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What do groundwater levels tell us about groundwater discharge to streamflow?

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Identifying the contribution of groundwater discharge to stream baseflow is of considerable importance for maintaining environmental flows and determining the potential effects of groundwater pumping on streamflow. The 'Rating Curve' method (Gonzales et al., 2009) is one of the few techniques that make empirical use of groundwater data by generating a relationship between groundwater levels in a bore and unregulated stream discharge. We applied the Rating Curve method to two catchments in south-eastern Australia; Gellibrand River (perennial river in a constrained valley with high baseflow) and Bet Bet Creek (intermittent stream with saline groundwater discharge contributing to intermittent baseflow).
An exponential function (1) was found to best describe the relationship between groundwater levels and stream discharge and quantile regression was used to determine the outer envelope to the data (using (1) to define the 5th percentile of the data).
Q_gw= e^((h-h_0)/A)+ Q_0 (1)
Where Qgw is the groundwater discharge to the stream, h is the groundwater level measured in the monitoring bore and h0, A and Q0 require calibration (h0 and A are curve-fitting parameters while the Q0 parameter shifts the curve to optimize the fit to the low flow data). Typical of this relationship in perennial catchments, at lower groundwater levels the relationship can be adequately defined by a linear function, indicating the expected Darcian behavior of regional groundwater. In the Gellibrand catchment the linear section of the relationship corresponded to low flows (typically 0.1 - 0.6 m3s-1) that occurred over the summer period in a catchment which shows a strongly seasonal flow response and consistently gaining gradients in the near stream environment. Previous studies (e.g. Gonzales et al., 2009) have considered the non-linear behavior to coincide with the onset of interflow and increased groundwater discharge into small tributary streams draining the river valley slopes. In the intermittent catchment, the apparent linear section of the relationship was typified by a near-horizontal section where streamflow remained very low (<0.01 m3s-1) over a range of groundwater levels. When fitted by (1) at the 5th percentile, the groundwater level at Qgw=0 corresponded with the approximate change from a losing to a gaining gradient between the stream and the monitoring bore.
An advantage of the Rating Curve method is that it provides a conceptually valid, empirical framework for assessing geochemical end-member analyses. Particularly in high baseflow, perennial rivers, the Rating Curve method can be used to constrain periods where groundwater levels indicate a linear relationship with streamflow discharge (representing regional groundwater discharge) compared to periods with a non-linear relationship where additional end-members may need to be invoked.
Gonzales AL, Nonner J, Heijkers J, Uhlenbrook S. 2009. Comparison of different base flow separation methods in a lowland catchment. Hydrol. Earth Syst. Sci. 13, 2055-2068.