Case Study of TCE Source Zone Treatment using Potassium Permanganate In Situ Chemical Oxidation in a Crystalline Bedrock Aquifer

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Background/Objectives. In situ chemical oxidation (ISCO) remedial action has been implemented at a former textile chemical manufacturing facility. The facility began operation in the early 1970s. A historic release occurred on-Site at a former aboveground storage tank farm. Excavation of impacted soils was completed in 1990, at the time of tank removal, but groundwater contamination was not addressed. Multiple environmental investigation activities have been conducted at the Site since the early 1990s. Trichloroethylene (TCE) and degradation products were identified as the primary constituents of concern. Secondary constituents of concern consisted of BTEX and chlorobenzene compounds. During baseline sampling, (prior to ISCO treatment) total chlorinated ethenes concentrations of up to 80 mg/L were identified beneath the former tank farm area. The Site geology consists of saprolite (0-40 ft thick) overlying crystalline bedrock (diorite and gabbro). Hydrogeologic assessments investigating flow velocity and flow paths have indicated that plume migration occurs primarily through the crystalline bedrock zone and discharges to a stream approximately 1,000 ft downgradient of the source zone.

Approach/Activities. Site characterization and evaluation of remedial alternatives led to the implementation of potassium permanganate ISCO injections via four-inch permanent injection wells. Multiple injection events have been completed within an approximately 17,000 square ft target treatment area. The injection approach consisted of 1) mixing the permanganate reagent in 15,000-gallon polyethylene tanks; 2) pumping the permanganate reagent through an injection manifold equipped with flow meters, pressure gauges, and throttle valves; and 3) distribution of the permanganate reagent to injection wells via flexible hoses. Fourteen shallow wells, three deep bedrock wells, and four water table interface wells were utilized for injections. Approximately 100,000 gallons of 1.0% to 1.5% potassium permanganate were injected into the aquifer over five separate injection events. Groundwater monitoring has been conducted on a quarterly or semi-annual basis since the initiation of remedial action.

Results/Lessons Learned. Permanganate ISCO injections have substantially reduced total chlorinated ethenes concentrations (typically 70% to 99% compared to pre-injection baseline concentrations) in source zone groundwater. Minor and temporary increases in concentrations were observed in immediate downgradient monitoring wells as a result of plume displacement that occurred during the injection events. Back diffusion concentration rebound in the injection wells typically occurred eight months after injection events; however, substantial concentration reductions are still evident. Downgradient monitoring wells, as far as 750 feet downgradient of the source, have begun to exhibit significant concentration declines along the treated groundwater flow path. Based upon downgradient monitoring, the observed travel velocity of the treated water in the shallow bedrock is approximately 150 feet per year, which is significantly faster than groundwater velocity estimates previously calculated based on slug test results. The permanganate injections have been effective in reducing source zone and downgradient concentrations; however, treatment effectiveness appears to be diminishing with each subsequent permanganate injection. Monitored natural attenuation and/or a supplemental remedial technology may be utilized in the future to attain Site-wide remedial goals.