COST AND PERFORMANCE REPORT

Pump and Treat and Permeable Reactive Barrier to Treat Contaminated Groundwater at the Former Intersil, Inc. Site Sunnyvale, California

September 1998

Prepared by:

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

SITE INFORMATION

Identifying Information:

Former Intersil, Inc. Site
Sunnyvale, California

CERCLIS #: Not Applicable (NA)

ROD Date: NA, not a CERCLA Site
Site Cleanup Requirements Order:
October 15, 1986

Treatment Application:

Type of Action: State cleanup

Period of operation:
Pump and treat (P&T) system: 11/87 - 2/95
Permeable Reactive Barrier: 2/95 - Ongoing
(Data on performance collected through November 1997)
(Cost data and data on mass removal collected through November 1996)

Quantity of material treated during application: 38 million gallons of groundwater
(36 million gallons through a P&T system)
(2 million gallons through treatment wall as of November 1996)

Background

Historical Activity that Generated Contamination at the Site: Semiconductor manufacturing

Corresponding SIC Code: 3674
(Semiconductors and Related Devices)

Waste Management Practice That Contributed to Contamination: Leakage from subgrade neutralization system

Location: Sunnyvale, California

Facility Operations: [2,3]

- Intersil operated at the site as a semi-conductor manufacturer from the early 1970s until 1983. In 1983, the facility shut down and was used to warehouse office equipment and surplus supplies. The site is currently owned by Sobrato Development Company. The site was released to another tenant in 1995.

- In 1972, Intersil installed a concrete, epoxy-lined, in-ground acid neutralization system at the facility to neutralize wastewater before discharge to a sanitary sewer.

- In 1982, the California Regional Water Quality Control Board (RWQCB) requested shallow groundwater and soil sampling near the neutralization holding tank. Investigations performed on behalf of Intersil identified halogenated volatile organic compounds (VOCs) as the main contaminant in the shallow groundwater beneath the site. In 1985, at the request of the RWQCB, further investigations were performed at the site. Intersil found halogenated VOC contamination in the soil beneath the site. Further soil and groundwater investigations performed in 1986 indicated a potential contaminant source was in the area of the neutralization holding tank. An unknown amount of contaminants was released to the soil and groundwater.

- In January 1987, Intersil inactivated the neutralization holding tank and removed it along with the associated contaminated soil. Further investigation of the soil and groundwater beneath the site was performed by Geomatrix on behalf of Intersil in 1987 and 1988, including the installation of an extraction well in the former tank area. Groundwater surveys were also performed by Western Microwave, Inc. (WM), at the property east of Intersil. These surveys identified VOC contamination at the WM facility. Groundwater extraction and treatment through an air stripper began at the Intersil site in November 1987 as an interim corrective action.

SITE INFORMATION (CONTINUED)

Background (Cont.)

- The extraction system was expanded in 1989 and again in 1991.
- An alternative remedy, a permeable reactive barrier (PRB), was installed and completed in February 1995 to replace the P&T system. PRBs are also referred to as *in situ* treatment walls for the purposes of this report.

Regulatory Context:

- Site activities are regulated by the RWQCB. Site activities during operation of the P&T system were conducted under provisions of two Waste Discharge Requirements (WDR) Orders for the site: Site Cleanup Requirements (SCR) Order dated October 15, 1986 for groundwater cleanup and a NPDES permit issued August 19, 1987. The initial NPDES Permit was replaced by General NPDES Permit No. 94-087 dated July 20, 1994.

Remedy Selection: Following seven years of a P&T application, a PRB, or *in situ* treatment wall, was selected as a final remedy for groundwater remediation because of its lower maintenance requirements, and because it allowed Intersil to transfer the lease [2].

Site Logistics/Contacts

Site Lead: PRP

Oversight: State

State Contact:
Habte Kifle*
RWQCB
2101 Webster Street, #500
Oakland, California 94612
510-286-0467

Scott Warner
Geomatrix
100 Pine St., 10th Fl.
San Francisco, CA 94111
415-434-9400

*Indicates primary contact

Treatment System Vendor:
Construction Prime: Geomatrix Consultants, Inc.
General Contractor: Inquip
Treatment Technology: EnviroMetal (Treatment Wall)
Treatment Technology (Pump and Treat)
Reidel Environmental Services/Delta Cooling Towers
Operations Contractor: Geomatrix Consultants, Inc.

PRP:
Deborah Hankins, Ph.D.
Intersil, Inc.
114 Sansome St., 14th Fl.
San Francisco, CA 94104
415-274-1904

MATRIX DESCRIPTION

Matrix Identification

Type of Matrix Processed Through the Treatment System: Groundwater

Contaminant Characterization [1, 2]

Primary Contaminant Groups: Halogenated volatile organic compounds (VOCs)

- The contaminants of concern at the site are trichlorethene (TCE), *cis*-1,2-dichloroethene (*cis*-1,2-DCE), vinyl chloride (VC), and

MATRIX DESCRIPTION (CONTINUED)

Contaminant Characterization (Cont.)

Freon-113. The maximum concentrations initially detected at the site during the 1986 shallow groundwater survey were TCE at 13,000 µg/L, *cis*-1,2-DCE at 19,000 µg/L, VC at 1,800 µg/L, and Freon-113 at 16,000 µg/L. Contamination has only been detected in the upper aquifer (A-zone).

- The source of the contamination is the former in-ground neutralization system, located east of the on-site building. However, groundwater survey data from wells installed at adjacent facilities reveal that the adjacent property, WM, has released tetrachloroethene (PCE) and other chemicals to the soil and groundwater. Intersil is cross- and down-gradient of WM. Geomatrix, the PRP's contractor, found that the distribution of VOC contamination at the Intersil facility did not change significantly from 1986 to 1993. However, documents maintained at the RWQCB show that VOC concentrations increased at the WM facility from 1986 to 1993.

- Figure 1 depicts the concentration contours of TCE detected during the 1986 shallow groundwater survey by Geomatrix in the A-zone (upper aquifer) at the Intersil site. The plume hot spots are north and northwest of the suspected source.

- Based on the 1986 contour map shown in Figure 1, an average aquifer thickness of four feet, and a porosity of 0.30, the initial contaminant plume was estimated for this report to be approximately 2.4 acres in surface area with a volume of approximately 933,730 gallons. No additional information on the size of the initial plume was available in references.

Matrix Characteristics Affecting Treatment Costs or Performance

Hydrogeology: [1,2]

Two distinct hydrogeological units have been identified beneath this site.

Unit 1	A-zone	The A-zone unit is a semiconfined aquifer that ranges in thickness from eight feet to less than one foot, with a general thickness in the area of the site of two to four feet. It is composed of interfingering zones of silty fine-grained sand, fine- to medium-grained sand, and gravelly sand. The geometry of the aquifer is irregular, with a local presence of clay lenses. The A-zone unit is mostly confined by an upper silty-clay and clay layer ranging from nine to 12 feet thick in the area of the site and by a lower aquitard of clay and silty clay, which is approximately 65 feet thick in the vicinity of the site. The A-zone aquifer is generally not usable for consumption due to a high level of total dissolved solids. Groundwater flow is northerly.
Unit 2	B-zone	The B-zone has not been fully penetrated by soil borings, and no contamination has been detected in this zone. It is separated from the A-zone by the 65-foot thick aquitard of clay and silty clay. Based on characteristics of the aquitard, and an upward vertical hydraulic gradient contaminated groundwater from the A-zone is not expected to migrate to the B-zone.

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

MATRIX DESCRIPTION (CONTINUED)

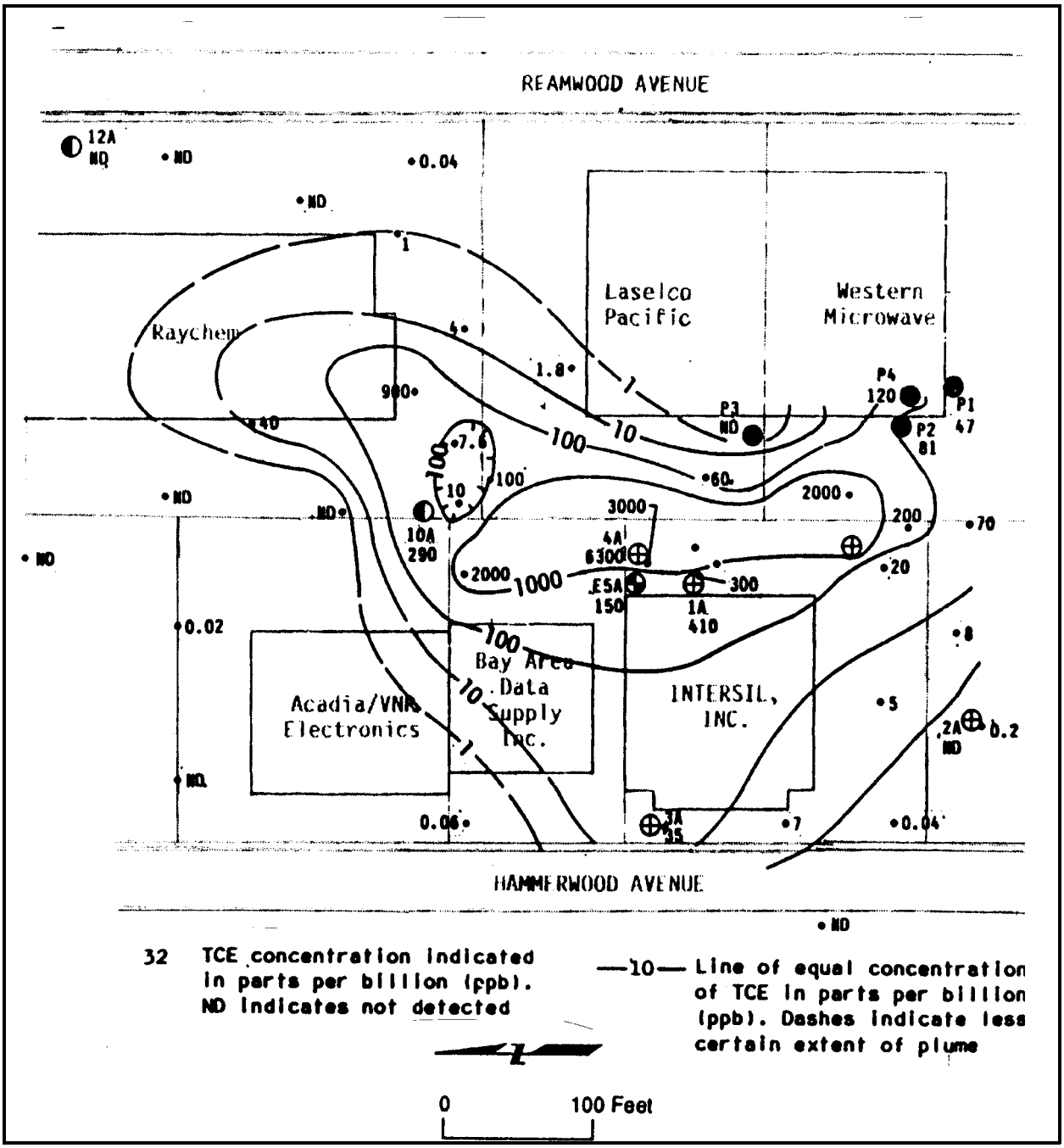

Figure 1. Estimated Distribution of TCE in the A-zone Aquifer Detected During 1986 Shallow Groundwater Survey (Best Copy Available) [1]. (The former neutralization system was located south of monitoring well 1A, along the eastern edge of the on-site building)

MATRIX DESCRIPTION (CONTINUED)

Matrix Characteristics Affecting Treatment Costs or Performance (Cont.)

Table 1. Technical Aquifer Information

Unit Name	Thickness (ft)	Transmissivity (ft^2/day)	Average Flow Rate (ft/day)	Flow Direction
A-zone	1-8 feet	370.0	0.8	Northwest to Northeast
B-zone	Not Characterized	Not Characterized	Not Characterized	Not Characterized

Source: [1]

TREATMENT SYSTEM DESCRIPTION

Primary Treatment Technology

Pump and treat with air stripping (1987 until 1995); Permeable Reactive Barrier (PRB) (1995 to present)

Supplemental Treatment Technology

Liquid-phase carbon adsorption (1987 until 1995, associated with the P&T system)

System Description and Operation [2,9,12,15,16]

Table 2. Technical Well Data

Well Name	Unit Name	Depth (ft)	Design Yield (gpm)
E7A	A-zone	18	6
E14A	A-zone	18	6
E15A	A-zone	18	6
E18A	A-zone	18	6

Source: [1,4-12,13]

System Description

- The original extraction system operated from 1987 until 1995. The system, initially one extraction trench well, was expanded to include three extraction wells; the system was then expanded to three extraction and one trench wells. The treatment system consisted of an air stripper. In addition, two carbon adsorption units were installed as backup if needed; however, these units were never used. Treated water was discharged to an on-site storm sewer under an NPDES permit. The stripper tower was three feet in diameter and designed to handle a maximum flow of 40 gpm. Treated water was discharged to a storm sewer.
- The PRB, or *in situ* treatment wall system, completed in 1995, consists of a granular iron treatment zone and hydraulic barrier system. The components are two slurry walls, permeability zones upgradient and downgradient of the treatment wall, and the treatment wall. Technical wall design data, including design transmissivity, are listed in Table 3. Figure 2 illustrates the plan view of the treatment wall system located at the northeast corner of the property, downgradient of the suspected on-site source area.

TREATMENT SYSTEM DESCRIPTION (CONT.)

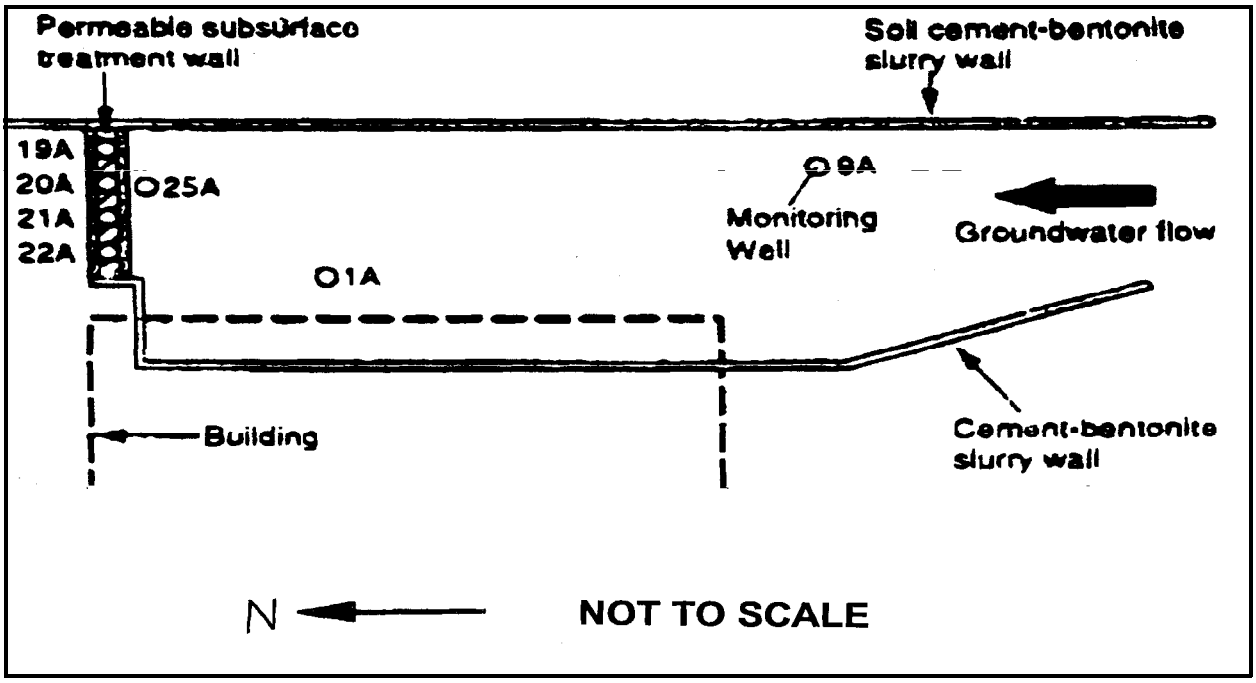

Figure 2. Plan View of the Treatment and Slurry Wall System (Best Copy Available) [16]

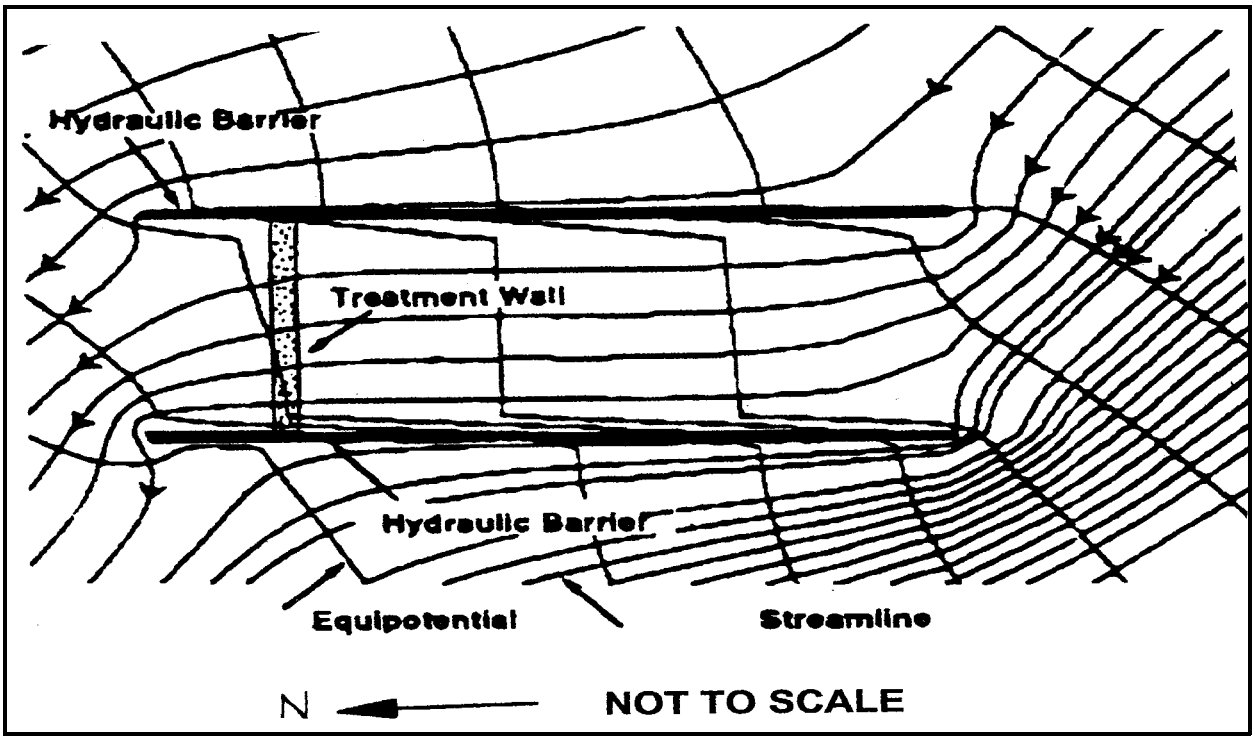

Figure 3. Example of Groundwater Flow Modeling of the Treatment and Slurry Wall System (Best Copy Available) [16]

TREATMENT SYSTEM DESCRIPTION (CONT.)

System Description and Operation (Cont.)

Table 3. Technical Wall Data - Design Parameters

Unit	Flow-Through Thickness	Transmissivity[1] (ft^2/day)	Material	Vertical Thickness
Flow Control Zone	2 feet	10,000	Pea Gravel	13 feet
Treatment Wall	4 feet	1,400	Granular Iron	13 feet
Flow Control Zone	2 feet	10,000	Pea Gravel	13 feet

[1]Approximate values used for model development

Source: [4]

- The two slurry walls, 300 feet long on one side of the treatment wall and 235 feet long on the other side, route groundwater through the treatment wall. Groundwater flow through the treatment and slurry wall system was modeled by Geomatrix. Figure 3 illustrates how groundwater flows north-northwest through the funnel and through the treatment wall. Modeling also was performed for groundwater flow to the north and northeast.

- Two permeable zones are used upgradient and downgradient of the treatment zone to provide uniform velocity. The permeable zones, called flow control zones, are composed of high permeability pea gravel. The zones are two feet thick, and are the same height and width as the treatment wall.

- The treatment zone of the wall is composed of 100% granular iron which degrades the chlorinated VOCs into end products of chloride and ethylene through reductive dechlorination. The zone is 4 feet thick, approximately 40 feet wide, and approximately 13 feet high.

- During the P&T system operation, groundwater quality was monitored through a network of 17 wells: 13 monitoring wells and up to four extraction wells. Water table levels were monitored through the wells and three piezometers.

- During the operation of the current treatment wall, the groundwater quality has been monitored through a network of 13 wells. Six monitoring wells were installed within the treatment wall; one additional was installed just upgradient of the treatment wall to measure its performance. The other seven monitoring wells are the same monitoring wells used during the P&T system operation. Water table levels are monitored through a network of 14 piezometers in addition to the 13 monitoring wells.

System Operation

- Quantity of groundwater treated:

Year	Average Volume Pumped (gal/day)	Treatment System
1987-1992	25,000,000[1]	P&T
1993-1994	10,659,465[1]	P&T
1995-1997	2,361,776[2]	Treatment Wall

[1]Based on actual pumping rate through the treatment system Calculated for this report, based on average groundwater velocity of 0.94 ft/day through treatment wall (in Final Design Report [4]) and dimensions of 40 feet wide and 13 feet high [6].

- The *in situ* treatment wall is operational 100% of the time. The P&T system was operational approximately 98% of the time.

- The extraction system was modified over the life of the P&T system from one trench well to three extraction wells and a trench well. Details on extraction well construction and use are specified in Table 5, Timeline.

TREATMENT SYSTEM DESCRIPTION (CONT.)

System Description and Operation (Cont.)

- In 1993, Intersil examined alternative groundwater remediation technologies to evaluate cost-effective alternatives. One goal was to minimize the cost of treatment while increasing the treatment effectiveness, given that the mass removal by the P&T system had asymptotically declined. Another goal was to return the site to leasable/sellable conditions. According to Intersil, as long as the P&T system was operating at the site, the company would have to continue to lease the site to provide for power and space for the system.

- The selected alternative approved by the RWQCB was an *in situ* granular iron treatment wall system, followed by shutdown and removal of the P&T system. Construction of the iron treatment wall was completed and the P&T system was shut down in February 1995.

- Groundwater is routed to the treatment wall by the two slurry walls which are keyed into the confining clay layer. The treatment wall is keyed into the slurry walls on the eastern and western ends and into the confining lower layer at the bottom. Groundwater flow varies from the northwest to the north on site. The low permeability slurry walls help provide uniform flow direction and velocity through the wall. In addition, the flow control zones provide uniform velocity.

- Pilot-scale studies and canister studies were performed by EnviroMetal, Inc., the treatment wall vendor, and Geomatrix to determine the required residence time to fully degrade the halogenated VOCs. VC was determined to take the longest time to degrade, with a required residence time of approximately two days in the wall, to reduce site concentrations to cleanup standards. Therefore, the full-scale iron treatment wall was designed based on a 4-foot flow through thickness and a maximum velocity of 1.2 feet per day, to provide a groundwater residence time greater than the required two days.

- In August 1995, the eastern slurry wall was determined by Geomatrix to be leaking. The cause of the leak was believed by Geomatrix to be damage from construction by others at the eastern adjacent WM facility and from pumping at the WM P&T system. The slurry wall was repaired in December 1995 by injecting grout into the ground adjacent to the wall. Eleven piezometers were added to monitor the effect of the WM extraction system, resulting in the current total network of 14 piezometers. Monitoring data since December 1995 indicate the slurry wall has been functioning properly.

TREATMENT SYSTEM DESCRIPTION (CONT.)

Operating Parameters Affecting Treatment Cost or Performance

The major operating parameters affecting cost or performance for the treatment wall and the P&T system are residence time and extraction rate, respectively. Table 4 presents the values measured for each.

Table 4. Performance Parameters

Parameter	Value
Actual Average Extraction Rate (P&T)	8 gpm
Average Flow Rate through Treatment Wall	2.5 gpm
Minimum Required Residence Time (Treatment Wall)	2 days
Approximate Residence Time	At least 3 days
Performance Standards for P&T NPDES Requirements (Effluent)	TCE: 5.0 µg/L *cis*-1,2-DCE: 5.0 µg/L VC: 0.5 µg/L Freon-113: 5.0 µg/L
Performance Standard for Treatment Wall California and EPA Maximum Contaminant Levels (MCL)	TCE: 5.0 µg/L *cis*-1,2-DCE: 6.0 µg/L VC: 0.5 µg/L Freon-113: 1,200 µg/L
Remedial Goal for P&T, in µg/L (aquifer)	California and EPA MCLs (same as Performance Standard for Treatment Wall)
Remedial Goal for Treatment wall, in µg/L	California and EPA MCLs (same as Performance Standard for Treatment Wall)

Source: [1,2]

Timeline

Table 5 presents a timeline for this remedial project.

Table 5. Project Timeline

Start Date	End Date	Activity
10/15/86	---	Site Cleanup Requirements (SCR) order issued
01/87	---	Inactive in-ground neutralization system and approximately 50 yd^3 of surrounding contaminated soil excavated under the direction of the RWQCB, first extraction well installed, monitoring of groundwater begun
11/87	---	Approximately 108 yd^3 of contaminated soil excavated from northeast corner of site, extraction of groundwater and treatment through air stripper begun as RWQCB approved interim measure
11/89	---	Groundwater extraction system expanded to three wells, and 11 monitoring wells installed
12/91	---	Fourth, temporary extraction well installed
02/92	12/92	Groundwater extracted through temporary extraction well
11/94	---	Installation of treatment wall initiated
02/95	---	Treatment wall installation completed, P&T system shut down
8/95	12/95	Low water levels observed near eastern slurry wall, 11 piezometer network installed and eastern slurry wall
1/96	---	Slurry wall repaired

Source: [1,2,6,15]

TREATMENT SYSTEM PERFORMANCE

Cleanup Goals/Standards

The cleanup goal for the site is to reduce concentrations of TCE, *cis*-1,2-DCE, VC, and Freon-113 to levels below the MCL set by the State of California and Primary Drinking Water Standards. The required cleanup levels are listed above in Table 4 and are applied throughout the aquifer, as measured in all on-site monitoring wells [1].

Treatment Performance Goals

- The primary goal of the treatment system was to reduce contaminant levels in the effluent to meet NPDES requirements, listed above in Table 4 [1].
- The secondary goal of the P&T system was to contain the contaminant plume by creating an inward hydraulic gradient [1].
- The primary goal of the treatment wall is to reduce contaminant levels in groundwater passing through the wall to the cleanup goals discussed in Table 4 [15].
- The secondary goal of the treatment wall is to contain the contaminant plume upgradient of the treatment wall system by using two slurry walls to route the plume through the treatment wall [15].

Performance Data Assessment [4-16]

For this report, total contaminant concentration includes the sum of the concentrations of TCE, cis-1,2-DCE, VC, and Freon-113. Performance is described in terms of the overall progress towards the cleanup goals, based on both the P&T and treatment wall systems, then in terms of each system.

Overall Progress

- The contaminant plume size has been reduced. However, contamination remains elevated at three hotspots: upgradient of the treatment wall (wells 1A and 25A), south of the treatment wall (well 9A), and northeast of the former Intersil property (well 10A).
- Figure 4 illustrates the temporal change in average total contaminant concentrations detected during monitoring. Average total contaminant concentrations have decreased from 1,609 µg/L in 1986 to 31 µg/L in 1997, a reduction of 98%.
- The average concentration of total contaminants in the aquifer after seven years and two months of P&T system operation was 312 µg/L. The average concentration of total contaminants downgradient of the wall after one year and eight months of treatment wall system operation was 39 µg/L. In addition, the contaminant plume has been contained.
- Figure 5 presents the removal of contaminants from the groundwater treated in the P&T system annually from 1987 until 1995 and through the treatment wall system from 1995 until August 1996. By February 1995, the P&T system had removed approximately 56 kg of total contaminant mass from the groundwater. From February 1995 until August 1996, the treatment wall system had removed 7 kg of total contaminant mass from the groundwater.

TREATMENT SYSTEM PERFORMANCE (CONT.)

Performance Data Assessment (Cont.)

P&T System

- Figure 5 shows the P&T system achieved a maximum rate of total contaminant removal of close to 0.05 kg/day when operations first began in December 1987. In December 1990, the P&T total contaminant removal rate was at its lowest (0.01 kg/day). Overall, the total contaminant removal rate during P&T operation declined exponentially from the initial P&T startup.
- During the P&T system operation, the contaminant concentrations in the effluent were below standards set by the NPDES permit in Table 4.
- During the P&T system operation, the extraction system was determined by site operators to have created an inward hydraulic gradient. In doing so, the P&T system assisted in containing the plume.

Treatment Wall

- During the treatment wall system operation, the concentrations of TCE and Freon-113 in monitoring wells downgradient of the treatment wall were all below cleanup goals during quarterly sampling events from March 1995 to November 1996. Levels of *cis*-1,2-DCE and VC have been detected at up to 26 µg/L and 2.1 µg/L, respectively (compared to cleanup goals of 6.0 µg/L and 0.5 µg/L, respectively) near the WM property line.
- A P&T remediation system was installed on the WM site in May 1995. The zone of capture for that system was determined not to have affected the treatment wall. Since the treatment wall was installed, contaminant levels in wells downgradient of the wall have not increased, indicating that the plume has been contained.
- During 1995, the eastern slurry wall of the treatment wall system leaked from being damaged, but subsequent repairs worked to seal the leak.
- According to the state contact, although some levels downgradient of the wall are above cleanup levels, natural attenuation is occurring, and contaminants are not migrating further.

Performance Data Completeness [3,4-14]

- Data for the P&T system were available for December 1987 until February 1995. Data for the treatment wall system were available for March 1995 until November 1997. Concentrations of contaminants in the groundwater have been monitored quarterly since January 1987. Previously, from February 1985 until January 1987, concentrations of contaminants in the influent and effluent were monitored weekly. These data are available from the site contact in the Self Monitoring and Technical Status Reports and the NPDES Self Monitoring Quarterly Reports. For the analyses in this report, annual data were used.
- Data from all monitoring wells within the original contaminant plume identified in Figure 1 were used to calculate the mean concentration for both P&T and treatment wall systems. This includes wells upgradient of the wall. When concentrations were below detection limits, half of the detection limit was used for evaluation purposes.
- The contaminant mass removal rate by the P&T system shown in Figure 5 was determined for this report using analytical results from the treatment plant influent and effluent, along with well extraction flow rate data. The contaminant mass removal rate by the

TREATMENT SYSTEM PERFORMANCE (CONT.)

Performance Data Completeness (Cont.)

treatment wall system shown in Figure 5 was determined for this report using an estimated average linear velocity of 0.94 ft/day, dimensions of the wall, and the contaminant concentration gradient observed across the wall from February 1995 to November 1996.

- For Figure 4, a geometric mean was used for average groundwater concentrations detected in monitoring wells to show the trend across the entire plume. Annual data from 11 wells were used for the P&T system, and data from nine wells were used for the treatment wall system.

Performance Data Quality

The QA/QC program used throughout the remedial action met the EPA and the State of California requirements. All monitoring was performed using EPA-approved methods SW-846 Methods 601, 602, 624, 625, Hardness, and TDS. The vendor did not note any exceptions to the QA/QC protocols [4-13].

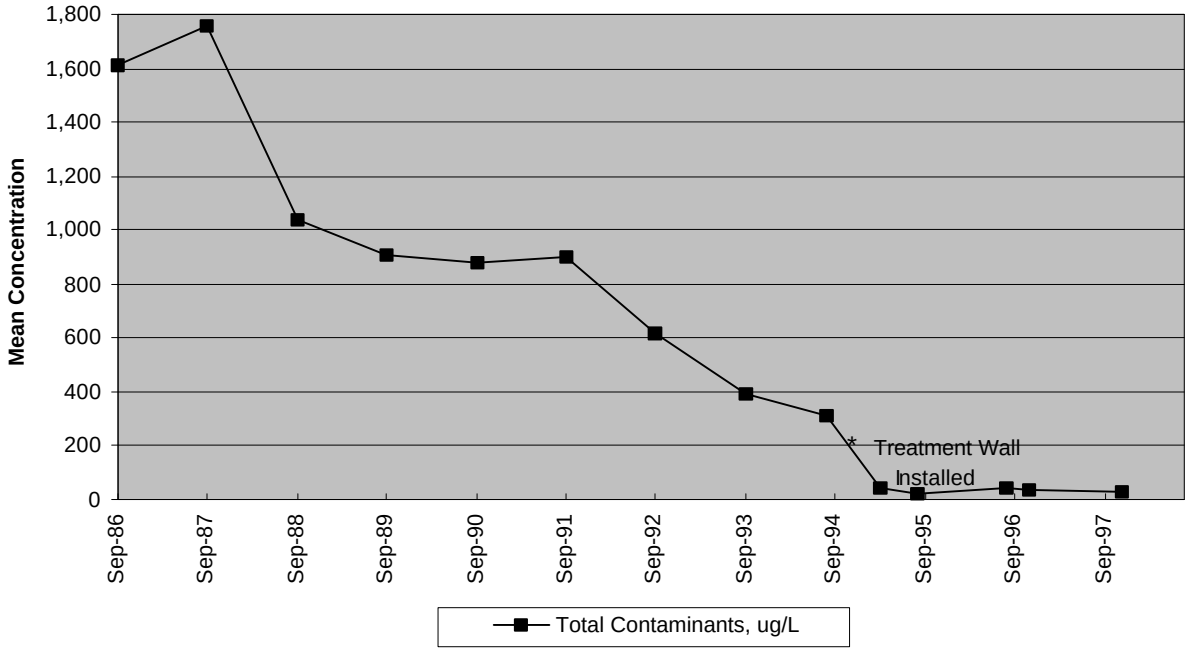

Figure 4. Total Contaminant Concentrations in the Groundwater(1987-1996) [4-13,16]

TREATMENT SYSTEM PERFORMANCE (CONT.)

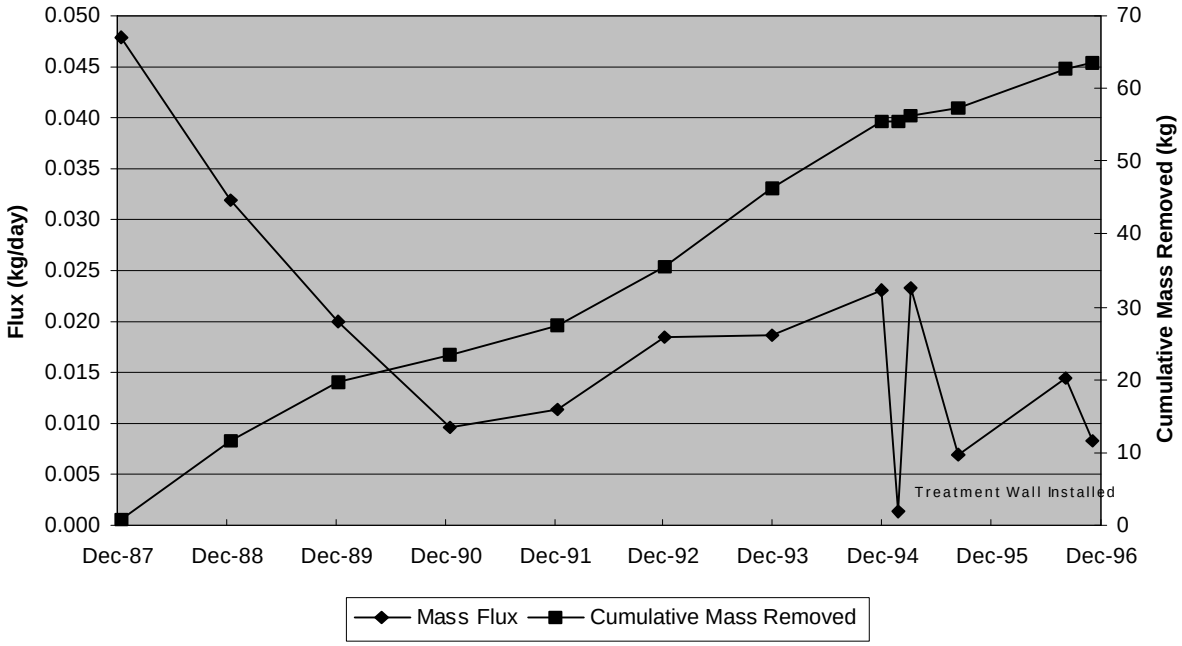

Figure 5. Total Contaminant Mass Flux and Mass Removed as a Function of Time (1987-1996) [4-13,16]

TREATMENT SYSTEM COST

Procurement Process

Intersil contracted with Geomatrix to construct and manage the on-site remediation systems. Intersil contracted with EnviroMetal, Inc. to contribute to design of the *in situ* treatment wall.

Cost Analysis

- All costs for investigation, design, construction and operation of the treatment system at this site were borne by Intersil.

Capital Costs (Estimated)

P&T Remedial Construction [1,3]	
1987 System Costs	
Extraction Well and Treatment System	$250,000
1990 System Costs	
Extraction Wells	$75,000
Total P&T Site Cost	**$325,000**
Treatment Wall Construction (1995) [2, 21]	
Slurry Walls	$178,000
Treatment Wall	$100,000
Transport/Disposal of Soil	$45,000
Treatment/Disposal of Water (dewatering)	$5,000
Site Restoration	$55,000
Demolition	$10,000
New Wells	$18,000
Permitting and Initial Sampling	$30,000
Bid and Scope Contingencies	$154,000
Total Cost Treatment Wall	**$595,000**

TREATMENT SYSTEM COST (CONT.)

Operating Costs (Estimated)

P&T System [1]

Plant Operation & Maintenance Costs (1987-1995)	$525,600
Annual NPDES Monitoring Costs	$349,200
Annual Groundwater Monitoring Costs	$144,000
Cumulative P&T Operating Costs 12/87 - 2/95	**$1,018,800**

Treatment Wall System [2, 21]

Cumulative Treatment Wall Operating Costs 2/95 - 11/96	**$167,000**

Other Costs (Estimated)

Construction Oversight (Treatment Wall)	$75,000
Engineering Design Costs	$100,000

Cost Data Quality

- The cost figures provided were based on estimates by Geomatrix, not actual vendor costs, which were not available for this site.
- The Geomatrix site contact reported that the cost estimate for the treatment wall system, including subsequent repairs, is within 10% of the actual costs incurred [17].

OBSERVATIONS AND LESSONS LEARNED

- Estimated costs for the P&T system at Intersil for the period from 1987 to 1995 were approximately $1,343,800 ($325,000 in capital construction costs and $1,018,800 in total operation and maintenance costs), corresponding to $10,900 per pound of total contaminants removed and $38 per 1,000 gallons of groundwater treated.
- Estimated costs for the treatment wall through November 1996 are approximately $762,000 ($595,000 in capital costs and $167,000 in total operation and maintenance costs) for the period from 1995 to 1996, corresponding to $38 per 1,000 gallons of groundwater treated and $108,900 per kg ($49,400/pound) of total contaminants removed.
- By using the passive, *in situ* treatment wall system, Intersil did not have to continue to lease the Sunnyvale property [17]. While this resulted in less cost to Intersil, information on specific cost savings was not provided.
- The P&T system removed 56 kg of contaminants from the groundwater over seven years; the treatment wall removed 7 kg over two years. However, cleanup goals have not yet been achieved.
- For the treatment wall to be effective, the entire contaminant plume upgradient of the wall must be routed through the wall. At the Intersil site, the plume was captured by the slurry walls and routed to the treatment wall [13,15]. For sites at which groundwater flow direction varies greatly, plume capture can be more difficult.
- If a subsurface source is present, the plume upgradient of the wall may persist, and cleanup goals may not be achieved. However, the overall goal to eliminate risk to human health and environment is immediately achieved downgradient of the wall. The advantage of the treatment wall over the P&T system is the ability to passively contain and treat the contaminated plume [20].
- The site hydrogeology enabled the treatment wall to be keyed into a bottom confining layer [15]. At sites where the contaminated aquifer is not fully confined on the bottom, vertical containment of the plume can be an issue [18].

REFERENCES

1. Final Remedial Action Plan, Geomatrix Consultants, May 30, 1989.
2. Draft Revised Final Remedial Action Plan, Volumes I and II, Geomatrix Consultants, Inc., January 1993.
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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.