Geophysical Research Abstracts, Vol. 7, 05750, 2005
SRef-ID: 1607-7962/gra/EGU05-A-05750

An integrated geoscience approach to salinity mapping and assessment in a cotton irrigation district, Lower Balonne, S.W. Queensland, Australia

K.C. Lawrie(1), A. Fitzpatrick(1), J. Clarke(1), M. Grundy (2), J Kellett (3), C. Pain(1), A. Heczeg (4), K. Wilkinson (2), & R. Lane(1).

(1)Cooperative Research Centre for Landscape Environments and Mineral Exploration (CRC LEME), c/o Geoscience Australia, Canberra, ACT 2601, Australia. ken.lawrie@ga.gov.au, (2) Queensland Department of Natural Resources and Mines, Inderoopilly, Queensland, (3) Bureau of Rural Sciences, GPO Box 858, Canberra ACT 2601, Australia, (4) Cooperative Research Centre for Landscape Environments and Mineral Exploration (CRC LEME), c/o CSIRO Land & Water, Adelaide, South Australia.

The Lower Balonne Airborne Geophysics Project (LBAGP) is the largest (time domain) airborne electromagnetic (TEMPEST) survey acquired in Australia for salinity (and broader natural resource management) purposes. A total of 28,912 line km of data were acquired in 2001 under the auspices of the National Action Plan for Salinity and Water Quality, in a project undertaken by the Queensland Department of Natural Resources and Mines (QNR&M), the Cooperative Research Centre for Landscape, Environments and Mineral Exploration (CRC LEME), and the Bureau of Rural Sciences (BRS). The project also collected airborne magnetics and gamma radiometrics, digital elevation data, ground-based geophysical data, hydrological data from borehole investigations, soil site data and surface and sub-surface regolith data. The study area, part of the Lower Balonne catchment in the Darling Basin, southern Queensland, was selected to evaluate the use of airborne geophysics for salinity hazard and risk mapping and assessments in a flat inland alluvial floodplain landscape in an area of high agricultural value (cotton irrigation) and environmental sensitivity (Chamberlain & Wilkinson, 2004).

Regolith landscape mapping in the project area has revealed that the present surface landscape in the study area consists of a mosaic of active and inactive low relief alluvial fans with anastomosing distributaries, including that of the modern Balonne River (Kernich *et al.*, 2004). However, beneath the flood plain is a large, bedrock-incised palaeovalley system (Dirrinbandi palaeo-valley), eroded into weathered Cretaceous marine sediments (Clarke & Riesz, 2004). The trunk valley has been buried to depths of up to 200 m, and tributaries contain approximately 100 m of sediment. A change in depositional environment from confined to unconfined flood plains resulted in a change from anastomosing or braided channels to extensive braid plains when the valley sides were first over-topped (Clarke & Riesz, 2004).

Aquifers occur in 'nested' groundwater flow systems concealed beneath the low relief landscape (Fitzpatrick *et al*., 2004). Three main salinity (land and groundwater) management units have been delineated in the study area (Chamberlain & Wilkinson, 2004). Groundwater flow paths are different in each of these zones. Management Unit A is characterized by areas where the bedrock either crops out, or underlies a relatively shallow cover of unconsolidated sediments. A dual-porosity, saline partial aquifer exists within the bedrock, however in most cases the water does is not free flowing due to generally low hydraulic conductivities. Within this unit, salinity risks occur at breaks of slope, and where perching of the water table occurs over shallow bedrock. There is also the potential for salinisation to develop as a result of rising water tables in areas of increased local recharge (Kellett *et al.* 2004, Grundy and Macaulay, 2004, Wilkinson *et al.* 2004).

Management Unit B comprises areas where a thicker sequence (10-40m) of sediments overlies the basement. The original cotton irrigation area is located within this unit, and AEM data indicate an effect of irrigation on soil salt store, with an increased salt load in the top few (5 - 10) metres of the irrigated areas. Groundwater quality of the upper alluvial aquifer is highly variable in this area, however salt load in the near surface is not as high as in Unit A. A variety of salinity drivers have been identified in this unit, operating independently and interacting in various parts of the landscape. There is evidence for both vertical and horizontal groundwater flows, and sustainability of agricultural enterprises and the natural resources in this area will depend on continued monitoring and an increased investment in water use efficiency measures (Wilkinson *et al.* 2004).

Management Unit C comprises deep alluvial materials (40 – 200 m) within which there are two alluvial aquifer systems, separated by a clay aquitard. Some newer cotton irrigation occurs in this unit, and exploitable groundwater resources occur in the north. Within the upper alluvial aquifer, water quality is highly variable, generally decreasing in quality from north to south and away from river recharge. In the lower alluvial aquifer, electrical conductivity increases gradually from north to south and the range of values is less than those in the upper aquifer. Short-term salinisation issues caused by rising groundwater are unlikely in this region. Recharge to the aquifer needs to be minimized, and monitoring of near-surface elevated salt loads is needed to ensure salts do not move downward into the aquifer.

Overall, this project has been successful in developing new methodologies for data processing, analysis and integration that have produced valuable new insights for regolith mapping, and salinity risk mapping and management in the study area. Of particular note was the development of a new method for producing reliable constrained inversions of time-domain AEM data in areas of electrically conductive basement (Lane *et al.,* 2004). This enabled integration of the AEM products with other biophysical data in an integrated geoscience approach that has revealed a compartmentalized sub-surface regolith and bedrock architecture that is not evident from the surface landscape (Clarke & Riesz, 2004). The study has demonstrated that airborne geophysics, particularly AEM, significantly improves the understanding of salinity risk and water security, in flat alluvial landscapes, in areas that are relatively data-poor. 'Post-mortem' analysis of the airborne geophysics survey design suggests that significant reductions in data acquisition costs could be achieved for future surveys in similar landscapes by utilizing lessons learned on the scale of regolith landscape elements (Lawrie *et al.,* 2003).

The project has identified areas in danger of salinisation if current practices are maintained. New salinity (land and groundwater management) units are identified and recommendations made to modify land management practices that should lead to reduction in salinity risks in the area, and more efficient water management (Wilkinson *et al.* 2004). Areas for further research and analysis have also been identified, and a full cost-benefit study on the project is planned. The project has also shown the value of extensive stakeholder consultation and participation, and has reinforced the message that significant value-adding from airborne geophysics can be achieved where project planning is undertaken to address specific questions, and is linked in with a broader natural resource management planning and decision making framework.

Acknowledgements

This overview paper draws on the authors' own observations and that of numerous co-workers in partner agencies as summarized in numerous technical reports and papers and a project summary report (Chamberlain & Wilkinson, 2004). The authors publish with the permission of the CEOs of CRC LEME and Geoscience Australia.

References

Chamberlain, T., & Wilkinson, K. E., (Eds), 2004. Salinity investigations using airborne geophysics in the Lower Balonne area, Southern Queensland. *Queensland Department of Natural Resources and Mines Technical Report QNRM 04255*.

Clarke, J. D. A., & Riesz, A. L., 2004. Fluvial architecture of the subsurface of the Lower Balonne area, Southern Queensland, Australia. *CRC LEME Open File Report 162*.

Fitzpatrick. A., Lawrie, K. C., Clarke, J., Coram, J., Wilkinson, K. & Herczeg, A., 2004. Mapping 'nested' groundwater flow systems, aquifers, water tables and salinity systems in the Lower Balonne, SW Queensland. *Aust. Soc. Explor. Geophys. Conference*, 2004.

Grundy, M. and Macaulay, S. (2004). Land management. In: Chamberlain T and Wilkinson KE (Eds) Salinity investigations using airborne geophysics in the Lower Balonne area, Southern Queensland. *Queensland Department of Natural Resources and Mines*, pp 175-206.

Kellett, J., Pearce, B., Coram, J., Herczeg, A. and Wilkinson, K. (2004). Groundwater. In: Chamberlain T and Wilkinson KE (Eds) Salinity investigations using airborne geophysics in the Lower Balonne area, Southern Queensland. *Queensland Department of Natural Resources* *and Mines*, pp 79-138.

Kernich, A., Pain, C. F., Kilgour, P., & Maly, B., 2004. Regolith landforms in the Lower Balonne area, Southern Queensland, Australia. *CRC LEME Open File Report 161*.

Lane, R., Brodie, R., & Fitzpatrick, A., 2004. Constrained inversion of AEM data from the Lower Balonne area, Southern Queensland, Australia. *CRC LEME Open File Report 163*.

Lawrie, K. C., Gray, M., Fitzpatrick, A., Wilkes, P. & Lane, R., 2003. Reducing the Acquisition Costs of Airborne Electromagnetic Surveys for Salinity and Groundwater Mapping. *Preview. October 2003*, 31-37.

Wilkinson, K., Grundy, M. and Chamberlain, T. (2004). Conclusions. In: Chamberlain T and Wilkinson KE (Eds) Salinity investigations using airborne geophysics in the Lower Balonne area, Southern Queensland. Queensland Department of Natural Resources and Mines, pp 207-222.