Challenges of Interpreting Micro-Scale Variations in Groundwater Conditions during and following Thermal Treatment at a Mixed LNAPL Site

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Background/Objectives.
Variations in micro-scale groundwater concentrations of both contaminants and naturally occurring metals during and after thermal treatment present challenges in assessing remedy completeness and the optimal approach to achieve low level groundwater cleanup goals following thermal treatment. Full scale in-situ thermal remediation via steam enhanced extraction (SEE) was implemented to address aromatic and chlorinated volatile organic compounds (VOCs) in an approximate 1-acre area mixed light non-aqueous phase liquid (LNAPL) source zone. The treatment area is one of several source areas at a former waste oil facility Superfund site where a multi-component remediation program is ongoing. SEE was effective in removing over 25,000 gallons of LNAPL and meeting the stringent site-specific soil leachability cleanup goals (including naphthalene) in the first of two areas for SEE thermal treatment. Further, concentrations of dissolved phase chlorinated VOCs, which were the driver for off-property drinking water impacts, were reduced below drinking water standards. Naphthalene and arsenic are the only two remaining contaminants above groundwater cleanup goals.

Approach/Activities.
Groundwater temperature, geochemical, and analytical data continue to be evaluated two-years after completion of thermal treatment to assess the relationship between concentration (naphthalene and arsenic) and geochemistry as the groundwater cools. At the request of the regulatory agencies, groundwater extraction was performed across the treatment area for the first six months following thermal treatment; the monitoring has been performed under natural groundwater flow conditions thereafter. Groundwater has been collected from up to 31 of the SEE treatment multi-phase extraction wells (MPEs), with six rounds during thermal treatment and five rounds post treatment (to date). While evaluating current conditions and the effectiveness of the remedy is a key focus, this monitoring program has also been designed and implemented with a focus on 1) better understanding progress during thermal treatment to aid in determining when to cease thermal operations for the second treatment area and 2) helping develop an effective post-thermal program for the upcoming SEE treatment in the second area at the site.

Results/Lessons Learned.
Throughout and post thermal treatment, groundwater concentrations have demonstrated the traditional patterns (rise during heating, decline towards end of treatment, rebound post-treatment, and further decline over time); however, while the response of the overall treatment area was as anticipated, the spatial variation and shifting on a micro-scale level throughout the treatment area present challenges for assessing remedy progress and attainment of overall goals. The removal of LNAPL and treatment of soil during thermal have resulted in achievement of all ROD soil and groundwater cleanup goals for chlorinated VOCs and a decline in concentrations of naphthalene (remaining Record of Decision driven VOC). While individual locations remain above the state drinking water standard, the average and median concentration of naphthalene declined during the post thermal extraction period and continue to decline with natural flushing of the treatment area. This presentation will present the robust analytical and geochemical dataset pre, during, and post-thermal treatment (focus on naphthalene and arsenic), the challenges encountered, and the implications in implementation of the second phase of thermal treatment at the site.