MULTI-STAGE REMEDIATION REMOVES CHLORINATED SOLVENTS FROM FORMER DRY CLEANING FACILITY

By **Grant Walsom** and **Michael Schriver**

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 chose active remediation to meet provincial Generic Site Condition Standards.

Historical dry cleaning operations resulted in sub-surface releases of chlorinated solvents, including perchloroethylene (PCE), and its breakdown products, trichloroethylene (TCE), cis&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. (See Table 1)

Direct injection of solutions of ISCO reagents to the subsurface using drilling equipment and low pressure pumping system.

Chlorinated solvents are extremely persistent in the natural environment, making remediation costly and often time-consuming. 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;
- Potential air quality issues in the active building space as a result of the contaminants in the subsurface;
- Shallow water table approximately one metre 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.

TABLE 1: Pre-remediation contaminant concentrations in groundwater.

	PCE	TCE	Cis-1,2-DCE	Trans-1,2-DCE	VC
Highest Concentration (µg/L)	260	57	220	40	1.2

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SOURCE REMOVAL

As stated previously, large-scale excavation of impacted soil for contaminant source removal was precluded by the continued occupancy of the building space, and the proximity of underground utilities and the foundation footings of the building.

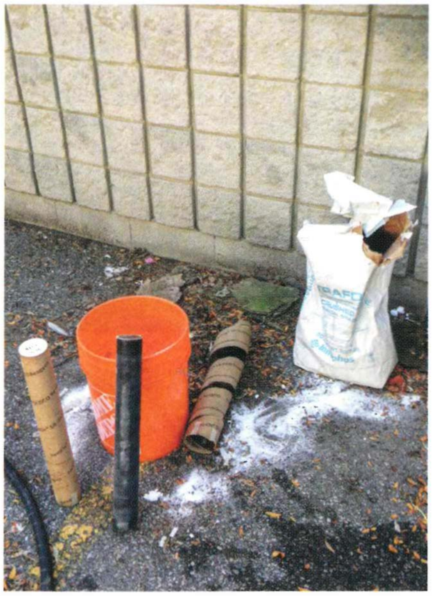
As an alternative means of source removal, XCG designed and oversaw the construction of a buried groundwater collection trench. This consisted of a horizontal perforated pipe, approximately eight metres long, set in a bed of crushed stone at approximately three metres below ground surface. A section of vertical riser pipe was connected to the horizontal pipe to allow for periodic extraction of impacted groundwater from the collection trench, using a vacuum truck and wastewater disposal service.

Dewatering the groundwater collection trench resulted in a drawdown of the water table. This increased the groundwater flow gradient to draw the stagnated (mounded) groundwater from impacted areas beneath the building space to the exterior areas (i.e., the collection trench). There, the contaminants were accessible for removal through dewatering.

The slow groundwater recharge rate and the dimensions of the groundwater collection trench resulted in the groundwater being drawn down for several weeks following each extraction event, creating an effective groundwater flow gradient from the impacted areas. Groundwater flow maps were prepared from water level measurements collected from the on-site network of monitoring wells.

IN SITU CHEMICAL OXIDATION THROUGH DIRECT INJECTION

Following the initiation of groundwater extraction events, XCG implemented 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 persulphate 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.



View of the RemOx®SR Plus ISCO reagent cylinders.

As part of the remedial activities, indoor air quality monitoring was conducted

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to assess if chlorinated solvent vapours, namely vinyl chloride, were migrating up through the floor and into occupied building space. The air quality samples were collected over a 24-hour period using flow-calibrated vacuum canisters. Analytical results reported no detection of vinyl chloride in the air samples collected from the occupied building space.

SMALL-SCALE REMEDIAL EXCAVATION

At exterior locations immediately adjacent to the building's foundation footings, direct injection was not successful in fully remediating groundwater impacts detected in the monitoring wells. Groundwater exceedances persisted following remedial injections of the ISCO compounds. This lack of success was attributed to preferential drainage near the footings, causing the ISCO compounds to migrate away from the impacted areas, and the continued release of chlorinated solvent compounds from the footings area and granular backfill.

To address these residual exterior groundwater impacts, XCG implemented a small-scale remedial excavation, using a "mini" excavator similar to equipment used in landscaping projects. A narrow (0.6 m x 2.5 m) trench was excavated at the exterior foundation wall to a depth of 1.8 metres. Impacted saturated soil and three decommissioned monitoring wells that had residual groundwater exceedances were removed.

At the base of the trench, gravel bedding and dry form potassium permanganate crystals were placed to facilitate oxidation of residual chlorinated solvents present in the soil adjacent to and potentially underlying the foundation footings. Prefabricated monitoring wells were placed in the trench prior to backfilling to allow for water quality monitoring in the remediated area. Subsequent groundwater sampling of the wells installed in the exterior remediated area reported no detection of chlorinated solvents.

IN SITU CHEMICAL OXIDATION THROUGH SLOW-RELEASE ISCO TECHNOLOGY

These remedial activities were generally successful, with contaminant concentrations in groundwater being reduced by approximately 50% to 100%. However, residual groundwater impact persisted, due mainly to fine-grained soil conditions and unfavourable groundwater flow characteristics. This resulted in contaminant concentrations exceeding the remediation targets.

To address this, XCG implemented a program to apply slow-release ISCO technology to the remaining impacted areas. It consisted of the advancement of boreholes through the concrete floor slab of the occupied building space, using small-scale, portable drilling equipment.

Within the saturated zone of each borehole, RemOx®SR Plus ISCO reagent cylinders and dispersant were applied to facilitate the slow release of oxidizing compounds (potassium permanganate and sodium persulphate) to the shallow groundwater in the remaining impacted areas. The reagent cylinders consisted of dry crystals of the oxidizing compounds, encased in degradable paraffin wax. As groundwater dissolves the wax, the oxidizing compounds are released and disperse slowly into the groundwater.

MONITORING OF REMEDIAL PROGRESS

The progress of the slow-release ISCO technology is being monitored on an ongoing basis through periodic collection of water samples and in situ field parameters (pH, electrical conductivity, oxidation-reduction potential) at monitoring wells within and near the remaining impacted areas.

Measurement of field parameters taken before and after the ISCO treatments indicates the conditions in the areas of the remaining groundwater became much more favourable for the oxidation of chlorinated solvents. 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 slow-release ISCO technology, groundwater sampling results have shown a gradual but sustained decrease in total mass of chlorinated solvents at the monitoring well locations. Only one monitoring well location continues to exceed the remedial targets, and this is for one VOC parameter (TCE) by a small margin of 2 µg/L (versus a remedial target concentration of 17 µg/L). (See Table 2)

Full remediation of remaining groundwater impacts is anticipated within three to six months. Continued extraction of groundwater from the collection trench provides control of groundwater flow and promotes subsurface migration of groundwater flow around the reagent cylinders. This further dissolves the cylinders to provide "contact" with the contaminants and increase the rate of oxidation. ■

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TABLE 2: Near completion concentrations in groundwater.

	PCE	TCE	Cis-1,2-DCE	Trans-1,2-DCE	VC
Highest Concentration (µg/L)	3.1	19	17	5.9	Less than 0.20
Remediation Target (µg/L)	17	17	17	17	1.7