

## Combined In Situ Treatment Methods and Technologies Reduce Mass at Large DNAPL Solvent Site

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**Background/Objectives.** This active U.S. site had been substantially contaminated since the 1950s. Compromised drainage pipes were assumed to be the source of chlorinated solvent contamination in both the saturated and unsaturated zones outside of the onsite structure. Contamination has been identified from depths of 8 feet (ft) below ground surface (bgs) to 46 ft bgs with an approximate depth to groundwater of 15 ft bgs. TCE concentrations have been detected in groundwater at a maximum concentration of 730 mg/L and in soils at 5,350 mg/kg. The subsurface is characterized by inter-bedded layers of Quaternary-aged Alluvium consisting of sand, silt, and clay. Bedrock beneath the site is interpreted to be the Middle Ordovician-aged Tyrone Limestone.

The objective of the source area remediation events was to sufficiently reduce the mass flux from the source area migrating toward the downgradient permeable reactive barrier (PRB). The objective of the PRB was to limit the mass flux such that the groundwater quality objectives could be met at the downgradient property boundary.

**Approach/Activities.** Initially, a remedial design characterization (RDC) that consisted of surface geophysics, collection of 186 soil samples from 26 boring locations, and 31 groundwater samples was performed. The intelligence gathered was used to design a PRB to reduce the off-site contaminant migration of contamination, an unsaturated soil mixing program that treated source level TCE impacted soil, and an injection program to treat DNAPL level impacts in the saturated zone immediately outside of the onsite structure. The selected remedies included a BOS 100® (granular activated carbon impregnated with reactive iron) PRB, RemOx® L (sodium permanganate) soil blending of the saturated and unsaturated zones, and CAT 100 (a biologically enhanced version of BOS 100) treatment of an exterior hot spot that could not be treated via soil mixing. The soil mixing treatment was optimized by utilizing real time sampling of contaminated soil.

The PRB injection of BOS 100 took place in 2014, followed by soil mixing of RemOx L in the unsaturated source area. In 2019 it was clear that upgradient contaminant mass was present in the saturated zone at concentrations requiring additional treatment. CAT 100 was the selected remedy and those injections took place in the Spring of 2020.

**Results/Lesson Learned.** Significant reductions in unsaturated and saturated soils and in groundwater have been observed to date. Downgradient of the PRB, groundwater TCE concentrations were reduced on average 98%. In the soil mixing area, post-remediation soil concentration reductions were confirmed by advancing four soil borings and collecting 20 soil samples. TCE concentrations in soil were reduced 95-99%. After a monitoring well was replaced within the soil mixing area and sampled, a 99% reduction in TCE was observed. Within the treatment area where the CAT 100 technology was applied, a total chlorinated volatile organic compound concentration reduction of 97% has been achieved to date.