Developing a CSM to Inform Application of Bioremediation in Fractured Rock

Claire Tiedeman, U.S. Geological Survey, Moffett Field, CA

Co-authors: Allen Shapiro, Paul Hsieh, Tom Imbrigiotta, and Dan Goode, U.S. Geological Survey

A conceptual site model (CSM) of a trichloroethene (TCE) source area in fractured mudstones was developed by using field characterization together with groundwater flow and chemical transport modeling. The field characterization produced a detailed understanding of the geology, contaminant distribution in fractures and the rock matrix, and hydraulic and transport properties. This information was used to develop flow and transport models that proved critical for designing bioremediation of the source area. The bioremediation involved injecting amendments (emulsified vegetable oil and bacteria) to enhance the naturally occurring biodegradation of TCE. The modeling showed that injection will spread amendments widely over a zone of lower-permeability fractures, with long residence times expected because of small velocities after injection and sorption of the vegetable oil onto solids. Amendments transported out of this zone will be diluted by groundwater flux from other areas, limiting bioremediation effectiveness downgradient. At a nearby pumping well, further dilution is expected to make bioremediation effects undetectable in the pumped water. The results emphasize that for in-situ remediation of heterogeneous groundwater flow systems such as fractured rock aquifers, the extent of injected amendments cannot be conceptualized using simple homogeneous models. Instead, it is important to develop CSMs that use site characterization data together with modeling that represents the dominant heterogeneous features controlling flow and transport. This modeling simulates the spatial variability of groundwater fluxes that strongly control in-situ remediation effectiveness, and facilitates designing injection strategies that target specific volumes of the aquifer and maximize the distribution of amendments over these volumes.