Successful Enhanced Reductive Dechlorination in Bedrock with Long-Term Monitoring: Two Case Studies

Paul M. Dombrowski, P.E. (pdombrowski@isotec-inc.com) (ISOTEC, Newton, MA)
Prasad Kakarla, P.E., Mike Temple, and Tom Musser (ISOTEC, Lawrenceville, NJ)
Michael Lee, Ph.D. and Richard Raymond, Jr. (Terra Systems, Inc., Claymont, DE)
Curt Weeden (AECOM, Manchester, NH, USA)

Background/Objectives. In situ injection into bedrock is one of the most challenging issues facing groundwater remediation practitioners. Monitoring wells and injection points are expensive to install, and many bedrock plumes are characterized with less observations than overburden plumes. This presentation features two example sites with bedrock groundwater impacted by chlorinated volatile organic compounds (CVOCs) with evaluation of project-specific objectives, remedial design, reagent selection, and injection methods. One site featured igneous bedrock (granite) with CVOCs detected as deep as 110 feet below ground surface, and the second site is underlain by sedimentary bedrock (siltstone and shale) targeted treatment to a depth of 60 feet. At both sites previous injections were performed with limited effect at reducing concentrations and/or CVOCs rebounded to baseline concentrations.

Approach/Activities. Enhanced in situ dechlorination (EISD) was selected as the full-scale remediation approach for both sites. At one site geophysical investigations and pump tests were performed as part of Remedial Design. At the other site geophysical investigations were not performed; however, observations of potential fractures were noted during installation of 10 additional boreholes. Injectates at both sites included emulsified vegetable oil (EVO), sodium lactate, and bioaugmentation with injection performed under low to moderate pressure using dual diaphragm pumps (<10 to 70 psi) with the objective of delivering remediation solutions into existing fractures where CVOCs were travelling. One site also included zero valent iron (ZVI) in the injectate solutions. Straddle packers were utilized at both sites to direct injections into identified fractures.

Results/Lessons Learned. Obtaining an understanding of fracture locations and contaminant distribution in bedrock was critical to implementing successful bedrock remediation at both sites. At both sites remedial design was specific for each injection point, with each borehole receiving the specified volume at both sites, in contrast to many bedrock injections where injection points often do not receive the appropriate volume, and significant volumes are re-distributed into the limited wells that do receive fluids. Three or more years of groundwater sampling at each site has demonstrated significant reductions in CVOC concentrations and favorable conditions for on-going reductive dechlorination, including concentrations of total organic carbon, Dehalococcoides bacteria, and/or terminal electron donors. The presentation will highlight key aspects of design and implementation that supported successful and sustained in situ remediation of bedrock.