

# **COST AND PERFORMANCE REPORT**

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Pump and Treat and Soil Vapor Extraction  
at the Commencement Bay  
South Tacoma Channel Superfund Site,  
Tacoma, Washington

December 2001

## SITE INFORMATION

### IDENTIFYING INFORMATION

**Site Name:** Commencement Bay South Tacoma Channel Superfund Site

**Location:** Tacoma, Washington<sup>1</sup>

**CERCLIS #:** WAD980726301

**ROD Date:** May 3, 1985

### TREATMENT APPLICATION [8,9,12]

**Type of Action:** Remedial

**Period of Operation:** November 1988 - Ongoing (data available through June 2000)

**Quantity of Groundwater Treated:** 450 million gallons (through May 2000)

### BACKGROUND [4,5,8,9]

**Historical Activity that Generated Contamination at the Site:** Oil recycling, paint/lacquer thinner manufacturing, oil canning

#### **Facility Operations:**

- The site operated as an oil recycling facility from the 1920s to 1976. In addition, paint/lacquer thinner manufacturing was performed at the site from the 1920s to 1964. From 1976 to 1995, facility operations were limited to canning new oil brought to the site in bulk containers.
- The site was purchased by Time Oil Company in 1964. The portion of the facility at which oil recycling operations occurred was leased to Golden Penn, Inc. between 1972 and 1976. The facility has been used as a warehouse for heating, ventilation, and air conditioning equipment since 1995.
- In 1981, chlorinated solvents were detected in Well 12A, a municipal water supply well owned and operated by the City of Tacoma Water Department. Further investigations identified the Time Oil property (Figure 1) as the source of the Well 12A contamination. A five tower air stripper was installed as an interim remedy to treat the effluent from Well 12A. The well was subsequently taken out of service as a source of municipal water. However, the well is pumped periodically during periods of peak water demand.
- Both soil and groundwater at the Time Oil site were determined to be contaminated with volatile organic compounds (VOCs). Soil contamination included shallow and subsurface soils, with the area west of the Time Oil building identified as a primary source of contamination.

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<sup>1</sup> This report supplements case studies for this project prepared by the U.S. Air Force titled "Pump and Treatment System at Commencement Bay, South Tacoma Channel (Well 12A) Phase 2, Tacoma, Washington", 1994, and "Soil Vapor Extraction System at Commencement Bay, South Tacoma Channel (Well 12A) Phase 2, Tacoma, Washington", 1995.

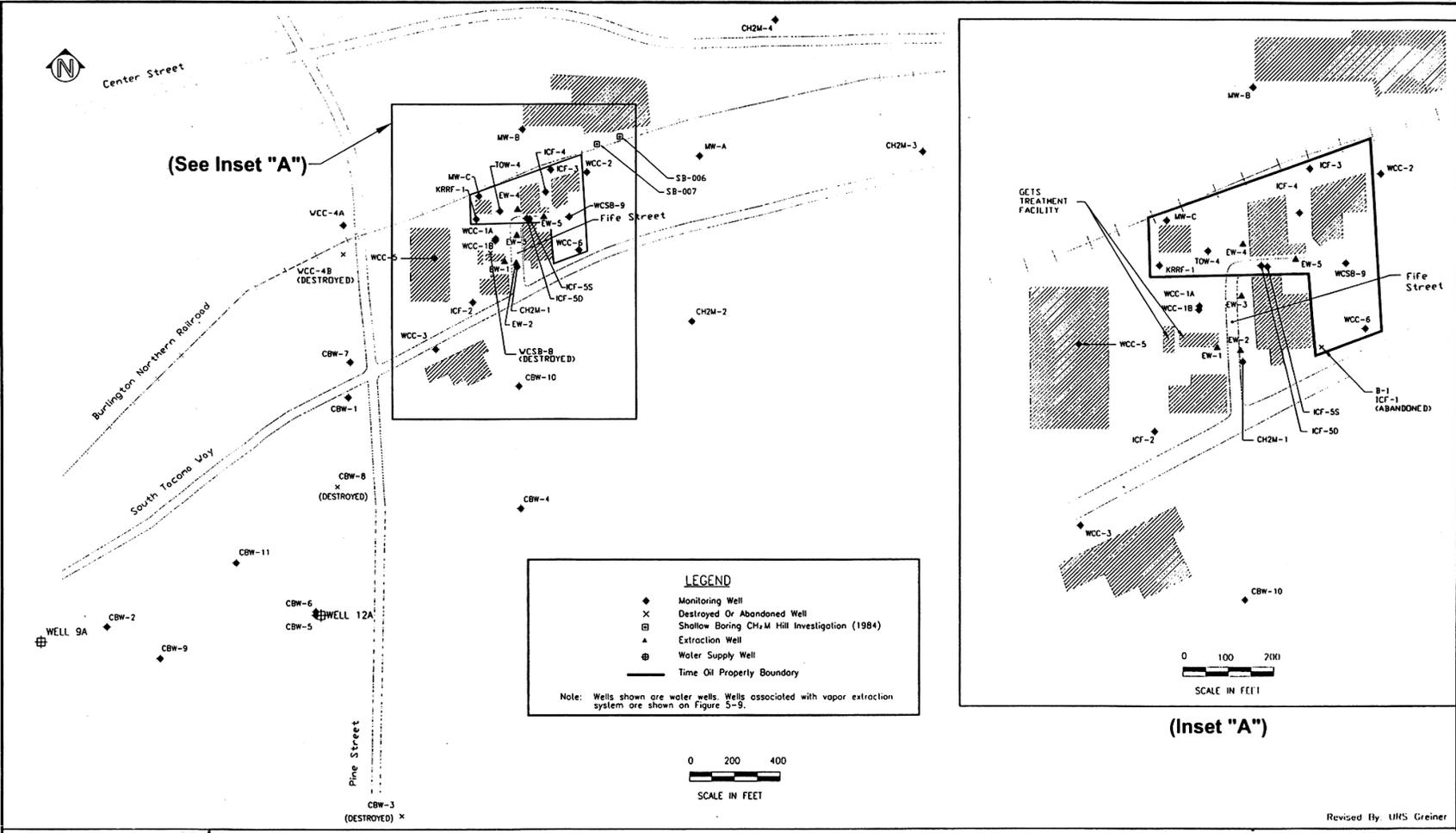


Figure 1. Site Map [9]

- The site was added to the NPL list on September 8, 1983. A record of decision (ROD) was signed in 1985 addressing the soil and groundwater contamination at the Time Oil property. The ROD specified continued operation of the interim air strippers, excavation and off-site disposal of contaminated soil, and pump and treat of contaminated groundwater.
- Contaminated soil was excavated from several areas at the site, including approximately 1,200 cubic yards from along a railroad spur on the north side of the site and 5,000 cubic yards of filter cake from recycling operations.
- Soil vapor extraction (SVE) was used from 1993 to 1997 to treat soil in the area west of the Time Oil Building.
- A pump and treat system was installed and began operating at the site in 1988; operation of the system is ongoing.

**Regulatory Context:** The ROD for OU 1 was signed on May 3, 1985 to address the source of contamination for Well 12A. The ROD specified treatment of VOC contamination in soil and groundwater at the Time Oil site.

**Groundwater Remedy Selection:** The selected groundwater remedy for the site is pump and treat of contaminated groundwater with either direct discharge of the treated groundwater to Commencement Bay through an existing storm sewer or reinjection of the treated groundwater into the aquifer at the source area.

#### **SITE LOGISTICS/CONTACTS**

**Site Lead:** PRP

**Remedial Project Manager (RPM):**

Kevin Rochlin\*  
U.S. EPA Region 10  
1200 Sixth Avenue  
Seattle, Washington 98101  
(206) 553-2106  
(206) 553-0149  
rochlin.kevin@epa.gov

**Pump and Treat System Operation**

**Contactor:**  
URS Greiner, Inc. (URSG)  
(Point of contact not provided)

**SVE System Vendor:**

Environmental Science and Engineering, Inc.  
(Point of contact not provided)

\*Indicates primary contact

## MATRIX DESCRIPTION

### MATRIX IDENTIFICATION

**Type of Matrix Processed Through the Treatment System:** Groundwater, Soil

### CONTAMINANT CHARACTERIZATION [4,5,8,9]

**Primary Contaminant Groups:** Chlorinated volatile organic compounds (cVOCs)

- During the remedial investigation, the following contaminants were identified in the groundwater at the site: 1,1,2,2-tetrachloroethane (PCA) (17 to 300 µg/L); 1,2-trans-dichloroethene (DCE) (30 to 100 µg/L); trichloroethene (TCE) (54 to 130 µg/L); and tetrachloroethene (PCE) (1.6 to 5.4 µg/L). These contaminants, along with vinyl chloride, were identified as the primary contaminants of concern at the site, based on risk evaluations performed in 1984.
- The presence of light non-aqueous phase liquids (LNAPLs) and dense non-aqueous phase liquids (DNAPLs) have been confirmed at the site.

### MATRIX CHARACTERISTICS AFFECTING TREATMENT COSTS OR PERFORMANCE [9]

#### **Hydrogeology:**

One hydraulic unit has been identified at the site. This aquifer extends from the water table (35 feet below ground surface (bgs)) to a depth of approximately 80 feet bgs. The soil beneath the site includes lower permeability layers, and low-permeable aquitards exist throughout the aquifer. A low-permeability aquitard layer consisting of silty sand, gravel, and clay exists below the aquifer and extends to a depth of approximately 120 feet bgs. The groundwater flow direction changes depending on whether or not groundwater is being pumped from Well 12A. Under non-pumping conditions, the groundwater flow is generally to the northeast. When Well 12A is pumping, the groundwater flow is generally to the southwest. Table 1 summarizes hydrogeologic information about the aquifer beneath the site.

**Table 1. Technical Aquifer Information [9]**

Thickness (ft)	Hydraulic Conductivity (ft/day)	Average Linear Velocity (ft/day)	Flow Direction
45	1,000	4.1	Northeast (non-pumping conditions) Southwest (pumping conditions)

## TREATMENT SYSTEM DESCRIPTION

### PRIMARY TREATMENT TECHNOLOGY [6,7,8,9]

- Pump and treat using liquid-phase granular activated carbon adsorption; soil vapor extraction with vapor-phase activated carbon adsorption.

### SYSTEM DESCRIPTION AND OPERATION [6,7,8,9,10,11,12]

#### System Description:

The pump and treat system at this site is referred to as the Groundwater Extraction and Treatment System (GETS). The initial system, which began operating in November 1988, included one extraction well (EW-1). In August 1995, the system was expanded to include four new wells (EW-2 through EW-5). Table 2 presents data for the five extraction wells.

**Table 2. Extraction Well Data [8,9]**

Well Name	Screen Depth (ft bgs)	Well Depth (ft bgs)	Design Yield (gal/min)
EW-1	61-81	85	500
EW-2	50.2-70.5	74	50
EW-3	47.3-67.6	71	50
EW-4	46.5-66.8	70	50
EW-5	47.6-67.9	71	50

- The above-ground treatment system consists of two granular activated carbon (GAC) vessels connected in series, each of which contain approximately 20,000 pounds of GAC, and an effluent storage tank.
- The soil vapor extraction (SVE) system was installed in the area west of the Time Oil Building and operated between August 1993 and May 1997. The SVE system consisted of 23 vapor extraction wells in the vadose zone and a vapor phase carbon adsorption system to treat the soil vapors. The design air flow rate for the system was 3,000 standard cubic feet per minute.
- Monitoring wells were installed in the following five locations: source area (wells KRRF-1, MW-C, TOW-4, and ICF-4), extraction area (wells WCC-1B, WCC-1A, ICF-5D, and ICF-5S), intermediate area (wells CBW-4, CBW-1, WCC-3, ICF-2, and WCC-5), 12A area (wells CBW-2, CBW-9, and CBW-11), and downgradient area (wells MW-B, ICF-3, WCC-2, MW-A, CH2M-4, and CH2M-3). As of December 1999, there were 30 active monitoring wells at the site.

#### System Operation:

- Since the pump and treat system began operating in November 1988, it has been operational 82 percent of the time. Downtime has been primarily for routine maintenance, including carbon replacement.

- The total design yield for the five extraction wells is 500 gallons per minute (gpm). The actual groundwater yield for the system is less than 100 gpm, with EW-1 extracting 50 gpm and EW-2 through EW-5 each extracting approximately 10 gpm. When initially installed, EW-1 was capable of extracting 500 gpm, but the actual extraction rate shortly dropped to 300 gpm, and later to 50 gpm. Iron fouling likely is a primary reason for the decrease in extraction rates for the site.
- Through December 1999, the carbon in the carbon adsorption unit has been replaced 13 times. The average number of days between carbon changeouts was 255 days and the average volume of water treated between changeouts was 33 million gallons.
- Groundwater sampling has been performed regularly since system startup. Each sampling event has involved approximately 20 monitoring wells. Samples are analyzed for VOCs, semi-volatile organic compounds (SVOCs), pesticides, inorganics, and total petroleum hydrocarbons (TPH).
- As of August 2001, the site objectives and remedy were being reviewed to determine future plans for the site. EPA conducted a Remediation System Evaluation (RSE) as part of a nation-wide effort by EPA headquarters to optimize pump and treat systems. Possible plans include aquifer modeling to help evaluate capture of the contaminant plume. Based on the results from such a study, pumping rates might be adjusted. Alternate strategies also are under consideration to address LNAPL and DNAPL at the site.

**Operating Parameters Affecting Treatment Cost or Performance**

Table 3 presents the major operating parameters affecting cost or performance for this technology.

**Table 3. Performance Parameters [1,8,9,12]**

Parameter	Value
Average Extraction Rate	100 gpm (through GAC) - 500 gpm maximum
Remedial Goal (aquifer) (µg/L)	PCA - 0.219 (per Washington State Model Toxics Control Act) PCE - 5 TCE - 5 trans-1,2-DCE - 100 cis-1,2-DCE - 70 Vinyl chloride - 2
Performance Standard (effluent for reinjection) (µg/L)	PCA - 10.7 PCE - 8.85 TCE - 80.7 trans-1,2-DCE - 1.85 Vinyl chloride - 100 Total VOCs - 193
Performance Standard (effluent discharges to surface water) (µg/L)	PCA - 6.48 PCE - 4.15 TCE - 55.6 trans-1,2-DCE - 32,800 Vinyl chloride - 2.92

**Timeline [4,5,6,7,8,9,10,11]**

Table 4 presents a timeline for the major events performed during this remedial project.

**Table 4. Project Timeline**

Start Date	End Date	Activity
1982	May 1983	Phase I Remedial Investigation/Feasibility Study (RI/FS) performed
October 1982	May 1995	Monitoring wells installed
September 1983	---	Commencement Bay added to the National Priorities List (NPL)
1984	---	Phase II RI/FS performed
June 1986	---	1,200 cubic yards of contaminated soil removed from site
September 1987	Spring 1988	Pump and treat system constructed
December 1987	February 1988	EW-1 constructed
November 1988	August 1995	Pump and treat system operational with one extraction well (EW-1)
September 1992	May 1993	SVE system constructed
September 1992	May 1993	5,000 cubic yards of filter cake excavated
August 1993	May 1997	SVE system operational
October 1994	---	Extraction wells EW-2, EW-3, EW-4, and EW-5 constructed
August 1995	Present	Extraction wells EW-1, EW-2, EW-3, EW-4, and EW-5 operational
August 2001	---	EPA Remediation System Evaluation conducted

## TREATMENT SYSTEM PERFORMANCE

**CLEANUP GOALS/STANDARDS [1,4,5,7,9,12]**

The ROD specified extraction and treatment of the contaminated groundwater at the site. Cleanup goals were not formally set, however target limits were identified as the Maximum Contaminant Levels (MCLs), as shown in Table 3 for PCE, TCE, trans-1,2-DCE, cis-1,2-DCE, and vinyl chloride. In addition, a target limit was identified for PCA based on the Washington State Model Toxics Control Act. In addition, Table 3 shows the performance standards for effluent discharges to reinjection or to surface waters. The ROD also required containment of the plume. No specific cleanup goals were established for SVE.

**PERFORMANCE DATA ASSESSMENT [6,8,9]**

Operation of the pump and treat system at the site is ongoing and performance data are available through June 2000. Data on mass removed and mass flux were provided for VOCs (the sum of the concentrations of vinyl chloride, trans-1,2-DCE, cis-1,2-DCE, TCE, 1,1,2-TCA, PCE, and PCA) from 1990 through 1999. The SVE system was operated from 1993 through 1997.

**Pump and Treat**

- As shown in Figure 2, the cumulative mass of VOCs removed from the groundwater from through December 1999 was 14,743 pounds, with 440 million gallons of groundwater treated. The RPM reported that approximately 15,000 pounds had been extracted by December 2000.
- As shown in Figure 3, the mass flux through the pump and treat system, as measured by pounds of VOCs removed by the treatment system per month, has decreased from approximately 3,500 pounds per month in January 1990 to approximately 1,400 pounds per month in December 1999. During this time, the mass flux varied by more than 2,000 pounds of VOCs. Variations in mass flux are likely due to fluctuations in groundwater extraction rates and possibly due to globules of NAPL dissolving into the groundwater. Higher concentrations may coincide with a water table that rises into the LNAPL smear zone and causes more LNAPL to dissolve into the groundwater.
- Figures 4 through 8 show system performance in terms of VOC concentrations in two extraction wells (EW-1, EW-2, and EW-5) [including total VOCs, total 1,2-DCE, TCE and PCA] and concentrations of TCE and trans-1,2-DCE in two monitoring wells (MW-C in the source area and MW-B in the down-gradient area). The locations of these wells are shown on Figure 1.
- As of June 2000, concentrations of PCA, TCE, and total-1,2-DCE in extraction wells remained above the remedial goals. Data were not provided about the concentrations of PCE and vinyl chloride, or the 1,2-DCE isomers (cis and trans) needed to compare them with their remedial goals.
- Between November 1988 and August 1995, when one extraction well was operational, contaminant concentrations in extraction well EW-1 generally increased, as shown in Figure 4. From late 1996 through June 2000, contaminant concentrations in EW-1 were lower and, by June 2000, were less than 500 ug/L. Information was not provided about the reason for the lower concentrations in EW-1 since December 1996.
- In August 1995, when the system was expanded, contaminant concentrations in extraction wells EW-2 through EW-5 initially increased for about the first year of operation (through August 1996). As shown in Figure 5, concentrations of VOCs in EW-2 decreased from more than 14,000 µg/L to about 1,500 µg/L and PCA decreased from more than 12,000 µg/L to less than 500 µg/L. Concentrations of TCE and total 1,2-DCE remained relatively steady at about 600 µg/L and 200 µg/L, respectively. Contaminant concentrations in the other extraction wells varied over this five year period, with some wells showing decreases (EW-1, EW-2, and EW-3) and others showing increases (EW-4 and EW-5; concentrations in EW-5 are shown in Figure 6). The placement of four new extraction wells in “hot zones” for the expanded system might have lead to the higher concentrations. Other possible reasons for the spikes in concentration include the presence of DNAPL and LNAPL, which would provide continuing sources of dissolved contaminant concentrations, and changes in extraction rates that might have affected mass flux.

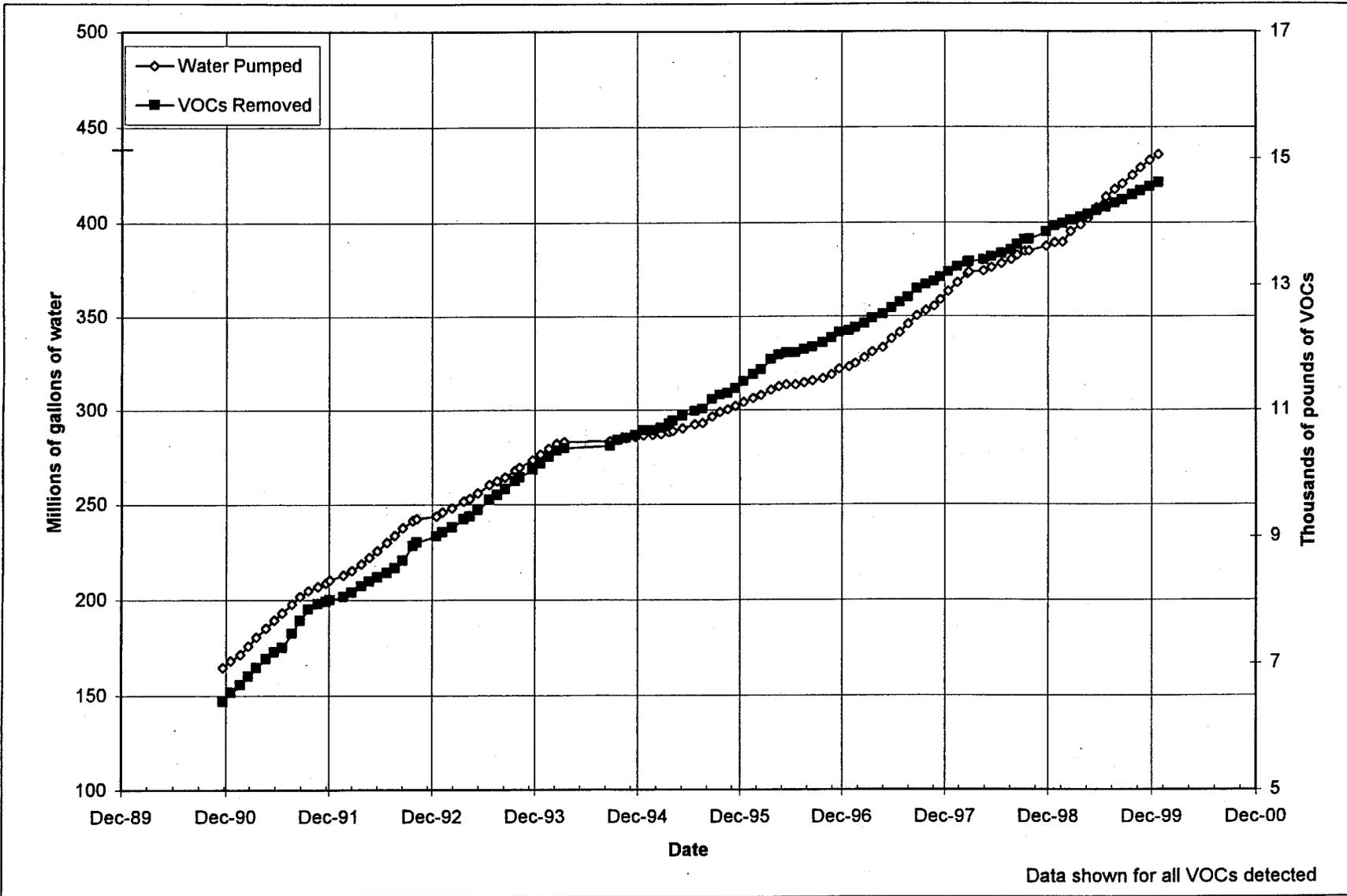


Figure 2. Cumulative Mass of VOCs Removed and Volume of Water Pumped from the GETS [8]

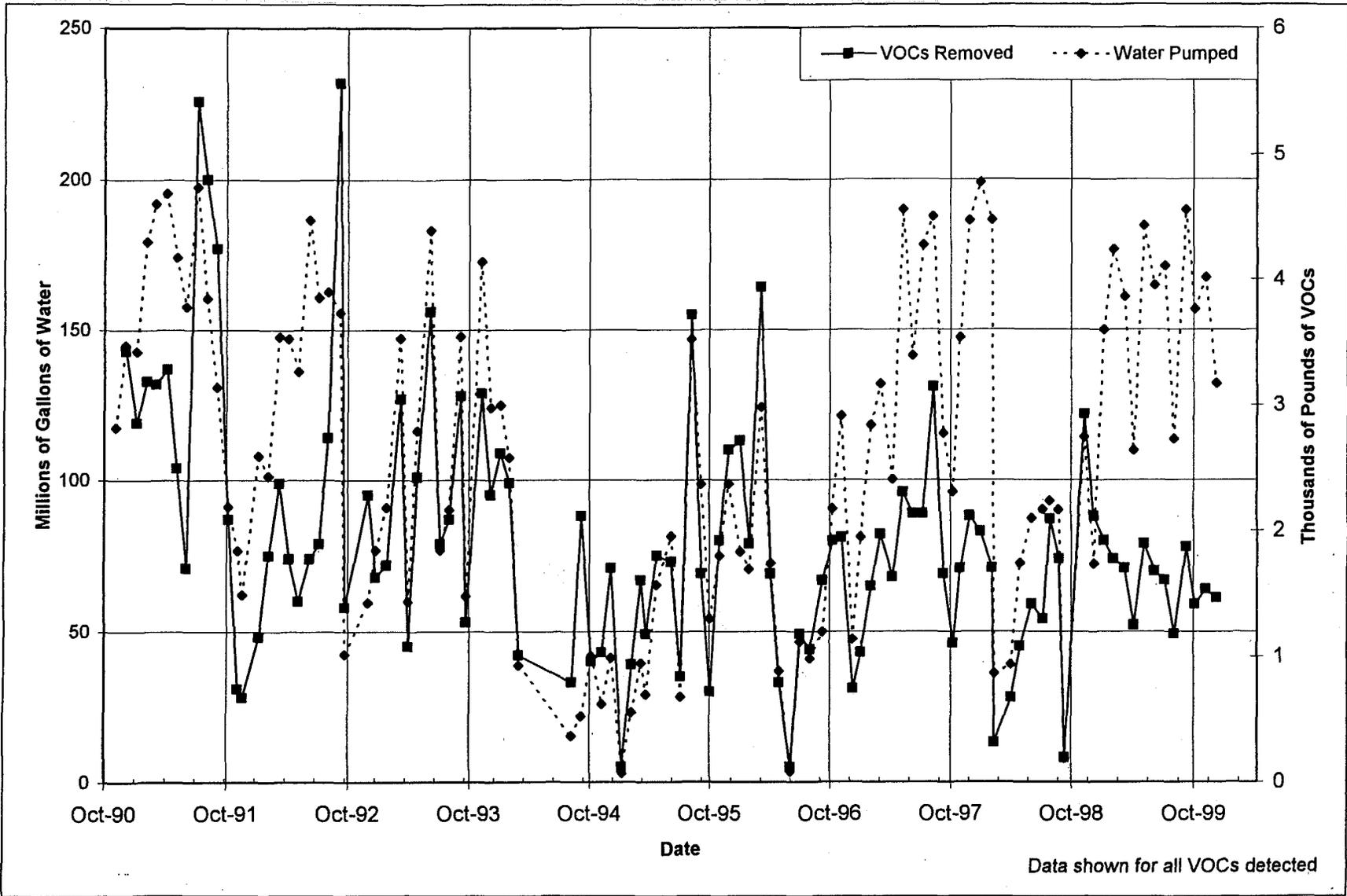


Figure 3. Mass Flux of VOCs Through the GETS [8]

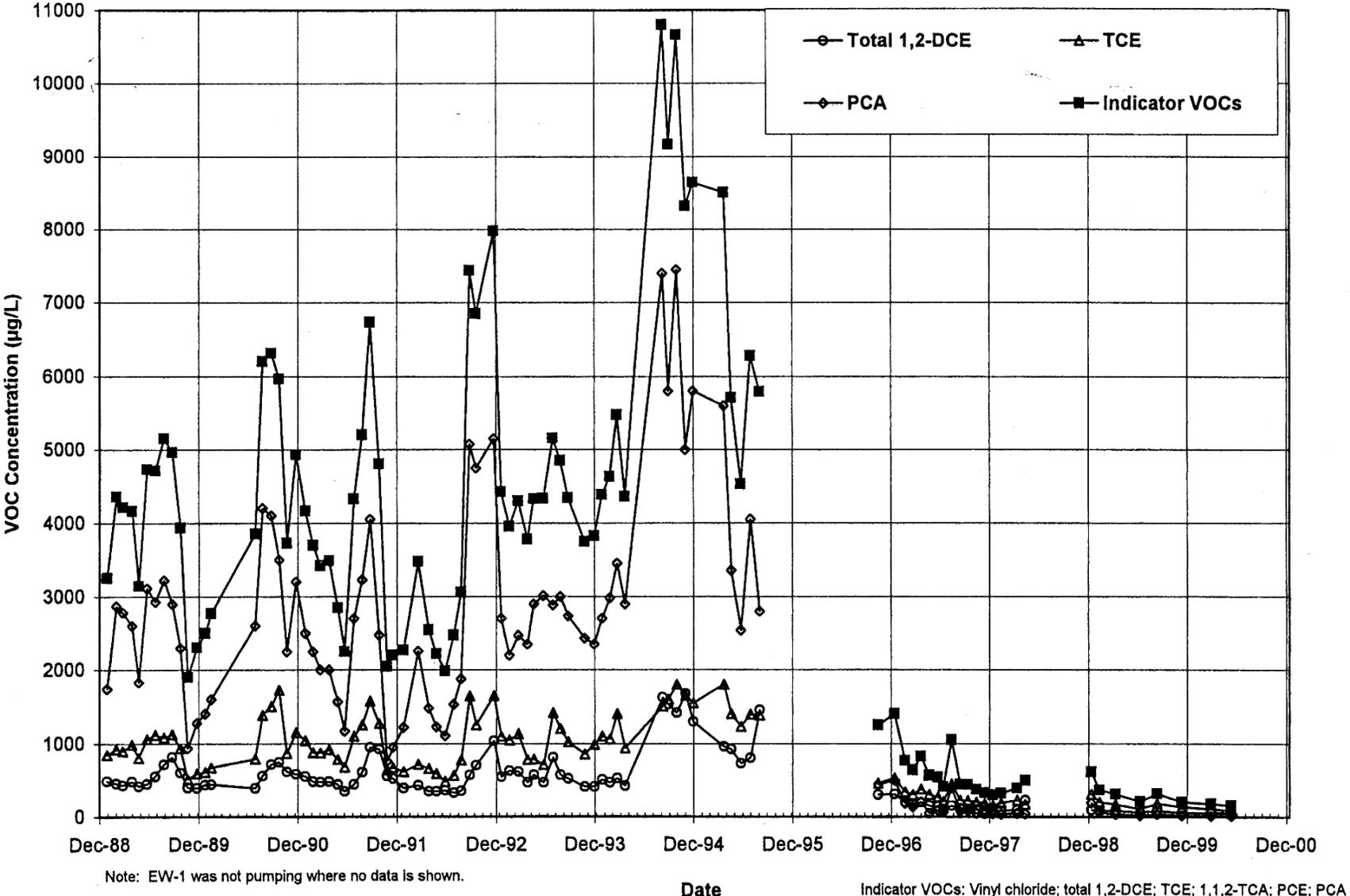


Figure 4. VOC Concentrations in EW-1 [12] (January 1989 to June 2000)

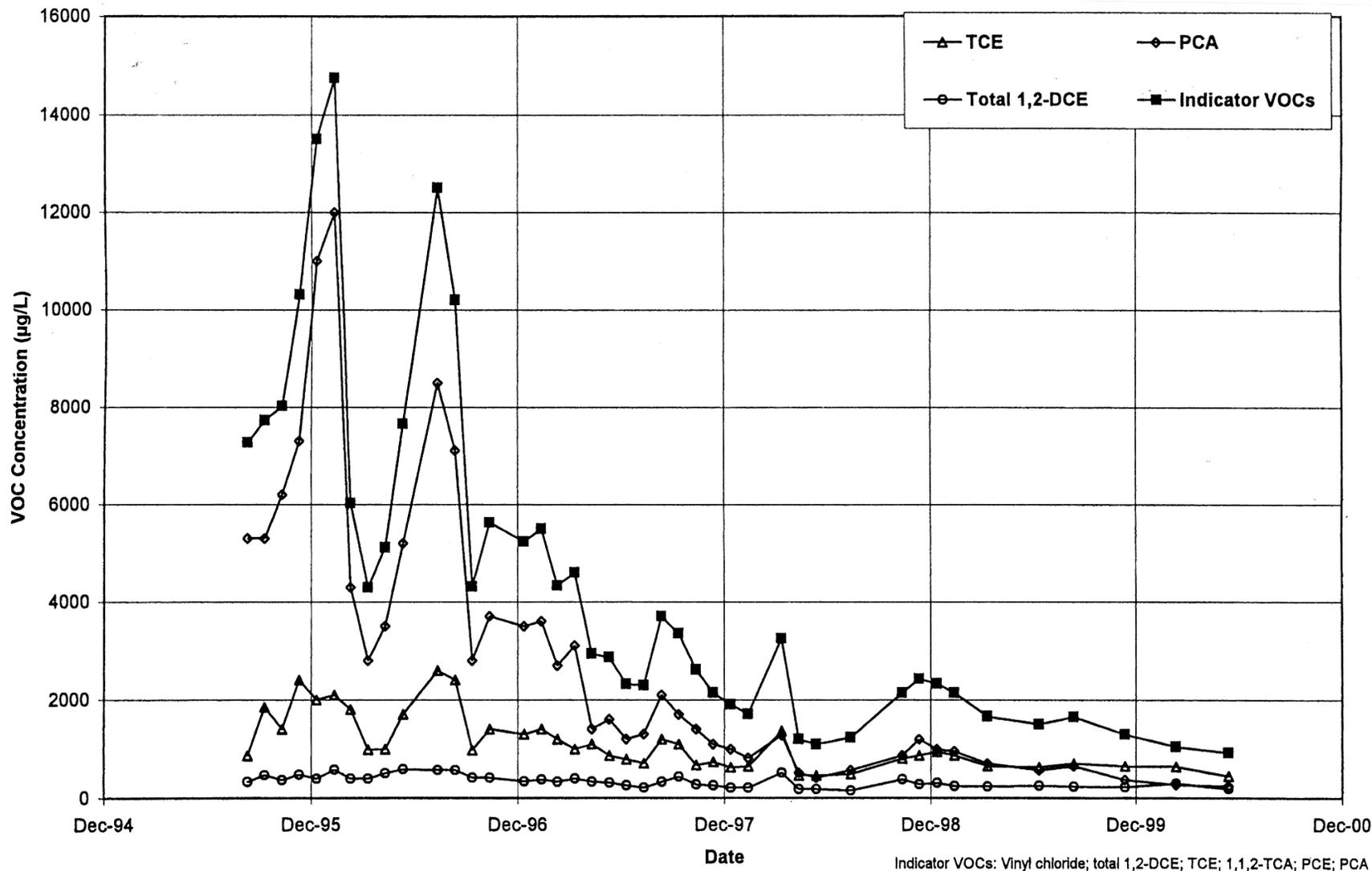


Figure 5. VOC Concentrations in EW-2 [12] (January 1989 to June 2000)

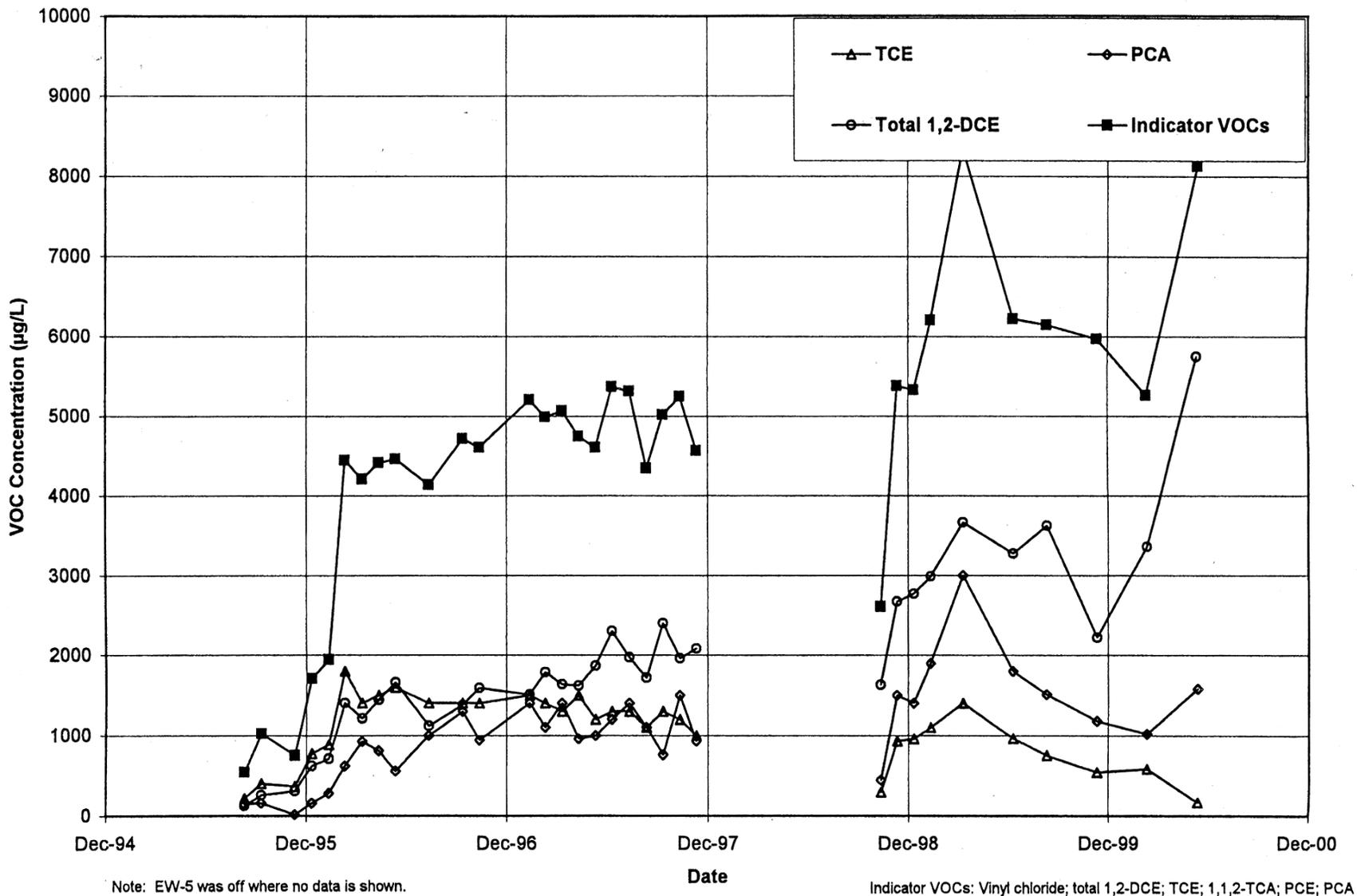


Figure 6. VOC Concentrations in EW-5 [12] (January 1989 to June 2000)

- In the source area monitoring well MW-C (Figure 7), TCE and trans-1,2-DCE concentrations remained relatively steady until about April 1995, when spikes in contaminant concentrations were observed. TCE concentrations rose from about 900 µg/L to more than 6,000 µg/L in August 1995 (when the system was expanded to 5 wells) and continued to rise to more than 9,000 µg/L immediately following startup of the expanded system. During this time, trans-1,2-DCE concentrations rose from about 500 µg/L to more than 1,000 µg/L by August 1995 and continued to rise to more than 1,500 µg/L following startup of the expanded system. Following the concentration spikes in 1995, concentrations of TCE and trans-1,2-DCE in source area monitoring well MW-C decreased steadily. As of January 1998, concentrations of TCE and trans-1,2-DCE were 2,700 µg/L and 600 µg/L, respectively.
- Data from down-gradient monitoring well MW-B (Figure 8) showed trans-1,2-DCE concentrations remaining steady at about 3 µg/L, and TCE concentrations remaining steady at about 10 to 20 µg/L, with the exception of a spike in concentration to about 75 µg/L in July 1992. This spike was potentially due to changes in recharge and/or water levels altering groundwater flow and contaminant transport.
- The size of the TCE and DCE contaminant plumes have decreased from 1993 to 1998. In 1993, the TCE plume (TCE concentration greater than or equal to 1 µg/L) was 4,200 feet long by 1,900 feet wide. By 1998, the TCE plume had decreased in size to 2,900 feet long by 2,100 feet wide. In 1993, the DCE plume (DCE concentration greater than or equal to 1 µg/L) was 4,400 feet long by 1,600 feet wide. By 1998, the DCE plume had decreased in size to 2,400 feet long by 1,500 feet wide. Earlier data (from December 1989) suggested a plume size of at least 2,500 feet long and 1,000 feet wide. The plume may not have been completely delineated by sampled monitoring wells at that time. According to the contractor at the site, recent data from well EW-5 suggest that the plume may be migrating. VOC concentrations in this well increased from approximately 500 µg/L in 1995 to approximately 8,000 µg/L in June 2000. Future site plans may involve monitoring to evaluate plume containment. The extraction wells are operating below their design rates suggesting that these wells may not be adequate to contain the plume.
- Data on the performance of the groundwater treatment system were available for the period October 1999 through December 1999, and the treatment system met the performance standards during this period. The RPM indicated that the treatment system has routinely met the performance standards during previous years.
- The RPM indicated that the current pump and treat system will not attain MCLs due to the presence of LNAPL and DNAPL. Future plans for the site are being evaluated to determine the optimal approach to address site-related contamination.

### **Soil Vapor Extraction**

- Between 1993 and May 1997, the soil vapor extraction system removed approximately 54,100 pounds of VOCs from the subsurface soils at the site. The recovered VOCs contained a mixture of light-end hydrocarbons and chlorinated compounds.
- The recovery rate of VOCs during the initial operation of the soil vapor extraction system was lower than expected due to the presence of kerosene-weight hydrocarbons in the vadose zone soils. In December 1994, the soil vapor extraction system was retrofitted with a three-phase separator to replace the two-phase separator, and the extraction rate increased.
- The SVE system was shut off in 1997 due to declining recovery rates. Residual LNAPL is believed to exist in a smear zone along the water table and likely will contribute to groundwater contamination. However, based on declining recovery rates from the SVE system in 1997, the RPM indicated that SVE probably will not remove or control the migration of the remaining LNAPL.

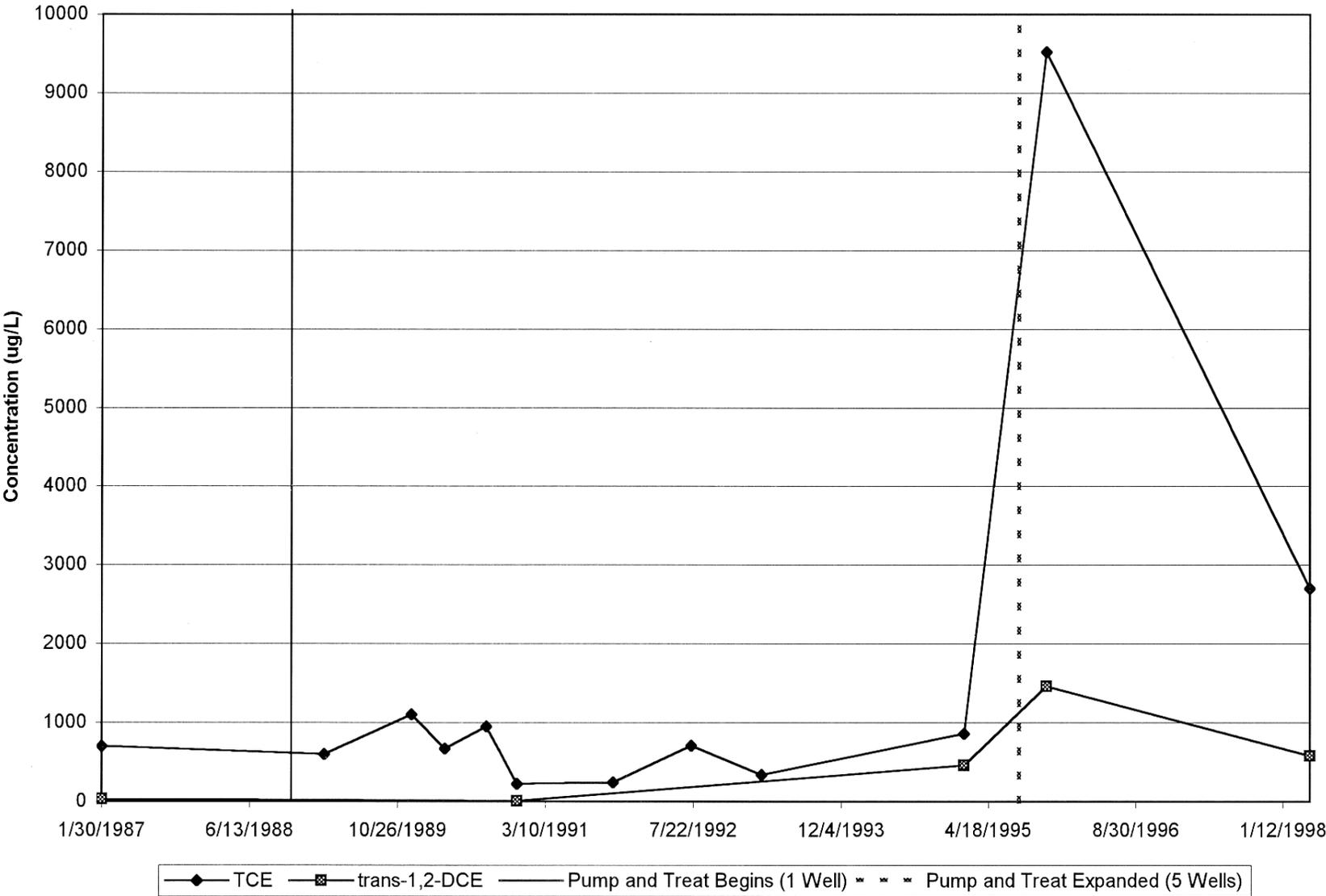


Figure 7. TCE and trans-1,2-DCE Concentrations in Source Area Monitoring Well MW-C [8] (1988 to 1998)

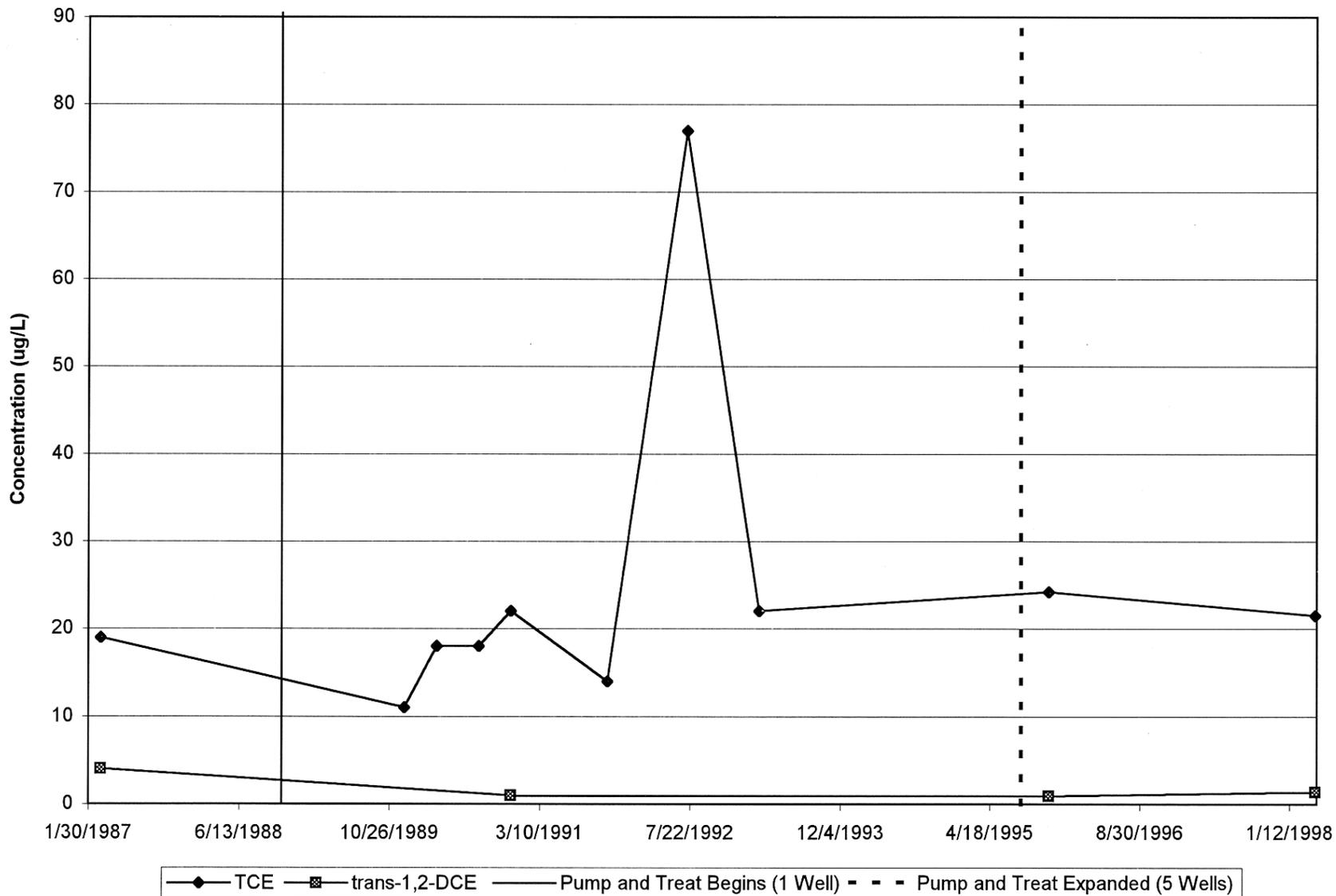


Figure 8. TCE and trans-1,2-DCE Concentrations in Down-gradient Monitoring Well MW-B [8] (1988 to 1998)

**PERFORMANCE DATA COMPLETENESS**

- C Groundwater monitoring has been performed at the site since November 1988 and data are available through June 2000. Groundwater monitoring data are available for 53 wells and 5 contaminants (PCE, PCA, TCE, DCE, and vinyl chloride).

**PERFORMANCE DATA QUALITY**

The QA/QC program used throughout this remedial action met EPA and State of Washington requirements. All monitoring was performed using EPA-approved methods. No deviations to the QA/QC protocols were noted in the available references.

## TREATMENT SYSTEM COST

**PROCUREMENT PROCESS [9]**

The PRP for the site contracted the design and construction and the operation and maintenance (O&M) of the remedial system. O&M first was contracted to ICF Kaiser Engineers, Inc. and then to URSG on a time and material basis. The basis for selecting these contractors was not provided in the available references.

**COST ANALYSIS [2,3]**

Table 5 shows the capital costs through May 2000 and year 2000 annual operating costs. Total operating costs from 1988 to 1999 were estimated by the RPM as \$3.6 million. The year 2000 operating costs are based on operating costs incurred from January 2000 through April 2000, and have been extrapolated to represent operating costs for an entire year. Assuming the \$3.6 million of operating costs were incurred at a level rate over an 11 year period would correspond to an annual operating cost of \$330,000, which is 20% less than the \$410,000 in operating costs estimated for the year 2000. The available references do not indicate if operating costs have increased in more recent years, or if the differences are due to estimating errors.

In addition to the costs for pump and treat, the RPM estimated that approximately \$2 million were spent on operating costs for the SVE system. The SVE system had an estimated capital cost of \$5,314,000.

**Table 5. Remediation Costs - Pump and Treat System [2,3]**

Capital Costs	
<b>Total Capital Cost (through May 2000)</b>	<b>\$1,800,000</b>
Year 2000 Operating Costs	
Project Planning and Support	\$15,000
Procurement	\$3,300
Labor (includes sampling, maintenance, backwash installation, etc.)	\$126,000
Reporting	\$90,000
Carbon Subcontractor	\$75,000

Year 2000 Operating Costs	
Travel	\$2,100
Hardware, supplies	\$15,000
Electrician (primarily backwash wiring)	\$19,500
Utilities	\$65,000
<b>Total Year 2000 Operating Costs (\$2000)</b>	<b>\$410,900</b>

## OBSERVATIONS AND LESSONS LEARNED

- Through December 2000, a total of 15,000 pounds of VOCs have been removed by the pump and treat system, and 450 million gallons of groundwater have been treated. As of June 2000, concentrations of PCA, TCE, and total-1,2-DCE in extraction wells remained above remedial goals.
- The presence of LNAPL and DNAPL provide continuing sources of dissolved phase contamination. The RPM indicated that the current pump and treat system will not attain MCLs due to the presence of LNAPL and DNAPL. Future plans for the site are being evaluated to determine the optimal approach to address site-related contamination.
- During the first seven years of operation (1988 to 1995), the pump and treat system included only one extraction well. During this time, concentrations of constituents of concern generally increased. The system was expanded to five wells in 1995, and since that time, concentrations of contaminants have decreased in some wells and increased in others.
- Well 12A no longer is operating (except during periods of peak demand) and the direction of plume migration appears to have shifted from transport in a southwesterly direction to a more easterly direction.
- The SVE system operated from 1993 to 1997, and removed a total of 54,100 pounds of VOCs, consisting of a mixture of light-end hydrocarbons and chlorinated compounds. Residual LNAPL is believed to exist in a smear zone along the water table and likely will contribute to groundwater contamination. However, based on declining recovery rates, the RPM indicated that continued operation of SVE probably will not remove or control the migration of the remaining LNAPL.

## REFERENCES

1. EPA. *Correspondence Between Tetra Tech EM Inc. and EPA*. July 31, 2000.
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4. EPA. *ROD for South Tacoma Channel - Well 12A*. May 3, 1985.

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12. GeoTrans, Inc. Memorandum to Kathy Yager, EPA/TIO. Responses to Items Requested by EPA/TIO Regarding a Case Study. September 10, 2001.

#### **ANALYSIS PREPARATION**

This case study was prepared for the U.S. Environmental Protection Agency's Office of Solid Waste and Emergency Response Technology Innovation Office. Assistance was provided by Tetra Tech EM Inc. under Contract No. 68-W-99-003.