Old ZVI and New ZVI: Enhanced Reductive Dechlorination and PlumeStop® Form Effective Backstop to ZVI PRB

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Background/Objectives. A zero-valent iron (ZVI) permeable reactive barrier (PRB) was installed near the leading edge of a groundwater plume containing trichloroethylene (TCE) and TCE degradation products in 2001. The PRB has successfully limited mass flux of chlorinated volatile organic compounds (CVOCs) for 20 years, but the PRB effectiveness has decreased over time. The project objective was to identify a cost-effective in situ approach to mitigate the decrease in PRB performance and to remediate residual CVOCs in the area immediately downgradient of the PRB. Pilot testing and full-scale application demonstrated that an in situ enhanced reductive dechlorination (ERD) approach that included microscale ZVI and PlumeStop® can effectively address breakthrough of CVOCs from the old ZVI PRB.

Approach/Activities. Groundwater monitoring data collected within and downgradient of the ZVI PRB demonstrated effective degradation of CVOCs for 20 years, but also indicates that breakthrough of CVOCs will likely occur within the next few years. An in situ remediation approach downgradient of the PRB was developed as an alternative to trying to restore or replace the reactivity of the PRB.

Detailed in situ hydraulic testing identified a transmissive zone for targeted in situ remediation downgradient of the PRB. A combination of PlumeStop®, S-MicroZVI™, Bio-Dechlor Inoculum® Plus (BDI PLUS™), a slow release fermentable carbon source and nutrients were injected into the transmissive zone. The remedial approach was first pilot tested in a 40-foot by 40-foot zone downgradient of the PRB. Groundwater in this pilot test area met drinking water standards for TCE and cis-1,2-dichloroethylene within one year of injections and continues to meet these standards three years after the pilot test. After the success of the pilot test, a second round of injections was conducted in a 4,800 square foot area.

Monitoring for the pilot and full-scale injections included compound specific isotope analysis (CSIA) and quantitative polymerase chain reaction (qPCR) testing. CSIA data for TCE and degradation products demonstrate fractionation, providing strong evidence of compound degradation to non-chlorinated end products. Baseline qPCR results revealed relatively low populations of Dehalobacter (DHB), and Dehalococcoides (DHC). Post-injection samples demonstrated that both DHC and DHB populations increased several orders of magnitude and enzymatic activity also increased.

Results/Lessons Learned. The in situ ERD stimulant and PlumeStop® injections have created an effective backstop to the decreasing effectiveness of the PRB and demonstrated the ability to meet drinking water criteria. Site characterization and identification of a transmissive zone was critical to cost-effective in situ treatment, as this enabled targeted injection of a smaller vertical interval. The focused pilot test provided proof of effectiveness and important design data for full-scale application. Based on the monitoring results, the treatment zone established downgradient of the PRB is expected to remain effective to manage partial or complete breakthrough of CVOCs.