Salinity extent and trends in South Australia

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Introduction

Two major types of salinity occur in South Australia (SA), groundwater-driven salinity and dry saline land. For the purposes of this paper, salinity refers to man-induced groundwater-driven salinity resulting from rising saline groundwater sourced predominantly from dryland (non-irrigated) recharge.

Evaluation of salinity extent, trends and impact is important for the purposes of adaptive management. Results from salinity assessment and monitoring activities undertaken in SA during the past decade are discussed in terms of their current validity, and their implications for future salinity management.

Materials and methods

Estimating salinity extent and impact in SA has been a component of several national assessments, including an expert opinion report (PMSEIC, 1998), a census postal survey (ABS, 2002) and the year 2000 national salinity audit (NLWRA, 2001). As part of the latter, Barnett (2000) used air photo interpretation, groundwater modelling results and trend information, and desktop review of existing salinity and topographic maps.

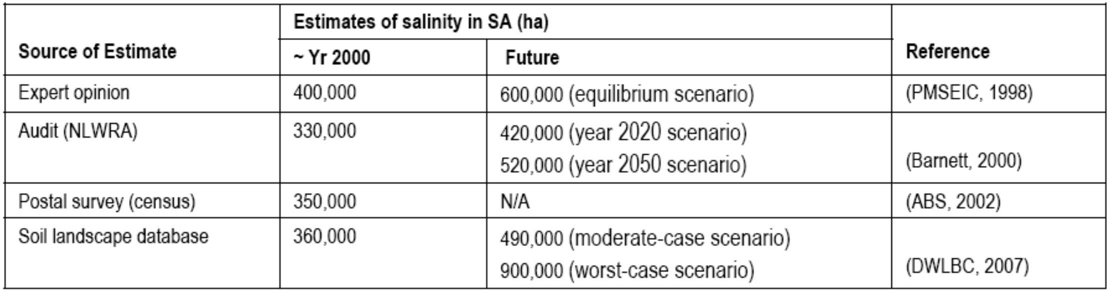
From 1986 to 2001, the State Land and Soil Mapping Program used extensive field work, laboratory analysis and desktop interpretation to assess a range of key land and soil attributes across the agricultural districts of SA. This data was captured within the SA soil landscape database (DWLBC, 2007), and first used in 2001 to generate maps of salinity extent and severity in SA. Several revisions of the maps have occurred since that time, and preliminary assessments of salinity risk to assets in SA have also been modelled using the soil landscape mapping framework (Hall et al, 2004).

Refinements to input data for groundwater modelling purposes have resulted in updated estimates of future salinity impact from dryland sources on the River Murray. Monitoring of piezometer networks and analysis of rainfall records have enabled better definition of trends in depth to groundwater. Repeat EM38 surveys (ground-based electromagnetic) have been undertaken in several focus subcatchments to quantify the change in extent of saltland over time.

Results

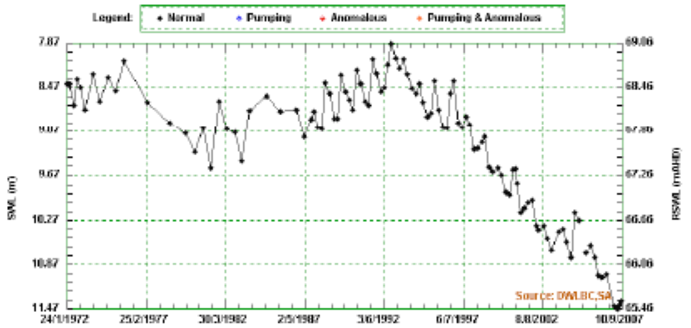
Results from several methods used to estimate salinity extent for the agricultural zones of SA are presented in Table 1. Spatial and temporal coverage across the state varied with each method, as did the attempts to delineate and discount the significant areas of natural (primary) salinity that exist in SA. However, the fairly consistent results add credence to the benchmark estimate used in SA for salinity extent circa the year 2000, being 350,000 ha (plus or minus 10%).

Table 1 Estimates of land affected by salinity in SA's agricultural regions



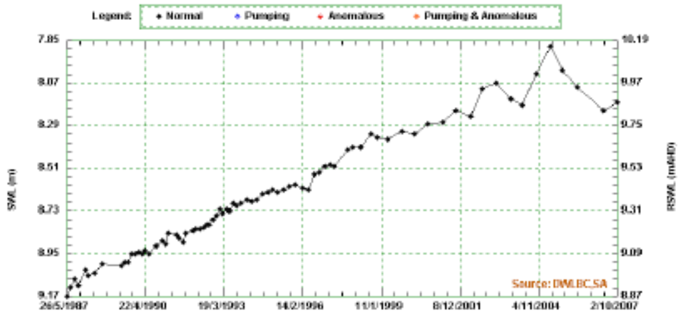
Source of Estimate	Estimates of salinity in SA (ha)		Reference
	~ Yr 2000	Future	
Expert opinion	400,000	600,000 (equilibrium scenario)	(PMSEIC, 1998)
Audit (NLWRA)	330,000	420,000 (year 2020 scenario) 520,000 (year 2050 scenario)	(Barnett, 2000)
Postal survey (census)	350,000	N/A	(ABS, 2002)
Soil landscape database	360,000	490,000 (moderate-case scenario) 900,000 (worst-case scenario)	(DWLBC, 2007)

Less confidence surrounds the estimates of future salinity extent in Table 1, given their underlying assumptions concerning continued/uniform/significant rising trends in depth to groundwater, and the assumed absence of effective intervention to slow or halt watertable rise. Figure 1 illustrates that both rising and falling trends in depth to groundwater in SA have occurred over the longer-term.



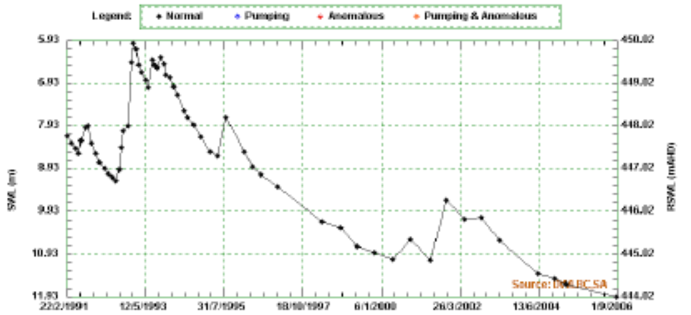
Regional GFS, Upper South East

- A downward trend in depth to groundwater since the early 1990s is evident
- The falling trend in depth to groundwater associated with below-average rainfall periods has been estimated at around 5cm/yr (AWE, 2006)



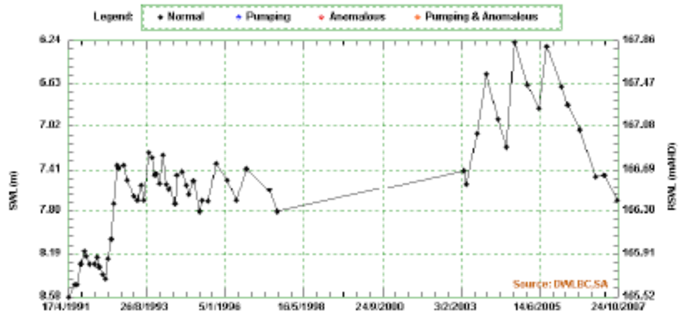
Regional GFS, Coorong District

- An overall long-term rising trend is evident despite below-average rainfall, with a recent decline due to the extreme dry years of 2006 and 2007
- Predicted increases in salinity extent for this district were based on long-term rising trends of around 10cm/yr



Local GFS, Mid-North District

- The falling groundwater trend evident since the early 1990s is associated with below-average rainfall over this period
- EM surveys undertaken in this catchment have quantified the contraction in saltland area at 3% per year from 1991 to 2006



Local GFS, Kangaroo Island

- A rising groundwater trend is evident, associated with average to above average rainfall, until the dry years of 2006 and 2007
- EM surveys in this catchment have quantified expansion of saltland area at 2.5% per year from 1991 to 2004

Figure 1 Hydrographs illustrating trends in depth to groundwater over the longer-term

A cursory analysis of results from 900 bores in the state's groundwater database (Obswell) reinforces the trend information illustrated in Figure 1. While an overall linear falling trend in groundwater depth (ranging from 2cm/yr to 10cm/yr, early 1990s to the present) can be calculated for all agricultural regions, 5% to 30% of bores in any one region still exhibit a linear rising trend over the same period.

Much of this site-specific variation in depth to groundwater can be correlated to trends in rainfall, whether annual, winter or episodic. Many of the observed longer-term declining trends relate strongly to extended periods of below-average rainfall following major recharge events (wet seasons and flooding) widely experienced across SA in the early 1990s.

Repeat EM surveys have quantified both expansion in area (from groundwater rising) and contraction in area (from groundwater falling) of saltland at an average rate of 2% to 3% per year in local GFS (Figure 1). Measuring change in salinity extent and relating it to groundwater/rainfall trends is more difficult for regional GFS, given the lag times associated with infiltration and recharge rates, and the often complex surface and groundwater interactions that occur over large catchment areas.

Distinguishing the relative impact on groundwater levels of long-term rainfall trends and management intervention is a difficult yet necessary task for monitoring and evaluating purposes. Adaptive management processes are part of the broad natural resource management program being implemented in the Upper South East (USE) of SA, where the state's largest area of extensive salinity threatens a range of valuable biodiversity, water resource and agricultural assets.

As one component of salinity intervention in the USE, a major surface and groundwater drainage system is nearing completion. For one section of this system, AWE (2006) reported an effective drawdown of groundwater (to 0.5m) at distances of 2.0 km and 0.5 km up and down gradient of a deep drain, suggesting an area of influence of 250 ha per linear km. Given the existence of more than 400 km of groundwater drains, it is conservatively estimated that salinity risk in the USE will be substantially mitigated over an area in excess of 100,000 ha.

Whether current declining trends in groundwater levels in the USE (Figure 1) will persist in the short or long term is unknown, as is the potential influence of climate change on rainfall frequency and intensity. Evaluating the effectiveness of the USE drainage scheme following the next major flood event will provide valuable information for adaptive salinity risk management purposes.

Significant salinity intervention has also occurred to protect the River Murray in SA, recognised as a major biodiversity and water supply asset. Increased discharge of saline groundwater to the river and its adjacent floodplains has followed historic clearance of the mallee vegetation and subsequent development of irrigated and dryland agriculture.

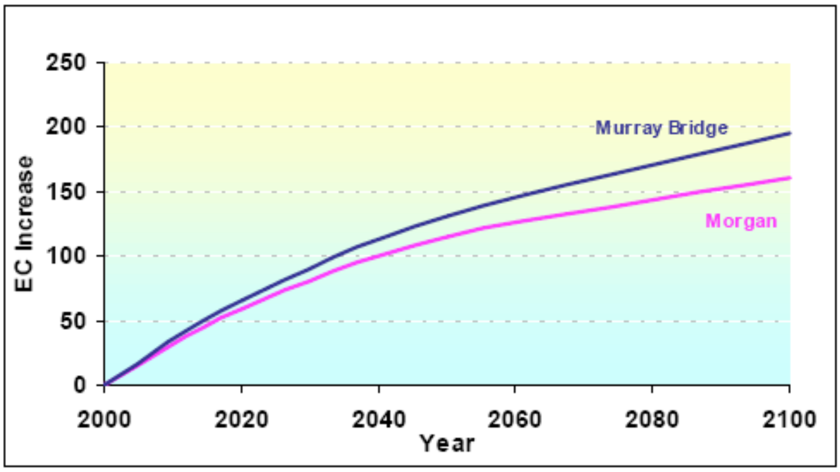


Figure 2 Increase in River Murray salinity due to mallee clearance (Barnett, 2000)

For the year 2000 audit, the expected increase in River Murray salinity at Morgan by the year 2050 was estimated at greater than 100 EC (Figure 2).

However, recent modelling using updated input data now estimates a 20 EC increase by the year 2050. The longer-term impact remains significant, with a 50 EC increase expected by the year 2100 (Barnett and Yan, 2006).

The updated modelling results have reduced the attractiveness of extensive recharge reduction (establishment of perennials) as a shorter-term salinity control measure. However, engineered groundwater interception schemes and improved irrigation efficiency have proven effective in salinity control, their combined influence resulting in a decrease in River Murray salinity levels at Morgan to 484 EC or less for 95% of the time (MDBC, 2007).

Falling groundwater levels resulting from the drought have also contributed to lower River Murray salinity levels, due to less saline inputs. However, maintenance of regulated dilution flows under continuing drought conditions has become difficult, resulting in recent increases in river salinity especially in the lower reaches. Higher river flow levels (when the drought breaks) may generate further increases in river salinity, as salt currently stored in subsoils and floodplains is released.

The existing and future threat that salinity poses in SA have generated major policy responses, with valuable asset areas such as the River Murray and the Upper South East being targeted for intervention. Similar but smaller scale approaches to salinity risk management are common across the state. To help target management initiatives, modelling undertaken using the SA soil landscape database has produced preliminary assessments of salinity risk to specific assets such as soil biodiversity, flora biodiversity, wetlands and agricultural land (Hall, 2004).

Discussion and conclusions

Where catchments in SA are at or close to water equilibrium, salinity extent cycles within a range largely determined by rainfall patterns and GFS type. In other catchments (predominantly more regional GFS), the risk of future salinity expansion towards an equilibrium state remains.

Land management and land use are also important determinants of salinity extent. Salinity expansion has been recorded on lower Eyre Peninsula following a major bushfire in 2005 that significantly reduced vegetative transpiration. Such secondary clearance events, notably the aphid devastation of lucerne stands in the late 1970s, have been responsible for major outbreaks of salinity in SA.

Given that salinity processes are site-specific and commonly operate within a dynamic equilibrium, it is difficult to meaningfully quantify salinity extent across the state for a single point in time. For operational purposes, a rounded estimate of 350,000 ha (plus or minus 10%) is considered an accurate representation of the range in salinity extent in SA for the decade spanning the year 2000. The net extent of salinity in SA has not measurably increased since the year 2000, largely due to declining groundwater trends associated with continuing below-average rainfall conditions.

Estimates of future salinity extent (Table 1) are unlikely to be reached within the original timeframes (where stated), given current falling trends in depth to groundwater, and the potential impact of management intervention such as major drainage works in the USE. While the worst-case scenario estimate appears extreme, the longer-term spatial and temporal influence of climate change/rainfall patterns on future salinity extent in SA cannot be confidently predicted.

Salinity risk management policy settings will seek to limit the impact of salinity on key assets, restrict salinity extent to the lower end of its equilibrium range, and minimise expansion of overall salinity extent where water equilibrium has yet to be reached. On-going monitoring and evaluation in focus catchments will inform adaptive management and provide a basis for future salinity assessment.

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