The Use of AEM as part of an Integrated Approach to Rapidly Identify and Assess Managed Aquifer Recharge Targets

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ABSTRACT

To meet the challenge of rapid identification and assessment of potential MAR targets and groundwater resources over a large area (7,541.5 sq km) of the River Darling Floodplain within relatively short timeframes (18 months), it was concluded that the only cost-effective method with the ability to resolve key features of the hydrogeological system in the 0-150 m depth range was airborne electromagnetics (AEM). The helicopter-borne SkyTEM transient EM system was selected after a rigorous technology assessment exercise. The SkyTEM survey involved acquisition of 31,834 line km of data (line spacing 200-300m), and was acquired by two systems over a 9-week period. Initial Fast Approximate Inversions (FAI) provided within 48 hours of acquisition were used to target a 7.5 km drilling program (100 sonic and rotary mud holes), and complementary borehole geophysics and field and laboratory measurements. Finally, a Wave Number Domain Approximate Inversion procedure with a 1D multi-layer model and constraints in 3D, was used to produce a 3D conductivity model.

The SkyTEM system successfully mapped a multi-layered hydrostratigraphic sequence of aquifers and aquifers in the near-surface (top 100 m). This included: the thickness and extent of near-surface unconfined aquifers and aquitards; the thickness, extent and internal textural variability of Pliocene sand aquifers; the thickness, extent and internal variability in upper (Blanchetown Clay) and lower (upper Renmark Group) confining aquitards that 'sandwich' the Pliocene Sand aquifers; and the 3D distribution of groundwater salinity (to help define fresh and brackish groundwater resources). The study revealed significant heterogeneity in the sub-surface electrical conductivity structure, reflecting a complex geology. Significant Neogene-to-Present faulting, warping and tilting are observed to disrupt hydrostratigraphic units. The survey also mapped heterogeneity within the near-surface aquifers and confining aquitards, zones of inter-aquifer leakage, and five hydraulic classes (based on grain size) within the main aquifers, as well as groundwater salinities. Locally, pump and slug tests, and NMR data were integrated with the AEM data to produce maps of aquifer transmissivity. Only in more localised domains, where groundwater quality within the Pliocene aquifers is extremely saline, did it become too difficult to resolve some of the key aquifer boundaries and internal aquifer characteristics.

Initial investigations determined that the Calivil Formation aquifer was most suited to potential MAR development. AEM mapping identified palaeochannels with medium-coarse grained sands in a relatively thick (30-50m) aquifer with a high storage capacity, very high transmissivities (up to 50 l/s), and significant volumes of fresh groundwater. The aquifer is sandwiched between variably thick clay aquitards, and can be characterised as varying from a confined to a 'leaky confined' system. The hydraulic properties make the Calivil Formation aquifer potentially suitable for groundwater extraction and/or MAR injection, with excellent recovery efficiencies predicted.

Overall, this study has shown that there are significant scientific, technical, economic and social challenges to be overcome to develop MAR options in inland Australia. Key to success in the BHMAR project was the utilization of AEM mapping and integrated assessment methodologies and workflows. It is our understanding that this is the first use of AEM as part of multi-disciplinary mapping and assessment of MAR targets. The investigations in this study also completely revised our understanding of the age, stratigraphy, structure and mode of deposition of the Darling floodplain sediments, with practical implications for the hydrogeological conceptual model underpinning the assessment of groundwater resources and MAR options.

Key words: Managed Aquifer Recharge; Airborne Electromagnetics; Darling Floodplain, Menindee Lakes