# Large-Scale In Situ Biotic and Abiotic Dechlorination of Groundwater Impacted with Commingled Chlorinated Ethenes and Chlorinated Methanes

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**Background/Objectives.** The site covers approximately 13 acres and has been used for industrial purposes since the 1940s. A 2018 site investigation conducted as part of facility closure identified the presence of chlorinated volatile organic compounds (cVOCs) in groundwater including trichloroethene (TCE) concentrations as high as 3,400 micrograms per liter (µg/L), carbon tetrachloride (CT) concentrations as high as 2,400 µg/L and chloroform (CF) concentrations as high as 1,060 µg/L. This cVOC impacted groundwater covered an area of approximately 70,000 square feet to a depth of approximately 20 feet below ground surface and is present within interbedded silty clay and silty sand soils. Remedial objectives include minimizing human health risks to future receptors due to ingestion and direct contact to groundwater and also due to inhalation of soil vapor. Substantial heterogeneities within the treatment zone, and the presence of a shallow water table and adjacent surface water receptor posed significant challenges to effective distribution of injected amendments.

**Approach/Activities.** Groundwater remediation using in situ chemical reduction (ISCR) paired with enhanced in situ anaerobic bioremediation (ISB) was implemented in late 2021 to address the cVOC-impacted groundwater. Pre-design testing of pressurized direct push injection (DPI) and pneumatic enhanced injection of zero-valent iron (ZVI), organic carbon substrate and bioaugmentation consortium was conducted to refine injection parameters and identify a preferred injection technology for full-scale remediation. Based on the occurrence of amendment daylighting during late 2021 pre-design testing, the pneumatic enhanced injection alternative was removed from consideration and the efficacy of pressurized DPI was solely evaluated based on several lines of evidence, including magnetic susceptibility (MS) measurements. A full-scale injection design was subsequently formulated based on the results of the pre-design testing. A total of 136,000 lbs of ZVI, 325,000 lbs of organic carbon substrate and 208 liters of dechlorinating culture was then injected through 264 DPI points in late 2021.

**Results/Lessons Learned.** The results of post-injection groundwater monitoring revealed effective electron donor distribution based on total organic carbon concentrations, establishment of reducing conditions based on nitrate, ferrous iron, sulfate, and methane data, and substantial reductive dechlorination based on evaluation of cVOC molar concentrations and molar fractions. The following reductions in cVOC concentrations have been observed (without rebound) in the most heavily impacted monitoring wells, two to 10 months post-injection:

- TCE decreased from 1,400 µg/L to <2.5 µg/L;
- CT decreased from 1,200 µg/L to <0.050 µg/L; and
- CF decreased from 660 µg/L to 28 µg/L.

Based on the most recent (late 2022) groundwater sample results, treatment zone groundwater no longer contained detectable TCE or CT, or their respective degradation products cis-1,2-dichloroethene or methylene chloride. Only one September 2022 sample contained vinyl chloride at a concentration above the Safe Drinking Water Act maximum contaminant level (MCL) of 2 µg/L. Post-injection groundwater data interpretation will be presented, along with discussions of rationales regarding injection approaches and next steps.