Improved Methods for Estimating K with the Hydraulic Profiling Tool (HPT)

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Background/Objectives. The hydraulic profiling tool (HPT) is a direct-push tool that is commonly used to generate vertical profiles of hydraulic conductivity (K). However, there is little information on accuracy and precision of HPT data for estimating K. Current HPT procedures are also not applicable to lower K formations. We evaluate the ability of existing HPT methods to estimate K and develop more reliable field methods and data analysis procedures for estimating K in various permeability formations.

Approach/Activities. Using the existing HPT system, water is injected at a constant rate Q, while advancing the HPT probe through the formation and monitoring injection pressure (P). The corrected pressure (P*) is the difference between the measured pressure (P) and hydrostatic pressure in the formation. K is estimated from a relationship between Q/P* and K. In general, there are two challenges in generating reliable K estimates: 1) excess pore pressure build-up; and 2) lack of published methods for estimating K from measured Q/P*.

Pore pressure build-up occurs when the probe is advanced through lower K material due to fluid injection and displacement of aquifer material by the advancing probe. In lower K formations, pore pressure can exceed the soil confining stress, possibly leading to formation alteration. Pressure buildup can be reduced by lowering the water injection rate and rate of probe advance through the formation. We evaluated the effect of reduced injection rates (2 ml/min to 100 ml/min) and slower probe advance rate (0.5 cm/sec) on measured pressures.

We also develop more reliable methods of estimating K from Q/P*. The functional form of the Q/P* versus K relationship was developed from numerical model simulations. However, potential formation alterations during tool advancement were not considered in the simulations. To account for the impact of formation alterations, the simulation-based relationship was further calibrated by comparing HPT results with slug test measurements in adjoining wells at multiple sites.

Results/Lessons Learned. We developed a revised protocol for measuring vertical profiles of K using HPT tools for a variety of formations including fine grained materials. This includes an improved relationship for estimating K from Q/P* measurements.