MISCELLANEOUS TOPICS IN MODELING AND GEOPHYSICS

The Value of Single-Well Tracer Studies for Characterizing Karst Sites

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Abstract

Water movement, contaminant migration and energy transfer in heterogeneous karst aquifers is challenging to describe quantitatively. Karst ground-water aquifers may be characterized by high velocity, turbulent flow within solution-enhanced fractures, conduits, or stratiform passageways. In other parts of the same aquifer, ground-water flow may be stagnant or very slow. Once a contaminant has entered a karst aquifer, it is often difficult to determine its precise flow-path or residence time in the bedrock. Attempts to characterize a karst site with traditional tracer tests may yield limited information, especially if the tracer cannot be detected at down-gradient monitoring sites. This project applied an integrated approach using local geology, data from fracture mapping, borehole geophysics, and hydraulic testing, as well as geochemical and single-well tracer tests to characterize aquifer hydraulic properties at several karst sites in Middle Tennessee. Two types of wells; existing wells with the characteristics of typical domestic-water wells, and wells constructed to meet project specifications were also evaluated. Single-well tracer studies were conducted by injecting a conservative salt tracer of known concentrations into several wells at known depths and measuring the decrease in tracer concentration with time. Changes in tracer concentration were then analyzed to provide information about aquifer advection and dispersion properties in the immediate proximity of the wells. Unfortunately, some of the wells used in this study were drilled approximately 25 years ago and proved to be less than ideal for single-well injection studies. The most difficult problem encountered involved wells characterized by long vertical sections with no bedrock openings for the tracer to enter the aquifer freely. These wells yielded very little useful information. For example, the mean residence time in the water column of bedrock wells with few openings was 65 hours or greater. Conversely, tracer injections in wells with good hydraulic communication with the bedrock aquifer provided useful data with mean residence times ranging from 14 to 45 hours. Single-well tracer studies conducted in properly designed wells provided valuable hydrologic information on the residence-time distribution and dispersion of the tracer in the vicinity of the injection wells. The information collected from single-well injection tests when combined with water chemistry and water level data can be useful for the design of remediation strategies at contaminated karst sites.