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Time-lapse Geophysical Monitoring of the Subsurface Hydrology at Kings Park, Western Australia

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The increasing occurrence of drought stress throughout Southwestern Western Australia is postulated to have contributed to the decline of Banksia populations both in Kings Park, Perth, and in the Banksia woodlands in the greater Swan Coastal Plain region. To help quantify these assertions, there is an urgent need to better understand the base levels of soil moisture content – as well as seasonal variations thereof – in these geographical regions. We conducted time-lapse (TL) electrical resistivity tomography (ERT) and ground penetrating radar (GPR) methods on a monthly basis (May-August 2014). In addition, at each site we hand-augured test holes to a depth of 3-4 m and collected samples at 20-cm intervals to enable grain-size analysis, soil moisture content and water retention tests. PR2 capacitance probe measurements were also acquired when augering to enable a moisture content comparison study.

The acquired TL ERT datasets were inverted using 2D EarthImager software and the temporal variations in resistivity were interpreted in terms of changes in moisture content. The TL ERT data reveal significant calendar variations in the spatial distribution of moisture content. The TL ERT inversions also detected isolated less resistive lithologies and the depth to groundwater. Processed TL GPR data were interpreted to show vertical variations in the vadose zone moisture content. The water content variations were consistent with the rainfall data. The grain-size distributions of the samples were analysed statistically. The apparent resistivity values from the analysed samples and observed volumetric water content are strongly correlated (R2=0.84) as may be expected from Archie's law. Soil moisture content analysis results including the PR2 probe measurements were plotted as a function of depth, the result shows vertical variations in moisture content with depth. The hydrological tests indicated the properties of the subsurface lithologies and confirm the responses of the resistivity measurements.

This research work monitors water variations within the Kings Park and how they are related to the hydrological properties of the subsurface soils. The geophysical investigations indicated that the seasonal wetting front propagates to at least 10 m below the surface. The hydrological tests reveal that the soils are mainly sands with low water retention capacity, however water retention capacity increases with depth from about 3.5 m (increase in silts/clay content). This suggests that during the long dry summer period, water may not be available to plants with shallow roots (plants with roots < 3.5 m deep). Water may therefore be a limiting factor responsible for the decline in Banksia plants.