Defining spatial patterns of inter-aquifer leakage through the application of a-priori constraints when inverting airborne EM data

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Key to the effective management of natural ecosystems that characterise the floodplains of the Murray Basin in south eastern Australia, and maintenance of river health (a critical water resource) in a setting where severe salinisation is an ever-present threat, is the need for a sound understanding of surface water-groundwater processes. The importance of this has been emphasised in the recent, prolonged drought throughout the Basin with riparian communities on the floodplains in severe decline reflecting the lack of water in the system. Protecting the natural floodplain environment and limiting the flow of saline groundwater into the river system presents particular management challenges requiring that our conceptual hydrogeological knowledge is soundly based. In the eastern margins of the Basin, the drying climate, causing permanent or temporary restrictions to existing surface water entitlements has led to increased demand for groundwater. Its sustainable extraction requires an understanding of aquifer integrity, geometry and quality, particularly where it is extracted from confined or multi-layered systems, and where shallow, unconfined aquifers are too saline for use either as a source of potable water or for irrigated agriculture or stock. In such situations, a major threat to the long-term sustainability of groundwater resources is leakage of saline water from formations that overlie and/or underlie the target aquifers. Interestingly, these issues have a wider relevance, particularly given the growing interest in managing groundwater resources through managed aquifer recharge (MAR) in rural areas, and from the growing interest in coal seam gas, where an understanding of aquifer integrity and variability is critical. From a hydrogeological perspective these various situations demand information on the spatial variations in groundwater quality, aquifer integrity and information on surface water-groundwater interactions.

This paper presents results from an examination of hydrogeophysics, specifically airborne electromagnetics (AEM) data acquired by the SkyTEM time domain helicopter EM system, as a means for improving our knowledge of spatial patterns associated with inter-aquifer mixing where groundwater flow is potentially complex. We are particularly interested the use of this technology as a means for providing a spatial picture of mixing which would assist in conceptual hydrogeological model development and refinement. We examine the potential of using prior-constraints developed through the employment of lithostratigraphic information on the various aquifers and aquitards that characterise the study area, as a framework for inverting the AEM data. The study, focussing on the Lower Murray of South Australia considers both inter-aquifer mixing and surface water-groundwater interaction. Recent studies in this area provided hydrochemical evidence for upward and downward leakage between aquifers, and given the highly saline nature of the lower groundwater system we believe AEM would have considerable potential to elucidate the nature of inter-aquifer leakage. When linked to spatial representations of conductivity with depth, conductivity patterns that may relate to discontinuities in the hydraulic characteristics of the aquitard or aquifer, particularly in response to mechanical or natural loading, may be discernable.