Passive Sustained-Release ISCO Technology Achieves Remedial Site Closure

Pamela J. Dugan, Ph.D., P.G. (pamela.dugan@caruscorporation.com) (Carus Corporation, Peru, IL, USA)
Grant Walsom (XCG Consulting Limited, Ontario, ON, Canada)

Background/Objectives. XCG Consulting Limited was retained by the owners of a commercial real estate property to remediate impacts in soil and groundwater related to the property's former use as a dry-cleaning facility. The client initially chose active remediation to meet provincial Generic Site Condition Standards. Historic dry-cleaning operations resulted in subsurface releases of chlorinated solvents, including perchloroethylene (PCE), and its breakdown products, trichloroethylene (TCE), cis- and trans-1,2-dichloroethylene (cis1,2-DCE, trans-1,2-DCE), and vinyl chloride (VC). The bulk of the impacted area was beneath the footprint of the slab-on-grade building, as well as outside the footprint under and adjacent to the foundation footings. The initial contaminant concentrations in groundwater were in the order of five to 10 times higher than the standards for the given land use. Remediation of this property presented several significant challenges, including:

- High concentrations of contaminant species having relatively low remedial target concentrations;
- Continued commercial use of the building space overlying the impacted area during remedial activities, which precluded source removal through large-scale excavation of impacted soil;
- Subsurface utilities in close proximity to the impacted areas;
- Shallow water table approximately one meter below the floor slab of the commercial space, with a stagnated or mounded groundwater flow pattern resulting from a combination of low hydraulic conductivity in the saturated soil, groundwater flow interference from foundation wall footings, and suspected poorly functioning roof drain and foundations drainage systems;
- Fine-grained soil conditions, resulting in low hydraulic conductivity, a tendency for contaminants to be retained in the soil matrix, and limited remedial access to contaminated zones due to preferential groundwater flow patterns

Approach/Activities. Initial remedial activities included a program of in situ chemical oxidation (ISCO) through the advancement of temporary subsurface injection points at interior locations through the concrete floor slab of the building, and at exterior locations through the asphalt surface. Solutions of oxidizing compounds (sodium persulfate and potassium permanganate) were injected at low pressure through the temporary injection points. The depth and location of these were designed by assessing contaminant distribution across the impacted areas and within the various soil types. These remedial activities were generally successful, with contaminant concentrations in groundwater reduced by approximately 50% to 100%. However, residual groundwater impacts persisted, due back diffusion from fine-grained soil conditions. This resulted in contaminant concentrations exceeding the remediation target of 17 ppb. To address the lingering contamination a passive remedial treatment option was chosen in the form of the sustained-release (SR) plus ISCO technology. The SR+ technology consists of a wax matrix that has oxidants evenly dispersed within in the form of a cylinder. The SR plus cylinders are 1.5 feet long and 2.5 inches in diameter and can quickly and easily be deployed using traditional direct push technology. The SR+ cylinders facilitated the slow release of oxidizing compounds (potassium permanganate and sodium persulfate) to the shallow groundwater in the remaining impacted areas. The SR+ cylinders consist of dry crystals of the oxidizing compounds, encased in degradable paraffin wax. As groundwater flows past the cylinders the oxidizing compounds are slowly and passively released into the groundwater to react quickly with organic compounds such as chlorinated solvents and 1,4 dioxane. SR+ cylinder deployment was achieved through the advancement of boreholes through the concrete floor slab of the occupied building space, using small-scale, portable drilling equipment.

Results/Lessons Learned. Remedial progress of the slow-release ISCO technology was monitored through periodic collection of water samples and analyses of chlorinated solvents within and near the remaining impacted areas. In addition, water quality parameters were also analyzed such as pH, electrical conductivity, and ORP at monitoring wells to monitor ongoing site remedial progress. Measurement of field parameters taken before and after the ISCO treatments indicates the conditions in the areas of the remaining groundwater became much more favorable for the oxidation of chlorinated solvents with ORP measurements of 300-400 mV. Immediate and continuing increases in the electrical conductivity and oxidation-reduction potential in the groundwater of the treated areas have been observed, indicating the continued release of oxidizing compounds from the dissolving reagent cylinders. Since the application of SR+ technology in 2015, groundwater sampling results in 2017 have shown a sustained decrease in the total mass of chlorinated solvents at the monitoring well locations with the remedial target concentration of 17 µg/L reached and subsequent site closure. Lessons learned include that a low-cost passive treatment option can be used to complement active remediation activities and assist with addressing the effects of "rebound" and back diffusion of chlorinated solvents from low permeability media.