel.

The EC monitoring stations at Lock 6 and Upstream Chowilla Creek show a small (5-10 tonnes/day) accession in this reach. 3D salinity mapping in December 2009 delineated a zone of low salinity accessions at 619 kilometres (from Murray Mouth travelling upstream) and a much

higher salinity accession at 617-616 kilometres. These accessions coincided well with the Run of River surveys conducted in this reach over past years. The high salinity accessions are adjacent to a large citrus orchard at Murtho.

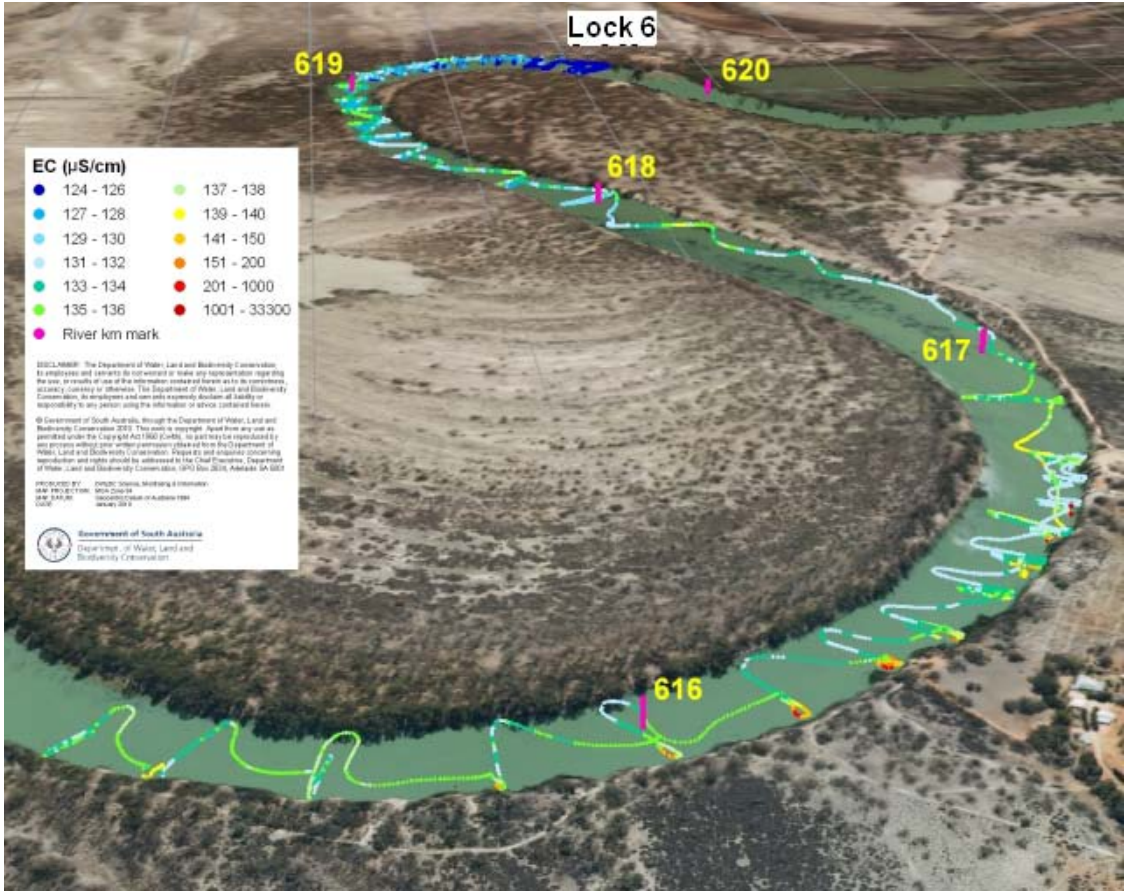


Figure 20: 3D EC mapping at Downstream Lock 6 looking upstream

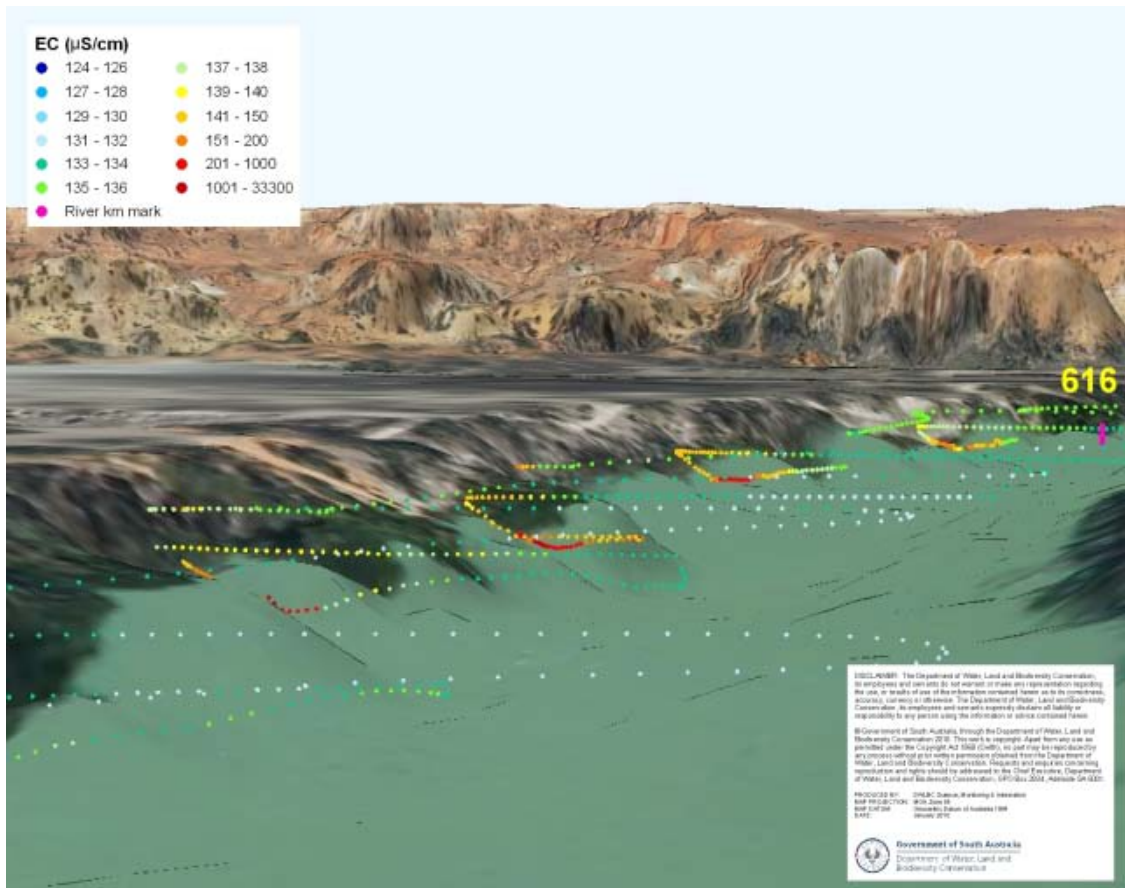


Figure 21: Detail of 3D EC mapping at Downstream Lock 6 looking downstream at 616 km AMTD

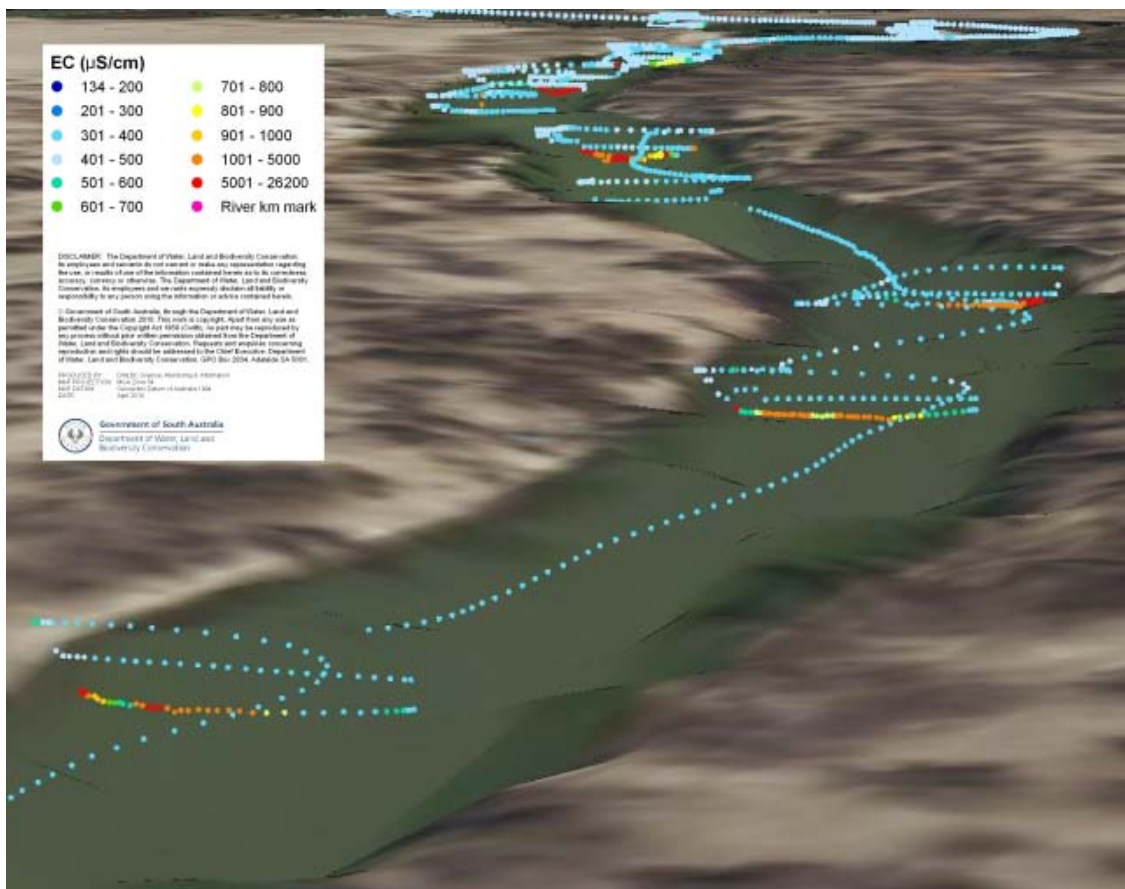


Figure 22: 3D EC mapping at Pike River downstream of Lettons (A4260644)

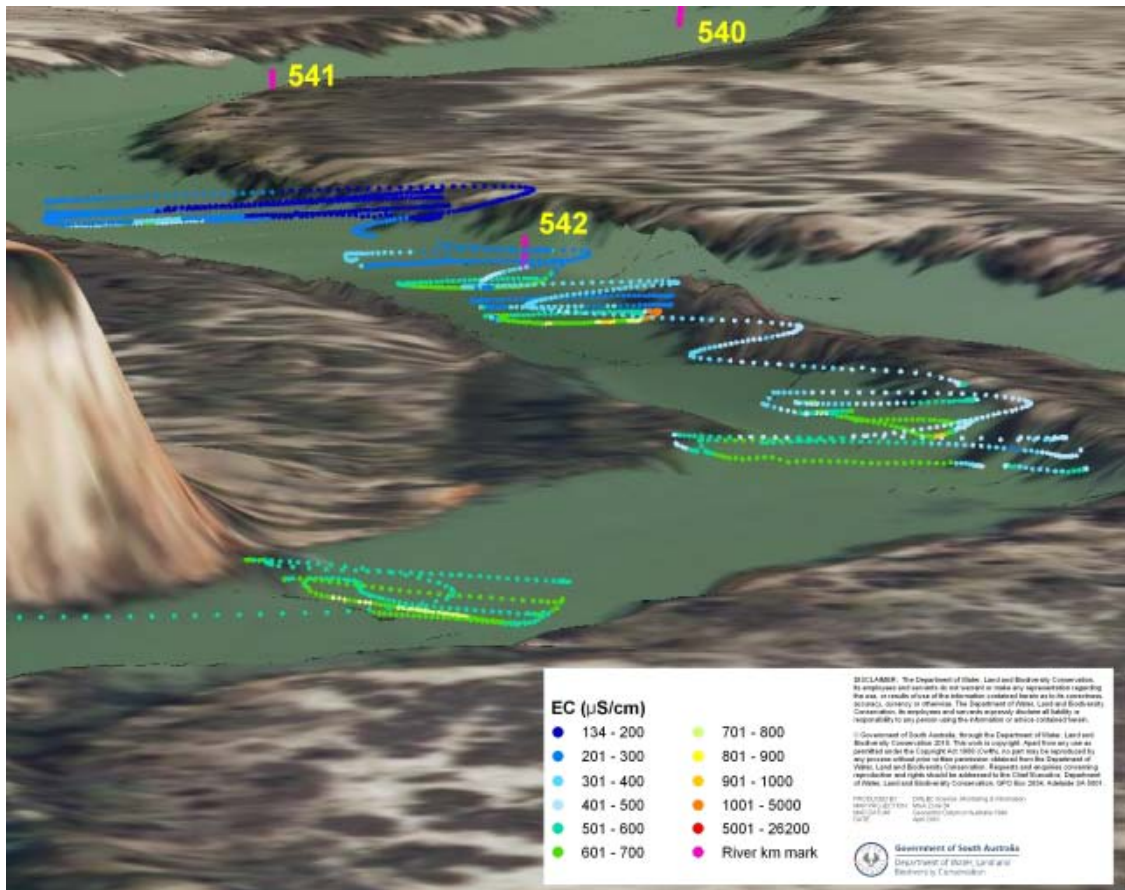


Figure 23: 3D EC mapping at Pike River – Murray river Junction

As reported in section 2.1.2, the Pike River Anabranch is a major remaining source of salt accessions to the River Murray in SA. A 3D mapping survey was conducted in February 2010 which showed the major accession zones and delineated between upward leakage and sideways floodplain water movement. The survey also showed unusual mixing patterns of the water at the junction of the Pike and Murray Rivers with fresher River Murray waters moving upstream a considerable distance on the surface of the Pike River. This survey adds considerably to the knowledge base of salinity accessions in this area.

The Lake Alexandrina images at Figures 24 and 25 show the extent of navigable water in March and early July 2010. In March the average EC in the lake was 6,000-7,000. After the increased flows in the Murray had reached Lake Alexandrina the average EC in early July was approximately 3,000 EC.

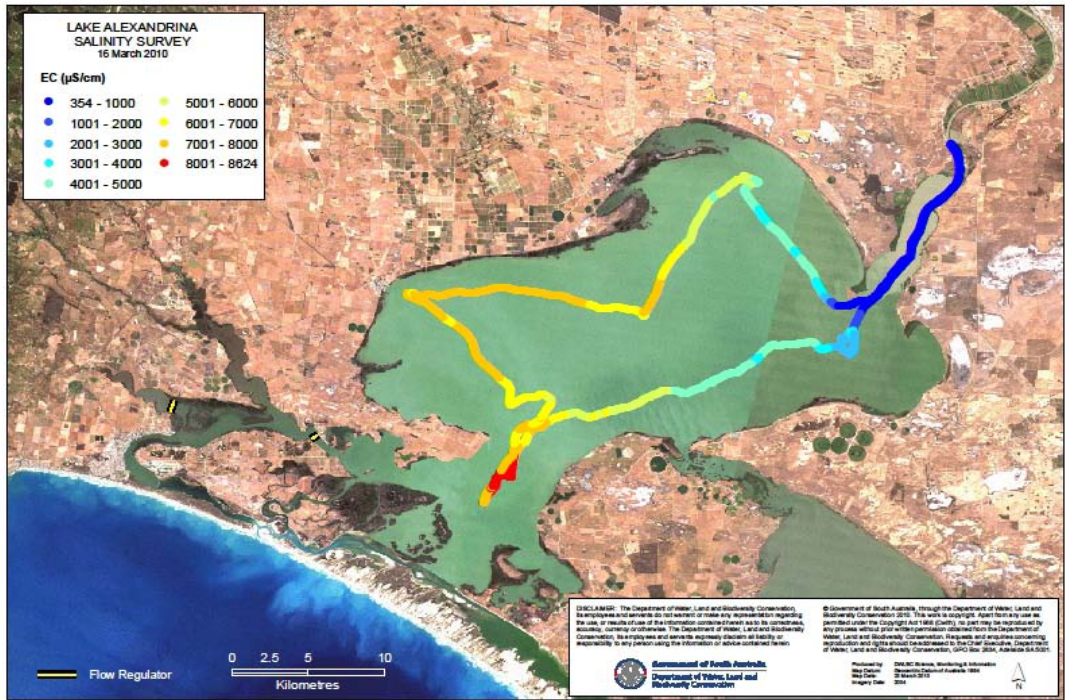


Figure 24: Track of surface salinity around the navigable edge of the Lower Lakes, March 2010 (imagery 2004).

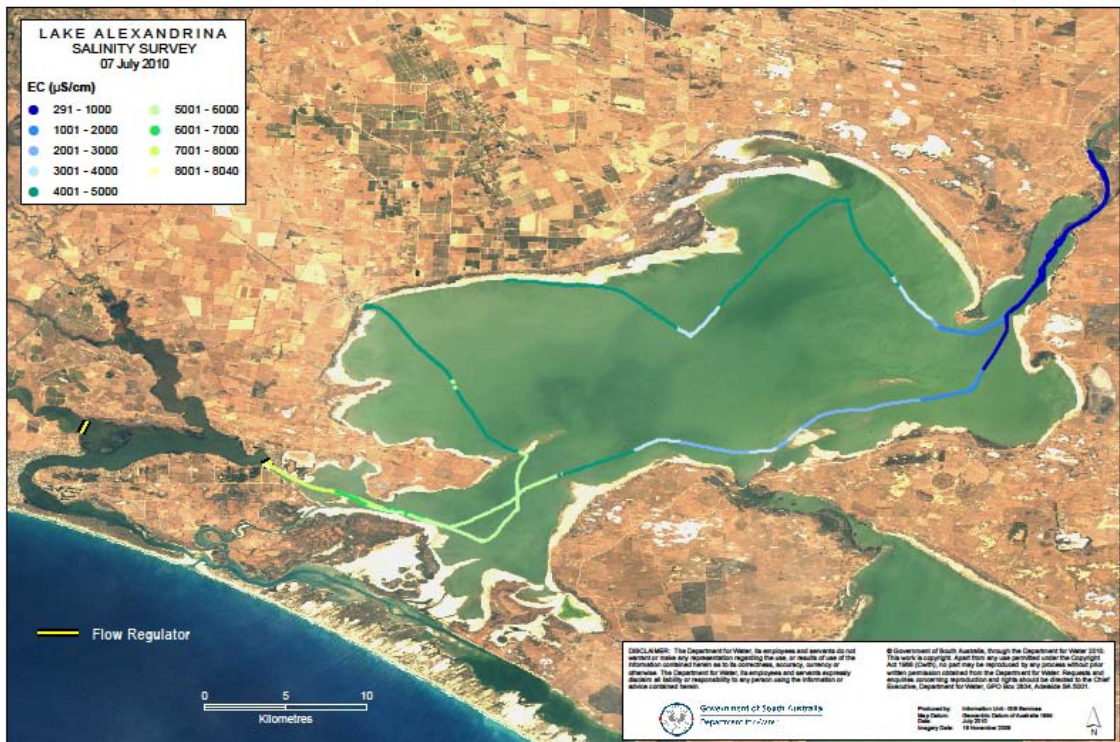


Figure 25: Track of surface salinity around the navigable edge of the Lower Lakes, July 2010 (imagery 2004).

Water levels in the Goolwa channel were dropping faster than expected after the area was blocked off from Lake Alexandrina. The salinity survey at the Goolwa Barrage delineated small zones of fresher water leaking through and under the barrage into the seawater zone of the Goolwa channel (Figure 26).



Figure 26: EC downstream of Goolwa barrage, January 2010

Run of River Salinity Surveys

Run of River salinity surveys were not conducted in 2009-10 due to river flows being too high to provide the slower travel times needed for salt load calculations. This can be attributed to the delivery patterns of the Queensland and New South Wales floodwaters into South Australia.

Nanotem Surveys

No Nanotem surveys were conducted in 2009-10.

The May 2009 NanoTEM survey results were compared with the February 2004 NanoTEM results along the same river reach (Lock 1 to upstream of Mildura). The analysis of NanoTEM data by Australian Water Environments shows that the NanoTEM surveys are repeatable. There is evidence that NanoTEM data can be used as an evaluation tool of SIS effectiveness. As an example, temporal surveys at Bookpurnong (2004 and 2009) infer that salinity beneath the river has reduced in correlation with SIS operation.

Riverland Watertable Time Series Maps

A time series of watertable elevation maps have been prepared for the Riverland area using observed data from existing monitoring networks and extrapolations back in time to pre-European levels. This has allowed the growth in the watertable mounds beneath highland irrigation areas over time to be observed and the volume of groundwater stored in them to be calculated. Figures 27 to 29 show the pre-European watertable contours and the 2005 watertable contours together with irrigated area extent in gray. The formation of the watertable mounds beneath Loxton, Berri-Barmera, Waikerie and Sunlands irrigation areas can be clearly seen.

The areal extent of mounds hasn't changed between 2005 (Figure 28) and 2010 (Figure 29), however, the height has decreased leading to a decrease in volume.

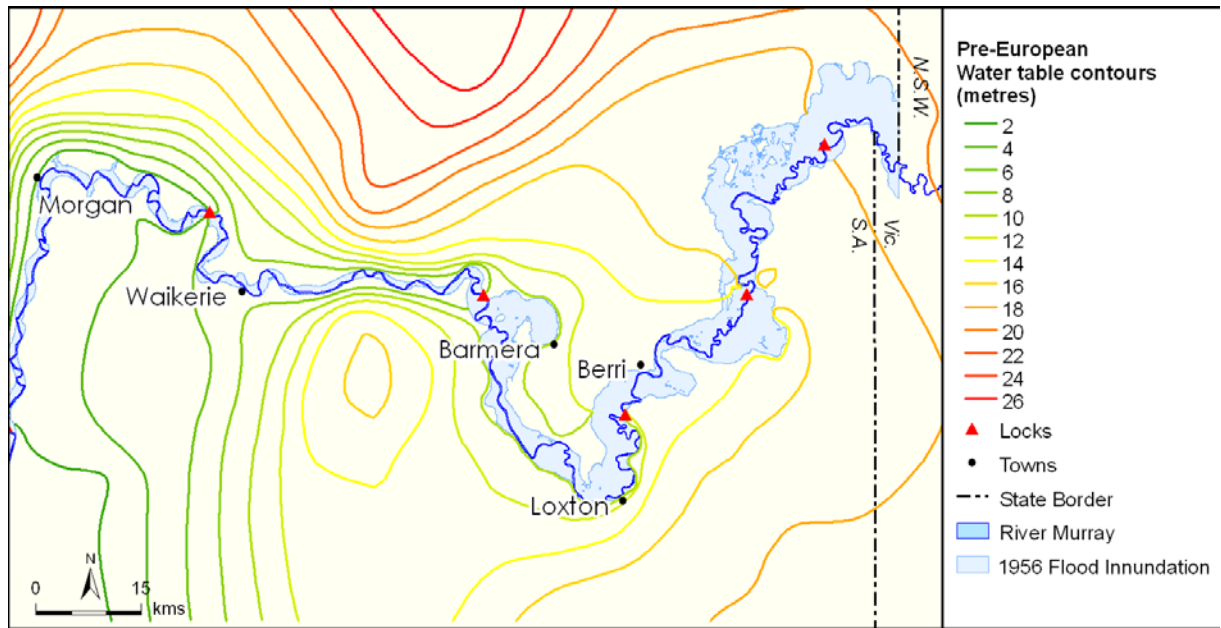


Figure 27: Pre-European water table contours

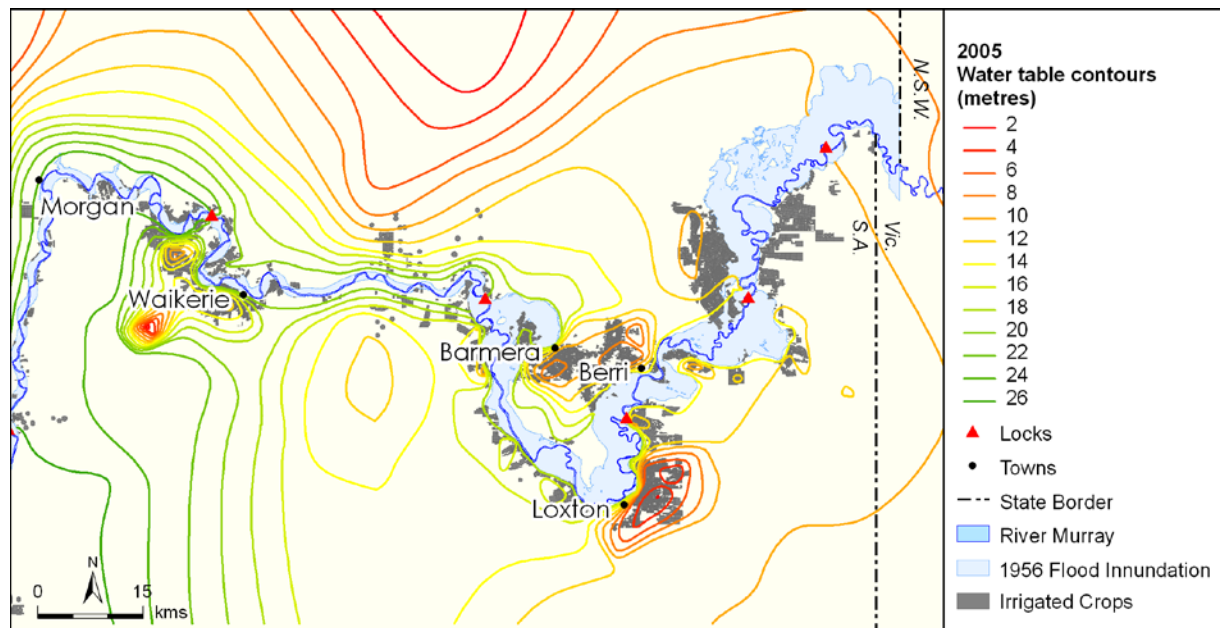


Figure 28: Pre-European water table contours and irrigated area

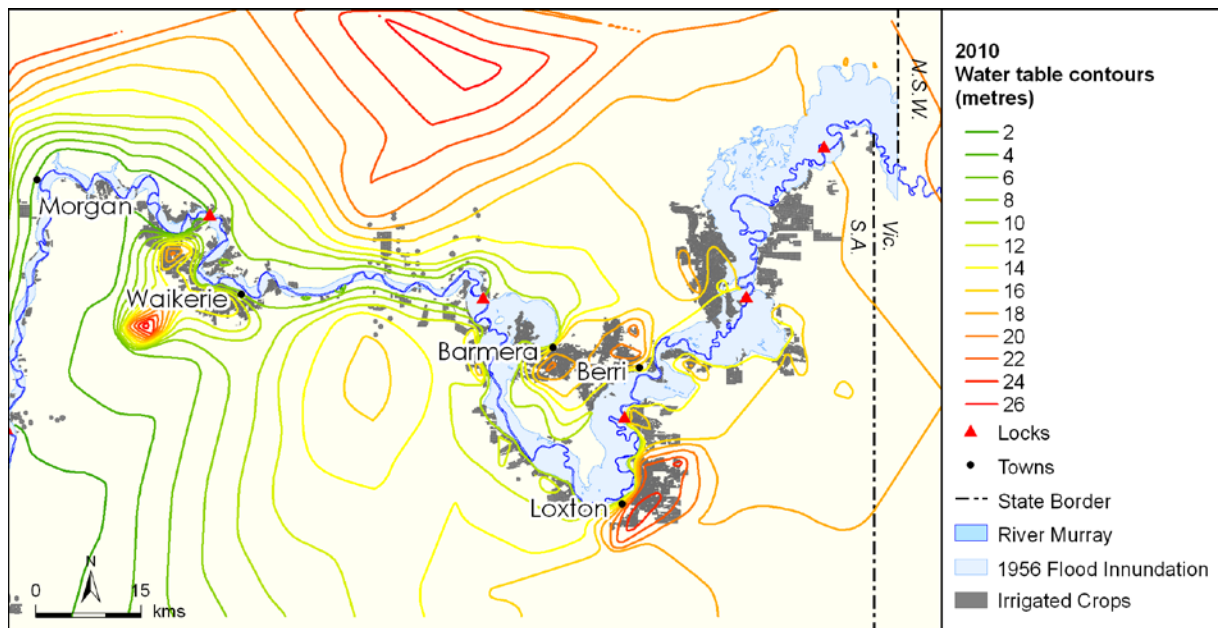


Figure 29: 2010 water table contours and irrigated area

The graph below (Figure 30) shows the steady rise in the volume of groundwater stored in these watertable mounds (excluding the mound beneath the Stockyard Plain Disposal Basin). A maximum of about 820 GL was reached in 2000, with a decrease in 2005 due to improved irrigation practices and rehabilitation of water distribution networks which is reflected in widespread falls in water levels in the observation networks. Further declines up until 2010 reflect the effects of the drought that resulted in reduced irrigation applications. The declining trend is expected to continue.

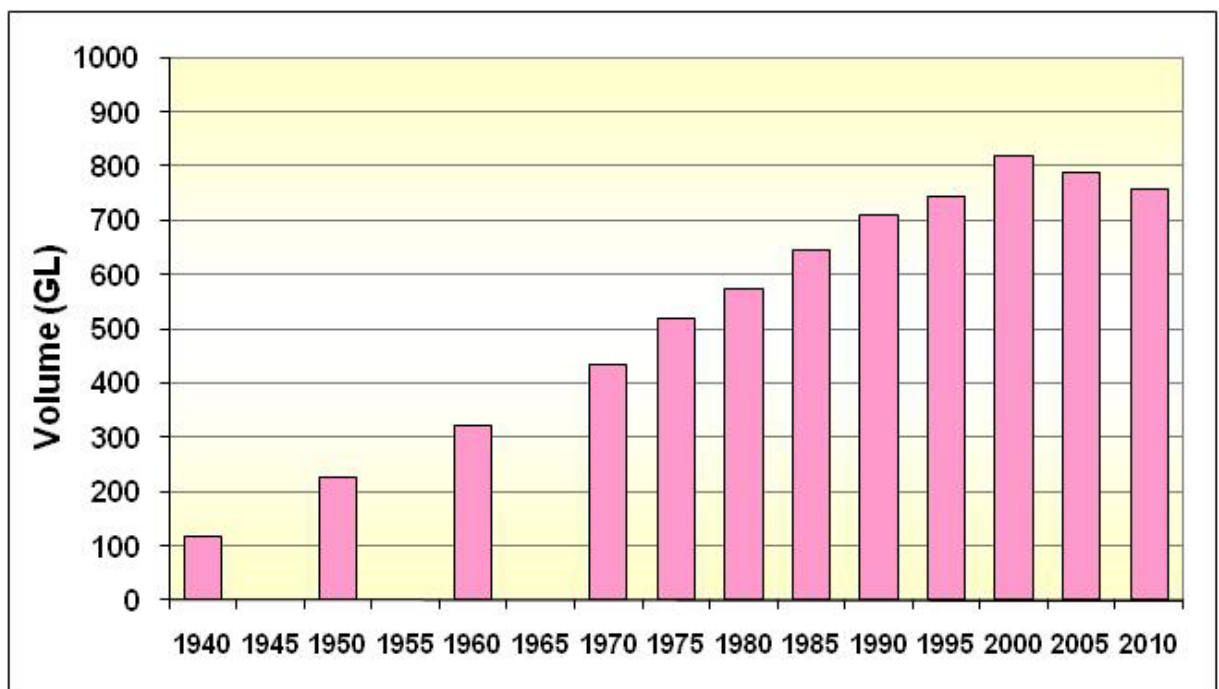


Figure 30: Estimated volumes stored in groundwater mounds

Community Stream Sampling

In 2009-10, the Community Stream Sampling project supported more than 40 community groups across the SA MDB region by providing them with the means to identify areas within their catchments that are at risk from salinity. The information obtained is used by groups to better understand their local water resources. In addition, this local-scale monitoring is used to enhance the regional water resource picture. Salinity monitoring forms part of a broader community monitoring program that also captures information on other water quality parameters such as nutrients, turbidity and pH.

During 2009-10, where low flows have persisted along with prolonged dry conditions, elevated salinity levels in streams and refuge pools was recorded. Seasonal summaries on the monitoring are provided to the community, publically accessible by visiting the Board's website: www.samdbnrm.sa.gov.au

Figure 31 indicates the variability in salinity in the Lower Lakes region, partly as a result of water and wetland management. It displays the effect of two summers of low/zero flow in the Goolwa Channel (Lower Lakes) and the impact in February 2010 (post regulator construction and water supplementation from Lake Alexandrina.)

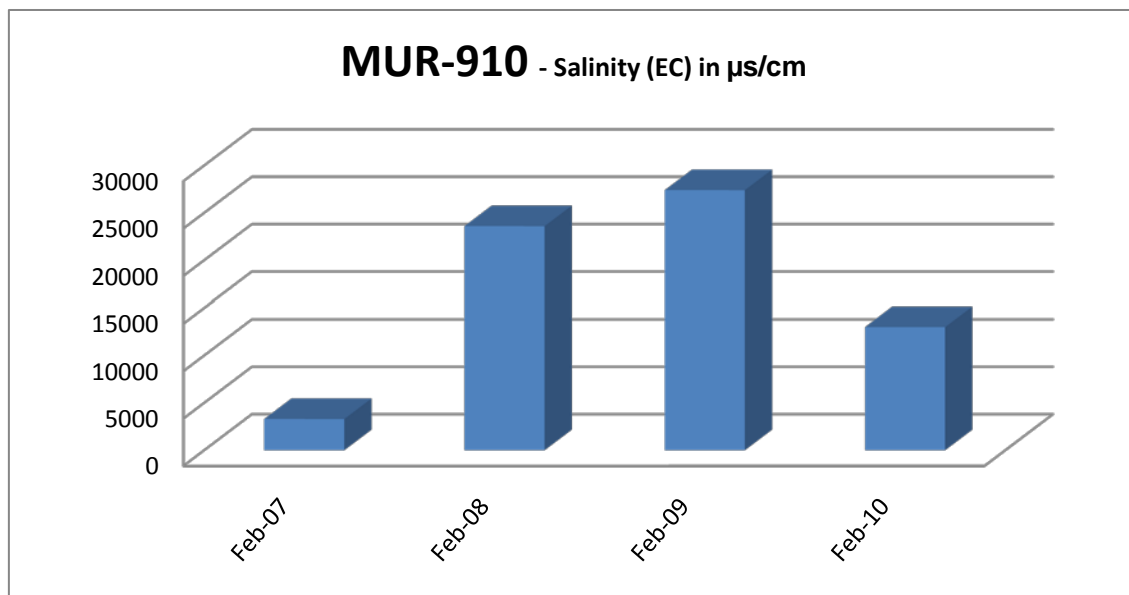


Figure 31: Community monitoring for salinity (EC)

Figure 32 indicates that salinity levels have not changed significantly across many streams that flow into the lower Murray (based on sampling by the community in February 2009 and February 2010 at the Angas River (ANG102 and ANG450), Currency Creek (CUR010 CUR015), Dry Creek (DRY020) and the Finniss River (FIN060)). Some streams recorded a slight increase while others showed a slight reduction.

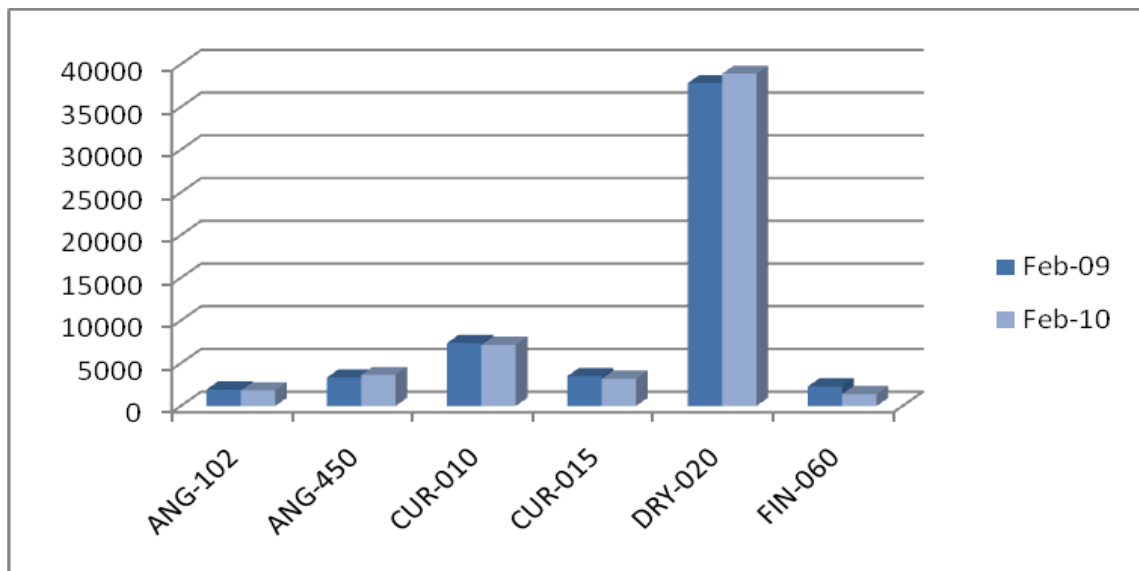


Figure 32: Community stream sampling for salinity (EC) at selected sites

Online Database as a Repository for Community Collected Data

Community stream sampling is now reported through an on-line, publicly accessible database that contains community collected data dating back to 1994. The Community Monitoring Online Database for the SA MDB region became operational in June 2010 and is designed to encourage and facilitate interaction between groups, landholders and education institutions. It allows for:

- direct entry of community surface water data;
- information about surface water groups and contacts;
- public access to the collected data;
- ability to spatially represent surface water information on approximately 100 monitoring sites;
- greater uptake and use of data collected; and
- designed for use by individuals with limited computer experience.

By making information publicly available, communities can showcase how they are part of natural resource management in their region, while also adding data they have collected. The database includes metadata detailing quality ratings.

Automatic Weather Monitoring Network

A regional automatic weather monitoring network was maintained and upgraded in 2009-10 in order to improve the capacity to schedule irrigation in the SA MDB NRM region. As reported in section 2.6.4, seven rainfall monitoring sites were upgraded to provide more regular data.

Rangelands Monitoring

The community stream sampling and groundwater bore monitoring at selected sites continues to be supported by the SA MDB NRM Board. A greater understanding of groundwater and surface water interactions of the Burra Creek catchment is being developed through engagement with the rangeland's community.

A key message from a SA MDB NRM Board workshop held in June was that the surface waters of the Burra Creek Catchment are highly dependent on groundwater and can be conceptually thought of in three parts; Upstream of Burra township; Burra to Worlds End gauging station; and the Floodout country.

Dryland Salinity Monitoring

In early 2010, a major report was released on long-term salinity monitoring at a key focus site near Tungkillo in the Eastern Mt Lofty Ranges. The Mt Eagle catchment falls just outside the SA MDB NRM region but is representative of the groundwater flow systems that operate in the eastern slopes of the ranges and therefore provides a useful indication of salinity trends in this part of the region. The catchment is part of a network of dryland salinity sites across the dryland agricultural regions of SA that are monitored by the State Government.

Different perennial vegetation treatments were planted in the two sub-catchments, with the third remaining as a control sub-catchment under annual crop/pasture. Groundwater monitoring within each sub-catchment has been undertaken over almost two decades, commencing in 1990. During the monitoring period, an overall declining trend in rainfall was experienced (long-term average rainfall being 525 mm). Although climate is a major driver of groundwater responses and dryland salinity, the establishment of perennials in the two sub-catchments resulted in a drop in groundwater levels above and beyond that which would be expected from the declining rainfall trend alone. The relative water use of different vegetation was shown to be trees > dryland lucerne > annual pasture.

Therefore, revegetating significant areas of a catchment with perennials can effectively lower groundwater levels and lead to amelioration of saline seepage areas. Potentially adverse impacts should also be noted, including reduced stream flow. This study showed that long-term monitoring is needed to understand the relative impacts of revegetation and of climate on salinity processes.

2.9.2 Evaluating

Risks to Registers Project

DWLBC (DFW) engaged Aquaterra in July 2009 to undertake the Future Risk Assessment of South Australian Entries on the MDBA Salinity Register project. This project was established to assess the risk to South Australia maintaining a positive balance on the Salinity Register by evaluating the impact of proposed changes to the types of models and methods being used to calculate the value of each entry. A challenge for South Australia is increasingly to generate cost effective credits, historically generated by investment in Joint Works and Measures (SIS).

In the report, it was identified that the main areas that could contribute to risk factors fall into three categories:

- Policy risks – methods for Register generation (i.e. ticking clock or 30 year average);
- Modelling risks – changes to models and the assumptions; and
- Accounting risks – conversion of modelling numbers to register entries.

It was noted that all entries on the Registers are based on models which in turn are interpretations of reality. As understanding of reality improves, models improve, and the resultant numbers generated can and do change. This poses a challenge in managing risks for the Registers. Some of the potential elements of risk identified include:

- Understatement of the impacts (debits) / overstatement of the offsets (credits);
- The modelling may not adequately establish scenarios that are appropriate;
- The transformation of modelling results to Register entries may be inappropriate; and
- Future assessments using different/refined models may generate different predictions.

It was concluded that the situation on the BSMS Salinity Registers for South Australia is very different from the biophysical situation. This was illustrated by the amalgamated results of all models in South Australia in terms of salt loads compared with the situation as expressed in the registers.

Overall this led to the conclusion that, from a biophysical perspective, salt mobilisation is under control in South Australia, a result of investment by South Australia and other jurisdictions in Joint Works and Measures. However this investment has reduced the number of credits available to South Australia, as well as the assignment of a large part of South Australia's share of the credits to the River Murray (rather than retaining them to offset the debits of further irrigation development). The BSMS Registers, however, reflect the accountability arrangements rather than the biophysical reality. By agreeing to the BSMS and the associated rules and investment, South Australia is accountable not for the biophysical status, but in terms of the policy of the day. This is the greatest risk for South Australia and needs to be recognised in planning of the future development of credits.

The report highlighted the need for South Australia to commit resources to the understanding and maintenance of the South Australian entries onto the Salinity Registers to ensure that changes made, either by South Australia or by the MDBA Office are understood, and the implications are clear.

A series of recommendations were made in relation to specific actions and the overall program. The problem facing South Australia was noted as significant, mainly because there are limited credits that can be made available with cost effective investment.

In terms of future investment, it was noted that due to the legacy of history and continued irrigation development, and partly due to increased mobilisation of salt resulting from environmental watering, the ongoing investment required is at least in the same order as the investment to date. This is because, while the model platforms exist, there is a requirement under the *Water Act, 2007* (Cth) to review and upgrade the models every 5-7 years. While the current suite of models were originally intended to be used to predict the effects of irrigation development impacts only, they do also provide the best available modelling platform for evaluating the impacts of environmental flows, provided their floodplain process features are upgraded.

It was recommended that South Australia needs to commit resources to supporting stakeholders in understanding the foundations of the South Australian entries onto the Salinity Registers, to ensure that changes made, either by South Australia or by the MDBA Office, are understood by all parties, and the implications are clear in terms of maintaining the overall balance.

The need for investment in a program of continuous improvement in data collection, modelling, research, and monitoring was emphasised as a critical part of any salinity management program. It was concluded that the amount of investment in these areas will be minor in comparison to the investment required to manage the significant salinity impacts South Australia has already in train.

South Australia is building the recommendations from this project into its forward salinity program.

Surface Water Models in South Australia

Modelling of surface water and salinity along the South Australian River Murray in 2009-10 has proven to be an invaluable instrument for the management of the river system. Modelling of salinity is fundamental to informing sound operational policy and management decision making in regard to water quality and salinity management in South Australia. Prior to the 2006-07 drought, River Murray surface water modelling was undertaken by the (then) Murray-Darling Basin Commission. A need to better manage the critical situation in South Australia has triggered a drive to improve modelling capabilities within DWLBC (DFW).

In 2009-10 South Australia has utilised surface water models to inform salinity and water quality operational policy and management decision making for:

- the proposed temporary weir at Pomanda Island (as described in Section 2.4.1);
- the blocking bank at Narrung and Lake Albert pumping programs;
- Goolwa Channel Water Level Management project; and
- purchase of water and ordering of flows to South Australia including those from the New South Wales and Queensland floods.

Additionally South Australia has now developed a scientifically robust assessment of the environmental water requirements for the Coorong, Lower Lakes and Murray Mouth indicator site by considering the ecological objectives and outcomes of the site and using the best available scientific information, as reported in Section 2.2.7.

As part of the project to develop environmental water requirements for the Coorong, Lower Lakes and Murray Mouth indicator site modelling has successfully been used to develop a flow regime that can manage salinity within Lake Alexandrina at levels below 1,000 EC. The move from an annual average barrage outflow target to a regime that considers the outflows over previous years to provide a more operationally relevant management strategy would not have been identified or able to be confirmed without the use of modelling.

The water quality and salinity modelling project for the Coorong, Lower Lakes and Murray Mouth also investigated opportunities to manage salinity in the Coorong using flows from the Upper South East (USE) drainage scheme. The project found that reduced freshwater inflows from the Murray-Darling Basin in conjunction with diminished South East flows in the recent past have resulted in salinity in the South Lagoon reaching levels that have precluded the presence of a healthy ecosystem in the lagoon. The work completed to date indicates that flows from the USE Drainage Scheme are no substitute for appropriate barrage flows and do not reduce the Coorong's dependence upon the Murray.

Groundwater Models in South Australia

In 2009-10 the Morgan to Wellington numerical groundwater model was completed. As a result, South Australia now has a complete set of ModFlow groundwater models that span the full length of the River Murray in South Australia (Figure 33). These models are used to bring entries forward to the BSMS Salinity Registers. The models are important salinity management tools that have been used to predict salt loads entering the River Murray from accountable

actions, resulting from existing and future irrigation development as well as SIS (where relevant).

Using the Morgan to Wellington 2009 model, two reports have been published:

- Morgan to Wellington Numerical Groundwater Model 2009 (DWLBC Report 2009/22). In this report, scenarios have been completed to assist in determining the origin and volume of salt entering the River Murray from groundwater sources resulting from accountable actions (e.g. irrigation efficiency improvements, irrigation area development and dryland clearing) and changes due to climate conditions (e.g. changes in river level below Lock 1).
- Morgan to Wellington Numerical Groundwater Model 2010 for Salinity Register Entry (DWLBC Report 2010/09). In this report, scenarios have been completed to assist in determining the origin and volume of salt entering the River Murray from groundwater sources resulting from accountable actions (e.g. irrigation efficiency improvements, irrigation area development and dryland clearing). According to MDBA's requirement for Salinity Registers entries, all assumptions were based on average climate conditions (e.g. changes in river level due to drought conditions were not included in the scenarios).

In 2009-10 three supplementary documents were also completed for the MDBA to support accreditation of numerical model results for the Salinity Register entry. Documents were produced for the Berri-Renmark and Pyap to Kingston models that provide additional details relating irrigation recharge and the simulation of Improved Irrigation Practices (IIP). These will be submitted for the 2010 Salinity Register update, refer to Section 2.9.3. For the Chowilla model, supplementary documentation gave additional details of the modelling approach. In addition, a comparison of model predictions with recent observation data gave extra confidence in the model.

As part of the five year review process for both the BSMS Salinity Registers entry and SIS all South Australian numerical groundwater models will be upgraded. Upgrades will be carried out using the latest knowledge and information and the best understanding of hydrogeology and management policies. The Loxton-Bookpurnong numerical groundwater model, which was developed and accredited by MDBA in 2005, will be upgraded in 2010-11 for the five year review process. Once the upgraded model has been accepted through the MDBA accreditation process, model results will be used again for both Salinity Registers entry and assessment of constructed salt interception scheme benefits in the Loxton and Bookpurnong area.

2.9.3 Reporting

Accountable Actions for 2010 Salinity Register Update

Salinity Assessment of Site Use Approvals

As advised in the 2008-09 Report to the Basin Salinity Management Strategy, the *Natural Resources Management (Water Resources and Other Matters) Amendment Act, 2007* came into operation on 1 July 2009, together with a range of regulations that support a staged implementation of unbundled water rights across the State. Accordingly, from 1 July 2009, changes to Site Use Approval will be assessed to represent the salinity impact of new irrigation development, rather than the previous surrogate, permanent water trade.

This is one of the most significant reforms to the management of South Australia's water resources in the past three decades. In particular, it has enabled the more efficient and effective processing of interstate and intrastate water trades. This has had several immediate benefits including significant 'red-tape' reduction and lower costs for licence and approval holders as well as reduced processing times for DFW water licensing staff.

All River Murray licensees were issued with their four separate instruments (where appropriate) in August 2009. The four instruments are:

- Water Access Entitlement: this is the ongoing right to a specified share of the water resource;
- Water Allocation: the right to take a specific volume of water for a given period of time, not exceeding 12 months, based on the volume of water available for allocation in that period;
- Water Resource Works Approval: the permission to construct, operate and maintain works for the purpose of taking water at a particular location, in a particular manner; and
- Site Use Approval: the permission to use the water at a particular site in a particular manner.

The DFW water licensing system (WILMA) had to undergo significant upgrades and amendments to deal administratively with the new unbundled environment. Due to delays related to these upgrades, the salinity impact assessment of new or increasing Site Use Approvals has not been completed. Therefore, South Australia will provide the salinity impact assessment of increased Site Use Approval for 2009-10 in the 2010-11 Report to the Basin Salinity Management Strategy.

Initial analysis indicates that there has been approximately 27.3 GL in adjustment to Site Use Approval volumes during 2009-10. This reflects all site use approvals, including those for sites outside of the River Murray Prescribed Area which are not required to undergo salinity impact assessment.

Berri-Renmark and Pyap to Kingston Numerical Groundwater Models

As reported in Section 2.9.2, South Australia's ModFlow groundwater models have been developed with the intention to ultimately inform the entry of multiple accountable actions on the BSMS Salinity Registers. Accreditation of a groundwater model by MDBA is required before the model outputs can be utilised for calculating BSMS Salinity Register entries. The MDBA fulfils this assessment obligation through a process of peer review. In 2009-10, South Australia

completed a number of documents available to support accreditation of groundwater models and upgrading BSMS Salinity Registers entries based on that information.

The Berri-Renmark model was submitted to the (then) Murray-Darling Basin Commission (MDBC) for accreditation in October 2007. The peer review for the Berri-Renmark model was carried out by Salient Solutions (Evans, 2009) for the MDBA with the overall findings of the peer review being that the model is not fit for the purpose of evaluating all required BSMS Salinity Register entries.

Supplementary documentation has now been prepared by SA to address the findings of the peer review for the Berri-Renmark model. The documentation supports the proposal for model accreditation for the purpose of informing multiple BSMS Salinity Registers entries.

Similarly, the Pyap to Kingston model result was submitted to the MDBC for accreditation in 2008. The peer review for the Pyap-Kingston model was carried out by Salient Solutions (Evans, 2009) for the MDBA with the overall findings of the peer review being that the model is not fit for the purpose of evaluating BSMS Salinity Register entries.

Supplementary documentation has now been prepared by SA to address the findings of the peer review for the Pyap to Kingston model. The documentation supports the proposal for model accreditation for the purpose of informing multiple BSMS Salinity Registers entries.

South Australia now needs to submit these pieces of documentation to the MDBA to support upgrading entries on the 2010 BSMS Salinity Registers based on these groundwater models. This will occur in time for calculations of the November 2010 Salinity Registers.

The values to update these entries are already entered on the 2009 Salinity Registers as provisional. These values need to now be moved from the provisional column and added to the respective entries to enable them to be reflected in the Salinity Registers balance. The source data sets for the entries will be resupplied to MDBA to confirm them as the inputs to the BIGMOD calculations undertaken by MDBA.

SA Mallee Legacy of History – Mallee Clearance

To date, data for entry 214 (SA Mallee legacy of History – Dryland) has been sourced from the report “Review of Mallee Clearing Salt Loads to the River Murray in SA - 2005” (DWLBC Report 2006/08). Since this report was produced, there has been further development, refinement, review and accreditation of South Australia’s groundwater models.

In March 2010, Aquaterra completed a report for the (then) DWLBC “Future Risks to South Australia’s BSMS Salinity Registers”. Amongst the recommendations, it was stated that the entry for Mallee Clearance should be updated with accredited model results, rather than the now out of date assessment of DWLBC Report 2006/08.

Recommendations made in the Impartial Peer Review of Mallee Zone SA Models and B Register Assessments for Irrigation Induced Legacy of History Impacts (CSIRO, 2008) were also supportive of the B Register Legacy of History assessments.

Therefore, South Australia proposes that data sourced from the 2006 report should be replaced with data from the following accredited numerical groundwater models:

- Border to Lock 3 (subzones to include Pike, Murtho, Bookpurnong, Loxton, Berri, Renmark, Pyap, New Residence, Moorook and Kingston)
- Morgan to Lock 3

- Morgan to Tailem Bend

In accordance with 5 year review requirements the Morgan to Tailem Bend model was updated during 2009-10 (the model has been extended south to Wellington and renamed the Morgan to Wellington model) and will shortly be submitted for independent peer review. Therefore, estimates for this region will be retained from the original report until further notice.

South Australia will formally submit this request to the MDBA to support upgrading entries on the 2010 BSMS Salinity Registers based on these groundwater models. As with the other examples above, the value to update this entry is on the 2009 Salinity Registers as provisional. This needs to now be moved from the provisional column and added to the entry above to enable it to be reflected in the Salinity Registers balance. This is expected to result in a reduction to the current debit entry, resulting in an increase to South Australia's Salinity Register credit balance. The source data sets for the entry will be resupplied to MDBA to confirm them as the inputs to the BIGMOD calculations undertaken by MDBA.

3. VALLEY REPORTS

South Australia is committed to contributing towards meeting the existing Basin Salinity Target and has also adopted it as a State target under the South Australian River Murray Salinity Strategy 2001-2015 (SARMSS). South Australia is keen for new operational targets to be specified in the forthcoming Water Quality and Salinity management Plan that facilitate actions to enable management of River Murray salinity below Morgan.

3.1 END OF VALLEY REPORT CARD

South Australia does not have any End-of-Valley targets defined under the BSMS. However, BSMS Basin Salinity Target is located within South Australia at Morgan. South Australia notes that in 2009-10, an existing 'review of salinity targets' report was prepared by Sinclair Knight Merz for MDBA, both in terms of fulfilling a Schedule B requirement for review of targets and to inform the MDBA's preparation of the Basin Plan (Water Quality and Salinity Management Plan). South Australia expects the Basin Plan may include additional targets for the lower River Murray to reflect the requirement to provide water of suitable quality for critical human needs down to Wellington.

It is understood that three reports associated with development of salinity targets as part of the Water Quality and Salinity Management Plan will be released at the time of the Basin Plan's release. Schedule B requires a peer review of the reports before it is considered fit for purpose for BSMS requirements and South Australia understands this will occur in due course.

In the meantime, South Australia is committed to contributing towards meeting the existing Basin Salinity Target and has also adopted it as a State target under the South Australian River Murray Salinity Strategy 2001-2015 (SARMSS). In addition, under SARMSS South Australia undertakes monitoring at a number of sites and this may give an ongoing indicator of likely performance against the Basin Salinity Target. These monitoring sites have been allocated salinity targets, derived from the Basin Salinity Target (Table 5).

Table 5: SARMSS Monitoring Sites

Monitoring site	Target EC *	Description
Border (downstream of Rufus River)	412	This site near the SA/NSW border effectively provides the salinity of water entering South Australia
Berri (Irrigation Pump Station)	543	This site has good long-term data and a continuous data recorder
Murray Bridge (Pump Station)	770	This site is a major off-take, and is downstream of the major urban off-take. The installation of a continuous recorder will ensure data quality will be maintained.

*Target EC for 80% of the time

The Independent Audit Group - Salinity has previously acknowledged that the End-of-valley Summary Report Card is not entirely suitable for South Australia, as it does not make provision for downstream targets, actions or reporting. However, South Australia has completed the relevant fields of the End-of-valley Summary Report Card (Table 6).

Table 6: End-of-valley Summary Report Card

Valley	Interim 2015 Target (% of 2000 Benchmark Conditions)			Valley Reporting Site (Shared resource sites shown in italics)	Assessed Baseline Conditions 1/1/2000	– “Do Nothing” Legacy of History Impact –2015 Effect	Agreed 2015 Target	Progress Given Actions To-Date
	Salinity		Salt load					Current Year 09-10
South Australia	Median	95%ile	Average					
Lock 6 to Morgan	Tba	800 EC	Tba	Murray at Morgan			800 EC	688 EC (Max) 671 EC (95 %ile) 575 EC (80 %ile) 8,296 ML/Day Max Flow
Monitoring Sites	Median	80%ile	Average					
Below Morgan	Tba	770 EC	Tba	Murray at Murray Bridge			770 EC	777 EC (Max) 756 EC (95 %ile) 690 EC (80 %ile) No flow data available
SA Border	Tba	412 EC	Tba	Murray at SA Border			412 EC	272 EC (Max) 244 EC (95 %ile) 223 EC (80 %ile) 9,745 ML/Day Max Flow
Berri	Tba	543 EC	Tba	Murray at Berri			543 EC	467 EC (Max) 448 EC (95 %ile) 423 EC (80 %ile) 8,674 ML/Day Max Flow

3.2 SUMMARY OF MONITORING SITES

3.2.1 Border (A4261022)

The pontoon-mounted salinity monitoring equipment located at the South Australian – Victorian Border generally provided reliable “good” coded data. However due to biofouling of the EC probe, 27 days or 8% was coded “fair”. The biofouling is thought to be caused by the high percentage of Darling River water entering South Australia this flow year.

Flow records for this site are derived from a rating at A4260200 (Victorian Gauging station, Murray River downstream of Rufus River) and A4140211 (Victorian Gauging station, Mullaroo Creek).

3.2.2 Berri (A4260537)

The salinity monitoring equipment located at the Berri Irrigation Pumping Station continued to operate reliably, with +99% of data of “good” quality in 2009/10 with only 1 day of data coded “fair”.

Generally EC data was reasonably smooth and a regular monthly visiting regime kept biofouling to a minimum.

Flows for this site are calculated at Lock 4 (A4260515, 8kms downstream of Berri), up to a stream-flow of 40,000 ML/day. Above 40,000 ML/day the high-flow gauging site at Lyrup (A4260663, 12kms upstream of Berri) is used. Flows at Lock 4 were quality coded “good” for 100% of record for 2009-10.

3.2.3 Morgan (A4260554)

The salinity monitoring equipment located at the Morgan Pumping Station pontoon operated reliably, with 100% of data coded “good” quality in 2009-10. Regular visits to the new flow gauging station DS of Morgan, now incorporate downloads of salinity data and cleaning of the EC probe. 10 days of EC data were coded “fair” with 97% coded “good”.

The new continuous flow station (A4261110) measuring continuous flow has been commissioned, 3.5 kms downstream of Morgan as detailed in Section 2.9.1.

3.2.4 Murray Bridge (A4261162)

The new water level and EC monitoring installation (A4261162) at Long Island (5 km downstream of the previous site) has now been operational for 18 months. Some instrumentation and biofouling problems have occurred, consequently only 88% of EC data has been quality coded “good”. However the upstream site at Mannum (A4261161) has been used to provide validation of the remaining “fair” coded data.

No flow measurements are currently possible at Murray Bridge.

4. RESPONSE TO INDEPENDENT AUDIT GROUP

South Australia values the process of annual audit by the Independent Audit Group – Salinity (IAG). The recommendations provided by the IAG in their annual reports promote action to address the high priority issues and highlight areas requiring additional investment. This is particularly valuable in a time of more limited resources for Murray-Darling Basin salinity management and a need to target key issues. South Australia's formal response to the IAG recommendations (as forwarded to the MDBA 28 January 2010) is provided below.

4.1 HIGH PRIORITY RECOMMENDATIONS

Recommendation 1: Flood recession salt risks

That the MDBA Office proceed with its project to facilitate development of a conceptual model of flood recession salt mobilisation in the flood plains, and prepare operational response management plans in preparation for the next high flow event.

South Australia supports this recommendation and notes that this recommendation has featured in all previous IAG-Salinity reports. Flood recession salt risks remain one of the most significant threats to water quality, especially for the lower River Murray. As reported in South Australia's 2008-09 annual report to the BSMS, addressing this issue will require a whole-of-basin approach. South Australia is keen to reiterate its interest to work with the MDBA on floodplain salinity and risks of future flooding and has previously provided a draft project proposal to the MDBA (March 2009) and this may be of use in developing a basin wide project. In particular, South Australia would like to see the following addressed:

- improvement in understanding of the processes of floodplain salt accumulation and salt mobilisation on salt load to river;
- improvement in understanding of how these processes can be influenced and/or controlled by other actions;
- development of a model with the ability to predict impacts of salinity in terms of in-river salt load, to enable regional scale salt accounting in the riverine corridor and risks to downstream water quality post-flood; and
- identification of management options and consideration of preparation of operational management guidelines.

Recommendation 2: Financial and human resources for BSMS implementation

That all Contracting Governments recognise the importance of continuing to manage salinity risks in the MDB, and ensure that human and financial resources are restored to levels that will allow the MDBA, in conjunction with the States and regional bodies, to successfully prepare and implement the Basin Plan; and that, in recognition of this, an injection of bridging funds be provided immediately for salinity and water quality until the financing of Basin Plan implementation is under way.

South Australia supports this recommendation.

South Australia remains strongly committed to the BSMS and River Murray salinity management. This is recognised through a salinity target in South Australia's Strategic Plan and a salinity action in the State's 'Water For Good' program.

South Australia intends to develop a new salinity management program and will be recruiting a program leader to drive this.

South Australia will be actively seeking opportunities to partner with the MDBA and other jurisdictions on key issues. For example, South Australia's River Murray groundwater models, utilised to support entries on the Salinity Registers, are collectively approaching their required review date (required under Schedule B cl39) and are currently only partially funded. Discussions have already been held with MDBA relating to funds for groundwater modelling for those models where there are mutual benefits.

More broadly, it is noted that with the conclusion of the National Action Plan for Salinity and Water Quality (NAP) and Natural Heritage Trust (NHT) funding sources, funds for on ground work by organisations such as the SA MDB NRM Board are also very limited.

Where appropriate, provision of support in the form of bridging funds would be greatly appreciated. This would assist in retaining expertise and knowledge to enable implementation of the Basin Plan (as it relates to salinity) in a timely manner.

Recommendation 3: Strategies for land based salinity management

That the MDBA facilitate a review of strategies and actions to reduce the mobilisation of salt in the landscape, and the strategies be assessed for their effectiveness using an evidence based approach, and that guidelines be prepared to assist catchment management organisations and state jurisdictions in the selection of sites and remediation methods with the best prospects of success. That research, development and implementation of the Living with Salt concept be encouraged to promote the use of moderately saline groundwater in the Basin.

South Australia supports this recommendation.

South Australia welcomes the opportunity to participate in an MDBA facilitated review. In terms of the Living with Salt concept, South Australia continues to support this with involvement in the Future Farm Industries Cooperative Research Centre (FFI CRC).

Recommendation 4: Salinity targets below Morgan

Salinity targets below Morgan: That Salinity targets below Morgan be provided to protect significant assets and populations that may be affected by high salinity below Morgan. These targets should include criteria set to aid real time operations. Fluctuations in salinity, which can be accommodated in the current Morgan target, may be unacceptably high for critical human needs or agricultural and ecological requirements.

South Australia supports this recommendation.

In late 2009 South Australia conducted an independent review of water quality and salinity issues which recommended a number of potential targets. An extract of the draft findings of the review report was provided to MDBA in January 2010 and it is intended that when finalised, the complete report will also be provided. South Australia anticipates that this information may be of interest to the MDBA in developing the Water Quality and Salinity Management Plan. The draft findings of this research (as reported in Section 2.3.1) suggest that:

- the existing Basin Salinity Target at Morgan should be retained as part of the Basin Salinity Management Strategy accountability framework with the frequency increased to 99.7% of the time;
- new operational salinity targets should be specified including:
- a target of less than 400 EC for 99.7% of the time at the South Australian border to ensure that environmental values downstream are protected;
- targets of less than 900 EC for 99.7% of the time at Murray Bridge and Wellington (this reflects the Australian Drinking Water Guidelines that state that total Dissolved Solids (TDS) should not exceed 500 mg/L which equates to between 800 and 900 EC depending on the conversion factor applied);
- a target of less than 1,000 EC for 95% of the time, with an upper limit of less than 1,800 EC for 99.7% of the time, should be specified in Lake Alexandrina to protect agriculture and aquatic ecosystems (It is noted in relation to this recommendation, the Department of Environment and Heritage are

currently conducting investigations into environmental water requirements for the Lower Lakes and Coorong including appropriate salinity levels. Preliminary investigations suggest an upper limit of 1,500 EC should not be exceeded at any time);

- salinity levels in the Coorong should be able to support healthy and diverse estuarine, marine and hyper-marine ecological communities.

It is noted that compliance and accountability around any new targets that are established under the Water Quality and Salinity Management Plan are issues that will need to be addressed. It would also be desirable for work being completed on the setting of targets to be closely linked to other work MDBA are completing for the Basin Plan, including identifying conveyance water requirements and setting of sustainable diversion limits.

Recommendation 5: End-of-valley salinity-flow interpretations/ Salinity hot spots

That further use be made of the end-of-valley target monitoring data to identify in-valley processes operating with changed flow conditions that, in combination with within-valley targets, can identify salinity 'hot spots' for management intervention. The BSMS MDBA Office should work with the BSM AP to develop appropriate techniques for data interpretation.

South Australia supports this recommendation.

The major salinity hotspots within the South Australian Murray-Darling Basin have been targeted with salt interception schemes. South Australia will continue to utilise in river sampling surveys, as presented in the 2008-09 report to the BSMS, to monitor effectiveness of salt interception schemes, identify potentially viable salt interception scheme extensions, identify new or previously unknown groundwater accession locations and to determine the effects to groundwater accession rates under lowered river levels (below Lock 1). South Australia welcomes the opportunity to share knowledge of new techniques with other jurisdictions via the Basin Salinity Management Advisory Panel.

Recommendation 6: Within-valley salinity targets

That all state and ACT contracting governments develop within-valley complementary targets for catchments with end-of-valley targets where salinity assessed as EC is greater than a decided level, commencing with those where EC increases with increasing flow to identify the processes contributing to the mobilisation of salt.

South Australia supports this recommendation.

South Australia notes the work being completed on the establishment of targets as part of the development of the Water Quality and Salinity Management Plan. The existing ModFlow groundwater models, covering the Murray-Darling Basin in South Australia, can be used to determine the likely sources of salt accessions and this can be confirmed using in river survey techniques, as discussed in the response to recommendation five.

Recommendation 7: Accountability for salt mobilised by environmental watering

That the BSM AP, with the support of the MDBA Office, prepare a proposal to build on the BSMS framework of accountability to provide accountability for the salinity effects of environmental watering using water released by the Commonwealth Environmental Water Holder and from other water holdings or sources and that the system so recommended be in place in time for the first such releases.

South Australia supports this recommendation.

South Australia is very keen to see this progressed, particularly in light of the recent approval for construction of the Chowilla environmental regulator that is acknowledged as having a high potential salinity impact, with implications for South Australia's salinity registers balance. A robust methodology for

incorporating the impacts of environmental watering within the accountability framework needs to be established so that the net balance on the salinity registers can be determined. Key issues that will need to be addressed include:

- complete assessment of both the long and short-term impacts of any watering event;
- ensuring that there is no double counting of debits where an environmental watering occurs between the river and an irrigation area (both impacts may be assessed using different models); and
- clarifying State versus shared accountability for impacts and ensuring that there is no double counting of debits where water from a combination of sources is applied to a single site, e.g. Chowilla is a The Living Murray (TLM) Icon Site. The salinity impact generated by applying TLM water is to be shared equally between the BSMS Contracting Governments, however, if Commonwealth Environmental Water Holder is source of water applied to Chowilla then the impact is accountable to the State in which the action occurs, i.e. South Australia.

Recommendation 8: Water management futures for climate change and salt

That a single set of scenarios be developed by the MDBA in conjunction with the Basin jurisdictions, and used to model the effects of climate change consistently across a number of issues including salinity.

South Australia supports this recommendation.

This work should occur as soon as possible – ideally it would commence by June 30 2010. The scenarios would then be able to be considered in the first of South Australia’s groundwater models required to undergo review, scheduled to commence in July 2010. South Australia notes that this information may also be of use in modelling that is occurring elsewhere in the MDBA, such as that under the River Murray System Operations Review, and in the setting of Sustainable Diversion Limits. Cross program consultation within the MDBA may assist in arriving at a single set of scenarios applicable to all areas of work.

Recommendation 9: Joint Works and Measures Program, including Pike River SIS

That the MDBA continue to support Pike River SIS investigations with a view towards implementation as early as possible, and continue preparation of the Joint Works and Measures Program to achieve at least a further 40 EC salinity improvement.

South Australia supports this recommendation and suggests that the preparation of the Joint Works and Measures Program should occur as a matter of priority, with involvement from all partner jurisdictions. Noting that the most effective areas for SIS have been targeted, the new program could include a component to investigate upgrade and expansion of existing schemes.

DWLBC wrote to the MDBA in September 2009 requesting MDBA support in progressing the Pike River SIS. The response received from MDBA in October 2009 indicates support to progress detailed design of the scheme and identification of a staged approach to construction, pending resolution of the requirements of the BSMS Phase 2 joint works (i.e. the recommended 40EC program).

4.2 NORMAL PRIORITY RECOMMENDATIONS

Recommendation 10: Flood and high flow SIS operational rules

That MDBA Office undertake a review of salt interception scheme operational rules during high flow events and flood events to determine the feasibility of operating groundwater pumps continuously during such events.

South Australia supports this recommendation.

South Australia welcomes the opportunity to discuss this issue amongst appropriate jurisdictional representatives.

Recommendation 11: Alignment of BSMS with catchment plans

That NSW seek closer alignment between BSMS obligations and regional Catchment Action Plans with a transparent role for Catchment Management Authorities in meeting targets particularly for catchments with end-of-valley targets through the development of within-valley targets, and that the CMAs be supported in upgrading data management and reporting.

Not directed at South Australia.

However, DWLBC continues to work with the SA MDB NRM Board, with particular involvement by the Board in the recent SA review of salinity and water quality (mentioned in the response to recommendation four). This included the identification of potential salinity targets for inclusion in the Water Quality and Salinity Management Plan.

Recommendation 12: Salinity implications of coal-seam gas production in Queensland and NSW

That Queensland further develop its coal seam gas water disposal policy to give clear direction on what are acceptable water uses which lower the short and long-term risks of damage from salinity. That NSW look to developing a policy in line with that developed in Queensland.

Not directly applicable to South Australia; however, South Australia supports this recommendation.

Recommendation 13: Assessment of uncertainty in Register entries:

That the MDBA Office routinely assess the uncertainty in new Salinity Effect Register entries by modelling for upper and lower estimates of error bounds.

South Australia supports this recommendation.

South Australia also notes the collaborative effort between DWLBC and MDBA to continually improve the accuracy and reduce uncertainty in salinity registers entries.

Recommendation 14: Inclusion of the Commonwealth Environmental Water Holder (CEWH) in the scope of the salinity audit

That the MDBA, in its review of Schedule B, consider recommending that the CEWH be included in the scope of the salinity audit because of the potential implication of environmental watering on salinity.

Not directly applicable to South Australia; however, South Australia supports this recommendation. South Australia suggests that reporting by the Australian Government should include any salinity impacts associated with the CEWH in accordance with 17 (1) of Schedule B that states “A Contracting Government must inform the Authority of any Proposal which the Government, acting reasonably, considers is likely to have a Significant Effect”.

5. REFERENCES

- Aquaterra, 2009 *South Australian Weir Pool Manipulation Compilation Report*, Report prepared for the SA Murray-Darling Basin NRM Board
- Aquaterra, 2010 *Chowilla Groundwater Model: Review of Salinity Impact Capability*, Report prepared for DWLBC (unpublished)
- Aquaterra, 2010 *Future Risks to South Australian BSMS Salinity Registers* Report prepared for DWLBC (unpublished)
- Aquaterra, 2010 *Salinity And Water Use Impacts Of River Murray Weir Pool Manipulations*. Report prepared for SA Murray-Darling Basin NRM Board
- Aquaterra, 2010 *Salinity Risks from River Murray Floodplains*, Report prepared for DWLBC (In draft)
- Barnett S, Cresswell D, Murdoch B, Walter M, Berens V, Yan W. 2003. *Salinity Impacts of River Murray Weir Pool Lowering in SA*. Department of Water, Land Biodiversity and Conservation , Report DWLBC 2003/26, 2003
- Brookes JD, Lamontagne S, Aldridge KT, et al 2009. *Ecosystem Assessment Framework to Guide Management of the Coorong. Final Report of the CLLAMMecology Research Cluster*. CSIRO: Water for a Healthy Country National Research Flagship, Canberra.
- Collard, S, Fisher, A and McKenna, D (2010) *Biodiversity value of saltbush (Atriplex nummularia) plantings in mixed farming landscapes of the Southern Mallee*, South Australia, DWLBC Report 2010/27, Government of South Australia
- Cugley, J., 2010 *Review of Water Quality and Salinity for the River Murray in South Australia*. Report prepared for the Department of Water, Land and Biodiversity Conservation (unpublished)
- Department of Water, Land and Biodiversity Conservation (DWLBC) (2004) *Basin Salinity Management Strategy Annual Report: South Australia 2004-05*, Strategic Policy Division, DWLBC Report 2005/26, Government of South Australia, Adelaide.
- Department of Water, Land and Biodiversity Conservation (DWLBC) (2006) *South Australia's 2005-06 Report to the Basin Salinity Management Strategy*, Strategic Policy Division, DWLBC Report 2007/05, Government of South Australia, Adelaide.
- Department of Water, Land and Biodiversity Conservation (DWLBC) (2007) *South Australia's 2006-07 Report to the Basin Salinity Management Strategy*, Strategic Policy Division, DWLBC Report 2007/21, Government of South Australia, Adelaide.
- Department of Water, Land and Biodiversity Conservation (DWLBC) (2008) *South Australia's 2007-08 Report to the Basin Salinity Management Strategy*, Strategic Policy Division, DWLBC Report 2008/16, Government of South Australia, Adelaide.
- Department of Water, Land and Biodiversity Conservation (DWLBC) (2009) *South Australia's 2008-09 Report to the Basin Salinity Management Strategy*, Strategic Policy Division, DWLBC Report 2009/15, Government of South Australia, Adelaide.
- Department of Water, Land and Biodiversity Conservation (DWLBC) (2006) *State Natural Resources Management Plan 2006*, Government of South Australia, Adelaide.

- Department of Water, Land and Biodiversity Conservation (DWLBC) (2007) *Groundwater Impact Assessment of the Proposed Chowilla Regulator using the Chowilla Numerical Groundwater Model*, Knowledge and Information Division, DWLBC report 2007/28, Government of South Australia, Adelaide.
- Dooley, T., Henschke, C. and Wright, S., 2009. *Decadal analysis of trends in depth to groundwater for dryland salinity areas of SA*. South Australia. Department of Water, Land and Biodiversity Conservation. DWLBC report (in prep).
- Fairweather PG and Lester RE (in press). *Predicting future ecological degradation based on modelled thresholds*. Marine Ecology Progress Series **413**: 291-304
- Government of South Australia (2007) *South Australia's Strategic Plan 2007*, Government of South Australia, Adelaide.
- Henschke C, Dooley T and Dutkiewicz A, 2010, *Impact of Perennial Vegetation on Watertables and Dryland Salinity*, DWLBC Report 2010/07, Government of South Australia, through Department of Water, Land and Biodiversity Conservation, Adelaide
- Heneker, TM (2009). *Interim report: Analysis of flow regimes required to meet water quality targets in the Lower Lakes*. Department of Water, Land and Biodiversity Conservation.
- Hobbs TJ, Neumann CR, Tucker M, 2010, *Carbon Sequestration from Revegetation: Southern Murray-Darling Basin Region*, DWLBC Report 2010/02, Government of South Australia & Future Farm Industries Cooperative Research Centre.
- Howe B., Yan W. and Stadter M. (2007) *Groundwater Impact Assessment of the Proposed Chowilla Regulator using the Chowilla Numerical Groundwater Model*. Prepared for the Department of Water, Land and Biodiversity Conservation of South Australia. DWLBC Report 2007/28, Government of South Australia, Adelaide.
- Kirk J., Cole P., Miles M. and Burrows D. (2004) *South Australian Salinity Accountability Statement 1988-2003*. Department of Water, Land and Biodiversity Conservation (DWLBC), DWLBC Report 2004/30, Government of South Australia, Adelaide.
- Lester, RE and Fairweather, PG (2009). *Ecosystem states of the Coorong: an ecosystem response model. Method development and sensitivity analyses*. CSIRO: Water for a Healthy Country National Research Flagship.
- Lester, RE, Webster, IT, Fairweather, PG & Langley RA, (2009). *Predicting the future ecological condition of the Coorong. Effects of management and climate change scenarios*. CSIRO: Water for a Healthy Country National Research Flagship.
- Lester RE, Fairweather, PG, Heneker, TM, Higham, JS & Muller KL (2010). *Specifying an environmental water requirement for the Coorong and Lake Alexandrina and Albert: A first iteration. Summary of methods and findings to date*. A draft report prepared for the South Australian Department of Environment and Natural Resources.
- Morgan, L and Yan, W, 2010, *Response to Peer Review of the Berri – Renmark Groundwater Model for Purposes of Salinity Register Entry*, Unpublished Document, Department of Water, Land and Biodiversity Conservation, Adelaide.
- Morgan, L and Yan, W, 2010, *Response to Peer Review of the Pyap to Kingston Groundwater Model for Purposes of Salinity Register Entry*, Unpublished Document, Department of Water, Land and Biodiversity Conservation, Adelaide.
- Murray-Darling Basin Authority (2010) *Report of the Independent Audit Group for Salinity 2008-2009*, Murray-Darling Basin Authority, MDBA Publication No. 52/10.

Murray-Darling Basin Commission (2005) *Murray-Darling Basin Commission Basin Salinity Management Strategy (BSMS) Operational Protocols*, Version 2.

Murray-Darling Basin Ministerial Council (2001), *Basin Salinity Management Strategy 2001–2015*, Commonwealth of Australia.

South Australian Murray-Darling Basin Natural Resources Management Board (2009) *Water Allocation Plan for the River Murray Prescribed Watercourse (as amended 15th July 2009)*, Government of South Australia, Adelaide.

Sinclair Knight Merz 2010 *Salinity Horizons Scenario Analysis Report* prepared for DWLBC (in draft)

Yan W., Howles S. and Marsden Z. (2004) *Chowilla Floodplain Numerical Groundwater Model*. Prepared for the Department of Water, Land and Biodiversity Conservation of South Australia. DWLBC Report Book 2004/65.

Yan W, Morgan L, Georgiou J, Evans S and Vears L, 2010, *Morgan to Wellington Numerical Groundwater Model 2009* (DWLBC Report 2009/22). Government of South Australia, through Department of Water, Land and Biodiversity Conservation, Adelaide.

Yan W, Morgan L, Georgiou J, Evans S and Vears L, 2010, *Morgan to Wellington numerical groundwater model 2010 for Salinity Register entry*, DWLBC Report 2010/09, Government of South Australia, through Department of Water, Land and Biodiversity Conservation, Adelaide.

Yan W. and Stadter M. (2008) *Pyap to Kingston Numerical Groundwater Model*. Prepared for the Department of Water, Land and Biodiversity Conservation of South Australia. DWLBC Report 2008/19, Government of South Australia, Adelaide.

6. APPENDIX A

Reports delivered under the Riverine Recovery Project

Definition of River Health.

Definition of River Health Project was to establish a benchmark of conditions which represent a healthy riverine environment in South Australia.

Bull, N. and Sheldon, R., 2009 Definition of River Health. Sinclair Knight Merz report to the Environmental Water Management Program, Department of Water, Land & Biodiversity Conservation.

Context and Method Background Paper

Context, method to develop plan

Department of Water, Land & Biodiversity Conservation, 2010, Riverine Recovery Project Context and Methods Background Paper, Riverine Recovery Project, Environmental Water Management Program.

River Murray Wetland Classification Project

Application of the SAAE methodology in the SA River Murray

Jones, L. and Miles, M., 2009, River Murray Wetland Classification Project. Department for Environment and Heritage report to the Environmental Water Management Program, Department of Water, Land & Biodiversity Conservation.

River Murray SAAE Wetland Type Conceptual Models

"For each wetland type a range of models were developed to depict differences between hydrology (terminal branch, through flow or overbank flow systems) and wet and dry phases. For each of the wetland types a series of models were developed:

- Control models which shows system drivers, stressors, ecosystem attributes, control points and their interactions and relationships
- Stressor models, which depict the major system stressors and the ecosystem attributes they affect
- Stommel diagrams which depict the spatial and temporal scales of ecosystem drivers and attributes."

Souter NJ, 2009 River Murray SAAE Wetland Type Conceptual Models. EcoKnowledge report to the Environmental Water Management Program, Department of Water, Land & Biodiversity Conservation.

Water Delivery Options Background Paper

Water delivery options for wetland and floodplain management

Department of Water, Land & Biodiversity Conservation, 2010. Riverine Recovery Project Water Delivery Options Background Paper, Riverine Recovery Project, Environmental Water Management Program.

Audit of Wetland Regulating Structures.

Infrastructure audit of all structures and barriers to flow in the SA River Murray environment

Tonkin Consulting, 2010 Audit of Wetland Regulating Structures. Report to the SA Murray Darling Basin Natural Resources Management Board

Wetland Infrastructure Options.

Standard Wetland Management Infrastructure Options and Cost Models (including spreadsheet models)

Aquaterra, 2010 Wetland Infrastructure Options. Report to the Environmental Water Management Program, Department of Water, Land & Biodiversity Conservation.

Integrated Modelling of River Management and Infrastructure Options to Improve Environmental Outcomes in the Lower River Murray

CSIRO report on the Multiple Criteria Decision Making (MCDM) model developed by CSIRO for the RRP

Overton, I.C., Bryan, B.A., Higgins, A.J., Holland, K., King, D., Lester, R.E., Nolan, M., Hatton MacDonald, D., Oliver, R., Lorenz, Z. and Connor, J.D. (2010). 'Integrated Modelling of River Management and Infrastructure Options to Improve Environmental Outcomes in the Lower River Murray'. CSIRO Water for a Healthy Country technical report prepared for the South Australian Department of Water, Land and Biodiversity Conservation. Draft

River Water Savings from Selected South Australian Wetlands – Stage 1.

"Using the Wetland Prioritisation project's interim output as a basis wetlands with a low to moderate score and greater than 80 ha were initially selected. These were then subjected to water use calculations using the 'Wetland Management Calculator' developed by DWLBC. Finally detailed assessment criteria were applied included ecological, hydrological, salinisation and acidification risk, as well as feasibility considerations."

Sinclair Knight Merz, 2009 River Water Savings from Selected South Australian Wetlands – Stage 1. Report to the Environmental Water Management Program, Department of Water, Land & Biodiversity Conservation.

River Water Savings from Selected South Australian Wetlands – Stage 2.

Stage 2 which is a detailed water use calculations assessment for the short listed wetlands for a range of water management regime scenarios. The end result will be a final list of wetlands where proposed water management regimes and concept plans for related infrastructure works can be taken out to wider consultation.

Sinclair Knight Merz, 2010 River Water Savings from Selected South Australian Wetlands – Stage 2. Report to the Environmental Water Management Program, Department of Water, Land & Biodiversity Conservation.

Monitoring and Management Background Paper

Monitoring chapter attachment includes additional information besides that presented in the RRP plan Department of Water, Land & Biodiversity Conservation, 2010. Monitoring and Management Background Paper, Riverine Recovery Project, Environmental Water Management Program.

Riverine Recovery Project Monitoring & Management Framework

Monitoring Framework developed for RRP

Aquaterra, 2010 Riverine Recovery Project Monitoring & Management Framework. Report to the Environmental Water Management Program, Department of Water, Land & Biodiversity Conservation.

Gurra Gurra Lakes Investigation: Stage 1

Gurra Gurra Lakes Investigations

Sinclair Knight Merz, 2009 Gurra Gurra Lakes Investigation – Stage 1. Report to the Environmental Water Management Program, Department of Water, Land & Biodiversity Conservation.

Management Action Database: Business Requirements Document

MAD – brief and review

Environmental Water Decision Support System: Conceptual Document

EW-DSS project brief

Riverine Recovery Project Engagement and Communications Summary Report

Stakeholders past engagement report

Department of Water, Land & Biodiversity Conservation, 2010. Riverine Recovery Project Engagement and Communications Summary Report, Riverine Recovery Project, Environmental Water Management Program.

Post Business Case Communications and Stakeholder Engagement Strategy

Stakeholders engagement plan for implementation from July 2010

Acid Sulfate Soils Risk Assessment Project: Results from Rapid Field Assessment

Rapid Assessment ASS

Review of the Social-Economic Values associated with the River Murray, floodplains and wetlands

Socio-economic values - paper in preparation

Hatton MacDonald et al., in prep. Review of the Social-Economic Values associated with the River Murray, floodplains and wetlands. CSIRO: Water for a Healthy Country National Research Flagship