Appendix 5 – River Murray Corridor Groundwater Investigation

AN AIRBORNE ELECTROMAGNETIC (AEM) SURVEY USED AS A PRECISION INVESTIGATION TOOL TO ADDRESS SALINITY AND LAND MANAGEMENT ISSUES IN THE RIVER MURRAY CORRIDOR, SOUTH EAST AUSTRALIA

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Introduction

An airborne electromagnetic (AEM) survey recently acquired under the auspices of the Australian Government’s Community Stream Sampling and Salinity Mapping Project (CSSSMP), is providing information vital for addressing salinity, land management and groundwater resource issues along a 450 km reach of the River Murray Corridor (RMC) in SE Australia (Tan *et. al.,* 2008*)*. The study area stretches from the South Australian border eastwards to Gunbower in Victoria. A total of 24,000 line km of AEM data were acquired (Figure 1).

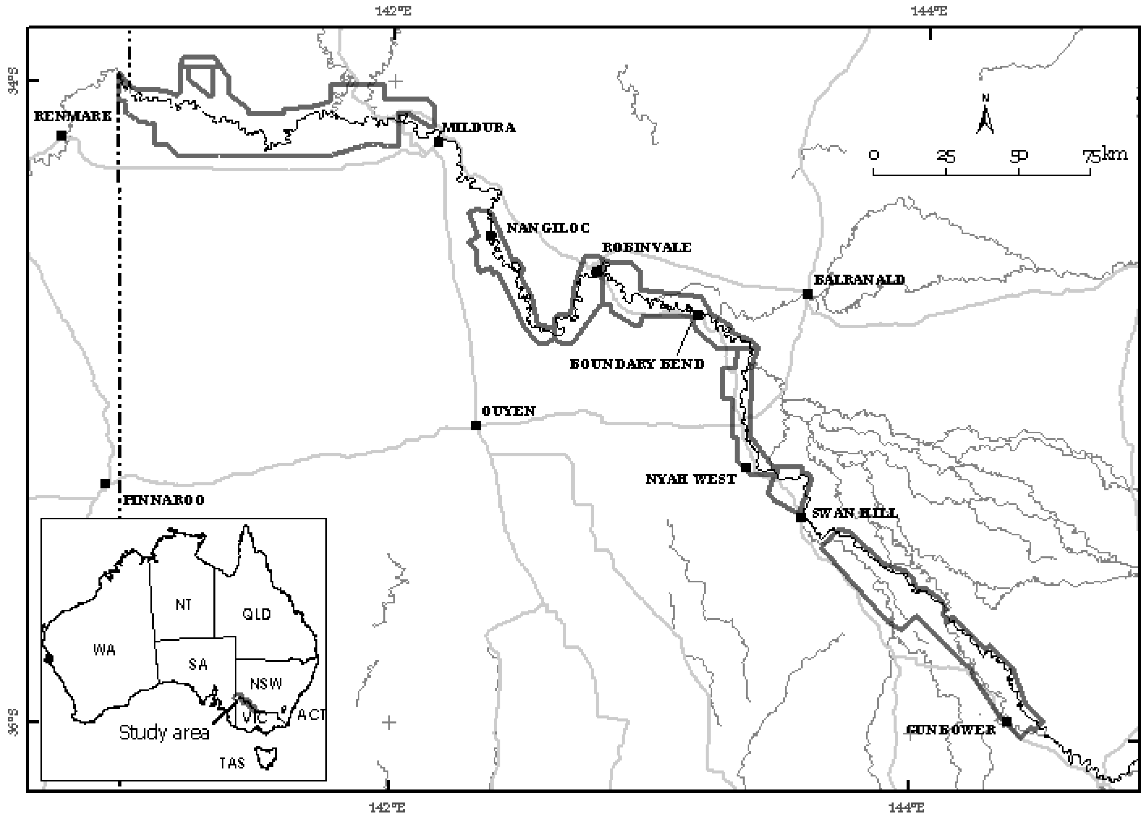


Figure 1. River Murray Corridor AEM survey areas (outlined) from the South Australia border to Gunbower in Victoria.

The survey area encompasses iconic wetland areas, national and State forest parks, and irrigation and dryland farming. Within the RMC project area key land management questions include (1) what is the impact of irrigation on the floodplain, river and groundwater system?; (2) what is the distribution of saline groundwaters that have the potential to impact on the floodplain and river?; (3) where are the salt stores in the unsaturated zone beneath the floodplain?; (4) what is the potential for salt mobilisation during Living Murray inundation actions and natural flood events; (5) what are the drivers for floodplain health with respect to groundwater processes?; (6) is there leakage from salt disposal infrastructure?; and (7) what is the extent of losing and gaining effects along different reaches of the river system?

Preliminary work results in a number of important new findings: (1) ‘flush’ zones (laterally and vertically) associated with the losing reaches of the Murray River appear to be much more extensive than previously thought; (2) near surface salt stores have been identified on the margins of and beneath the floodplain at points adjacent to some irrigation areas; (3) there are extensive ‘flush’ zones beneath some of the irrigation areas on the floodplain; (4) overall, there is a strong correlation between land use and AEM response in many areas.

The following sections outline the methodology used to derive some of the products that complement geomorphic mapping (e.g. Halas *et al.* 2008) and allow land managers to take advantage of these findings, specifically flush zones water quality, near surface conductance (salt store) and distribution of specific lithological unis (e.g. Blanchetown Clay). These are shown in Figure 2.

Flush zones

The salinity of the river flush zones include fresh water (up to 1000 µS/cm) and slightly brackish water (1000 to 3000 µS/cm) that is suitable for desalinisation. Brackish water with EC up to 5000 µS/cm may be suitable for desalinisation in the future but at this stage it is not included in the flush zone maps. Taking porosity of fine to medium sand to be approximately 35 vol%, the apparent conductivity of the saturated sediment can be calculated as:

Customized AEM conductivity depth slices using the smoothed surface of modern floodplain unit as datum were used. These conductivity depth slices were tilted with respect to the Australian Height Datum (AHD) as the floodplain slopes from east to west across the study areas. The flush zone maps were produced on depth slices starting 2m below the floodplain in the saturated zone.

Water quality maps

In the RMC study areas, especially at Lindsay-Walpolla, groundwater salinity may reach up to that of seawater (approx. 30,000 mg/l TDS, or 45,000 µS/cm). Since Loxton-Parilla Sands forms the majority of the regional aquifer in the RMC study areas, the porosity (35 vol. %) of fine to medium sand has been chosen to translate the water salinity into apparent conductivity. The conductive groundwater has been classified into 2 classes, brackish and saline (Table 1).

Table 1. Classification of water quality and apparent conductivity.

Water quality	Brackish	Saline
Water EC µS/cm	5000 - 17000	>17000
TDS mg/l	2600 - 10000	>10000
EC_a mS/m	175 – 595*	>595*

* - Porosity correction using 35 vol %.

Customized AEM conductivity depth slices using the surface of modern floodplain units as datum were selected. These conductivity depth slices were tilted with respect to the Australian Height Datum (AHD) as the floodplain slopes from east to west across the study areas. The conductive groundwater maps were produced on depth slices starting 2m below the floodplain in the saturated zone.

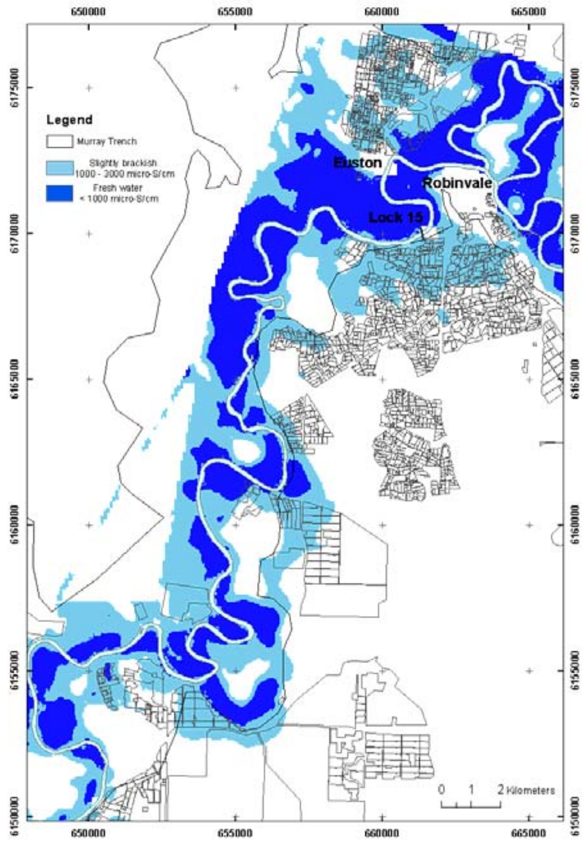
Near surface conductivity (salt store) maps

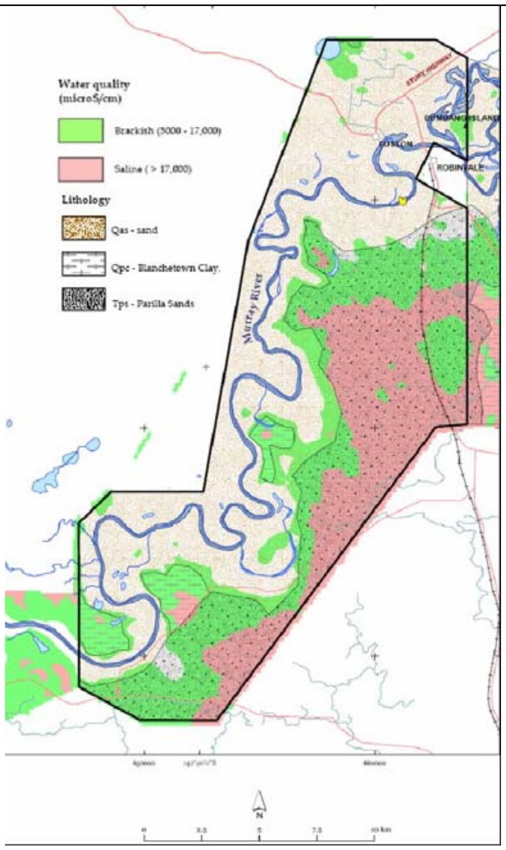
Apparent conductivity responds to the amount of salt in saturated regolith. Data from the Bland sub-basin in NSW (Lenehan *et al.* 2004) suggest that the causal relationship between EC_a and salt can be expressed as a linear function. On average, the bulk conductivity of sediments is approximately 1.6 g/cm^3 (or t/m^3). Since the ArcGIS software calculates the total-salt as voxels (*i.e.* 40 x 40 x 1 m^3).
The average conductivity between the surface and water table is used to produce the near surface salt store map. The average apparent conductivity is translated into total salt as tonnes per hectare. The spatial distribution of fine textured materials (mud and clay of Coonambidgal Formation of the floodplain and Blanchetown Clay of the shallow pre-alluvial succession) are overlain onto the total salt image and the salt in these areas are unlikely to be mobilised as it is held within these low permeability clays. The salt hosted in permeable sand (*i.e.* rest of the areas) is interpreted as having a higher degree of mobility.

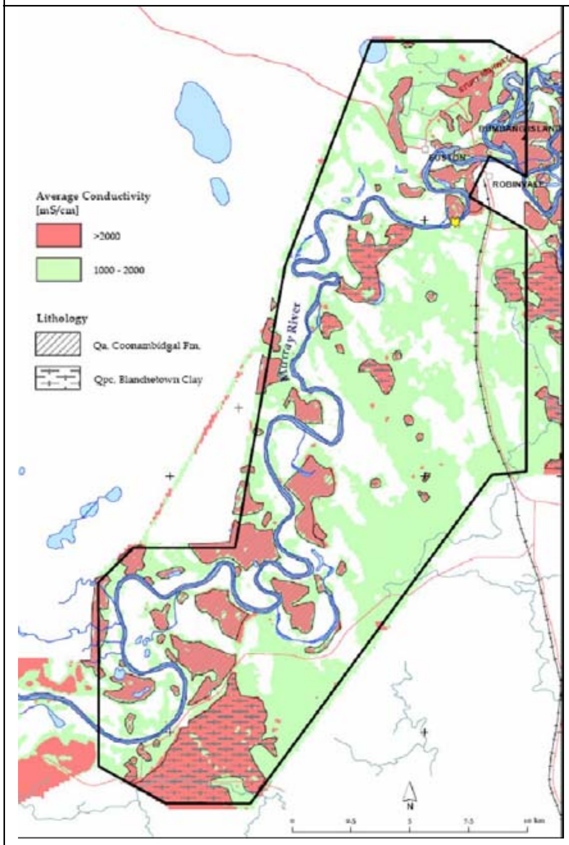
Blanchetown Clay maps

The Conductivity Depth Slices data (holistic inversion, tilted with respect to the modern floodplain) are imported into ERMapper. Images using various histogram stretches are examined to determine the most suitable conductivity contrast which aids in the digitising of conductive polygons (> 150 mS/m). The polygons (.ers files) are then converted to shape files and imported into ArcMap. Based on interpreted lithologic information from borehole logs, the relevant polygons are assigned as Blanchetown Clay.

The Blanchetown Clay polygons have been digitised for the following depth slices: 0 to -5m, -5 to -10m, -10 to -15m, -15 to -20m, -20 to -25m, -25 to -30m and -30 to -35m. Beneath 35m, the boundary between conductivity and resistive areas become very fuzzy and is near impossible to delineate.


Legend
Murray Trench
Slightly brackish 1000 - 3000 micro-S/cm
Fresh water < 1000 micro-S/cm
Euston
Robinvale
Lock 15
0 1 2 Kilometers
650000
655000
660000
665000
6175000
6170000
6165000
6160000
6155000
6150000


Water quality (microS/cm)
Brackish (5000 - 17,000)
Saline (> 17,000)
Lithology
Qas - sand
Qpc - Blanchetown Clay.
Tps - Parilla Sands
Murray River
EUSTON
ROBINVALE
BUMBANG ISLAND
STURT HIGHWAY
N
0 2.5 5 7.5 10 km


Average Conductivity [mS/cm]
>2000
1000 - 2000
Lithology
Qa. Coonambidgal Fm.
Qpc. Blanchetown Clay
Murray River
EUSTON
ROBINVALE
BUMBANG ISLAND
STURT HIGHWAY
N
0 2.5 5 7.5 10 km

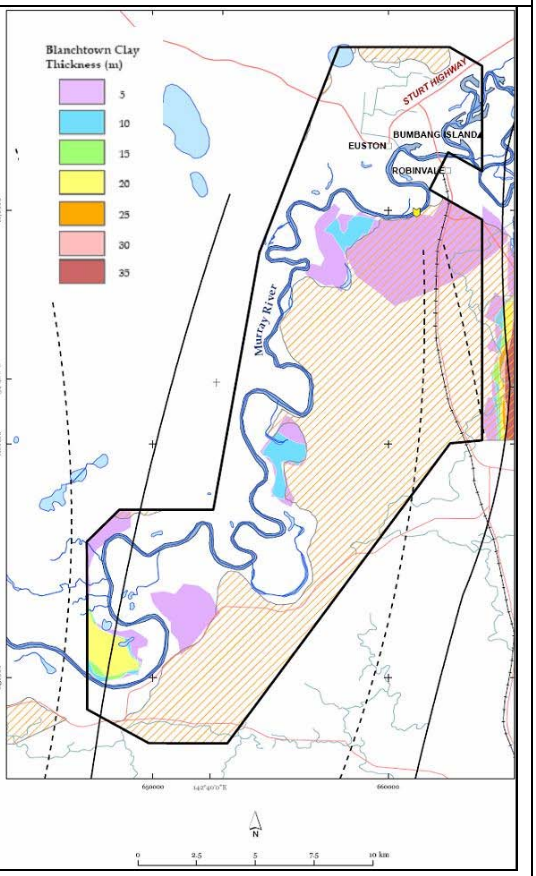

Blanchtown Clay Thickness (m)
5
10
15
20
25
30
35
Murray River
EUSTON
ROBINVALE
BUMBANG ISLAND
STURT HIGHWAY
N
0 2.5 5 7.5 10 km

Figure 2. Example interpreted products Top left – flush zones from interpreted conductance. Top right – interpreted water quality maps from derived conductance values. Bottom left near surface conductance maps. Bottom right – Blanchetown Clay thickness.

The average conductivity between the surface and water table is used to produce the near surface salt store map. The average apparent conductivity is translated into total salt as tonnes per hectare. The spatial distribution of fine textured materials (mud and clay of Coonambidgal Formation of the floodplain and Blanchetown Clay of the shallow pre-alluvial succession) are overlain onto the total salt image and the salt in these areas are unlikely to be mobilised as it is held within these low permeability clays. The salt hosted in permeable sand (*i.e.* rest of the areas) is interpreted as having a higher degree of mobility.

Conclusions

The AEM data are being interpreted using a 4-D landscape analysis approach to complement more traditional hydrogeological analytical techniques, a process developed across many depositional landscapes used for irrigation in Australia (Clarke and Lawrie 2008). This approach provides key constraints on interpretation of both near-surface AEM responses and floodplain hydrostratigraphy. On a broader regional scale this approach has been used to predict major changes in AEM responses and hydrostratigraphy related to the avulsion of the Murray – Wakool- Edwards River systems (Wong *et al.* 2008).

References

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