Mapping subsurface saline material at Bourke

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In the irrigated districts of the arid and semi-arid regions of the world, soil salinisation is one of the major factors affecting agricultural production. It's the result of complex interactions between geology, hydrology, topography, climate and agronomy.

This is the case in the Bourke Irrigation District (BID), where isolated point source salinisation first became evident in the late 1980s. The problem appears to be a function of water use efficiency issues associated with water storages and supply channels.

As a consequence, soluble salts stored in marine sediments (15 metres below the surface), have been mobilised and caused isolated instances of soil salinisation, which appears to be a driven by the presence of a saline aquifer. For the most part, the problems have been managed effectively using integrated soil, water and crop management strategies.

Nevertheless, and in order to assist in improving irrigated production systems in the BID, information is required to map the location and extent of the saline material which lies approximately 6–12 metres below the soil surface.

Such investigations require large investments in detailed soil sampling and laboratory analysis. This is time consuming, labour intensive and costly — but the information is necessary.

One way to improve the value of this investment is the use of ground-based electromagnetic (EM) induction instruments. This is because EM instruments measure the bulk soil electrical conductivity (ECa), which is a function of soil salinity, clay and moisture content and soil mineralogy.

In the following article we show how an EM34 survey and a complementary soil-sampling program can be used to produce a map of saline subsurface material in the BID.

STUDY AREA AND EM SURVEY

The BID consists of approximately 10,000 hectares of irrigated cotton production. This includes "Darling Farms," "Ferguson's Farm," "Janbeth," and "Alambi" located north of the Darling River and "Long Meadows," and "Prattenville" to the south.

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An EM34 instrument with transmitter coil and control (left) and receiver coil/control (right).

FIGURE 1: Air-photo mosaic of Bourke Irrigation District

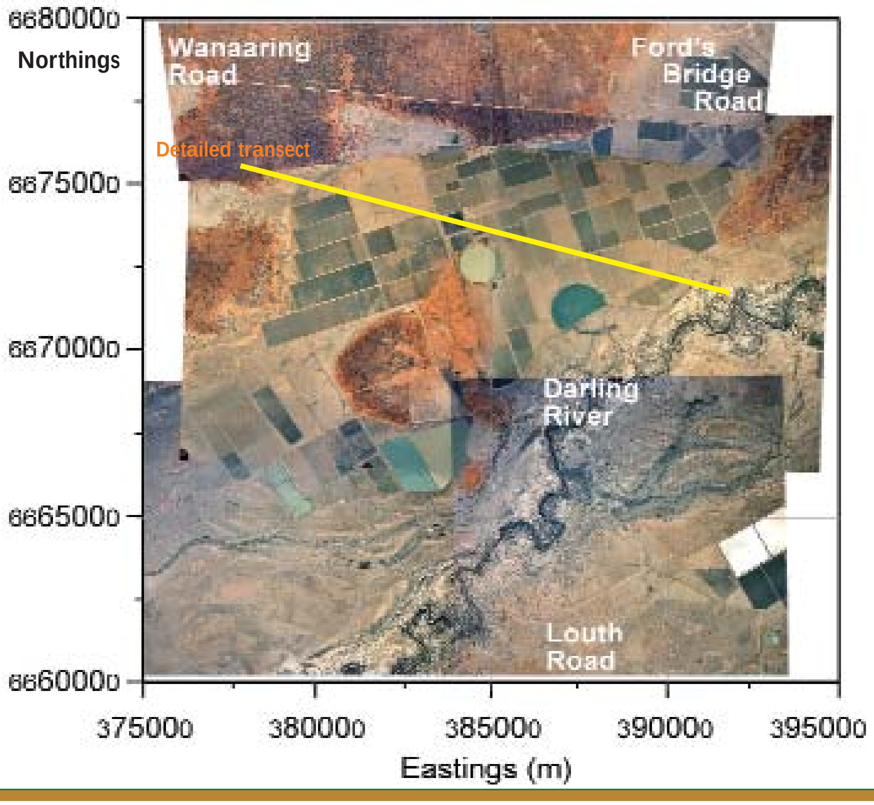


Figure 1 shows an air-photo of the BID. The redder areas are the sandier and elevated parts of the landscape. These are dunal in nature and have generally not been developed for irrigated or dryland agricultural production.

But supply channels have been constructed across the red ridge in the central part of the BID (Figure 2). Generally, the soil types used for cotton production are deep yellow-grey and grey-cracking clays. These have developed on the alluvial plains of the Darling River.

An EM34 survey was undertaken which involved taking measurements at approximately 500 metre sampling intervals. A total of 900 measurements were made (Figure 2).

The EM34 instrument was selected because it can provide information at various depths up to 30 metres depending on the spacing of the independent transmitter and receiver coils.

The EM34 survey showed that the areas associated with irrigated cotton fields have ECa values greater than 150 mS/m near the surface. This is similarly the case with the various water storages and supply channels.

Similar patterns applied at up to 30 metres depth, apart from areas adjacent to the Darling River and associated with the red ridges.

SOIL SAMPLING

Our aim was to relate the ECa measurements to salinity levels in the soil. A total of 50 soil sampling sites were selected from the 900 EM34 survey locations and also a detailed transect of 11 sites was sampled through the BID. At each site, holes were drilled to a depth of 12 metres with samples collected every metre.

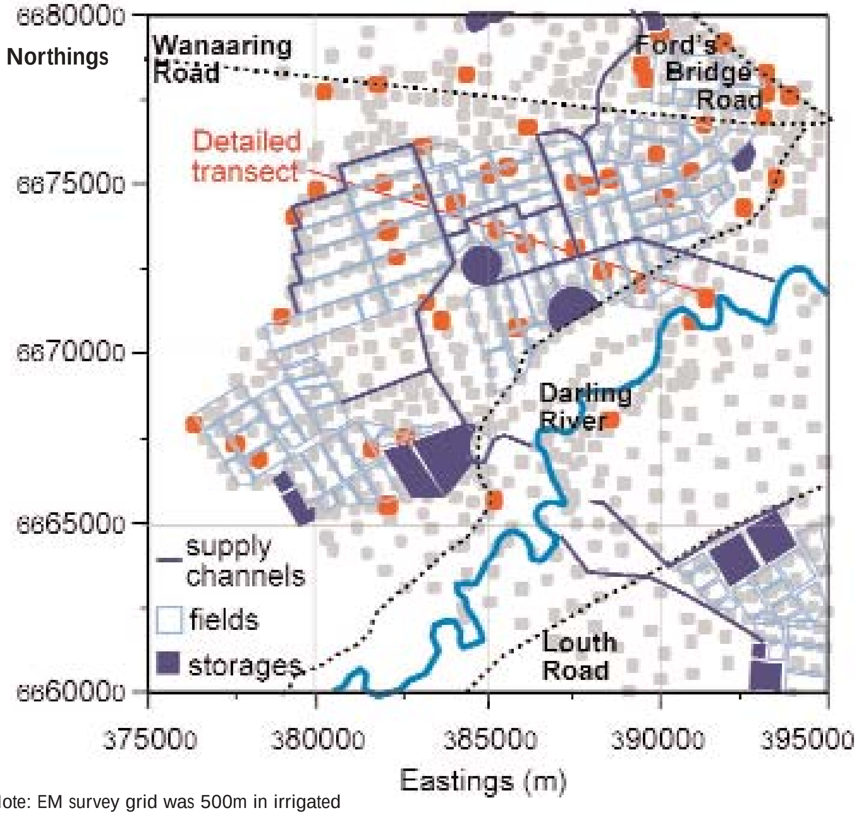
For each soil sample collected, the electrical conductivity (ECe) was determined by laboratory analysis. This figure gives the best description of the salinity of the soil.

The relationship between the ECe values and the EM34 measurement at these soil sampling sites was used to give estimates of salinity at each of the 900 survey locations.

The important depth is between six and 12 metres (ECe 6–12) where the saline subsurface material is most prevalent. Figure 3 shows the location and extent of saline subsurface material beneath the BID as represented by ECe (6–12m).

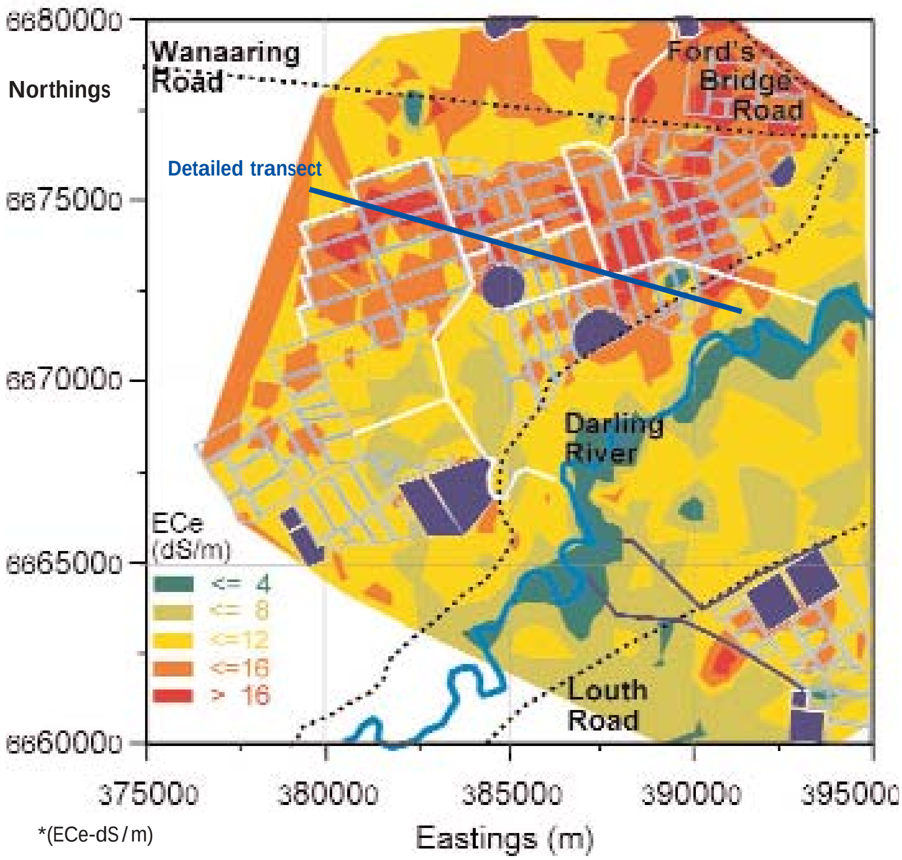
The orange and red areas indicate where ECe (6–12m) is greater than 12 and

FIGURE 2: Location of EM34 survey (light grey) and soil sampling (red) locations



Note: EM survey grid was 500m in irrigated areas and 1km elsewhere.

FIGURE 3: Distribution of saline subsurface material* between six and 12 metres



*(ECe-dS/m)

16 dS/m, respectively. Most saline subsurface material coincides with the areas developed for irrigated cotton production. Sixteen dS/m is equivalent to twice the level of salinisation where cotton would begin to become affected. So if these levels of salinisation were found in the rootzone, some form of soil, water and crop management would be required even for tolerant crops such as cotton.

Conversely, lower values (below eight dS/m) were consistent with the red ridge country. The areas adjacent to the Darling River had the lowest predicted values (below 4 dS/m).

To better understand the location of this saline subsurface material, the soil information along the detailed transect was plotted (Figure 4).

Clay content

The western part of the traverse (associated with the red ridge) has a clay content of less than 20 per cent in the top metre. This is similarly the case at the other end of the traverse, near the Darling River. Here, clay content was less than 40 per cent to a depth of 12 metres.

Conversely and along almost the entire length of the traverse, clay content to a depth of five metres is generally greater than 50 per cent. What is also worth noting is that clay content is also greater than 50 per cent:

- At a depth of about 12 metres along the whole traverse; and,
- Between Eastings of 386000 and 391000 (and to a depth of 12 metres).

It is also worth noting the water table, as recorded at the time of sampling, coincides with where clay content is less than 40 per cent.

Salinity

Figure 5 shows the distribution of ECe along this traverse. At either end, ECe is generally below four dS/m, while in the cotton growing areas it is less than eight dS/m in the root zone.

As with clay content, ECe is similarly greatest (above 16 dS/m):

- At a depth of about 12 metres along the whole traverse; and,
- Between Eastings of 386000 and 391000 (to a depth of 12 metres).

This suggests that the salts are naturally stored in the clayier sediments and are mobilised by the presence of the water table in the sandier sediments. This is the most likely explanation for the large values of ECe recorded in the sandier sediments in the eastern part of the traverse.

FIGURE 4: Distribution of clay (per cent) along the detailed soil transect

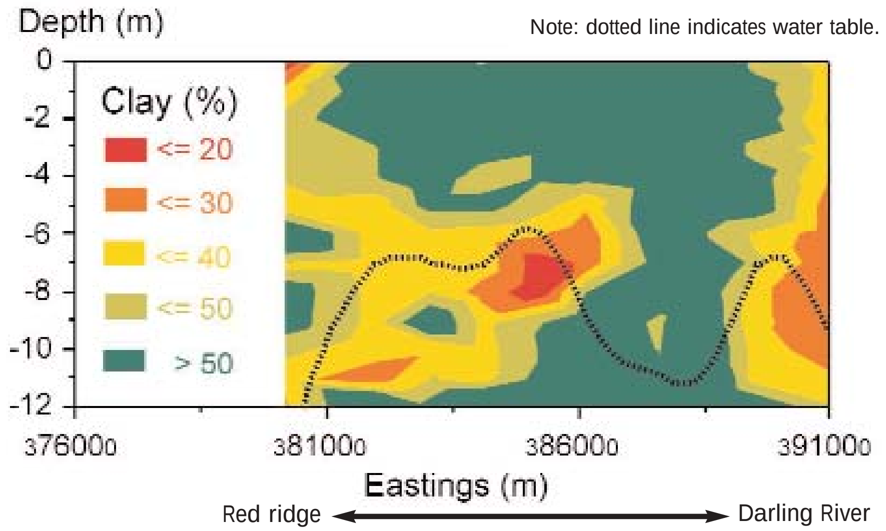
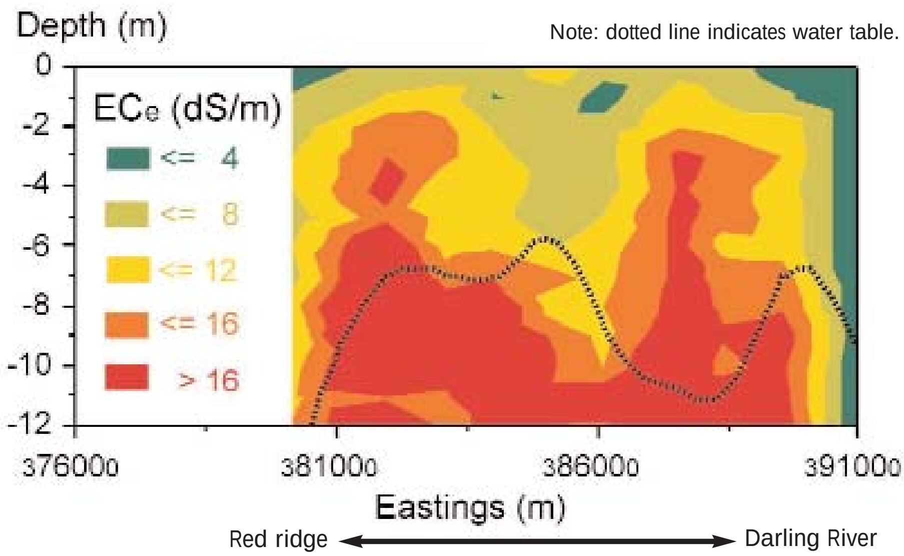


FIGURE 5: Distribution of ECe along the detailed soil transect



FUTURE WORK

Future work will aim to provide further information and a framework for gathering data on groundwater hydrology and impacts of high and low river flow and irrigation events. We also want to model the interaction between the subsurface salinity mapped here and the Darling River.

The information will be used to produce a groundwater model for the BID. The model will identify any threats of diminishing water quality and the most appropriate management options to minimise their impact and mitigate the effects of the subsurface saline material on surface soil salinity.

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