Title: **The Effect of Construction, Installation, and Development Techniques on the Performance of Monitoring Wells in Fine-grained Glacial Tills (Study No. 18)**

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Objectives: To analyze the effect of piezometer construction, installation and development techniques on the calculated formation hydraulic conductivity and well-water turbidity.

Methods: Twenty monitoring wells were installed at two field sites in the fine-grained glacial till of the Oak Creek Formation in southeastern Wisconsin. Laboratory tests determined the permeabilities and porosities of the screens and sand packing materials used in piezometer construction and samples collected in the field. Engineering soil tests evaluated grain-size distribution and soil consistency of formation materials. Time-consolidation tests and constant head tests in a triaxial cell determined the inter-granular hydraulic conductivity of formation materials. A critical evaluation of the currently used analytical solutions for determining hydraulic conductivity from slug test data in fine-grained materials was completed. Comparisons were made of the hydraulic conductivity calculated by various analytical solutions with field and laboratory measurements.

Results/Conclusions: Installation of monitoring wells in essentially dry boreholes produced water samples of very low turbidity compared to those wells which were installed in wet boreholes. Water samples of surged wells were much more turbid than the water samples from wells which were bailed only. Turbidity decreased significantly on the second sample bailed, though it did not show a substantial change for the surged sample. A silt-sized sand pack and smaller than 0.05 millimeter screen are required to filter clay-sized particles.

Formation hydraulic conductivity calculated from slug tests showed consistent differences among methods used. The commonly used Hvorslev method produced values which were 133% and 33% of those obtained using the Bouwer-Rice procedure and the Cooper-Papadopulous method, respectively. All calculations used the same data, so the Bouwer-Rice method tends to produce the lowest permeabilities, while Cooper-Papadopulous seemingly overestimates.

Field tests also showed a bimodal distribution of hydraulic conductivities in the till with one mode at about $10^{-6.5}$ centimeters per second (cm/sec) and the second at $10^{-7.6}$ cm/sec. The higher values result from fracturing or other heterogeneities in the till. Lab testing showed permeabilities only around the lower mode because the samples were not large enough to intersect the heterogeneities. Consequently lab procedures underestimate the effective permeability of tills. Well development by surging did not increase observed field permeabilities, so did not reduce the skin effects associated with smearing of the borehole wall during drilling.

Recommendations/ Implications:

Investigators suggest the following techniques for well construction necessary to obtain representative hydraulic conductivities from bail tests and sediment-free water samples. A non-surged factory slot piezometer set in an essentially dry borehole and packed with TDS2150 will provide an appropriate design for monitoring wells in fine-grained tills. Surging is discouraged due to increased water sample turbidity. Factory slot screens are recommended for turbidity testing. A monitoring well which is set in an essentially dry borehole is best for reducing water sample turbidity. Joints connecting PVC standpipe should be threaded and sealed to avoid leakage from friction near the surface. Hydraulic conductivities must be measured in the field in order to properly determine the effects of heterogeneities. Comparisons of values obtained by different calculation methods should be done with caution.

Availability of Report:

This report is available for viewing and loan at:

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Glacial till, hydraulic conductivity, well construction, well development.

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