

COST AND PERFORMANCE REPORT

Electrical Resistive Heating at the
Avery Dennison Site
Waukegan, Illinois

June 2003

SITE INFORMATION

IDENTIFYING INFORMATION [1,2]

Site Name: Avery Dennison Site
Location: Waukegan-Gurnee Industrial Park, Illinois
Regulatory Context: Illinois EPA Site Remediation Program
Technology: Electrical Resistive Heating
Scale: Full Scale

TECHNOLOGY APPLICATION [1,2]

Period of Operation: December 1999 to November 2000

Type/Quantity of Material Treated during Application: Source zone - Estimated to be 16,000 yds³ based on an estimated soil density of 1.3 tons per yd³, corresponds to 21,000 tons treated.

BACKGROUND [1,2]

The Avery Dennison site is located in the Waukegan-Gurnee Industrial Park in Waukegan, Illinois. From 1975 through 1992 film coating operations were performed at the site. Methylene chloride (MeCl) used in these operations was unloaded in the northeast corner of the building, and transferred by underground piping to above-ground storage tanks in the northwest corner of the building. In May 1985, an inventory check indicated that approximately 1,585 gallons of MeCl had been released from an underground pipe. Site investigations indicated that the released MeCl was present in the soil and groundwater beneath the loading area, the bulk storage tank area, the underground transfer pipe, and a former stormwater drainage system. The site is described in terms of the western and eastern portions.

In 1985, cleanup activities began at the site, including the removal of the above-ground storage tanks, 260 yds³ of soil from beneath the tanks, and 175 feet (ft) of storm sewer and surrounding fill. In addition, 4,600 gallons of contaminated groundwater and 14,000 gallons of rainwater that collected in the excavation were removed. In 1988, a subsurface grout curtain was installed around the former bulk storage area.

In 1991, a soil vapor extraction system (seven vapor extraction wells) was installed. Over the next several years, several remediation technologies were used at the site and operated until 1994, at which time the operation of the system was discontinued. The vendor had determined that the relatively impermeable silty-clay soils at the site rendered the treatment ineffective. From 1992 through 1998, pump and treat of groundwater was performed with four of the extraction wells converted to air sparging wells in 1994. The air sparging and pump and treat wells were shut down in 1998. A risk-based analysis of groundwater contamination performed by the vendor indicated that additional remediation of groundwater was not required. The results of additional investigations indicated that DNAPL was present in soil at the site. ERH was used from December 1999 through November 2000 to address the DNAPL source in the unsaturated zone.

CONTACTS [1,2]

Technology System Vendor:

Chris Thomas
Current Environmental Solutions
Telephone: (847) 298-2764
Email: Chris@cesiweb.com

Site Contact:

Wayne Wirtanen
Avery Dennison
330 East Main Street
Milford, MA 01757
Telephone: (508) 422-3187

State Contact:

Jennifer Seul
Illinois Environmental Protection Agency Bureau of Land
Division of Remediation Management
Remedial Project Management Section
1021 North Grand Avenue East
Post Office Box 19276
Springfield, IL 62794-9276
Telephone: (217)785-9399
Email: Jennifer.Seul@epa.state.il.us

MATRIX DESCRIPTION

MATRIX IDENTIFICATION [1,2]

Type of Media Treated With Technology System: Source Zone (unsaturated)

Primary Contaminant Groups: Chlorinated Solvents (MeCl)

SITE HYDROGEOLOGY AND EXTENT OF THE CONTAMINATION [1,2]

The topography of the site is generally flat, with a slight manmade slope that drains toward stormwater collection drains. The geology underlying the site is predominantly heterogeneous silty-clay, glacial till to a depth of about 180 ft below ground surface (bgs). Discontinuous silty sand and sand lenses are present at some locations within the till. Bedrock (Niagaran dolomite) is encountered at depths ranging from 180 to 270 ft bgs. Depth to groundwater ranges from approximately 6 ft to 25 ft bgs.

Approximately 17,000 ft² of soil along the north side of the building on the site was contaminated with MeCl to depths as great as 24 ft bgs, with concentrations as high as 40,000 mg/kg. MeCl concentrations in the soil in this area averaged 1,900 mg/kg.

Table 1 lists the matrix characteristics affecting the technology cost and performance for this application.

Table 1. Matrix Characteristics Affecting Technology Cost or Performance [1,2]

Parameter	Value
Soil Classification	Glacial till consisting of silty clay
Clay Content and/or Particle Size Distribution	Silty clay
Depth to Groundwater	Between 6 and 25 ft bgs
Hydraulic conductivity	Not available
Air permeability	Not available
Porosity	Not available
Presence of DNAPLs	Suggested presence of DNAPL
Moisture content	Not available
Total organic carbon	Not available
Electrical resistivity of soil	Not available

TECHNOLOGY SYSTEM DESCRIPTION

TREATMENT TECHNOLOGY [2]

Electrical resistive heating

TREATMENT TECHNOLOGY DESCRIPTION [1,2]

ERH was used to treat MeCl-contaminated soil at the site from December 1999 to November 2000. The treatment area was divided into 20 treatment cells. For each treatment cell, electrodes were installed around the perimeter to a depth of 24 ft. A total of 95 copper electrodes were installed including 6 installed below an active street, and 16 installed inside the existing building. Two thermocouples were installed in the center of each treatment cell, at the shallowest and deepest levels of contamination, 4 and 24 ft bgs. In addition, 34 recovery wells were installed at 20 locations to extract soil vapor and steam. The designed power input was 610 kW. The treatment system was expected to raise soil temperatures at a rate of at least 1°C per day until a temperature above 75°C was achieved.

Operation of the western portion of the treatment zone began in December, 1999. The subsurface temperature in this area was 13°C prior to treatment. After four weeks of operation, the expected targets had not been met. The average soil temperature was 34°C, the average heating rate was 0.4°C per day, and input to the subsurface was about 320 kW. The vendor determined that the copper electrodes had oxidized, which reduced conductivity, and that many of the down hole connections between the power cables and the electrodes were damaged, though the reason for the damage was not identified. In January 2000, 1-inch galvanized steel pipes were installed around each electrode, and the power cables were attached to the pipes above ground. Typically, five pipes were installed around each of the copper electrodes to add conductive surface area and improve power output. When the system was restarted, the heating rate was 1°C per day and the power input to the subsurface was 410 kW.

Operation of the eastern portion of the treatment zone began in June, 2000. Galvanized steel pipe electrodes were installed. Most of the treatment system was shut down in October, 2000. While operational data were not provided for this portion of the treatment zone, the vendor indicated that the heating rate and power input were similar to that achieved in the western portion using galvanized steel

pipe electrodes (heating rate of 1°C per date and power input of 410 kW). However, soil samples in four treatment cells indicated that concentrations of MeCl remained above the treatment goals. Additional galvanized steel pipe electrodes were added to these cells, and the treatment system was operated in the four cells for another month, and was shut down in November, 2000. The maximum temperature achieved ranged from 65°C to 100°C. The average delivery of power to the subsurface was 320 kW, less than the expected delivery of 610kW.

TIMELINE [1,2]

- 1985 Removal Action
- 1988 Installation of grout curtain around the former bulk storage area.
- 1991-1994 Seven point soil vapor extraction at former bulk storage area. This was ineffective and discontinued at the end of 1994.
- 1992-1994 Pump and treating of groundwater
- 1994-1998 Air sparging of groundwater
- December 1999 ERH initiated in western portion
- June 2000 ERH initiated in eastern portion
- November 2000 ERH completed

TECHNOLOGY SYSTEM PERFORMANCE

PERFORMANCE OBJECTIVES [1,2]

The remediation objective was to reduce the concentration of MeCl in the soil to below 24 mg/kg, based on Illinois EPA's Tiered Approach to Corrective Action Objectives (TACO).

TREATMENT PERFORMANCE [1,2]

A total of 125 soil samples were collected and analyzed for MeCl. Average MeCl concentrations in soil were reduced to 2.51 mg/kg, below the cleanup goal. Based on the results of the confirmatory samples, the Illinois EPA issued a No Further Remediation (NFR) letter for this property.

The soil vapor extraction system removed VOCs at a rate of approximately 3 pounds per day. According to the vendor, the amount of MeCl in the extracted vapor was less than expected. Additional sampling and analysis was conducted to determine whether MeCl was being removed by degradation processes, including biodegradation, hydrous/pyrolysis oxidation (HPO), and hydrolysis. In May 2000, one background soil sample and four soil samples in the treatment area were collected. As shown in Table 2, biological activity in the background and 30°C samples were moderate. While no microbial activity was identified in the samples at 70°C and 100°C, the vendor concluded that biological degradation was not contributing significantly to MeCl removal. The concentration of soluble chloride in each of the soil samples in the treatment area were above background levels. According to the vendor, the elevated soluble chloride levels indicated that thermally enhanced degradation was occurring. Additional sampling of extracted vapor and analysis for carbon dioxide and methane were conducted to determine whether the degradation mechanism was HPO or hydrolysis. According to the vendor, methane in the extracted vapor was negligible, while carbon dioxide was at 4 times the background level. Based on these results, the ERH vendor concluded that HPO was a significant contributor to the degradation of MeCl, while hydrolysis was not. No further information on the degradation mechanism was provided.

Table 2. Results of Sampling and Analysis to Identify MeCl Degradation Mechanisms [1]

Sample Location	Temperature (°C)	Microbiological Activity	Soluble Chloride (mg/L)
Background	10	moderate	<50
Thermocouple 17	30	moderate	240
Thermocouple 6	70	none	340
Thermocouple 2	100	none	445
Electrode 2	100	none	230

COST OF THE TECHNOLOGY SYSTEM

No cost information was provided for this application.

OBSERVATIONS AND LESSONS LEARNED

OBSERVATIONS AND LESSONS LEARNED [1,2]

ERH reduced MeCl concentrations in 16,000 yds³ of soil to below the remediation objective in about a year. MeCl soil concentrations were reduced from as high as 40,000 mg/kg with an average concentration of 1,400 mg/kg to an average concentration of 2.51 mg/kg.

According to the vendor, ERH was selected to remediate soil at the site because of a variety of factors, including the location of existing structures and the low permeability of the soil. The presence of the Avery Dennison building and a neighboring building just to the north made excavations to the depths required to meet remediation objectives (approximately 24 ft) impractical. A previous application of SVE to the site from 1991 to 1994 was unsuccessful due to the low permeability of the soil.

The treatment system's ability to transfer power to the subsurface soils was hindered by equipment failures, including power cable failures and corrosion of copper electrodes. The use of additional galvanized steel pipe electrodes with above-ground power cable connections improved power input, but the system did not achieve the expected power input levels. As a result, the planned operating temperature of greater than 75°C was not achieved in all treatment areas, and the treatment time was extended from the originally anticipated 25 weeks to 47 weeks.

Analyses of soil samples for microbial activity and soluble chloride levels, and analyses of extracted vapor samples for methane and carbon dioxide were performed by the vendor to identify whether degradation of MeCl was contributing to the remediation. The vendor concluded from the results of these analyses that in addition to extraction through the vapor recovery system, MeCl was removed by degradation, primarily via HPO.

REFERENCES

1. Nienkerk, Monte M., et al. 2001. "Cleanup of Methylene Chloride Spill." Vendor report. August, 2001.
2. Jeff L. Pope, and Monte M. Nienkerk, CPG. 2002. "In Situ Remediation of Methylene Chloride in Low Permeability Soils Using Electrical Resistive Heating." Undated.
http://www.claytongrp.com/insiturement_art.html