COST AND PERFORMANCE REPORT

Pump and Treat of Contaminated Groundwater at the
Sol Lynn/Industrial Transformers Superfund Site
Houston, Texas

September 1998

EPA

Prepared by:

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Technology Innovation Office

SITE INFORMATION

Identifying Information:

Sol Lynn/Industrial Transformers Superfund Site
Houston, Texas

CERCLIS #: TXD980973327

ROD Date: September 23, 1988

Treatment Application:

Type of Action: Remedial

Period of operation: October 1993 - October 1996
(Performance data collected through October 1996)

Quantity of material treated during application: 13 million gallons of contaminated groundwater.

Background

Historical Activity that Generated Contamination at the Site: Chemical recycling and supply

Corresponding SIC Code: 2869

Waste Management Practice That Contributed to Contamination: Disposal of punctured trichloroethylene drums on the ground surface

Location: Houston, Texas

Facility Operations: [1, 2, 3, 4, 5]

- Mr. Sol Lynn owned and operated the site as Industrial Transformers, a scrap metal and electrical transformer reclamation facility, from 1971 through 1978. Sol Lynn then leased the 3/4-acre property to Ken James, who operated the site as Sila King, Inc., a chemical supply business, in 1979 and 1980 [1,2].
- The first documented investigation of this site took place during the fall of 1971 when the City of Houston Water Pollution Control Division discovered that workers at Industrial Transformers poured oil out of electrical transformers onto the ground during transformer dismantling. In 1981, strong odors originating from the site were brought to the attention of the Texas Department of Water Resources, the predecessor of the Texas Water Commission (TWC). Upon inspection, approximately 75 drums were found scattered about the property. Most of the drums, labeled "Trichloroethylene" (TCE), were empty and had puncture holes [2].
- A remedial investigation (RI) and feasibility study was performed from December 26, 1984 through February 21, 1991. Remedial design was performed from June 22, 1989 through August 26, 1992 [2].
- The results of the RI showed elevated levels of polychlorinated biphenyl (PCB) in surficial soils and TCE in shallow soils and groundwater [3]. The RI also showed that the plume had migrated off site [3].
- An unidentified silty water-bearing unit was discovered and investigated in 1991, concurrent with groundwater remedial design activities. Groundwater samples taken in this zone as part of a Field Investigation of the Silty Zone Report revealed high concentrations of TCE, the highest of which was 1,200 mg/L [4].
- Approximately 2,400 cubic yards of soil, which included all soils with PCB contamination of 25 mg/kg or greater, were excavated and treated in a dechlorination unit for source control in late 1992. Treated soils were disposed of in an off-site landfill [5].
- The Sol Lynn/Industrial Transformer Superfund Site was listed on the National Priorities List (NPL) March 31, 1989 [1].

SITE INFORMATION (CONT.)

Background (Cont.)

Regulatory Context:

- A Record of Decision (ROD) was signed for this site on September 23, 1988.
- Site activities are conducted under provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) §121, and the National Contingency Plan (NCP), 40 CFR 300.

Groundwater Remedy Selection:

- The selected groundwater remedy for this site is extraction and treatment via air stripping and carbon adsorption. Air stripper exhaust is treated through vapor-phase carbon adsorption to meet Texas air quality criteria.

Site Logistics/Contacts

Site Lead: State

Oversight: EPA

Remedial Project Manager:
Ernest R. Franke
U.S. EPA Region 6
1445 Ross Ave., Ste. 1200
Dallas, TX 75202-2733
(214) 665-8521

State Contact:
James Sher*
Texas Natural Resources Conservation Commission (TNRCC), Mail Code 144
12100 Park Circle
Austin, Texas 78753
Phone: (512) 239-2444
FAX: (512) 239-2450

*Indicates primary contacts

Installation, Startup, and Operation Subcontractor:
Maxim Technologies, Inc.
(previously named Huntingdon Engineering and Environmental, Inc. and Southwest Laboratories, Inc.)

Treatment System Vendor:
Clearwater Systems, Inc.
P.O. Box 822
New Caney, Texas 77357
(713) 399-1980

Site Management:
John Kovski*
Radian International LLC
(formerly Radian Corporation)
9801 Westheimer, Ste. 500
Houston, TX 77042
(713) 914-6426

MATRIX DESCRIPTION

Matrix Identification

Type of Matrix Processed Through the Treatment System: Groundwater

MATRIX DESCRIPTION (CONT.)

Contaminant Characterization [3, 4, 20]

Primary Contaminant Groups: Halogenated volatile organic compounds

- The on-site groundwater is contaminated with TCE. In 1988, during the remedial investigation site sampling of the shallow and intermediate aquifer zones, the maximum concentration of TCE detected in groundwater on site was 600 mg/L. An off-site maximum TCE concentration of 790 mg/L also was detected during this sampling episode [3]. During the field investigation of the silty zone, the maximum concentration of TCE detected in the groundwater was 1,200 mg/L [4].
- While free product was not observed, according to the Silty Zone Investigation report, the high dissolved concentrations of TCE detected at the site suggest that residual TCE product, a dense non-aqueous phase liquid (DNAPL), exists in the aquifer material. This residual TCE is most likely adsorbed in the interstitial spaces of the aquifer matrix, rather than pooled as a free-phase DNAPL at the base of the zone [4].
- The EPA Region 6 Fact Sheet reports that 4.2 million gallons of groundwater are contaminated with site wastes; groundwater contamination in the 90-foot zone has not been determined [2]. Figures 1 and 2 are contour maps which depict the silty and shallow sand zone groundwater contamination during design sampling episodes [3, 4].

Matrix Characteristics Affecting Treatment Costs or Performance

Hydrogeology [2,3,4, 8]:

Groundwater is found at this site in two distinct zones -- the Upper Aquifer and the Lower Aquifer. The Upper Aquifer is composed of two units: a discontinuous perched zone, called the Silty Zone (Unit 1), and the Shallow Sand Zone (Unit 2). Neither serves as a known supply of drinking water. The groundwater flows in a northwesterly to westerly direction and is encountered at approximately 20 to 25 feet below land surface. Both aquifers are composed of similarly sandy material, resulting in relatively homogeneous flow conditions. The three water-bearing units are described below:

Unit 1	Silty Zone	A layer of silty clay with low yield. This unit is not continuous across the site.
Unit 2	Shallow Sand Zone	A layer of water-bearing sand with sand content varying from 50% to 70 percent. This unit is underlain by a stiff clay layer. Investigations in March 1998 revealed an additional sandy layer beneath this layer. No further characterization was available on the newly discovered sand layer.
Unit 3	Intermediate Aquifer	A layer of water-bearing sand that is underlain by a thick clay layer.

MATRIX DESCRIPTION (CONT.)

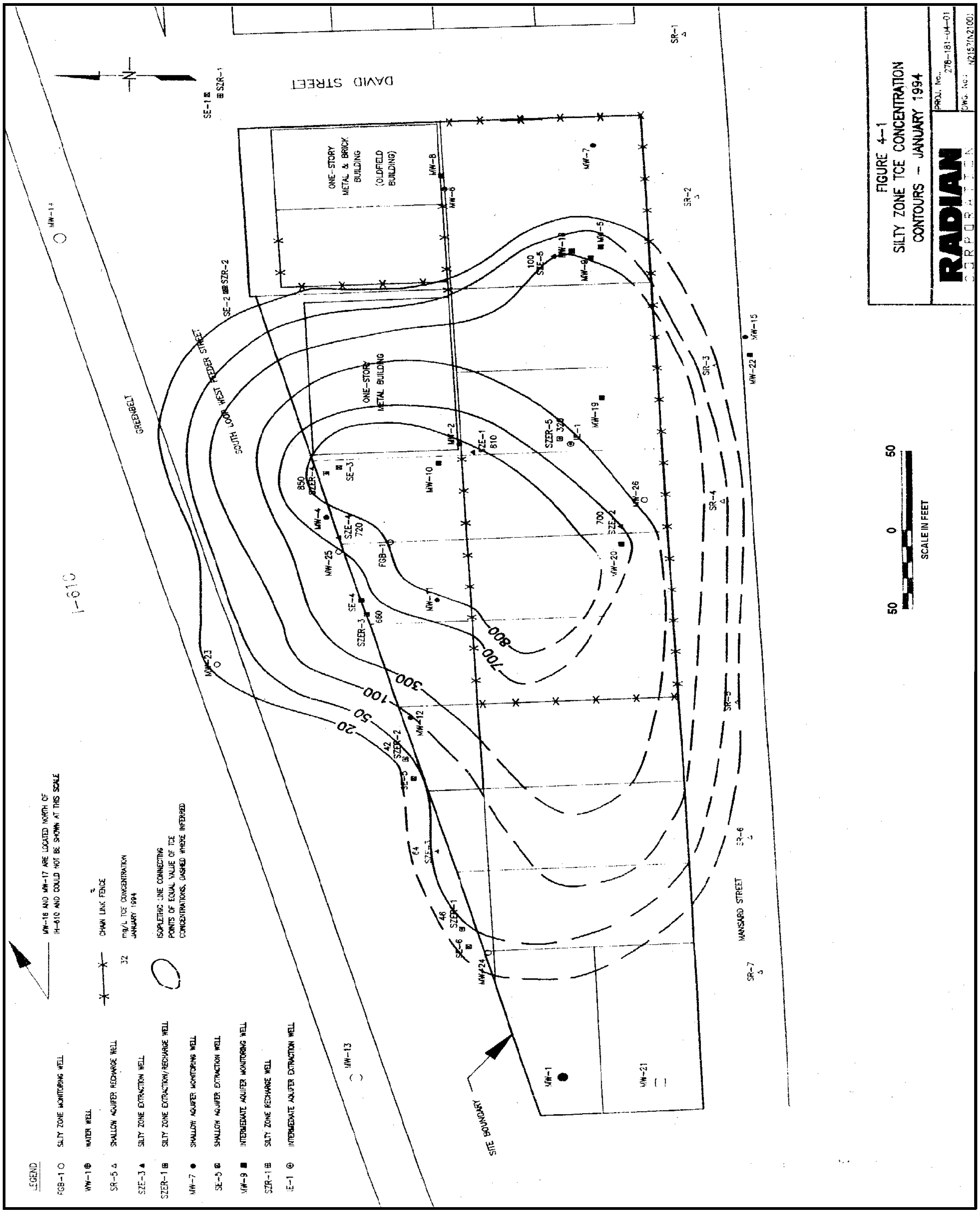

Figure 1. TCE Concentration Contours Detected in Silty Zone (1994) [3]
(Best Copy Available)

MATRIX DESCRIPTION (CONT.)

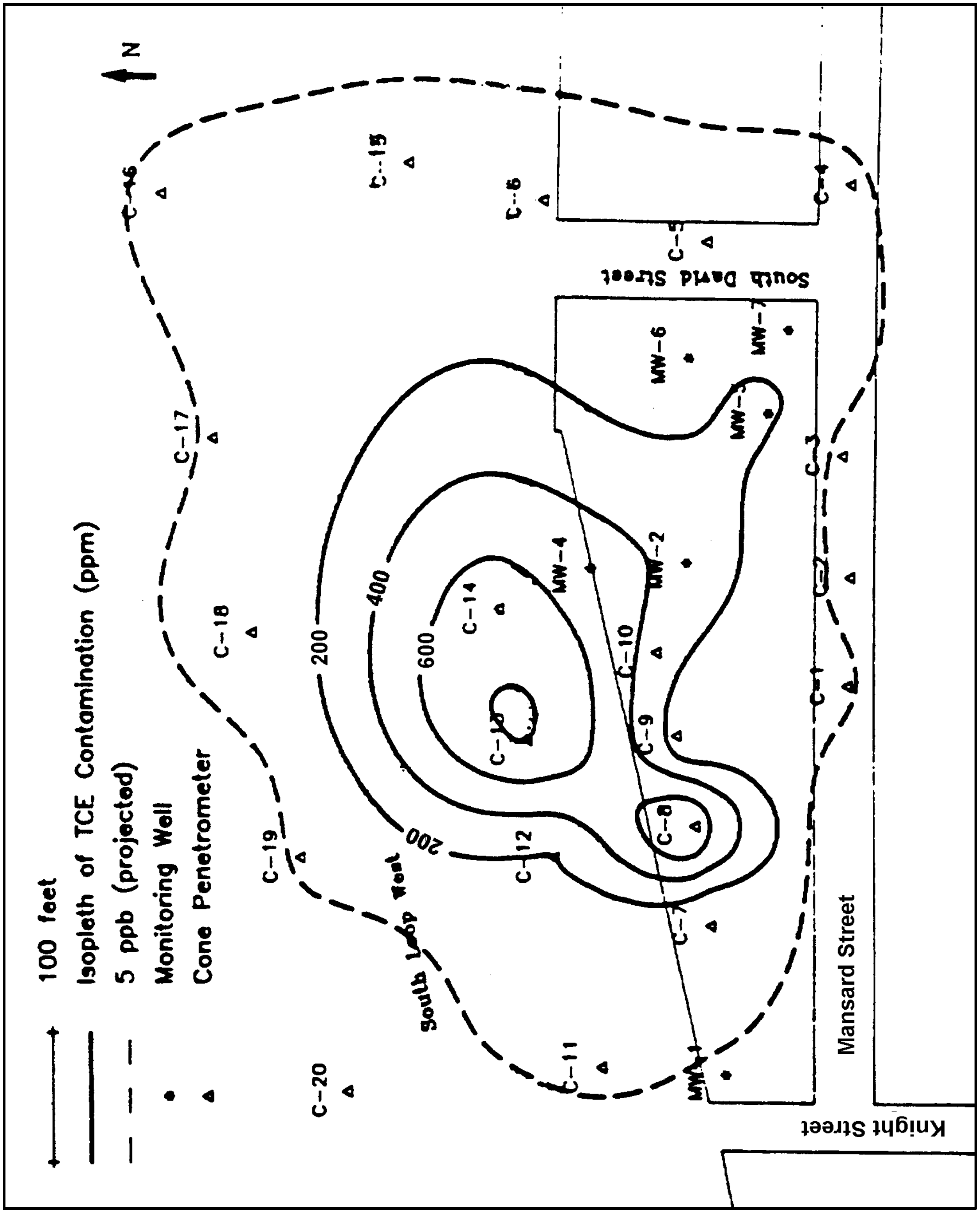

Figure 2. TCE Concentration Contours Detected in the Shallow Sand Zone (February 1991, Best Copy Available) [3]

Matrix Description (Cont.)

Tables 1 and 2 provide technical aquifer information and extraction well data, respectively.

Table 1. Technical Aquifer Information

Unit Name	Average Depth (ft)	Thickness (ft)	Conductivity (ft/day)	Average Velocity (ft/year)	Flow Direction
Silty Zone	20	5-10	3.8	10.5	Northwest
Shallow Sand Zone	35	2-12	25.5	106	Northwest
Intermediate Aquifer	80	11	0.14	NA	West

NA - The average velocity of the groundwater in the lower aquifer is not available.
Source: [2]

Treatment System Description

Primary Treatment Technology

Pump and treat with air stripping and liquid-phase carbon adsorption

Supplemental Treatment Technology

Vapor-phase carbon adsorption

System Description and Operation [3, 4, 20]

Table 2. Extraction Well Data

Well Name	Unit Name	Depth (ft)	Design Yield (gal/min)
SZE-1 through SZE-5	silty zone	25	0.5-5.0
SZR-1 through SZR-2	silty zone	25	0.5-5.0
SZER-1 through SZER-5	silty zone	25	0.5-5.0
SE-1 through SE-6	shallow sand zone	40	3-10
SR-1 through SR-7	shallow sand zone	40	3-10
IE 1	intermediate aquifer	92	3-10

Note: Extraction well designations end in “E,” recharge well designations end in “R.”

Source: [2]

TREATMENT SYSTEM DESCRIPTION (CONT.)

System Description and Operation (Cont.)

System Description [6]

- The recovery system is designed to maintain hydraulic control over the contaminant plume. The system includes five wells in the silty zone, six wells in the shallow sand zone, and one well in the lower aquifer, as listed in Table 2. Eight of the 12 wells are located across the centerline of the plume along the site's northern boundary. This placement serves to intercept contaminated groundwater as it moves across the site and to draw back the off-site plume. The remaining extraction wells in the upper aquifer are installed in the silty zone along or near the center line of the plume. The single extraction well installed in the intermediate aquifer is placed near the center of the plume.

- A groundwater model, MODFLOW, was used to identify well placement and extraction rates. The possibility of ground settlement as a result of dewatering in the silty zone supported the use of a groundwater model for well placement and designing extraction rates.

- Groundwater treatment consists of air stripping and carbon polishing. To minimize fouling in the air stripper packing, an iron filter and pH adjustment unit were installed up stream of the air stripper. The iron filter consists of two parallel tanks filled with Pyrolox media. Hydrochloric acid is added to lower the pH to inhibit the formation of mineral salts in the stripper.

- The 15 foot high, 36 inch diameter air stripper tower is filled with polypropylene packing. The air stripper removes the majority of the volatile organic contaminants in the water.

- After air stripping, liquid-phase carbon absorption is used to remove the remaining volatile and nonvolatile organic contaminants in the water. Two activated carbon adsorption columns are operated in series; each contains 80 cubic feet of activated carbon.

- Filters remove suspended solids above 0.45 micron size from the treated groundwater prior to recharge or on-site release.

- The secondary treatment system consists of activated carbon adsorption of the volatile organic contaminants in the off gas from the air stripper. Two activated carbon columns are operated in series; each holds 60 cubic feet of activated carbon.

- The groundwater reinjection system consists of 14 recharge wells, seven wells in the silty zone and seven wells in the shallow sand zone. Groundwater was designed to be reinjected at approximately 60 gpm, which is consistent with the design extraction rate.

- The groundwater monitoring system consists of 20 monitoring wells: five wells in the silty zone, eight wells in the shallow sand zone, and seven wells in the intermediate zone.

System Operation [12, 14, 19, 20]

- Quantity of groundwater pumped from aquifer in gallons:

Volume Pumped (gallons)

Year	Silty Zone	Shallow Aquifer	Intermediate Aquifer
1993	Not available	Not available	Not available
1994	347,962	630,791	2,858,755
1995	744,024	3,955,502	7,576,419
1996	113,880	1,559,517	2,256,088

Source: [14]

- The remedial action strategy at this site employed a two-phase approach. During Phase I, groundwater was extracted from the silty and intermediate zones. Treated groundwater was discharged to the local publicly owned treatment works (POTW). This pumping strategy was intended to reduce or eliminate contamination migration from the silty zone into the shallow zone. The Phase II pumping strategy shifted extraction to the shallow and the

TREATMENT SYSTEM DESCRIPTION (CONT.)

System Description and Operation [3, 4, 20]

intermediate zones. Treated groundwater was recharged through seven silty zone and seven shallow zone wells [4]. The decision to start Phase II operations was made based on evaluation of the contamination levels and the groundwater levels in the silty zone. The reduction in contamination levels from Phase I operations had leveled off and further reductions in the groundwater level would be unproductive [19].

- As of March 1996, the site engineer reported that system had been approximately 69% operational. More recent information on operational status was not available [12].

- The RI did not identify contamination in the Silty Zone. As a result, construction and design were altered after the later investigation of the silty zone found contamination.

- During operation, site engineers were unable to achieve design extraction rates, and pumping rates were low.

- Although remediation is not complete, the site engineers shut down the extraction system in October 1996. Extraction well pipes were leaking and fouled, and the extraction system lost plume containment.

- Currently, the site is being reevaluated. Aquifer usage, alternative remedial actions, and plume boundaries are being examined. The redesign for the piping system and electrical distribution system was completed in January 1998 and the bid was opened in April 1998 [20].

Operating Parameters Affecting Treatment Cost or Performance

The groundwater extraction rate is the major operating parameter affecting cost or performance for this technology. Table 3 presents the values for all performance parameters.

Table 3: Performance Parameters

Parameter	Value
Average Pump Rate	8 gpm*
Effluent Performance Standard (POTW and Recharge)	TCE (5 ppb)
Cleanup Goal	TCE (5 ppb)
Air Emission Limit	TCE (0.4 lbs/hr)

Source: [1,6]
*Based on 13 million gallons of groundwater pumped and a 69% operation rate over three years.

TREATMENT SYSTEM DESCRIPTION (CONT.)

Timeline

Table 4 presents a timeline for this remedial project.

Table 4: Project Timeline

Start Date	End Date	Activity
9/23/88	---	Record of Decision approved
6/22/89	8/26/92	Design of remediation system
8/92	10/93	Remedial construction
10/8/93	---	Begin Phase I Remedial Operations
10/12/94	---	Begin Phase II Remedial Operations
10/96	ongoing	Site shutdown for redesign

Source: [1, 2, 11]

TREATMENT SYSTEM PERFORMANCE

Cleanup Goals/Standards [1]

The remedial goal for TCE in the groundwater is the maximum concentration limit (MCL) of 5 µg/L, set under the Safe Drinking Water Act. This goal must be met throughout all aquifers.

Treatment Performance Goals [3, 4]

- The goal of the extraction system is hydraulic containment of the plume.
- The performance goal for the treatment system is to meet the effluent standard of 5 ppb for TCE in recharge.
- The air emission limit from the vapor phase carbon filter is 0.4 lbs/hr, or 30 ppmv, for TCE as measured at the vent stack.

Performance Data Assessment [8, 14, 15, 16, 19, 20]

- After two years of operation, concentrations of TCE in most areas of the plume remained above remedial goals; overall concentrations in the lower aquifer have been below goals but exceeded goals on a periodic basis [15].
- Figure 3 shows TCE concentrations in the silty zone wells from August 1994 to October 1996. These data show that average TCE concentrations in the silty zone declined in all wells. However, the decline varied from well to well, and by October 1996, TCE levels in the silty zone still exceeded 100,000 µg/L in two of these wells. In three wells, concentrations had dropped below 70,000 µg/L, with the lowest concentration recorded at 32,650 µg/L [15].
- Figure 4 presents TCE concentrations in shallow sand zone wells over the same period. During the first three months of Phase II operations (beginning October 1994) TCE concentrations rose in four of the five wells, including rapid increases in SE-3 and SE-4. In December 1994,

concentrations in SE-4 had risen to more than 500,000 µg/L. However, by late 1995 and early 1996, a discernable downward trend emerged. By October 1996, concentrations in the two shallow zone wells with the highest levels of TCE remained in excess of 200,000 µg/L while concentrations in SE-1 and SE-2 were 136 µg/L and 2,920 µg/L, respectively [15].

- Figure 5 shows TCE concentrations in the single intermediate aquifer well from August 1994 to October 1996. Over much of this period, TCE concentrations remained below the remedial goal of 5 µg/L, with the exception of short periods in the late summer of 1994 and 1996, when concentrations increased to 34 µg/L and 72 µg/L, respectively [14].

- Concentrations of contaminants increased in the lower aquifer and the newly discovered sandy layer after pumping began, indicating connectivity between the shallow zone and these layers.

- Hydraulic containment of the plume has not been achieved, according to the TNRCC manager [16].

- Influent concentrations of TCE were consistently reduced by the treatment system to levels below the 5 µg/L remedial goal [15].

- Concentrations of TCE in air emissions have not exceeded the 0.4 lb/hr limit specified in the air permit during remedial operations [16].

- Figure 6 presents the removal of contaminants through the treatment system from 1993 to 1996. Over this period, the pump and treat system has removed approximately 4,960 pounds of contaminant mass from the groundwater [8]. Contaminant removal rates reported in annual performance reports have fluctuated; however, the trend of the contaminant removal rate declines from 7.1 lbs/day in July 1995 to 1.8 lbs/day in October 1996 [8].

- From 1993 to 1996, a total of 13 million gallons of groundwater were treated. Taking into account the hours of system operation, the average treatment rate is 12,000 gpd [8].

Performance Data Completeness

- Contaminant mass removal information is available in monthly reports for the period December 1993 through October 1996. Figure 6 incorporates these data.

- Water level measurements and influent concentrations were collected on a biweekly basis over the period from December 1993 through October 1996.

- Groundwater concentration data were available for all extraction wells and five silty zone recharge wells for the period August 1994 through October 1996. These data were used to calculate the three-month rolling averages shown in Figures 3 through 6. A rolling average was used to smooth out for graphical purposes the extreme variation present in the monthly data.

Performance Data Quality

The QA/QC program used throughout the remedial action met the EPA and the State of Texas requirements. All monitoring was performed using EPA-approved methods, and the vendor did not note any exceptions to the QA/QC protocols.

TREATMENT SYSTEM PERFORMANCE (CONT.)

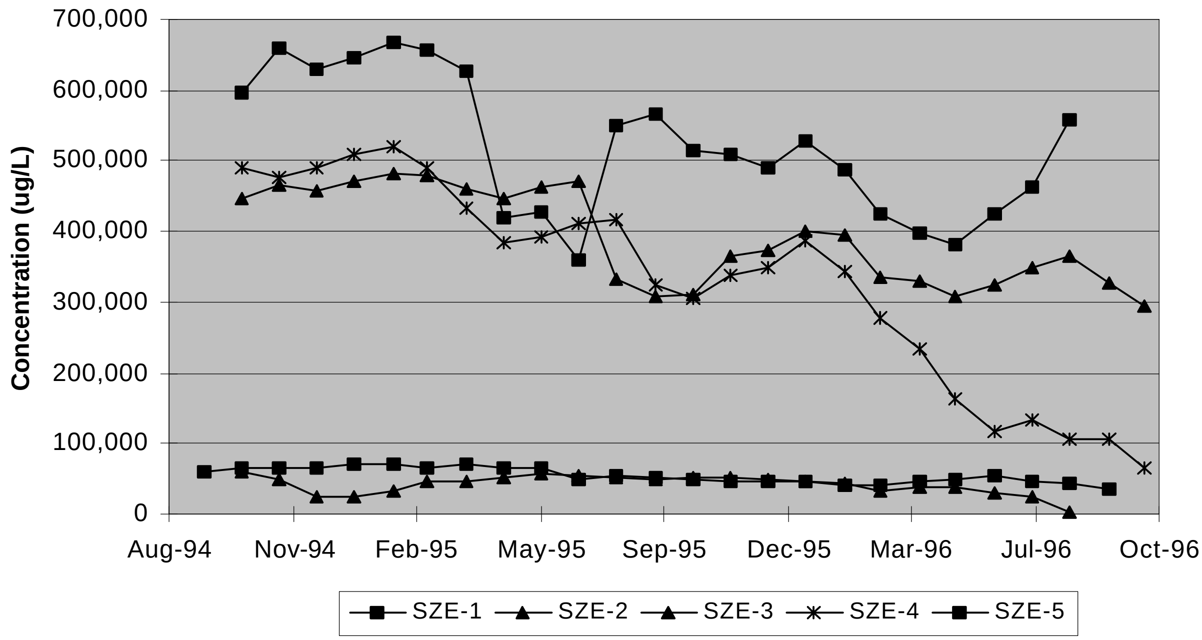

Figure 3. TCE Concentrations in Silty Zone Wells (August 1994 - October 1996) [15]

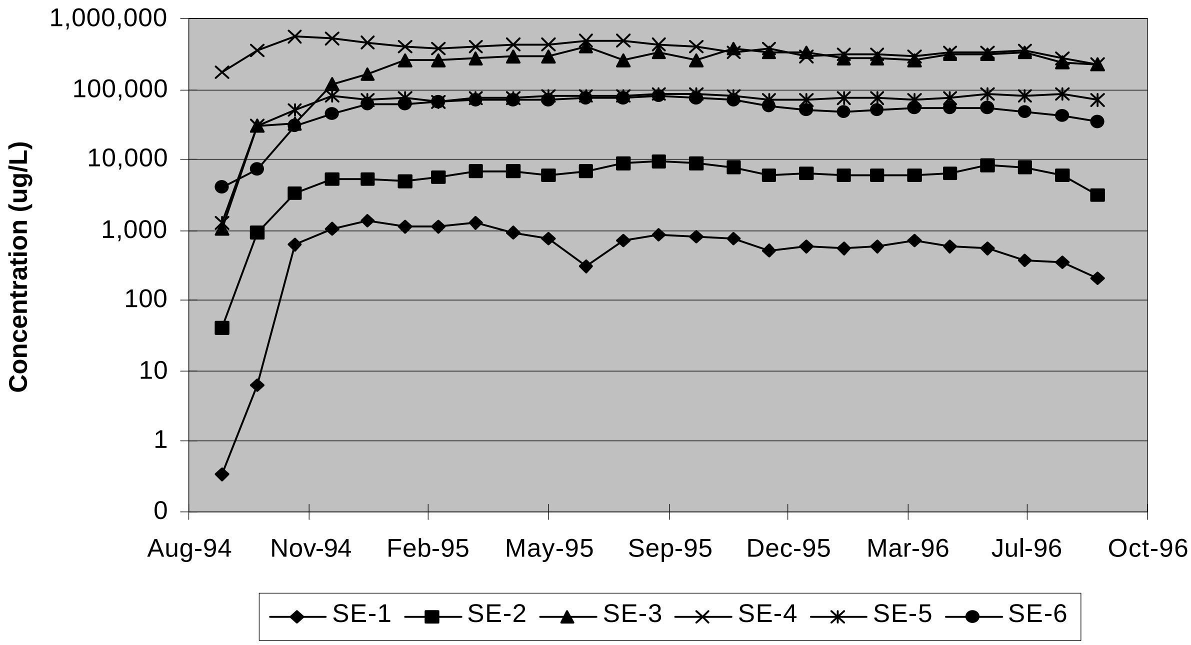

Figure 4. TCE Concentrations in Shallow Zone Wells (August 1994 - October 1996) [15]

TREATMENT SYSTEM PERFORMANCE (CONT.)

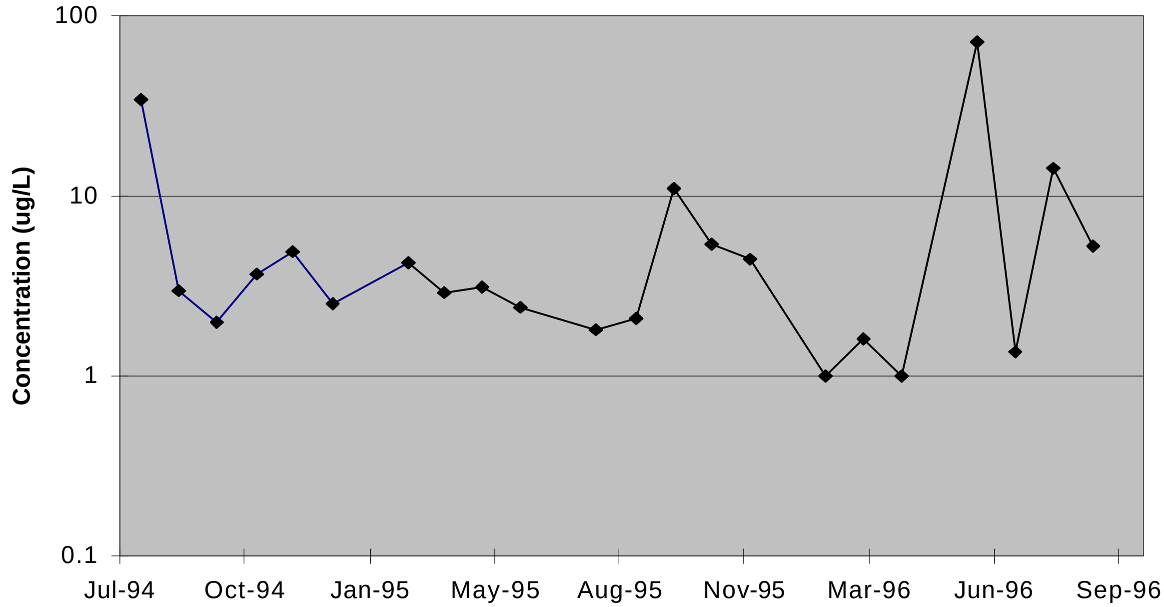

Figure 5. TCE Concentrations in Intermediate Zone Wells (August 1994 - September 1996) {15}

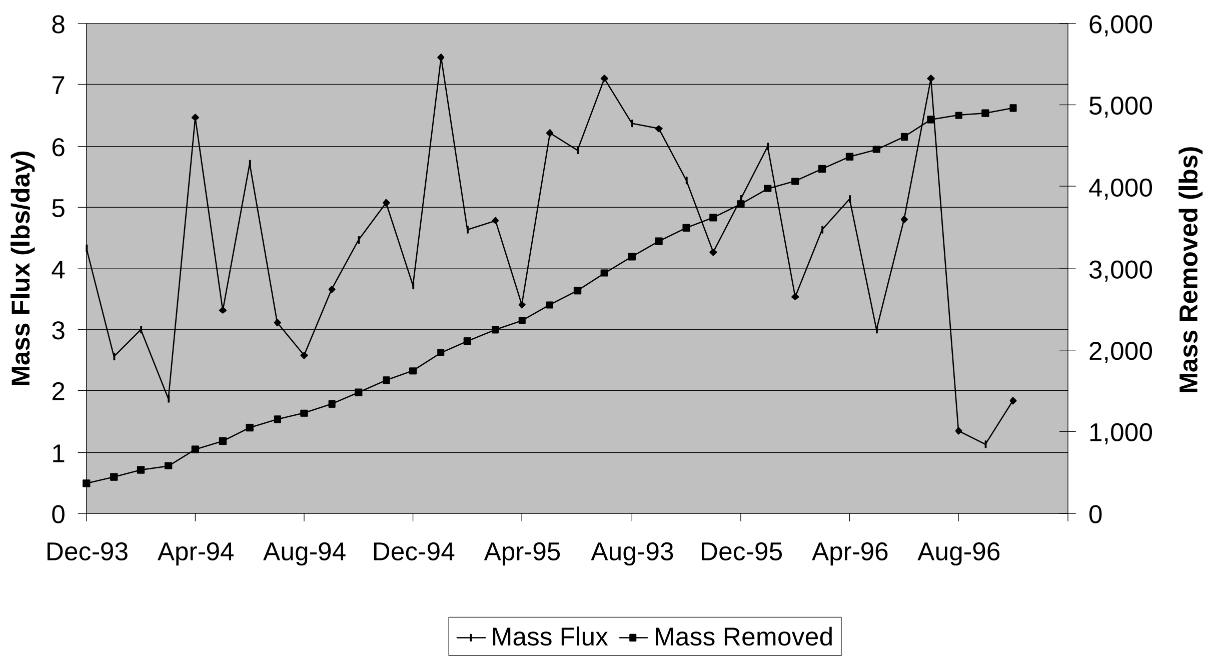

Figure 6. Mass Flux Rate and Cumulative Containment Removal (December 1993 - October 1996) [15]

TREATMENT SYSTEM COST

Procurement Process

Texas Natural Resource Conservation Commission is the lead at this site. Radian International LLC (formerly Radian Corporation) is responsible for oversight of the Sol Lynn site. Maxim Technologies, Inc., was the installation, startup, and operation contractor through April 1997. (Maxim Technologies, Inc. was previously operated as Huntingdon Engineering and Environmental, Inc. and as Southwest Laboratories, Inc.)

Cost Analysis

All costs for investigation design, construction and operation of the treatment system at this site were shared by EPA and the TNRCC.

Capital Costs [9,11,14]

Remedial Construction	
Mobilization and Preparatory Work	$351,275
Monitoring, Sampling, Analysis	$8,759
Fences, Gates, etc.	$26,106
Groundwater Collection and Control	$712,971
Treatment System	$359,526
Site Security	$58,941
Construction Management and Engineering	$348,446
Other	$238,886
Total Remedial Construction	**$2,104,910**

Operating Costs [14]

1993 Operations and Maintenance Costs	$59,443
1994 Operating and Maintenance Costs	$173,517
1995 Operating and Maintenance Costs	$123,511
1996 Operating and Maintenance Costs	$86,006
Total Cumulative Operating Costs	**$442,477**

Other Costs [10]

Remedial Investigation	**$750,030**
Remedial Design	
Design	$490,490
Analytical	$7,016
TNRCC Review	$4,300
Technical Support	$102,452
Total Design	**$614,305**
EPA Oversight	$114,446

Cost Data Quality

Actual capital and operations and maintenance cost data are available from TNRCC and Radian International for this application.

OBSERVATIONS AND LESSONS LEARNED

- Total actual cost to date for the pump and treat system at the Sol Lynn/Industrial Transformers site was $2,547,387 ($2,104,910 in capital and $442,477 in operations and maintenance), which corresponds to $196 per 1,000 gallons of groundwater treated and $514 per pound of contaminant removed [14].

- The treatment system has removed 4,960 pounds of volatile organic compounds from the groundwater over three years. However, after two years of pump and treat system operation at Sol Lynn, TCE concentrations remain above the remedial goal of 5 µg/L. Data from the silty and the shallow sand zones show concentrations above 100,000 µg/L. While TCE concentrations in the intermediate aquifer have generally remained below the remedial goal, concentrations increased above the goal during the summer of 1996 [15].

OBSERVATIONS AND LESSONS LEARNED (CONT.)

- Monthly sampling in monitoring wells downgradient of the capture zone showed an increase in TCE concentrations in groundwater after August 1996, indicating that the plume had extended beyond the capture zone. Therefore, the system was shut down in October 1996 for redesign. System redesign was completed in January 1998. Further plume delineation was being performed at the time of this report [15, 16].
- The site characterization performed during the RI did not identify silty zone contamination. As a result, problems were encountered with the original design. The design and construction had to be modified after the Remedial Design was completed [2].

REFERENCES

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2. ITS Remedial Action Interim Report, Volume 1. Radian Corporation. February 1995.
3. Feasibility Study Report Phase II. Radian Corporation. 1994.
4. Field Investigation of the Silty Zone Report. Radian Corporation. 1992.
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10. Remedial Design Phase Invoice History. Radian Corporation. 1989-1991.
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12. Personal Communication with James Sher, TNRCC, June 17, 1997.
13. Personal Communication with John Kovski, Radian Corporation, June 3, 1997.
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15. Monthly Reports. Radian Corporation. August 1994 to November 1996.
16. Personal Communication with James Sher, TNRCC. April 11, 1997.
17. Personal Communication with James Sher, TNRCC. November 20, 1997.
18. Sol Lynn Site Facts Sheet, EPA Region 6. March 31, 1998.
19. Comments on draft report provided by John Kovski, Radian International LLC, June 1998.
20. Comments on draft report provided by James Sher, TNRCC, June 1998.

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 Eastern Research Group, Inc. and Tetra Tech EM, Inc. under EPA Contract No. 68-W4-0004.

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