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Six-Phase Heating™ for DNAPL at Large Industrial Site in SKOKIE

Client: Bell Labs/Lucent Technologies **Supervising Engineer: William Heath**

Location: Skokie, Illinois

Duration: 130 days

SITE

ENSR and Current Environmental Solutions (CES™) successfully applied Six-Phase Heating™ (SPH) to remediate soil containing dense non-aqueous phase liquid (DNAPL) at a former manufacturing facility near Skokie, Illinois. ENSR had been working at removing solvents from the subsurface of the site since 1991. These chemicals, used in various manufacturing processes, were released when underground storage tanks leaked between 1958 and 1988. After seven years, technologies including steam injection combined with various extraction technologies and bioremediation had already reduced the contaminant levels; however, DNAPL remained was as pools of TCE and 1,1,1-TCA at depths up to 21 ft. bg.

The lithology of the site consisted of a shallow groundwater table at 7 ft bg, heterogeneous sandy silts to 18 ft bg, and a dense clay till aquitard from 18 to 25 ft. bg. Hydraulic conductivity through the remediation zone ranged from10^{-4} to 10^{-8} cm/s. As DNAPL migrated downward, it was trapped in the silt-rich stringers or on top of the clay aquitard. Over time, pockets of elevated chloride ions were detected and attributed to the in-situ biological dechlorination of the solvents.

TECHNOLOGY

SPH has emerged as the leading in-situ treatment technology for soil and groundwater remediation, especially in more difficult site conditions involving heterogeneous and low-permeability soils. It has proven to be an efficient, effective and rapid means of remediating soil contaminated with VOCs and SVOCs. The technique uses conventional polyphase electricity to resistively heat the soil and groundwater to the boiling point of water. This increases the volatility of contaminants thereby improving the efficiency of SVE. The heat also initiates VOC degradation through various pathways. Once steam is generated in situ, it acts as a carrier gas which strips out contaminants from the soil or groundwater. The steam is collected from the subsurface by an SVE process, and the contaminants are treated aboveground by conventional means such as activated carbon or catalytic oxidization.

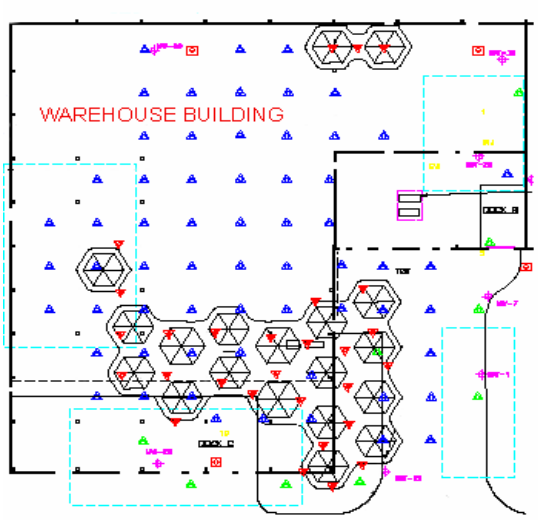
APPLICATION To ensure complete treatment of the DNAPL pools, 107 electrodes were placed across two-thirds of an acre, covering the site. Of these, 85 were located beneath the floor of an existing warehouse.

The electrodes were electrically conductive from 11 to 21 ft. bg., and were designed to heat a zone from 5 to 24 ft. bg. to the boiling point of groundwater.

Within 60 days, temperatures throughout the entire 23,100 yd^3 treatment volume had reached the boiling point. At this stage, steam laden with chlorinated solvents rose to the surface and was collected by a network of 37 SVE wells screened to 5 ft. bg.

Subsurface regions displaying higher electrical conductivity were preferentially heated, such as clay-rich soil lenses and pockets where the concentration of chloride ion was elevated. As a result, SPH specifically targeted those subsurface locations which held most of the DNAPL mass.

SPH Electrode Layout



RESULTS For 70 days, temperatures throughout the treatment volume were maintained at 100 ºC. All the separate phase DNAPL was removed from the area, and overall groundwater concentrations of TCE and TCA were reduced to below the site clean-up targets. The cleanup goal for the site was based on the State of Illinois RBCA Tier III standards, but in fact most of the area was cleaned to the more stringent Tier I standards.

Typical Groundwater Cleanup Results

Well	*Compound*	*March 1998 (mg/l)*	*November 1998 (mg/l)*	*Reduction (%)*
B-3	TCE	34,000	120	99.6
	TCA	82,000	31	99.9
Fa2	TCE	22,000	70	99.7
	TCA	24,000	24	99.9
C4	TCE	76,000	280	99.9
	TCA	11,000	15	99.9

SPH successfully remediated this site within 130 days. After four quarters of post-remediation monitoring, no rebound was detected. The Illinois Environmental Protection Agency issued a letter of "No Further Action" for the site on August 10, 1999. To our knowledge, this project represented the USA's first regulatory closure of a DNAPL site.