Tools for Managing, Modelling and Accounting for Salinity in the South Australian Murray-Darling Basin (SAMDB)

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Abstract
South Australia (SA) faces a unique challenge when managing salinity along its part of the River Murray System. Under the Murray-Darling Basin Agreement, SA, together with New South Wales and Victoria, has committed to hold the line on River Murray salinity. SA has to deal with a combination of reduced river flows and increased saline groundwater inflows to the river system as a result of irrigation and land clearing.

Policy, planning and modelling tools need to address land use adjacent to the River, accumulation of salt on the floodplain and the potential impacts of wetland management. Tools are required at State, catchment and community level.

SA has taken on this challenge by developing a comprehensive toolkit for salinity management, such as powerful legislation, planning at both regional and community levels with a collaborative approach between community, regional NRM managers and State Government and an impressive set of salinity modelling tools that deal with impacts of land use change, identify floodplain salinisation risks and salinity impacts of wetland management.

SA is now in a strong position to develop best practice salinity management in the Murray-Darling Basin.

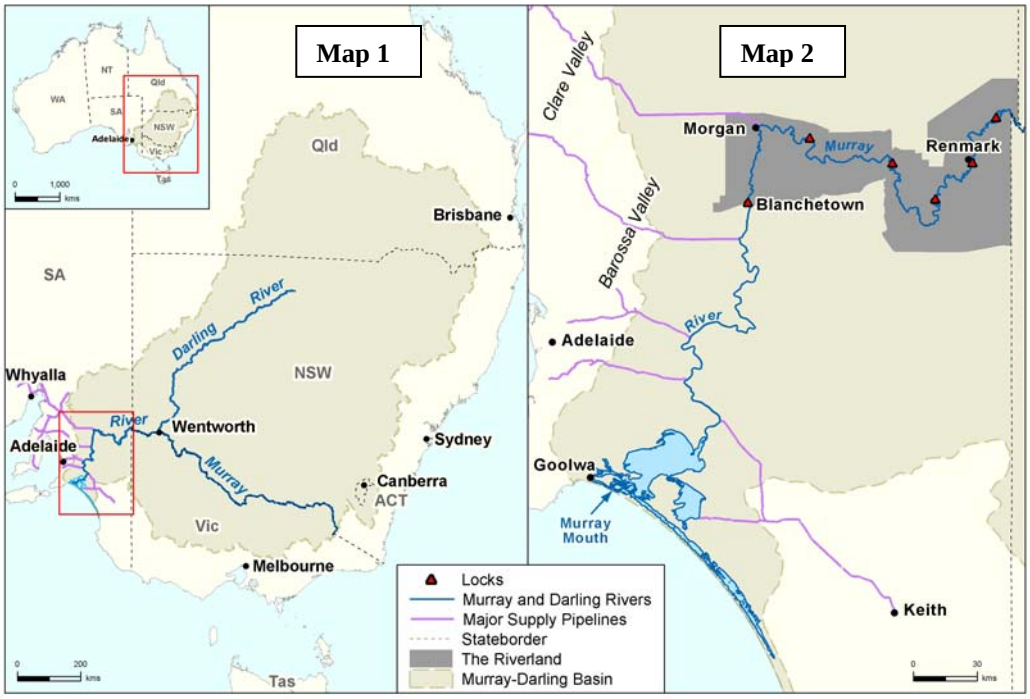
Keywords
Salinity; Tools; Policy; Planning; Models

INTRODUCTION

The Murray-Darling Basin covers approximately one million square kilometres, or 14% of Australia and extends through several states including South Australia (RMCWMB 2003[1]). The River Murray (the River) dominates the South Australian portion (Map 1) of the basin and for the most part, the River is a gaining stream as it receives groundwater inflows from the surrounding area. Much of the riverine corridor in the SA has been developed for irrigated crops including grapes (both wine and table), citrus, stone fruit, pome fruit, nuts (almonds and pistachios) and vegetables. Downstream, dairying is common with the water used to irrigate pasture for feed.

The River is not only widely utilised for irrigation and farming, it supplies up to 90% of Metropolitan Adelaide during times of drought (DWR 2001). It is piped to other country towns and is diverted to provide supplementary water for the Clare and Barossa Valleys (Map 2). Recreational uses such as water sports, house boating and fishing are also supported by the resource.

The flow of the River Murray is highly regulated by locks and weirs that have been in place since the 1930s. In SA, there are six lock and weir structures along the River Murray's course with Lock 1 at Blanchetown and Lock 6 near the South Australian-Victorian Border. The town of Morgan between Locks 1 and 2 is used to measure relative changes in salinity in the mainstream of the River.



Maps 1 shows the location of the Murray-Darling Basin and Map2 shows the South Australian Section with the "Riverland" and major supply pipelines highlighted.

Irrigated horticulture along the River in SA has experienced strong growth in the last 15 years, as a result of water savings due to water supply infrastructure improvements, improved on farm irrigation efficiency, the development of a water market both within SA and interstate and good market conditions for crops such as wine grapes. Between 1988-2003, approximately 90 GL of trade (both inter and intra-state) occurred resulting in 14,000 ha of new irrigation development. Because of SA's hydrogeology, with saline groundwater underlying most of the basin, and the River acting as a drain for this groundwater, this growth has also set in train increased salt loads to the River and its floodplains. It is estimated that as a result of irrigation developments since 1988, salinity at Morgan will increase by approximately 9EC (averaged over 30 years) the state can offset this impact through salt interception, rehabilitation and improved water use efficiency/drainage reduction.

The floodplains adjacent to the River Murray have been subjected to changes in the duration and frequency of flooding events via the regulation of the river. The health and distribution of several key species is considered to be highly indicative of overall floodplain condition and is thus an important factor in the decision making process for floodplains. The accumulation of salt in the floodplain has been increased by saline groundwater accessions from irrigation seepage and dryland recharge. The health of vegetation has been in rapid decline and the general floodplain environment has been degraded due to these influences. Salt that accumulates on the floodplain also has the potential to be driven to the river in times of higher flows.

The River Murray in SA has 1100 wetlands in 250 complexes (SARMWMC 1996) that supply a range of habitats to fish, macro-invertebrates, birds and vegetation. These wetlands are recognised as important national assets (DEH & DWLBC 2003) Regulation of the River Murray has altered the flood and drought regime that characterises the "natural" seasonality of river flows. Structures are often installed on the inlet and/or outlet of a wetland to enable wetting or drying cycles to be adopted in an attempt to mimic natural flow regimes.

SA has developed a comprehensive toolkit for salinity management, comprising of policy, planning and modelling tools that support State, regional and district level action to manage salinity. These

tools support SA's aim to hold the line on salinity, as committed to under the Murray-Darling Basin Agreement and to develop best practice in salinity management in the Murray-Darling Basin.

POLICY TOOLS

There are a number of policy tools that support management of the River Murray in South Australia. These tools range from legislation to strategic policy and statutory policy for the management of water allocations. The following documents have implications for salinity management:

River Murray Act 2003

The *River Murray Act 2003* predominantly aims to achieve a healthy working river system through the protection and enhancement of the River Murray its anabranches, tributaries, floodplains, wetlands. It ensures that existing and new activities that may have an impact on the River Murray are undertaken in a sustainable manner.

Water Resources Act 1997

The *Water Resources Act 1997* provides for the management of the State's water resources through controlling water affecting activities, water allocations, licensing, transfers, and the establishment of Catchment Water Management Boards. It also defines processes for the Catchment Water Management Boards to develop additional planning and policy documents for the catchment area and any prescribed water resources.

The *Water Resources Act 1997* is soon to be repealed by the *Natural Resource Management Act 2004*; however, proclamation of this Act is pending. Once proclaimed, the *Natural Resource Management Act 2004* will provide protection and promote sustainable and integrated management of the State's natural resources. The *Natural Resource Management Act 2004* will include many provisions currently in the *Water Resources Act 1997*.

River Murray Salinity Strategy 2001

This documents set out the strategic framework for River Murray salinity management in South Australia. Key elements of the Strategy are:

- Accountability for salinity impacts from irrigation practices is assigned to all irrigators.
- Land and Water Management Plans provide for collective action and salinity accountability.
- Protect floodplains and wetlands by preventing development in certain adjacent highland zones and prioritising salinity mitigation works.
- A range of mitigating actions will be pursued including revegetation, reducing irrigation drainage, investment in drainage management infrastructure, saline groundwater mitigation and purchase of credits.

Water Allocation Plan for the River Murray Prescribed Watercourse

The Water Allocation Plan for the River Murray Prescribed Water Course (WAP) was adopted by the Minister for Environment and Conservation on 1st July 2002. The WAP is a legal document prepared under the *Water Resources Act 1997* by the River Murray Catchment Water Management Board. It outlines the rules for the allocation, transfer and use of water from the River Murray prescribed watercourse and details the amount of water that can be taken and used for all uses including consumptive water uses and environmental water use. Additionally, the WAP outlines monitoring and reporting requirements for irrigation allocations (RMCWMB 2002[2]).

To assist in the management of salinity, the WAP outlines specific criteria requiring the offset of any salinity impacts and water use efficiency targets to be met. The assessment of the salinity

impact of each proposed transfer is essential to administer the policy, and this has required development of specific modelling tools (see Modelling Tools).

PLANNING TOOLS

Along with the suite of policy outlined above, several planning and implementation documents are available to guide sustainable use of the river, both at the catchment and district level

Catchment Water Management Plan for the River Murray in South Australia (CWMP)

The Catchment Water Management Plan (CWMP) is a strategic plan to improve the condition of the catchment and its water resources. The CWMP identifies the goals, principles and strategies for integrated water management and assesses the threats and opportunities for sustainable development.

The CWMP introduces controls over activities within the catchment that are likely to harm water resources including those that have the potential to increase salinisation. The CWMP includes a costed work program of actions needed to tackle priority catchment issues and locations. Further, the plan outlines a range of actions that can be undertaken including on-ground works, education programs and research and development (RMCWMB 2003[1]). When the *Natural Resource Management Act 2004* is proclaimed, the CWMP will be replaced with the Integrated Natural Resource Management Plan (INRM) that will address all of the SAMDB's natural resource management issues under an integrated framework. However, the intent, actions and goals of the CWMP are to be maintained in this document.

Land and Water Management Planning (LWMP)

Since the mid 1990s, Local Action Planning Associations, community, based, district-scale groups focussing on achieving on-ground actions to tackle local environmental concerns and promote sustainable development, have invested in Land and Water Management Plans (LWMP) as vehicles for achieving on-ground actions in their district. The LWMPs provide strategies to attract investment to manage the impacts of irrigation and drainage. The plans assess the actual and potential threats to the sustainability of the district and suggest the actions to mitigate these issues whilst still maintaining productivity of the region.

Recently, there has been a shift towards revitalising the existing LWMP documents and in some cases enabling them to be rewritten and updated to meet a new set of LWMP Guidelines, which were agreed upon by the broader community, land holders (including irrigation and dryland properties), the River Murray Catchment Water Management Board and key Local and State government agencies. The guidelines allow for regional variations to be made between the plans but they provide a consistent format and process to be adopted. The guidelines promote a partnership approach to developing and updating the LWMP and also represent a formal commitment by all stakeholders to support the plans. The guidelines were established to provide a consistent framework and provide clarity for the process (Marsden & Jacobs Associates 2004). They will be a key tool to allow irrigation communities in particular to set their own priorities and implement actions for salinity management within the broader regional, State and basin wide policy frameworks.

Wetland Management Plans (WMP)

Under current legislation, any action that controls the movement of water in or out of a wetland that is connected to the River at normal pool level, requires a water licence and water allocation. As a component of the licence application, a Wetland Management Plan (WMP) is required to ensure the efficient and effective use of the resources. To assist wetland managers in preparing these plans, guidelines for wetland management have been prepared. The guidelines outline some key criteria that should be included in the WMP. In a similar vein to LWMPs, the potential threats, solutions, actions and responsibilities are outlined in the plan.

The WMP is a planning document that focuses on achieving an improvement to the biological and physical health of the wetland. In order to reach these outcomes, the introduction of an artificial hydrological regime to mimic natural seasonality is required and an understanding of the associated benefits or impacts is needed.

Wetland Management Plans are necessary for demonstrating the ability to manage a wetland in an accepted and sustainable manner, and are the basic mechanism by which wetland managers are able to meet legislative requirements (RMCWMB & DWLBC 2003). As part of the Wetland Management Plan, an assessment of the potential salinity impacts of the proposed development and the water allocation is required. This has posed some challenges for model development.

Floodplain Management Plans (FMP)

The Floodplain Management Plan (FMP) concept has only recently been discussed and is undergoing the initial stages of development. It has been highlighted that certain areas may require more specific information and actions to protect or recover the floodplain environment. These areas do not conform to the outcomes sought by either the LWMP or the WMP process and will therefore require a plan for management of the floodplain.

It is the intention that Land and Water Management Plans and Floodplain Management Plans will form an integrated management planning profile that allows the riverine corridor to be managed in a more holistic manner. The development of these plans provides carriage to attract investment and enable communities to manage the natural resources in partnership with government and other stakeholder groups.

MODELS

The range of modelling tools available in SA reflect a detailed understanding of the salinity processes in the River Murray system and make use of the increasingly more detailed datasets on hydrogeology, hydrology, ecology, land use and soil types. They allow prediction of salinity impacts of actions, to support assessment and approval processes and they inform policy development. SA has been at the forefront of salinity model development within the Murray-Darling Basin.

Salinity Impacts Model (SIMPACT)

In an attempt to quantify the salinity impacts and potential benefits of changes to on ground actions, MODFLOW groundwater models were developed in a number of areas. These are able to model the flow of groundwater over time considering increasing recharge rates or Salt Interception Scheme extractions in particular areas. In an attempt to 'fill the gaps' between MODFLOW models, a GIS based groundwater model was developed.

This model called SIMPACT, (MDBC 2003) assesses the salinity impacts of actions that increase or decrease recharge to regional aquifers. It differs from the MODFLOW models by providing continuous coverage of the river corridor in a single model and by calculating aquifer recharge rates prior to calculating salt implications for the river corridor from changes to groundwater flow.

SIMPACT is populated by geophysical data layers derived from drilling information, airborne EM32 survey, groundwater monitoring and digital elevation models. Outputs from SIMPACT are in the form of increased groundwater flux and hence tonnes of salt delivered to the floodplain. These are then converted to in river estimates of EC debits or credits using the Murray-Darling Basin Commission's BIGMOD model.

SIMPACT has been accredited by the MDBC for use in quantifying salinity impacts of interstate water trade. It has been used to estimate the impacts of native vegetation clearance, as well as the

benefits from revegetation strategies. It has also been instrumental in developing salinity-zoning policies to encourage sustainable development (Fig 1).

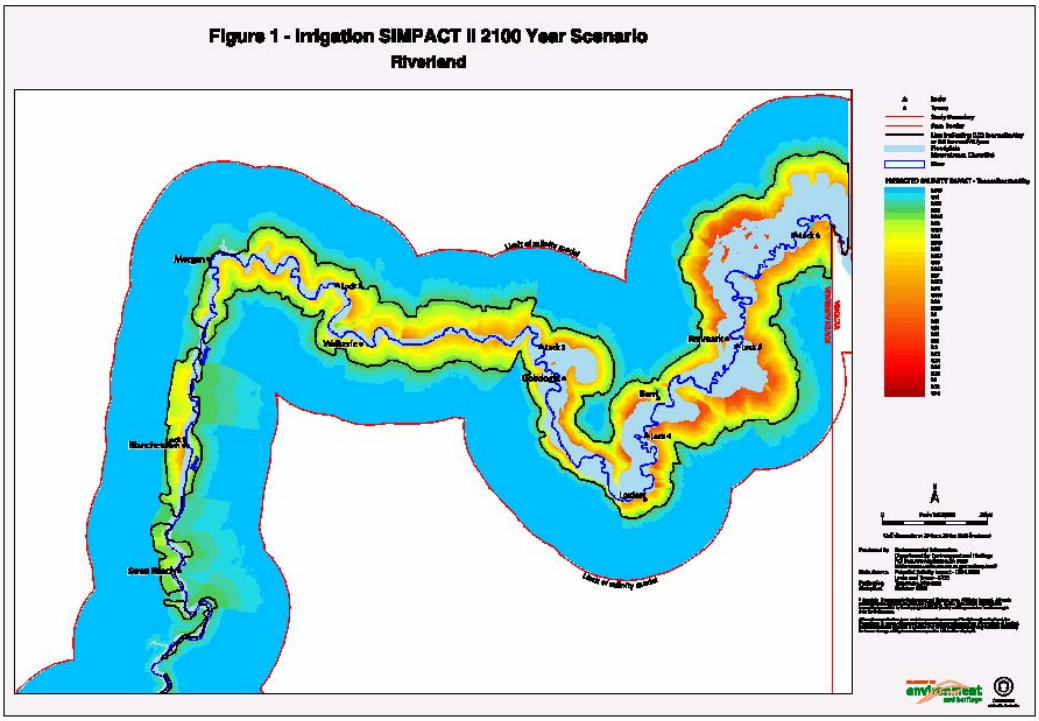


Figure 1 Shows the output form SIMPACT modelling and displays a gradational representation of the potential salt impacts to the River Murray over 100 years (Swan Reach Area to the NSW, Victoria and SA Border)

Salinity Impacts of Wetland Manipulation Model (SIWM)

An assessment process has been initiated to quantify salinity impacts associated with wetland management. In past years, many structures have been constructed and operated on wetlands in attempt to mimic "natural" flow events in wetlands. Potentially, this attempt to mimic a natural flow regime could return saline surface water to the river. Wetlands do not create their own salt and so their impact to the river revolves around attempting to ascertain the change in timing of a saline release.

This culminated in a combined project to devise a model suitable for predicting the potential salt impacts and water volume requirements of various management strategies. To this end, the Salinity Impacts of Wetland Manipulation (SIWM) model was developed.

The model uses a daily water and salt balance approach in attempt to simulate wetland behaviour when applied to most wetlands in the SA (AWE and Earth Tech 2002). It was intended that the SIWM model could be used by all stakeholder groups involved in wetland management including government (for water allocation and EC Impact) and wetland managers (accumulation of salt in the wetland over time).

The SIWM model can provide an output that can be run through the Murray-Darling Basin Commission's BIGMOD model to obtain the cumulative rise in salinity at Morgan from wetland management.

To meet the requirements of a wetland water licence, some assessment of the salt impacts and the most appropriate volumes of water to assign to wetlands are required. The SIWM modelling work has outlined the major difficulties in modelling complex hydrological units like wetland systems. As understanding of these systems improves and the data needed for calibration of the model becomes available, the options for further development will become apparent.

Floodplain Impacts Model (FIM)

The Floodplain Impacts Model has been developed to predict floodplain areas at risk of salinisation due to increased saline groundwater inflows and salt accumulation into the floodplain (Fig 2). The FIM enables a comparison of the current condition of the floodplain vegetation with predicted changes to the health of the floodplain under various groundwater inflow scenarios.

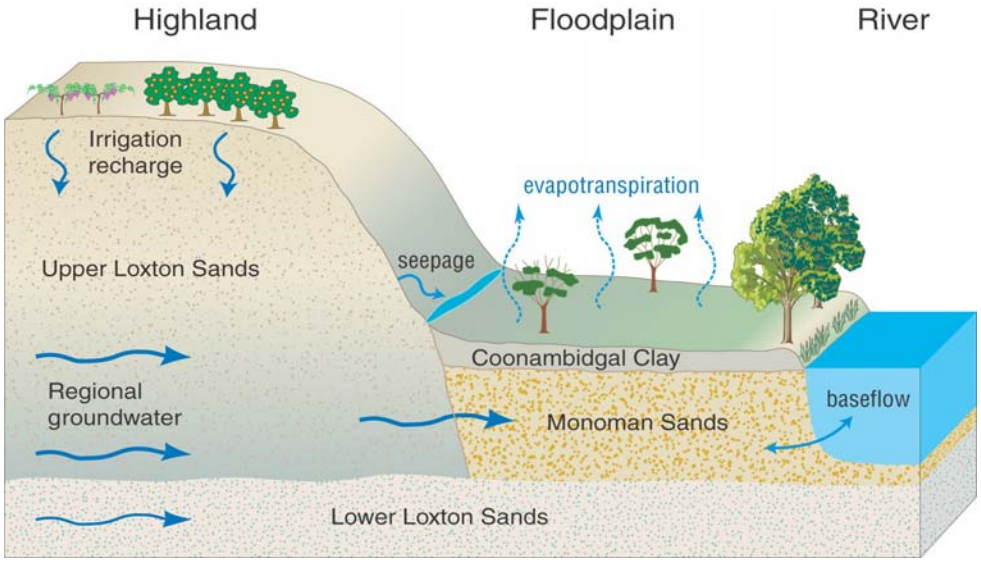


Figure 2 Diagrammatic cross-section showing typical processes and impacts upon the floodplain in the Riverland SA

The Floodplain Impacts Model is able to provide improved planning ability for determining appropriate siting for new irrigation development, to provide a basis for assessing future floodplain impacts resulting from current and future irrigation development and dryland recharge, and to enable the facilitation of community actions on key salinity risk areas and floodplain and wetland priorities.

As part of its development the model has been calibrated against run-of-river salinity data, observed seepage areas and floodplain vegetation health mapping. The preliminary results of the model show that it is useful for predicting impacts from groundwater inflows and thus is able to inform policy for floodplain protection and salinity mitigation.

CONCLUSION

SA is facing a unique challenge to manage salinity in the River Murray system. Salinity management involves management of changes in land use, in particular irrigation, and management of floodplains and wetlands. It also requires planning and action at the State, catchment and district levels.

SA has developed a comprehensive toolkit to manage salinity, in terms of policies, planning tools and modelling tools. It is therefore in a strong position to develop best practice salinity management in the Murray-Darling Basin. However, there also needs to be a sustained effort in maintaining the toolkit, ensuring it is kept up to date.

ACKNOWLEDGEMENTS

The establishment of the tools represented in this paper reflects a significant investment of both time and money in the SAMDB. Many stakeholders including the community, various government agencies and consultants have had input to these projects. This paper outlines some of the end products derived from these projects and does not do justice to the level of commitment, expertise and work that has been included in their development.

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