COST AND PERFORMANCE REPORT

Pump and Treat of Contaminated Groundwater at the
United Chrome Superfund Site
Corvallis, Oregon

September 1998

Prepared by:

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

SITE INFORMATION

Identifying Information:

United Chrome Superfund Site
Corvallis, Oregon

CERCLIS #: ORD009043001

ROD Date: September 12, 1986

ESD Date: December 12, 1991

Treatment Application:

Type of Action: Remedial

Period of operation: 8/1/88 - Ongoing
(Mass Removal Data Collected From 8/88 through 3/97)
(Monitoring Well Data Collected from 8/88 through 12/96)

Quantity of groundwater treated during application [1]: 62 million gallons

Background

Historical Activity that Generated Contamination at the Site: Chrome plating

Corresponding SIC Code: 3471 (Plating of Metals)

Waste Management Practice That Contributed to Contamination: Discharge to unlined disposal pit

Facility Operations [1-4]:

- United Chrome Products is a former industrial hard chrome plating facility that manufactured and repaired hard chrome plated parts from 1956 until early 1985.
- In 1956, a disposal pit for liquid waste was dug in the area west of the former on-site building. Plating tanks were located just northeast of the disposal pit. Chromium-laden wastewater was discharged to the pit from 1956 to 1982. Sludges were removed from the pit and disposed of under the guidance of the Oregon Department of Environmental Quality (DEQ) in 1982 and 1983.
- In June 1983, EPA conducted a field investigation at the site, discovering chromium contamination in on-site surface water and soils. United Chrome Products was placed on the National Priorities List (NPL) on September 21, 1984.
- EPA performed contaminated soil removal activities at the site from July 2, 1985 until November 6, 1985. An on-site surface drainage ditch was dammed and rerouted as part of remedial activities in 1988.
- Groundwater contamination was addressed in two phases. Phase I was directed at remediation of the upper aquifer and containment of the plume. Phase II focused on remediation of the lower aquifer. Phase I began in August 1988 and Phase II began in September 1991.

Regulatory Context:

- The Record of Decision (ROD) for the site was signed on September 12, 1986.
- An Explanation of Significant Differences (ESD) was signed on December 12, 1991.
- Site activities are conducted under provisions of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), 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 remedy was for extraction, treatment, and surface discharge of groundwater from the unconfined and confined aquifers and limited excavation of contaminated soil and removal of plating tanks and residual sludge. The remedy was modified by the ESD that allowed for discharge to the City of Corvallis Publicly Owned Treatment Works (POTW) in accordance with the Pretreatment Requirements.

SITE INFORMATION (CONT.)

Site Logistics/Contacts

Site Lead: PRP

Oversight: EPA

Site Contact:
Tom Penpraze
Utilities Division Manager
Public Works Department
City of Corvallis
P.O. Box 1083
Corvallis, OR 97339-1083

*Indicates primary contact

Remedial Project Manager:
Al Goodman*
U.S. EPA Region 10
811 Southwest Sixth Avenue
Portland, Oregon 97204
(503) 326-3685

Treatment System Vendor:
Operations Contractor: CH2M Hill, Inc.

MATRIX DESCRIPTION

Matrix Identification

Type of Matrix Processed Through the Treatment System: Groundwater

Contaminant Characterization

Primary Contaminant Groups: Chromium

- The contaminant of concern in the groundwater is chromium. The groundwater is contaminated with the hexavalent chromium species. However, cleanup standards are set for total chromium. Likewise, laboratory analyses test for total chromium. For these reasons, chromium levels tested and regulated at the United Chrome site are for total chromium [3].
- Initial testing for chromium in the groundwater in 1983 revealed levels of up to 3,619 mg/L in the shallow aquifer and 3.0 mg/L in the deep aquifer. Later sampling in 1984 revealed levels of chromium of up to 30 mg/L in the deep aquifer [3].
- The contaminant plume in the upper unconfined aquifer as estimated by the 1985 remedial investigation (RI) was approximately 1 acre in size and 17 feet thick, with a plume volume of over 2 million gallons. The RI revealed that the contaminant plume in the deep aquifer was approximately 1.4 acres in size and 15 feet thick, with a plume volume of 2.4 million gallons [5].
- In 1988, a plume map was drawn to show the extent of contamination. Figure 1 shows the approximate boundary of the chromium contamination plumes in the upper and deep aquifers prior to treatment in August 1988. At that time, chromium concentrations in the upper aquifer as high as 19,000 mg/L were measured near the location of the plating tanks.
- Based on the plumes shown in Figure 1, the surface areas of the upper and deep plumes were 1.5 and 1.7 acres, respectively. The upper plume had migrated to the northeast concurrent with on-site flow direction. The chromium contamination plume in the deep aquifer migrated northeast of the former plating tanks, concurrent with groundwater flow in the deep aquifer.

MATRIX DESCRIPTION (CONT.)

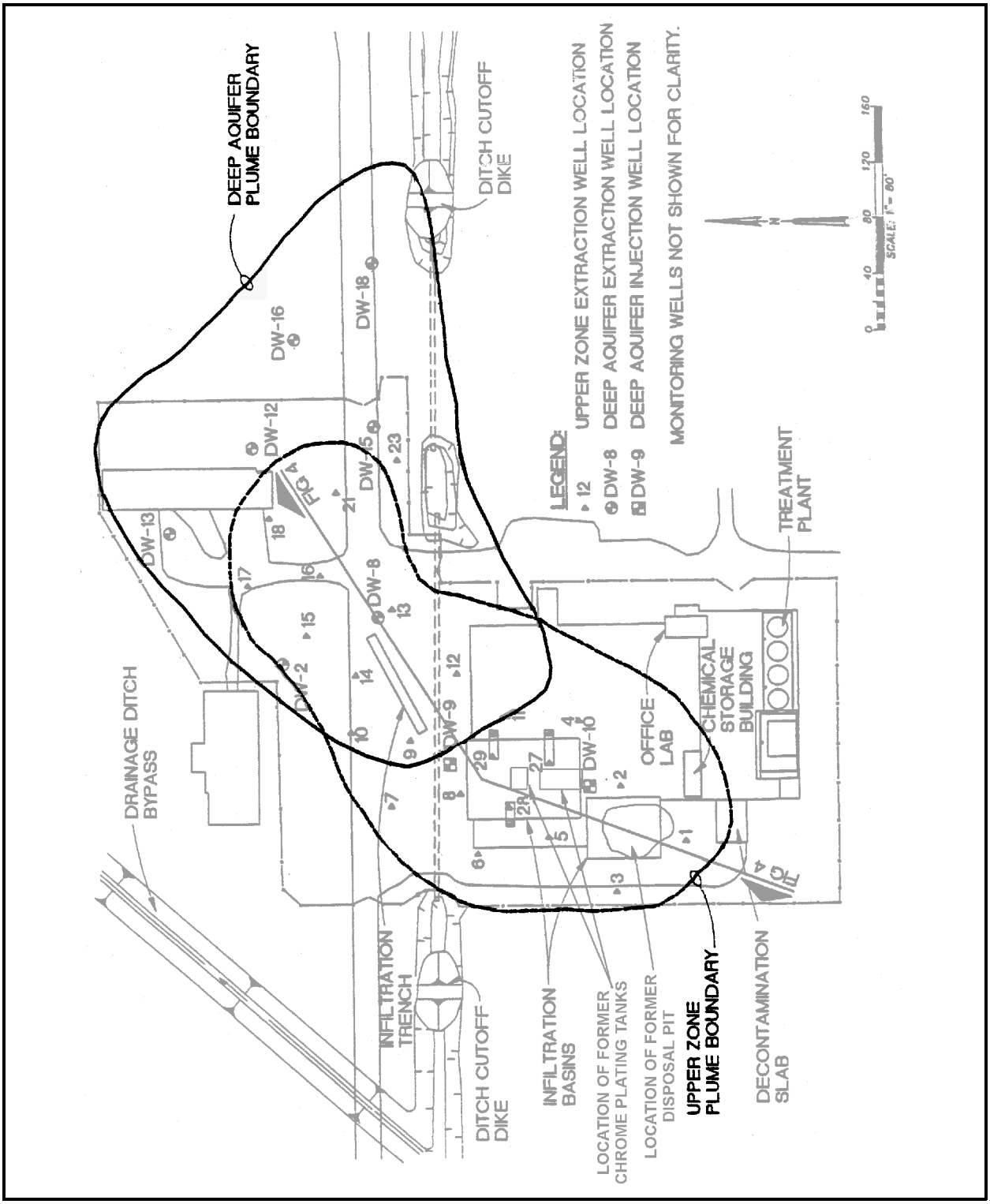

Figure 1. Chromium Contaminant Plumes in the Upper and Deep Aquifers Prior to August 1988 [2]

MATRIX DESCRIPTION (CONT.)

Matrix Characteristics Affecting Treatment Costs or Performance

Hydrogeology [2,5]:

The site hydrogeology consists of four hydrogeologic units, beginning with an upper aquifer (also called the upper zone) underlain by an upper aquitard and ending with a deep aquifer underlain by a lower aquitard.

Unit 1	Upper Aquifer	Approximately 18 feet thick and consisting of fine silt overlying the upper aquitard. Recharge to the upper aquifer is limited.
Unit 2	Upper Aquitard	Stiff dark gray clay, ranging from 2 to 10 feet thick, that grades into deep aquifer soils at about 23 feet below the ground surface.
Unit 3	Deep Aquifer	Interbedded silty sand and sandy gravel, ranging from 15 to 25 feet thick. It is semiconfined above by the upper aquitard and confined below by the lower aquitard. Recharge is supplied from the overlying silts. Water in this aquifer is used for drinking purposes. The nearest drinking water well is approximately 3,000 feet northeast of the site. Recharge to the lower aquifer is not limited.
Unit 2	Lower Aquitard	Plastic clay at least 40 feet thick.

Groundwater in the upper and deep aquifers regionally flows northeast. The unconfined water table in the upper zone fluctuates seasonally between 0 and 10 feet below the ground surface. Based on water level comparison between aquifers, groundwater flow through the upper aquitard is estimated as high as 0.4 foot per year from the upper aquifer to the deep aquifer. For about one month a year during dry summer conditions, the groundwater flows from the deep aquifer to the upper aquifer.

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

Table 1. Technical Aquifer Information

Unit Name	Thickness (ft)	Conductivity (ft/day)	Average Velocity (ft/day)	Flow Direction
Upper Aquifer	15 - 18	0.5 - 2.5	0.008 - 0.04	North to Northeast*
Deep Aquifer	15 - 25	50 - 60	0.04 - 0.16	North to Northeast

*Previously, local groundwater flow in the upper aquifer was affected by a former drainage ditch and flowed south to southeast. The ditch has since been dammed and rerouted.

Source: [5]

TREATMENT SYSTEM DESCRIPTION

Primary Treatment Technology

Pump and treat (P&T) (original system)
Pump and discharge to POTW (current system)

Supplemental Treatment Technology

None

TREATMENT SYSTEM DESCRIPTION (CONT.)

System Description and Operation [1,2,6,7,9]

Table 2. Extraction Well Data

Wells	Unit Name	Depth (ft)	Design Pumping Rate (gpm)*
23 Wells	Upper Aquifer	9 - 19	7.5
7 Wells	Deep Aquifer	35 - 40	10.0

*Pumping rate for all wells in each unit

Source: [1,7]

System Description

- Since 1988, groundwater has been extracted from both aquifers. The initial extraction system used 23 wells in the upper aquifer and seven in the deep, as listed in Table 2. The current extraction system consists of 10 recovery wells, nine for the upper aquifer and one for the deep aquifer. Extracted water is discharged to the City of Corvallis POTW.

- Two infiltration basins and one infiltration trench (discontinued in 1993) were constructed to inject water from the City of Corvallis into the upper aquifer.

- Extracted water from the upper aquifer was formerly treated through a reduction and precipitation system with a 50 gpm capacity; however, since November 1994, chromium levels have been sufficiently reduced to allow discharge to the POTW in accordance with Pretreatment Standards. Extracted water from the deep aquifer has always been discharged to the POTW.

- Recovery wells were placed throughout the plume, with higher extraction rates from recovery wells with higher chromium contamination levels. No computer model was used, and upper zone extraction well spacing was determined from a pump test and plume geometry. Pumping rates are adjusted with orifice plates. Originally, 23 extraction wells were placed in the upper aquifer and seven extraction wells were placed in the deep aquifer. As chromium concentrations in extraction wells decreased below remedial goals, pumping from these wells was stopped, as discussed in the System Operation section.

- Groundwater quality is monitored semi-annually through a network of seven monitoring wells in the upper aquifer and five monitoring wells in the deep aquifer. Active extraction wells (nine in the upper aquifer and one in the deep aquifer) are monitored quarterly.

System Operation

- Average groundwater pumping rate from aquifer in gallons per minute (gpm):

Dates	Unit	Average Pumping Rate (gpm)
8/1/88 - 12/31/88	Upper	10.4
	Deep	None
1/1/89 - 12/31/89	Upper	9.3
	Deep	None
1/1/90 - 12/31/90	Upper	11.5
6/1/90 - 12/31/90	Deep	1.6
1/1/91 - 12/31/91	Upper	11.2
	Deep	6.6
1/1/92 - 12/31/92	Upper	8.8
	Deep	5.5
1/1/93 - 12/31/93	Upper	6.4
	Deep	15.8
1/1/94 - 12/31/94	Upper	4.5
	Deep	4.0
1/1/95 - 12/31/95	Upper	4.4
	Deep	10.1
1/1/96 - 12/31/96	Upper	4.0
	Deep	1.5
1/1/97 - 3/31/97	Upper	7.0
	Deep	3.2

TREATMENT SYSTEM DESCRIPTION (CONT.)

- The volume of water in the upper aquifer available for extraction is limited, and the upper aquifer becomes dewatered with too much pumping. Clean potable water was reinjected to recharge the aquifer and flush any sorbed chromium. By 1992, chromium levels had decreased more quickly than originally anticipated. Some wells that had chromium levels below the 10 mg/L cleanup goal were no longer pumped. In addition, by 1995, chromium levels had decreased sufficiently so that treatment of the water extracted from upper aquifer was no longer necessary.

- In 1991, because of the drop in chromium levels in the upper aquifer, an ESD was approved for the site to discharge extracted water which met pretreatment standards to the POTW. In November 1995, with permission from EPA, the treatment system was discontinued.

- Adjustments have been made to the upper aquifer extraction system since 1988 to optimize contaminant capture. Higher pumping rates were used at wells with greater levels of chromium contamination. Pumping has continued from nine of the original 23 extraction wells in the upper aquifer, because those nine had elevated levels of chromium. The remaining extraction wells in the upper aquifer were not used because levels of chromium were either below or slightly above the cleanup level of 10 mg/L (less than 15 mg/L).

- In the deep aquifer extraction system, only one of the seven original extraction wells was still operating during 1997. The cleanup goal of 0.10 mg/L of Cr in the lower aquifer was met in the other six extraction wells.

- Future operations of the groundwater extraction systems will be determined following a 1998 investigation of the remaining soil in the area of the former plating tanks and the disposal pit.

Operating Parameters Affecting Treatment Cost or Performance

One operating parameter affecting cost or performance for pump and treat is the extraction rate. Table 3 presents values for this and other performance parameters.

Table 3. Performance Parameters

Parameter	Value
Pump Rate Range (August 1988 - March 1997)	4.0 - 11.5 gpm, upper aquifer 1.5 - 15.8 gpm, deep aquifer
Remedial Goals	Upper Aquifer 10 mg/L, Cr Deep Aquifer 0.10 mg/L Cr
Treatment Performance Goals: Pretreatment Requirement	Cr 7 lbs/day maximum average discharge to POTW

Source: [1,3,4]

TREATMENT SYSTEM DESCRIPTION (CONT.)

Timeline

Table 4 presents a timeline for this application.

Table 4. Timeline

Start Date	End Date	Activity
9/12/86	---	ROD signed
2/4/87	9/11/87	Remedial design completed
8/88	---	Phase I of the remediation system begun. Pumping and treating from upper aquifer and monitoring begun.
9/91	---	Phase II of the remediation system begun. Pumping and treating from deep aquifer begun.
7/91	---	EW-77, EW-18, and EW-23 shut down
3/92	---	EW-21 shut down
5/92	---	EW-43 shut down
9/92	---	EW-3 shut down
1/94	---	EW-1 shut down
2/94	---	EW-11 shut down
9/94	---	EW-13 and EW-27 shut down
6/95	---	EW-16 shut down
1995	---	EW-9, DW-13, DW-17, and DW-18 shut down
1996	---	DW-16, DW-12, and DW-15 shut down
12/97	---	EW-2, EW-7, EW-12, and EW-15 shut down
11/1/92	---	ESD signed.
11/28/94	---	EPA approval to pump groundwater and discharge to POTW without pretreatment received

Source: [2,3]

TREATMENT SYSTEM PERFORMANCE

Cleanup Goals/Standards [3]

The cleanup goals require a level of 10 mg/L for chromium in the upper aquifer and 0.10 mg/L (the current maximum contaminant limit, or MCL) for chromium in the deep aquifer.

Additional Information on Goals [3]

The cleanup goal of 10 mg/L for chromium in the upper aquifer was determined to be the maximum allowable concentration in the upper aquifer that was still protective of the deep aquifer, and that met the risk requirement for the upper aquifer. In addition, the MCL established by EPA for total chromium was originally 0.05 mg/L but was revised to 0.10 mg/L in 1992.

Treatment Performance Goals [3]

- The primary treatment performance goal is to hydraulically contain the contaminant plume.

TREATMENT SYSTEM PERFORMANCE (CONT.)

Performance Data Assessment [1,6]

- Chromium concentrations in both aquifers have been reduced. Figure 2 illustrates the decrease in average chromium concentrations in both the upper and the deep aquifers over time. Performance data indicate that the average chromium concentrations in the upper aquifer have been reduced 99%, from 1,923 mg/L in August 1988 to 18 mg/L in March 1997. Average chromium concentrations in the deep aquifer have been reduced 92%, from 1.4 mg/L in August 1991 to 0.11 mg/L in March 1997.

- Cleanup goals for chromium have been met in 11 of 23 wells in the upper aquifer and in six of seven wells in the deep aquifer. Cleanup goals have been met in all perimeter wells. In the upper aquifer, chromium concentrations in 12 wells remain above the 10 mg/L cleanup goal, with a maximum concentration of 64 mg/L. In the deep aquifer, chromium concentrations in one well remain slightly above the 0.10 mg/L cleanup goal, with a maximum concentration of 0.11 mg/L.

- Approximately 31,363 lbs of chromium have been removed from the upper aquifer and approximately 96 lbs of chromium have been removed from the deep aquifer, for a total of 31,459 lbs removed. Figures 3 and 4 show mass removal over time from August 1988 through March 1997 for the shallow and deep aquifers, respectively. The mass removal rate has decreased since August 1988. The upper aquifer continues to yield approximately 0.8 lbs/day of chromium; however, the deep aquifer yields less than 0.01 lbs/day of chromium.

Performance Data Completeness

Average chromium concentrations and mass removal data used in Figures 2, 3, and 4 were provided in the 1997 First Quarterly Report. Chromium concentrations in individual wells are available in various quarterly reports. Monthly data from August 1988 through December 1996, the most recent data available, were used for Figure 2. Monthly data from August 1988 through March 1997 were used to depict mass removal in Figures 3 and 4.

Performance Data Quality

The QA/QC program used throughout the remedial action met EPA and State of Oregon 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.)

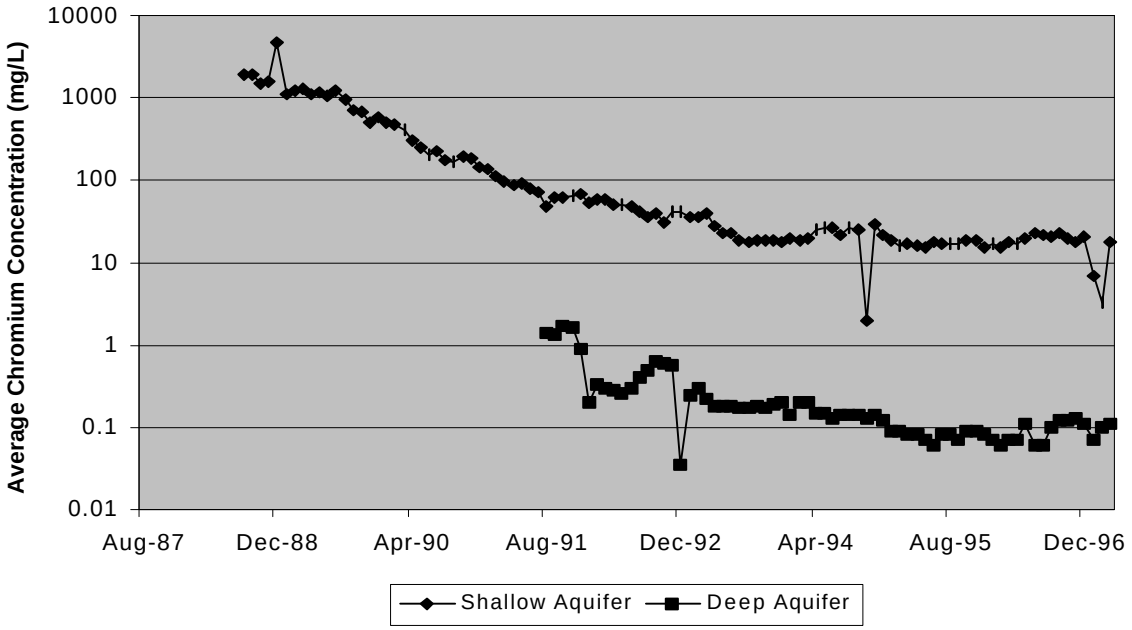

Figure 2. Chromium Levels in the Groundwater as a Function of Time [1]

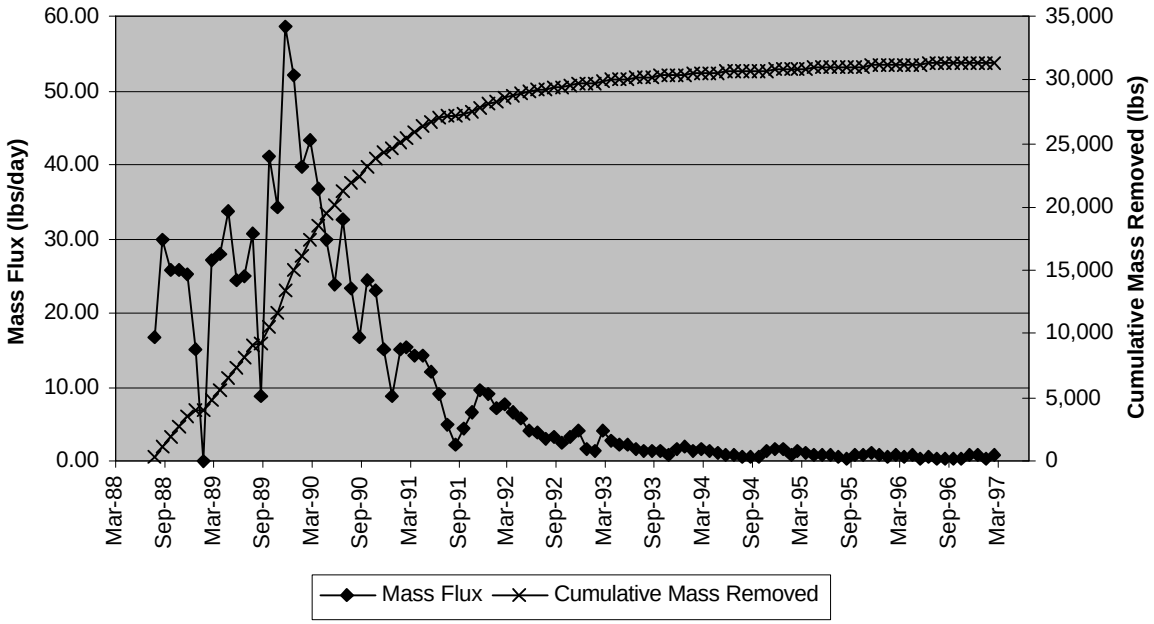

Figure 3. Chromium Mass Removed from the Upper Aquifer as a Function of Time [1]

TREATMENT SYSTEM COST

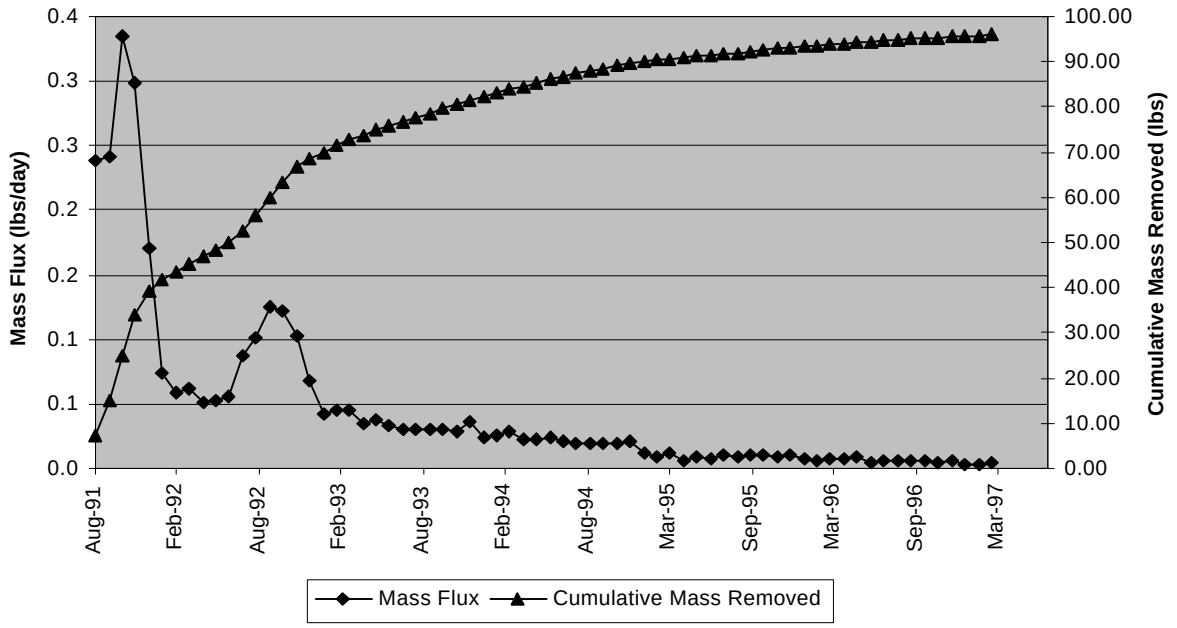

Figure 4. Chromium Mass Removed from the Deep Aquifer as a Function of Time [1]

Procurement Process

The City of Corvallis operates the remediation systems. EPA has contracted with CH2M Hill, Inc. to oversee and evaluate the remediation system.

Cost Analysis

All costs for investigation, design, and construction of the treatment system at this site were borne by EPA. The City of Corvallis has borne the costs of operation and made payment to EPA under terms of a Consent Decree.

TREATMENT SYSTEM COST (CONT.)

Capital Costs [8]

Administration and Mobilization	$745,035
Monitoring Wells and Sampling	$131,903
Site Work	$300,195
Groundwater Extraction	$611,669
Treatment System	$1,374,625
Construction Management and Other Engineering Services	$130,235
State Oversight	$13,656
Other Costs	$22,522
Total Remedial Construction	**$3,329,840**

Operating Costs [9]

1987-1998 (fiscal year)	$11,722
1988-1989	$177,405
1989-1990	$97,838
1990-1991	$531,626
1991-1992	$251,573
1992-1993	$90,523
1993-1994	$53,428
1994-1995	$36,748
1995-1996	$25,374
1996-1997	$31,081
Cumulative 1987-1997	**$1,307,318**

Other Costs [8]

Remedial Investigation/Feasibility Study	$263,832
Corps Oversight	$4,759
Total RI/FS	**$268,590**
Remedial Design	$348,810
State Oversight	$15,059
Total Remedial Design	**$363,869**
EPA Oversight (Contractor included)	$250,000

Cost Data Quality

Actual capital and operating cost data were provided by the EPA Remedial Project Manager (RPM) and the City of Corvallis for this site.

OBSERVATIONS AND LESSONS LEARNED

- Actual costs for the P&T application at United Chrome were approximately $4,637,160 ($3,329,840 in capital costs and $1,307,320 in operating costs. This cost corresponds to $75 per 1,000 gallons of water treated and $140 per pound of contaminant removed.
- Operations costs dropped by an order of magnitude when the treatment system was discontinued in 1992.
- The City of Corvallis realized the chromium level in the treatment system influent would drop below pretreatment standards prior to complete remediation, and planned accordingly. They used a modular shorter-term treatment system at a cost of $1.3 million, compared to a more expensive permanent remedy.
- Normal groundwater recharge to the upper aquifer is limited and reinjection of water into the aquifer was necessary to continue flushing the contaminated aquifer. Therefore, it was necessary to remove as little water as possible from the upper aquifer and to optimize the contaminant removal per gallon of water pumped. The flexible pumping and injecting system enabled the remediation system to operate in these conditions.

REFERENCES

1. United Chrome Quarterly Report/First Quarter 1997, Tom Penpraze, City of Corvallis, April 4, 1997.

2. Case History: Effective Groundwater Remediation at the United Chrome Superfund Site, U.S. EPA Region 10, CH2M Hill, undated.

3. Record of Decision, U.S. EPA Region 10, September 12, 1986.

4. Explanation of Significant Differences, U.S. EPA Region 10, November 1, 1992.

5. Final Remedial Investigation Report, Ecology and Environment, Inc., July 26, 1985.

6. Process Modification Request, Correspondence U.S. EPA Region 10, November 28, 1994.

7. United Chrome 1996 Annual Report, Tom Penpraze, City of Corvallis, March 11, 1997.

8. Ground-water Remedial Cost Analysis, Pump and Treat of Contaminated Groundwater at the United Chrome Products Site, Corvallis, OR, unpublished document prepared under the U.S. EPA Hazardous Site Control Division Remedial Operations Guidance Branch.

9. Draft comments provided by the City of Corvallis, August 1998.

10. Draft comments provided by Allan Goodman, EPA Region 10.

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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