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SCIENCE *for* DECISION MAKERS

Sourcing the Salt

HOW TO FIND OUT IF YOUR CATCHMENT IS CONTRIBUTING TO A SALINITY PROBLEM

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Key Points

- 1 Salinity is a much more localised problem in eastern Australia than previously thought. Areas of hazard typically lie within gentle terrains that have average annual rainfalls of 500-800mm. Within these areas, underground salt only becomes a risk if it is moved by groundwater into streams or the root areas of plants.
- 2 Stream salinity surveys conducted by community groups can identify these areas within a catchment. As a bonus, stream surveys can locate areas that are significant sources of fresh water.
- 3 Survey results help catchment managers to decide whether there are areas that need more thorough investigation.

- 4 These investigations may include salinity mapping to understand how much salt is stored and where and how it is being moved through the landscape.
- 5 This information enables managers to develop options to control salinity and minimise the impact on agricultural production.
- 6 Stream surveys are a cost effective way of collecting important information, to help communities build an understanding of local salinity issues and contribute to catchment management.



The Issue

Salinity is a key natural resource management issue for Australia. Preliminary assessments suggested that about 5.7 million hectares of our agricultural and pastoral zones have the potential to develop salinity problems (National Land and Water Resources Audit 2001).

Salt is much more localised in the landscape in Eastern Australia than previously thought.

To manage salinity more effectively, we need to know the locations of salt stores in the landscape, whether these are likely to be mobilised by groundwater, and the extent to which they may pose a risk to assets such as agricultural lands, water quality, the environment and infrastructure.

The Bureau of Rural Sciences (BRS) has conducted detailed studies of 2.85 million hectares in the Murray-Darling Basin at 10 sites identified by the Murray-Darling Basin Commission or State agencies as having significant salinity problems. Only 25 percent of the area studied so far is underlain by salt,

Managers can develop specifically targeted strategies to cope with salinity.

and a substantially smaller proportion of this salt is likely to be moved by water into streams or soil profiles where it can cause salinity problems.

These results indicate that for eastern Australia

- salt is much more localised in the landscape than previously thought and only represents a salinity risk if it is likely to be mobilised;
- airborne electromagnetic mapping (AEM) can be used in conjunction with other information to define the location and quantity of salt in the landscape and how it moves;
- specific management interventions can be tailored to individual situations, substantially reducing the cost of managing salinity and minimising potential disruption to agriculture.

Locating the Salt using Rapid Stream Survey

A first step towards establishing the extent and likely source of a catchment's salinity problem is to undertake systematic sampling of stream salinities. This information can then be combined with any pre-existing water quality and groundwater data to help identify which sub-catchments within the larger system are contributing the major salt loads. The results will help catchment management authorities to choose areas for detailed airborne electromagnetic mapping (AEM see Box 1).

The AEM data are used in conjunction with hydrogeological modelling to identify where salt is stored in the landscape, and which areas are at risk from salinisation as a result of mobilisation of stored salt by water. Importantly, areas of providing freshwater in catchments can also be identified and protected. Once this information is known, managers can develop specifically targeted strategies to cope with salinity.

The rapid stream survey approach has successfully identified the sources of salt within the Mid Macquarie catchment in NSW and is currently being applied in many other regions. The results of the Mid Macquarie study (Baker and Evans 2002) are summarised here.

Sources of Salt in Mid Macquarie Catchment

The Mid Macquarie region (Figure 1) is in the central west of New South Wales between Burrendong Dam and Dubbo. It comprises the Talbragar, Bell and Little River catchments, and the Macquarie River catchment between Wellington and Dubbo. The Macquarie River flows north west, eventually flowing into the Darling River. Land use in the area is mainly cropping and grazing, with some irrigation primarily downstream of Dubbo. Mean annual rainfall is less than 650 mm over most of the area, although the north east and south east receive up to 900 mm per year.

FIGURE 1 Location of the Mid Macquarie catchment and the Bell, Little, Talbragar and Macquarie subcatchments.



A 1994 rapid stream survey showed that streams in parts of the catchment were highly saline, with some sites exceeding 10,000 $\mu\text{S}/\text{cm}$ (microsiemens/cm, about one fifth sea water salinity). About 50,000 hectares of salinised land in the region had been mapped from aerial photographs by the then Department of Land and Water Conservation (DLWC, now NSW Department of Natural Resources, DNR). The region was considered to be at serious risk of land and stream salinisation, and a major contributor to salt loads in the Macquarie River.

In 1998 the Mid Macquarie Landcare Inc (consortium of eight Landcare groups) commissioned the BRS and DLWC to determine the extent of the salinity problem. The community wanted to establish the source of the high stream salinities, and to compare the salinity situation in the four main catchments of the region. The work was undertaken by the Mid Macquarie community groups, BRS, NSW DLWC and Salient Solutions Australia, and funded by the National Heritage Trust.

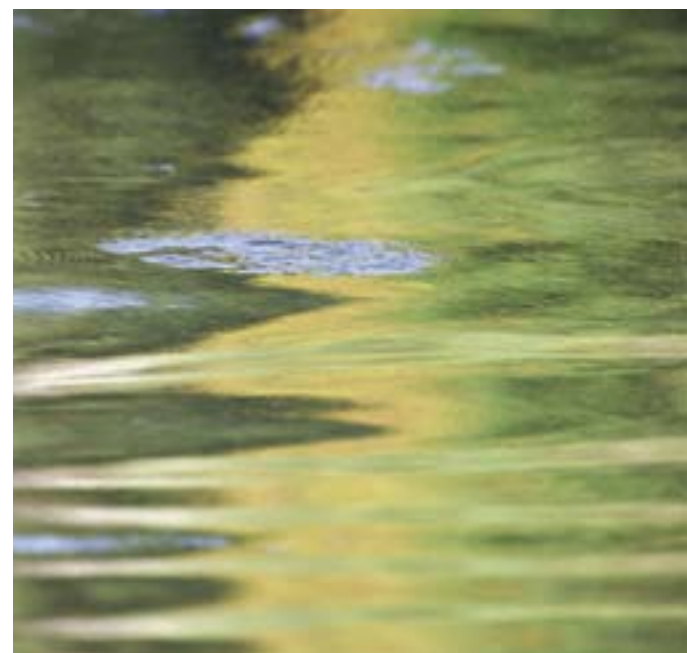
Understanding the Mid Macquarie Environment

The project team gathered existing data on the region, such as the geology, groundwater levels, information from bores and climate data. Rapid stream surveys (Figure 3) were undertaken by members of the community and the project team to identify where best to place electrical conductivity loggers to record the salinity in streams.

Data from about 100 bore holes with three or more groundwater level measurements were analysed to identify whether there were any trends in water

levels over time (see Box 2). The team wanted to know whether groundwater levels were rising or falling in different parts of the study area to establish which groundwater systems might be moving stored salt into the Mid Macquarie system.

In addition to monitoring water tables, the scientists also interpreted the rates of flow in streams at DLWC gauging stations to see whether stream flow was changing, and whether this was related to rising groundwater flowing into creeks.



BOX 1

AIRBORNE ELECTROMAGNETICS (AEM)

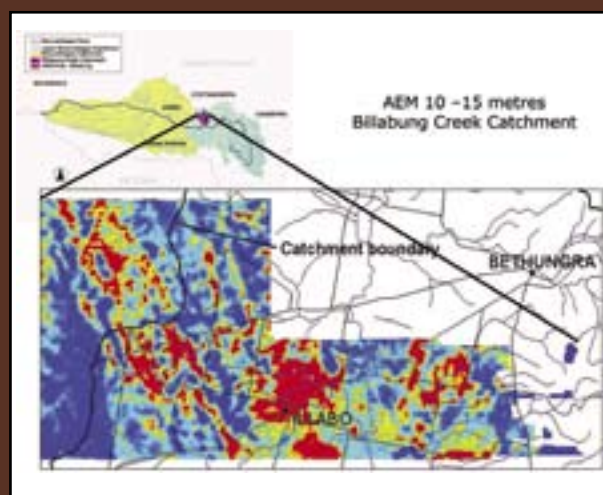
Underground salt can be mapped in three dimensions by measuring the conductivity of the ground—which is directly related to its salt content. Salt water is more conductive than fresh water or solid rock.

Specially equipped aircraft are used to map large areas quickly. An on-board generator sends pulses of electric current through the aircraft's transmitter loop. These create an electromagnetic field that penetrates the ground, inducing a secondary current in conductive materials. This is detected by a receiver towed behind the aircraft.

The signals are translated into a three-dimensional map that is calibrated by measurements from bores. The calibration bores also provide an opportunity to measure the hydraulic conductivity (the ease of transmission of groundwater) of the various sub-surface layers. Figure 2 shows the conductivity pattern 10–15 metres below the ground surface, in the Billabung Creek catchment. Red indicates conductive materials (and therefore salt), and blue indicates resistive materials—bedrock and fresh water.

This technique (sometimes in combination with others such as airborne radiometrics and magnetics) has been used by BRS to study salinity in nine catchments in the Murray-Darling Basin region, all of which show that salt stores are localised in the landscape.

FIGURE 2 Airborne electromagnetics image for part of the Billabung catchment, Southern NSW.



The Findings

The Mid Macquarie study answered the community's question about the origins of the salt, and showed that catchments in the area could be ranked according to their contribution to the salinity of streams.

The most important finding was that salinity was only likely to be a problem in the western (lower) portion of the Talbragar catchment and parts of the Little River catchment, not the entire Mid Macquarie region.

Figure 4 shows the salinity as mapped by the rapid stream survey. The main contributors of salt to the Mid Macquarie within the region were the Talbragar River downstream of Elong Elong, and the Little River upstream of Obley. The Bell River is a freshwater source and helps reduce salinity, as does the Little River where it flows through granite country, and the Talbragar River upstream of Elong Elong.

The Macquarie River above Burrendong Dam contributed about half of the Mid Macquarie's stream salinity during the study period. The results show that only about 20 percent of the Mid Macquarie catchment is underlain by salt.

Where Next for the Mid Macquarie?

More accurately delineating the location and size of the salt stores in the Talbragar and Little River catchments is a top priority for New South Wales under the National Action Plan. Rapid stream surveys have identified the main areas contributing to salinity in the Mid Macquarie. The next step is to use AEM, the only broadacre mapping technique currently available for remote sensing of salt loads below the soil surface (Spies and Woodgate 2004), to more accurately delineate salt store locations.

FIGURE 3 Rapid stream survey sampling in Two Mile Creek, Bell River catchment.



The AEM results, together with estimates of deep drainage (water lost to groundwater) from existing land uses in or near areas where salt is stored, will provide the additional information needed by catchment and land managers to establish the most effective salinity control options. These may include tree planting, moving from annual crops and pastures to perennial pastures or changing cropping practices.

Effective salinity control options may include tree planting, moving from annual crops and pastures to perennial pastures or changing cropping practices.

The objective is to identify land uses that utilise all the available water from rainfall at sites where deep drainage losses of water increase the risk of mobilising salt.

Preliminary estimates suggest that for the 1.1 million hectares of the Mid Macquarie catchment, changes will be needed over less than 220,000 hectares; AEM results will provide the necessary confirmation.

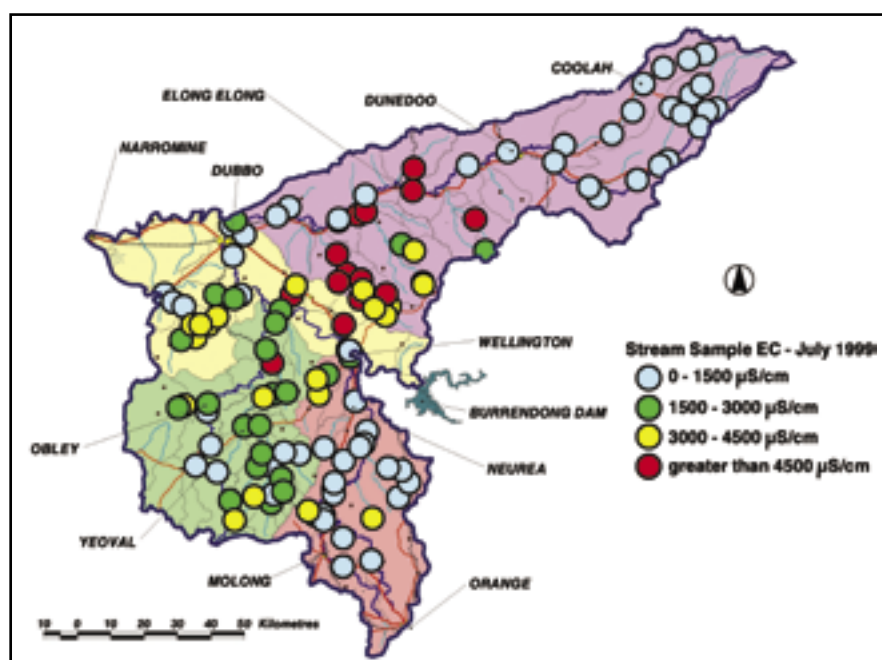
The results from the rapid stream survey have revealed how any action to manage salinity needs to be carefully considered. For example, tree planting previously proposed for the granite country of the Little River catchment has the potential to reduce freshwater flows into the Macquarie River, increasing river salinity.

Implications for Policy and Management

The rapid stream survey approach used in this study has been recognised in a report reviewed and endorsed by the Australian Academies of Science and Technological Sciences (Spies and Woodgate 2004) as an essential first step in determining whether a catchment is likely to have a problem with salt discharging into streams.

The results from rapid stream surveys, together with an analysis of existing information on geology, borehole and land use data, identify the subcatchments that are making the larger contributions of salt to streams, and may therefore require further investigation using airborne electromagnetic techniques.

FIGURE 4 Results of the Mid Macquarie rapid stream survey. Salinity in microsiemens ($\mu\text{S}/\text{cm}$).



Community groups have been active in recent times in a number of other catchments, for example the Castlereagh and Jugiong catchments in NSW using funding provided under the National Landcare Programme. The Australian Government has also provided \$20M under the National Action Plan for Salinity and Water Quality for community based salinity stream sampling and AEM surveys in the Murray Darling Basin. The stream sampling component of this initiative will help communities identify likely sources of salt, and enable catchment



management authorities to prioritise areas for more detailed future AEM investigations. The stream survey results will also identify subcatchments contributing fresh water, which under the National Water Initiative may need to be protected from major land use changes, such as very extensive tree planting, likely to intercept water before it enters the ground or surface water systems.

Frequent interaction with the project team helped people feel that their concerns were being addressed, and improved their understanding of the salinity issue.

Community Collaboration: The Key to Success

Other BRS salinity studies (for example Dent 2003) have also used rapid stream survey techniques, together with analysis of preexisting data, to establish the likely location of salt stores. In the Mid Macquarie, the community helped with the rapid stream surveys and played an important role in steering the project. Frequent interaction with the project team helped people feel that their concerns were being addressed, and improved their understanding of the salinity issue. Their enthusiastic cooperation also reduced the costs of data gathering to about 20 cents per hectare.

BOX 2

GROUNDWATER TREND ANALYSIS

Groundwater levels fluctuate seasonally and over time depending on the climate cycle and current and past land uses and management practices. Rising groundwater levels can mobilise salt stored within the landscape and contribute to increased stream and dryland salinity, so it is important to understand the processes that are driving groundwater level change.

Replacing native vegetation with annual crops and pastures often causes groundwater levels to rise. In the Mid Macquarie region, annual crops and pastures do not use all the winter rainfall, often resulting in an increase in the amount of water moving below the root zone to the groundwater system. When studying changes in groundwater levels, it is important to understand and separate the contribution made by land management practices and those caused by the climatic regime.

The HARTT programme (Hydrograph Analysis—Rainfall and Time Trends) (Ferdowsian et al., 2001) provides a statistical method to determine the relationship between fluctuations in rainfall and the response over time in groundwater levels recorded in bore hydrographs. By combining rainfall records with groundwater level measurements, the HARTT programme produces a rainfall corrected groundwater level, the level at which the groundwater would be if rainfall was the only input to the system.

Differences between the measured and rainfall corrected groundwater levels identify periods where other factors, such as land management practices, are increasing or decreasing recharge to groundwater levels. This allows landholders to identify land uses and management practices that may be contributing to groundwater level rise, and to take appropriate remedial actions.

CONCLUSIONS

Rapid stream surveys undertaken by community members offer a practical low cost method for prioritising subcatchments needing more detailed mapping of salt stores and those contributing freshwater inflows which may need protection from major land use change.

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