Monitoring of *In Situ* Chemical Oxidation (ISCO) Treatment with Time-Series Geophysical Surveys, Savage Municipal Water Supply Superfund Site, Milford, New Hampshire

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Philip T. Harte (ptharte@usgs.gov) (U.S. Geological Survey, NH/VT Water Science Center, Pembroke, New Hampshire, USA)
Robin Mongeon (robin.mongeon@des.nh.gov) (N.H. Department of Environmental Services, Concord, New Hampshire, USA)
Richard Goehlert (goehlert.dick@epa.gov) (U.S. Environmental Protection Agency, Region 1, Boston, Massachusetts, USA)
Bette Nowack (bette.nowack@westonsolutions.com) (Weston Solutions, Inc., 45 Constitution Avenue, Concord, NH, USA)
Thor E. Smith (tesmith@usgs.gov) (U.S. Geological Survey, NH/VT Water Science Center, Pembroke, New Hampshire, USA)
James R. Degnan (jrdegnan@usgs.gov) (U.S. Geological Survey, NH/VT Water Science Center, Pembroke, New Hampshire, USA)

Program session suggestions:
Characterization, Fate and Transport, Risk Assessment, and Environmental Forensics
1.1 Chlorinated solvents
1.8 DNAPLs and LNAPLs—*Advances in source and solvent plume characterization*
Site Management
2.3 Innovative site assessment and performance-monitoring tools
2.4 Remedy optimization and long-term monitoring strategies

In situ chemical oxidation (ISCO) treatment with an electrically conductive injectate, like sodium or potassium permanganate, provides a strong electrical signal for tracking of injectate transport using time-series geophysical surveys including direct current (DC) and electromagnetic (EM) methods. Geophysical surveys can enhance the monitoring coverage provided by conventional well sampling and they are non-invasive and can efficiently cover large areas.

The Savage Municipal Water Supply Superfund Site (Site) contains a large volatile organic compound (VOC) plume (0.5 mi^2 area as of 1994), predominantly tetrachloroethylene (PCE), within a permeable sand and gravel aquifer. The Site has been divided into two Operable Units: OU1, which is the OK Tool source contamination area, and OU2, which is the extended groundwater plume. The OU1 remedial systems consist of a slurry wall barrier that extends from ground surface into the basal till or to the bedrock surface (80 to 100 feet deep) to contain the VOC source material, a pump and treat system with extraction wells inside the barrier wall to maintain an inward gradient, and external extraction wells to capture contaminants outside the barrier. To facilitate the remediation inside the barrier wall, a series of ISCO treatments have been performed including two pilot test in 2003 and 2004. The difficulty in tracking the spread of permanganate with conventional well sampling methods alone during the 2003-04 test prompted modifications in the monitoring of subsequent ISCO test. The latest OU1 ISCO treatment occurred in 2008 (injection number three), and focused on deep injection (greater than 60 feet deep) of sodium permanganate.

Borehole electromagnetic (EM) induction logging and surface D.C. resistivity and electromagnetic surveys were performed following the most recent ISCO treatment in 2008. The surveys were done multiple times over a span of a year to help map the spread of sodium permanganate and its breakdown products in time-series mode to assist in evaluation of ISCO treatment effectiveness. Time-series EM logging shows that sodium permanganate injectate is initially transported within 3 to 5 foot thick layers and then spreads vertically downward, apparently due to density differences between the injectate and ground water. Because the EM log can measure beyond the solid polyvinyl chloride (PVC) wall of the well, it can detect the spread of the injectate outside the full vertical penetration of the solid well riser through the aquifer. Time-series surface D.C. resistivity surveys have identified several areas where decreases in resistivity at depths below 60 ft due to increases in electrical conductivity. Vertical profiling using new drilling and groundwater sampling methods is being done to substantiate the spread of injectate.

This poster presentation will provide evidence of time-series changes in subsurface electrical properties, description of injectate transport, and implications for ISCO treatment effectiveness.

Abstract information
http://www.battelle.org/Conferences/chlorinated/publications.aspx