



Chlorinated Solvents: Methylene Chloride and TCE

Longbeach, California

Introduction

This paper presents the results of a scaled and phased approach to source remediation of high concentrations of recalcitrant chlorinated solvent compounds via soil vapor extraction (SVE) and vapor treatment at a Site in Southern California.

Phase I began with refrigerated condensation (C3) in order to achieve high mass removal rates to reduce lifecycle costs and time of remediation. The first two years (Phase I) resulted in recovery of over 92,000 pounds of mixed chlorinated solvents in the form of NAPL. The VOC constituents consisted primarily of MeCl, TCE, acetone, and isopropanol.

Phase II will involve the installation of additional SVE wells in the source area and surrounding low-concentration VOC areas, and implementation of a dual-phase extraction system to treat source area groundwater. The vapors from both the vacuum extraction as well as the groundwater air stripping system from the source will be treated using a thermal oxidation system. The vapors from the SVE wells in the surrounding low-concentration VOC areas will be treated using GAC. A thermal oxidation system was selected in Phase II instead of a GAC system due to the presence of MeCl in the source area, which is not effectively absorbed by GAC. Phase II was used to manage long term venting.

Phase III will involve using a GAC system to manage diffusion limited asymptotic removal rates.

This case study review demonstrates the benefits of a phased approach, scalability in sizing systems, provides insight into off-gas treatment selection criteria for high concentration VOC or NAPL sites, and presents some available metrics and approaches for consideration of sustainability.

Project Description

Industrial operations were conducted on this property since early 1940's and included operations of manufacturing, testing and repair. Environmental activities included chemical storage and mixing and fuel storage and testing in support of manufacturing operations. Operations were discontinued in 2002 and demolition activities began in 2005. Numerous environmental site assessments and remediation have been conducted at the subject remediation site since mid 1980s. Remedial activities within the project treatment area pertaining to this study included solvent and jet fuel underground storage tank removal, jet fuel and solvent impacted soil excavation and free product removal.

Site Geology

The geology and hydrogeology of the site can be summarized as intercalated sands and silty sands separated by competent silt and clay horizons. The geological formations present beneath the site are illustrated in Figure 1 Conceptual Site Model. Groundwater is present at the site at approximately 35 feet below ground surface (ft bgs). MeCL and TCE impacts to soil and groundwater beneath the site through the heterogeneous geology and Bellflower Aquitard.

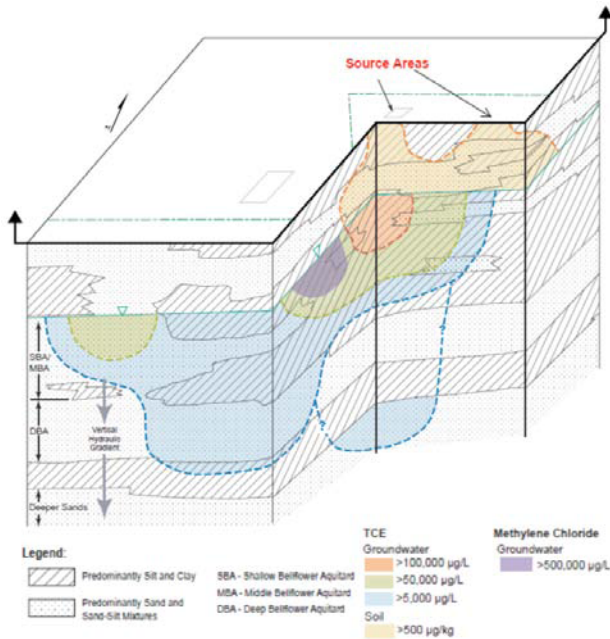


Figure 1. Conceptual Site Model illustrating the geology and contaminant distribution

Contaminants of Concern

Chlorinated solvent impacts included (but were not limited to) MeCl, TCE, tetrachloroethene, acetone, isopropanol, vinyl chloride, cis-1,2-dichloroethene, 1,1,1- and 1,1,2-trichloroethane, trimethylbenzene, dichlorobenzene. Petroleum hydrocarbon impacts included benzene, toluene, ethylbenzene, and xylenes.

Target Contaminant Ranges:

- MeCl: 3.3 to 33,000 ppm (v/v)
- TCE: 5.8 to 21,000 ppm (v/v)
- Acetone: 12 to 6,400 ppm (volume/volume)
- Isopropanol: 12 to 6,000 ppm (v/v)

Vapor Treatment System Design

The vapor extraction was initially accomplished using existing SVE wells installed at approximately 50-foot intervals and located within the estimated confines of source area. Each well was dual-nested, with a shallow screened interval from approximately 10- to 20-feet bgs and a second interval from approximately 25- to 35-feet bgs. The extraction system was subsequently expanded after 9 months of operation to add seven new dual-nested SVE wells and to expand the capabilities of the system.

The vapor treatment system consisted of the following:

- Two SVE treatment units, each consisting of two skid-mounted extraction/compression units (including two positive displacement blowers and piston-type air compressors. Each SVE treatment unit was capable of producing a maximum airflow rate of 200 scfm for a combined treatment capacity of 400 scfm.
- Two refrigeration condensation (C3) mobile units, with regenerated adsorbers,
- A 2,000-gallon double-walled aboveground storage tank for storing accumulated VOC condensate,
- Two 2,000-pound Granular Activated Carbon (GAC) adsorption vessels operated in a lead-lag (series) configuration to scrub the remaining VOCs in the effluent from the C3 systems in order to meet the air quality permit requirements
- One 2,000-pound permanganate-impregnated zeolite media vessel to remove traces of vinyl chloride, if present, in the effluent from the C3 systems.
- Twenty-four vapor extraction wells with separate shallow and deep screen intervals, control valves, and sample ports, and
- Piping manifold.



System Performance Evaluation and Results

Phase I performance of the G.E.O. system resulted in the removal efficiency for VOCs, including TCE and MeCl, at near 100 percent. The G.E.O. system removed approximately 92,000 pounds of VOCs (including 21,000 pounds of TCE and 56,000 pounds of MeCl). These quantities were calculated by averaging the influent vapor concentrations collected during monthly sampling events and assuming that these average concentrations remain constant between the two sampling events. Figure 2 below reveals influent total VOC vapor concentrations collected from the system. The calculation for VOC mass removed is equivalent to approximately 1,800 gallons of TCE and 5,100 gallons of MeCl. Removal efficiency and VOC mass removal by the SVE system was calculated for total VOCs, TCE, and MeCl, using laboratory analytical data and estimated system flow rate measurements.

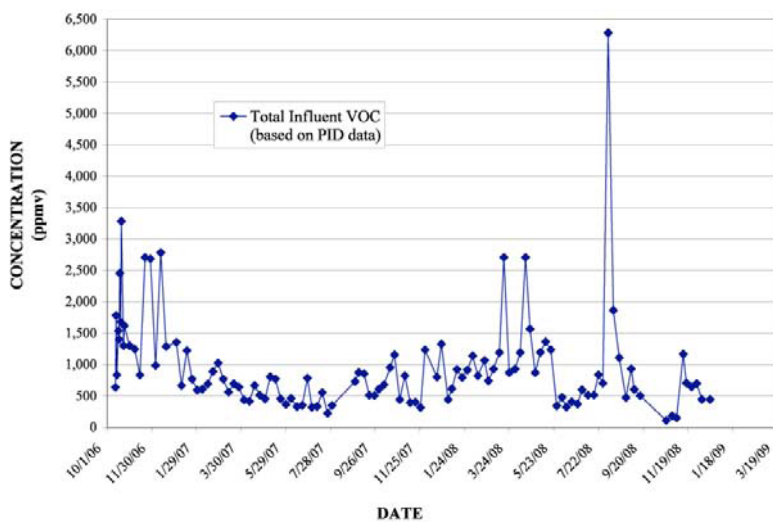


Figure 2. Influent vapor concentrations

The system ran for 16,881 hours (approximately 700 days). The SVE system was shut off on December 19, 2008, due to low influent VOC concentrations in preparation of Phase II.

Figure 3 below illustrates the total mass removed over time based on laboratory data. The total condensate removed, condensed water and VOCs extracted from soil vapors and transferred to the AST by the C3 G.E.O. units since start up was 16,763 gallons. The actual volume of removed condensate differs from the calculated VOC mass removal volume (6,900 gallons) primarily due to water that is also condensed by the C3 G.E.O. units adding to the total actual volume recovered in the condensate.

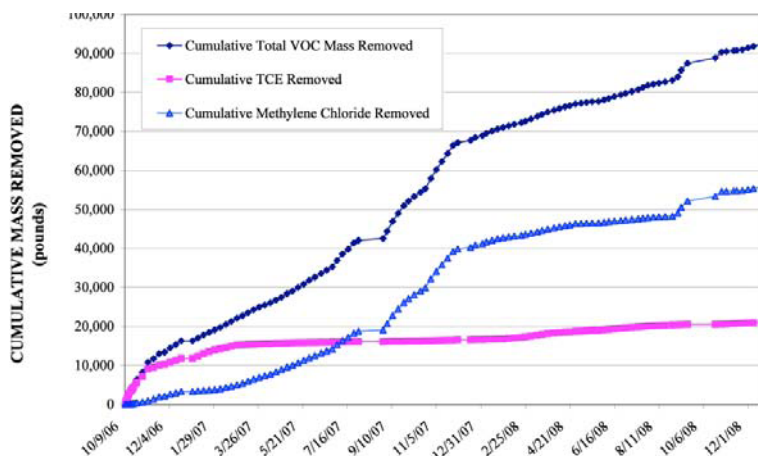


Figure 3. Cumulative mass removed for total VOCs, TCE, and MeCl based on laboratory analytical data



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Summary

During Phase I, G.E.O.'s refrigerated condensation units demonstrated an operational uptime of 93.5% over a 27-month period, and operated in full compliance with stringent SCAQMD air quality operating permit conditions. The treatment efficiency of the refrigerated condensation units was nearly 100 percent, with minimal carbon usage. The units ran for approximately 16,881 hours and removed approximately 92,000 pounds of VOCs. G.E.O.'s refrigerated condensation units produced approximately 16,763 gallons of condensed liquid, which was transferred into the AST and disposed off-site. The maximum TCE concentrations recorded at the site reduced from 21,000 ppmv to 290 ppmv and the maximum MeCl concentrations reduced from 33,000 ppmv to 340 ppmv.

The system was manually shut down after two years of operation as the goals of Phase I (i.e. mass removal) were achieved, and because the influent VOC concentrations reached levels that were below the cost effective breakeven point for C3 technology at this Site.

Based on the *total project costs* (including design, engineering, permitting, project management, equipment leases, construction, decommissioning, and O&M), the cost per pound of VOCs removed was approximately \$18/lb. Based on *actual operational costs* (i.e. equipment leases, analytical costs, engineering and O&M), **the cost per pound of VOCs removed was approximately \$12/lb.**

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