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Using expert participation to evaluate the accuracy and variability of hand-drawn water table mapping

Sarah K. Marshall [a], **Okke Batelaan** [b] **and Luk Peeters** [a]

[a] *CSIRO Land and Water, Adelaide, Australia*
[b] *Flinders University of South Australia, Adelaide, Australia*
Email: s.marshall@csiro.au

Abstract: Producing a model of a water table surface is a fundamental part of a hydrogeological site characterisation. Yet often point-source measurements of hydraulic head at groundwater wells are the only available information to constrain the water table surface. This leaves large regions where spatially-continuous water table prediction require geostatistical, physically-based, or data-driven models. Several challenges exist in using these methods, such as the level of technical proficiency required for their implementation, a lack of flexibility around the input datasets used, and interpolation artefacts not explainable by hydrological phenomena. For these reasons, many hydrogeologists choose to draw water table contours manually by hand.

This research aims to explicitly quantify the variability associated with hand-drawn water table mapping. In a unique experiment, 64 participants working in the groundwater profession drew water table equipotential contours and completed a questionnaire about their experience. The survey map contained hydraulic head data, topographic contours, the spatial extent of a large-scale fault, and the surface water drainage network for the Willunga sub-basin, South Australia. The results show that the dominant horizontal groundwater flow direction was identified consistently. Conversely, estimated hydraulic head values at various specified locations did not agree, particularly in areas of low water level data or areas of greater topographic variability. The accuracy at groundwater observation wells with known values of hydraulic head was calculated to be 10 m. At locations without observations, the prediction error was approximately 40 m. The survey showed that participants were not consistently able to use the mapping to inform conceptual aspects of the system such as whether the surface water system was gaining or losing.

A hand-drawn approach enables the practitioner to rely on their own cognitive model, whereby consideration of spatial and conceptual hydrogeological phenomenon is inherent. The questionnaire enabled the elicitation of knowledge about the process of hand-drawn water table mapping and what factors are inherently considered by an expert when conceptualising a system. Auxiliary datasets, such as knowledge of the topography, surface-water groundwater connectivity, or recharge and discharge areas, can be considered without their relation to the water table surface being explicitly defined. However, a hand-drawn approach is insufficient to enable transparent, rapid, and repeatable water table surfaces with an estimate of uncertainty. Novel methods are required that can facilitate the same flexible and adaptive incorporation of multiple datasets that hand-drawn contouring allows, but in a repeatable and transparent manner. This study presents findings about human-based interpolation that can assist with developing new, robust water table mapping methodologies.

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