Bioremediation and Sustainable Environmental Technologies—2017. Fourth International Symposium on Bioremediation and Sustainable Environmental Technologies (Miami, FL; May 2017). ©2017 Battelle Memorial Institute, Columbus, OH, www.battelle.org/biosymp. A. Barton and S. Rosansky (Chairs)

Successful On-Site Treatability Study Evaluating Feasibility of Biostimulation to Enhance Microbial Degradation of 1,3,5-Trimethylbenzene under Anaerobic Conditions Principal

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Background/Objectives. Background: Bulk fuel supply facility with underground storage tanks (USTs) containing petroleum hydrocarbon (PHC) products since 1960s. Site characterization documented soils above water table within allowable State of Colorado risk-based screening levels (RBSLs); however, concentrations of 1,3,5-Trimethylbenzene ([1,3,5-TMB]) were detected in groundwater above the allowable [70.0 µg/L]. In February 2014 the plume extended from source area MW5 ≈270-ft downgradient (NNE) towards and inclusive of off-site monitoring location MW7. Laterally plume extends ≈60ft; with impact estimated ≈15-ft vertically. Soils described red-brown med-coarse sand with fine-med gravel, loose, damp from 0-30ft below ground surface (bgs). Wet soils, staining and odor observed from ≈20-30ft bgs.

Approach/Activities. Approach: Sept. 28, 2015 additive deployed using GeoProbe DT7822 direct push 'Vista Clean Inject' system/injection tooling. Target amendment depth 18ft to 28ft bgs, at 2ft intervals to vertically distribute TPHenhanced™. Three injection nodes advanced ≈15ft from performance well MW5, one upgradient and two crossgradient; 160 pounds biostimulant with 230-gallons water injected per node (3.82% slurry). Baseline sampling performed June 2015, four additional rounds of performance groundwater monitoring/sampling conducted September 2015 to June 2016. Background: June 2015 [1,3,5-TMB] in plume groundwater ranged from 474 micrograms per Liter (µg/L) at MW5 to 168 µg/L at MW-4 (proximate center) and 195 µg/L MW7; geochemical conditions characterized by dissolved oxygen (DO) levels 0.72 mg/L to 1.98 mg/L, neutral pH, and oxygen reduction potential (ORP) < 0.00 mV. Outside plume [1,3,5-TMB] ND with DO >3.6 mg/L to <7.4 mg/L and ORP readings >100 mV.

Results/Lessons Learned. Results: At end of 9-month evaluation period, source zone [1,3,5-TMB] decreased 83.5% from peak bioavailability, 89.9% at MW4 and 99.5% at off-site location MW7. Specifically, post-injection, [1,3,5-TMB] initially increased 273% (MW5) and 104% (MW4) due to additive enhanced residual source mass solubilization. From peak-bioavailability observed in January 2016 (MW4)/April 2016 (MW5), dissolve-phase [1,3,5-TMB] decreased 76.9% and 83.5%, respectively. No solubilization was observed at MW7; rather, steady reduction in dissolve-phase [1,3,5-TMB] was; such that, by evaluation end both MW5 and MW7 were compliant with State standards. Geochemically, increases in native alternative electron acceptors iron (Fe), manganese (Mn), and sulfate (SO4) were observed during peak periods of additive enhanced contaminant destruction; typically, September 2015 through April 2015. Whereas, afterwards each were exhausted or reduced, indicating native microbial respiration. Concurrently, DO values decreased to ND, ORP values remained <100mV, and additive provided Nitrate (NO4) was also exhausted. Additionally, TOC levels increased during periods of solubilization and decreased during contaminant consumption while pH remained neutral, at 7.2-7.7 s.u. Conclusions: Analytical and geochemical metrics generated during the evaluation period confirmed amending treatment zone(s) 1,3,5-TMB contaminated groundwater/soils with the additive TPHenhanced™, native microbial populations effectively and sustainably destroyed [1,3,5-TMB] under anaerobic conditions; proving, biostimulation a safe, sustainable, cost-effective solution to in-situ saturated soil/groundwater contaminant concerns.