Successful TCE DNAPL Source Area Remediation through Real-Time Analysis of Oxidant Concentration during ISCO

Russ Bunker and Jack T. Spadaro (AMEC Foster Wheeler, Portland, OR, USA)
Michael G. Sweetenham (msweetenham@trihydro.com), Friedrich J. Krembs, and Kyle McDonald (Trihydro Corporation, Golden, CO, USA)

Background/Objectives. This presentation documents the successful treatment of a trichloroethene (TCE) dense non-aqueous phase liquid (DNAPL) source area through a real-time monitoring and optimization program and adaptive approach to field implementation for treatment of both aqueous and non-aqueous phase TCE. Historical releases from underground storage tanks buried within a low permeability silt zone overlying weathered basalt bedrock at a manufacturing facility resulted in aqueous phase TCE concentrations from 1,000 to 300,000 µg/L prior to remediation in the source zone. In situ chemical oxidation (ISCO) with sodium permanganate was identified as the source zone treatment technology. Groundwater samples were collected during ISCO from monitoring wells and analyzed in real time for sodium permanganate concentrations to optimize active and subsequent injection events.

Approach/Activities. Bench-scale testing was used to develop kinetic natural oxidant demand (NOD) for site soils and a conceptual design approach. Based upon relatively low NOD and complete TCE treatment in bench testing, ISCO was implemented at the field scale. Injection wells were installed on 10-ft centers based on the desire for thorough treatment, anticipated low injection rates into the low permeability treatment zone, and reactive transport modeling of oxidant delivery radius of influence (ROI). Monitoring wells were installed between injection wells creating a tightly spaced monitoring network for collection of groundwater samples during injection.

Groundwater samples were collected from monitoring wells and injection wells during ISCO for analysis of sodium permanganate concentration. Samples were diluted and analyzed for total manganese concentration using a colorimeter and converted to sodium permanganate concentrations. These data were used to assess the ROI and reaction kinetics of sodium permanganate with TCE. This analysis was used real-time to optimize oxidant delivery during injection events by adjusting the injection sequence and target volumes to deliver oxidant to under-treated areas due to variability in delivery or rapid consumption kinetics. Groundwater samples were also collected post-injection and analyzed for sodium permanganate using a colorimeter. Sodium permanganate concentrations collected during and post-injection were then used to aid design of subsequent injection events. Two full-scale and three polishing rounds of ISCO injections have now been performed at the site and suggest that the real-time data optimization worked effectively.

Results/Lessons Learned. Real-time data analysis of sodium permanganate concentrations proved effective during ISCO as it provided insight into oxidant distribution due to variability in delivery and reaction kinetics. This evaluation resulted in reallocation of target sodium permanganate mass and injection volumes at individual injection wells. Data collected during and after injection suggested optimal delivery of sodium permanganate would not have been achieved without real-time data evaluation and ISCO may not have been as successful. Subsequent injection events were also optimized to include enhancements based on real-time observations from previous injection events. Injection volumes were modified both prior to and during implementation based on permanganate and TCE concentration data.