

Low-Impact Pilot Study Leads to Expanded Treatability Evaluation Confirming Biostimulation as Safe, Sustainable and Cost-Effective cVOC Remediation Strategy

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Background/Objectives. The site is an inactive manufacturing facility in Belmont County, Ohio. Chlorinated volatile organic compound (cVOC) groundwater contaminants are documented in saturated/non-saturated soils/fractured bedrock. An existing pump-and-treat (PT) system utilized for hydraulic containment has been operating since the mid-2000s; one (EW-3) of the three extraction wells realizes minimal recovery. Geology fill/alluvial soils are overlying sandstone/shale bedrock; the 'water table aquifer' is hydraulically connected to unconsolidated alluvial sediments atop fractured sandstone bedrock; a vertical component slopes downward near the source, and upwards downgradient at abutting creek. The contaminant of concern (COC), trichloroethylene (TCE), is found in fractured bedrock above State of Ohio-EPA standards. Daughter cVOCs dichloroethylene (DCE) and vinyl chloride (VC) are also present. Baseline totals equal: [cVOC_{total}] >50,000 µg/L to >1,000,000 µg/L; parent:parent daughter (P:PD) molar ratios 78%-97%.

Approach/Action. On-site evaluation was performed March 2013-May 2014, followed by an expanded treatability evaluation in September 2015 to identify a sustainable alternative to PT strategy/costs. ERD**enhanced**[™], a patented biostimulant, enhances native dehalorespiring bacteria and sustainable reducing conditions while facilitating complete cVOC biotransformation, was evaluated. Groundwater data were collected from March 2013 through October 2016. Bio-Trap microbial CENSUS data were collected in February 2014. Additive filled Passive-Release-Sock (PRS) deployment units were used to amend ≈3 ft area of influence (AOI) in saturated bedrock. Three wells amended with PRS units were replaced every 8-10 weeks (5-8 replacements, location dependent); one remained non-amended as the control well. Groundwater was monitored/sampled during each PRS replacement event and quarterly thereafter, through October 2016. No amendment was deployed post September 2014.

PRS evaluation prompted an expanded 2015 treatability evaluation; two 35 ft x 35 ft treatment zones (TZ) were amended, each with 10 ft vertical fractured bedrock component. Evaluations were conducted downgradient from the PRS amended areas. Dissolved phase/residual source mass cVOCs were present. EW-3, downgradient injection wells IW-1A/MW-40A, were shut down and monitored during the evaluation. ERD**enhanced**[™] slurry (1,089 lbs/1,000 gal water) was passively deployed in each of two injection wells. Groundwater geochemistry was monitored at one upgradient location (MW-39A), both injection wells, and downgradient at EW-3 and six other downgradient wells monthly; analytical testing was performed quarterly, to present.

Results/Lessons Learned. After 14-months of PRS evaluation, [cVOC_{total}] and P:PD ratios decreased >95% at each amended location. No additive enhanced changes were observed at the control well. During pilot testing, DHC populations and densities of key microbial biomarkers (tceA, BAV1, VCR) increased at each amended location, no such increases were observed at the control well. Geochemical metrics at amended locations, not control well, provide secondary evidence supportive of additive enhanced reductive dechlorination. By T=17 months [cVOC_{total}] realized > 98% reductions at each amended location.

Through October 2016, upgradient [cVOCtotal] remained asymptotic, while [TOC/Cl-]/ORP values unchanged. September 2017, ≈40 ft lateral (MW-27A) to the injection locations, [TCE] decreased >98.4%↓ and [cVOCtotal] 95.6%↓. Downgradient location EW-3 realized >99.9%↓ and 98.6%↓ reductions [TCE], [cVOCtotal], respectively. Downgradient ≈50-60ft (MW-42A, MW-43A and MW-44A) recorded > 99.9%↓, 99.7%↓, and >99.5%↓ reductions [TCE]. [Ethene] consistently recorded throughout at all monitoring well/injection locations but upgradient MW-39A.

Treatability evaluation demonstrated results from PRS pilot transferable to full-scale. Treatability demonstrated biostimulation was a success in fractured bedrock. QuantArray-Chlor analysis performed at PRS locations >3 years post last PRS replacement event (June 2017) recorded no DHCs/biomarkers at the control well, while densities two to three orders of magnitude greater were recorded at the amended location MW-38A.