

**ANNUAL REPORT
FOR THE
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY
SITE
GROUNDWATER PLUME TREATMENT SYSTEMS
January through December 2002**

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TABLE OF CONTENTS

1 0 INTRODUCTION	1
2 0 MOUND SITE PLUME TREATMENT SYSTEM	2
2 1 Project Activities	2
2 2 Treatment Effectiveness	2
2 2 1 Treatment System Effectiveness	5
2 2 2 Downgradient Water Quality	6
2 3 Conclusions and Planned Changes	10
3 0 EAST TRENCHES PLUME TREATMENT SYSTEM	10
3 1 Project Activities	10
3 2 Treatment Effectiveness	10
3 2 1 Treatment System Effectiveness	13
3 2 2 Upgradient Water Quality	14
3 2 3 Downgradient Water Quality	15
3 3 Conclusions and Planned Changes	18
4 0 SOLAR PONDS PLUME TREATMENT SYSTEM	18
4 1 Project Activities	20
4 2 Treatment Effectiveness	21
4 2 1 Treatment System Effectiveness	23
4 2 2 Downgradient Water Quality	25
4 2 3 Conclusions and Planned Changes	28
5 0 OU1, 881 HILLSIDE GROUNDWATER TREATMENT SYSTEM	29
5 1 Project Activities and Status	30
5 2 Conclusions and Planned Changes	31
6 0 OU7, PRESENT LANDFILL PASSIVE SEEP INTERCEPTION AND TREATMENT SYSTEM	32
6 1 Volume of Seep Water Treated	32
6 2 Treatment Effectiveness	33
6 3 Conclusions and Planned Changes	34
7 0 PU&D YARD PLUME TREATABILITY STUDY	34
7 1 Project Activities	35
7 2 Treatment Effectiveness	35
7 3 Conclusions and Work Planned	44
REFERENCES	45

FIGURES

Figure 1	Mound Site Plume Collection and Treatment System Locations	3
Figure 2	Comparison of Monthly Precipitation to the Average Monthly Flow Rate for Mound Site Plume, East Trenches Plume, and Solar Ponds Plume Treatment Systems	4
Figure 3	Conceptual Model of Flow Downgradient from Mound Collection Trench	7
Figure 4	Mound Site Plume Water Elevations	7
Figure 5	Trichloroethene Concentrations in Mound Site Plume Downgradient Wells	9
Figure 6	Tetrachloroethene Concentrations in Mound Site Plume Downgradient Wells	9
Figure 7	East Trenches Plume Collection System	11
Figure 8	East Trenches Plume System Water Elevations	12
Figure 9	Historical Trichloroethene Trend in Well 23296	16
Figure 10	Trichloroethene Levels in Well 23296 During System Operation	16
Figure 11	Historical Tetrachloroethene Trend in Well 23296	17
Figure 12	Tetrachloroethene Levels in Well 23296 During System Operation	17
Figure 13	Solar Ponds Plume Treatment System Locations	19
Figure 14	Effluent Flow Rates From the Solar Ponds Plume Treatment System	20
Figure 15	Solar Ponds Plume Collection Trench Piezometer Water Levels	22
Figure 16	Solar Ponds Plume System 2002 Downgradient Well Water Elevations	23
Figure 17	Solar Ponds Plume Treatment System Nitrate Concentrations	24
Figure 18	Solar Ponds Plume Treatment System Uranium Activities	24
Figure 19	Nitrate Concentrations in Solar Ponds Surface Water Locations	28
Figure 20	Uranium Activities in Solar Ponds Surface Water Locations	29
Figure 21	Trichloroethene Concentrations in the OU1 Collection Well	31
Figure 22	PU&D Yard Groundwater VOC Plume Project Area	36
Figure 23	PU&D Yard Groundwater VOC Plume Material Insertion Point Configuration	37
Figure 24	Tetrachloroethene and Degradation Products Concentration versus Time in Well 30900	39
Figure 25	Tetrachloroethene and Degradation Products Concentration versus Time in Well 31001	39
Figure 26	Tetrachloroethene Concentration and Depth to Water in Source Area Well 30900 versus Time	40

Figure 27	Mole Fraction Percent of Tetrachloroethene in Source Area Well 30900 Relative to its Degradation Products Over Time	41
Figure 28	Mole Fraction Percent of Tetrachloroethene in Downgradient Well 31001 Relative to its Degradation Products Over Time	42
Figure 29	Oxidation Reduction Potential in PU&D Yard Wells versus Time	42
Figure 30	Lithology and Soil Concentrations of Tetrachloroethene in the Source Area	43

TABLES

Table 1	Groundwater Treatment Projects at RFETS	1
Table 2	Mound Site Plume Upgradient and Downgradient Water Elevations	4
Table 3	Summary of Mound Site Plume CY2002 Sampling Events	5
Table 4	Downgradient Well Analytical Results	8
Table 5	CY2002 East Trenches Plume Piezometer and Well Water Levels	12
Table 6	Summary of East Trenches Plume CY2002 Sample Results	14
Table 7	Downgradient Well Analytical Results	15
Table 8	Groundwater Elevations in Downgradient Solar Ponds System Wells	22
Table 9	Solar Ponds Plume Treatment System CY2002 Analytical Results	23
Table 10	Solar Ponds Plume Downgradient Well Analytical Results	26
Table 11	Solar Ponds Plume Summary of Downgradient Surface Water Locations	27
Table 12	Volume of Groundwater Collected from the OU1 Collection Well	30
Table 13	OU1 Collection Well Analytical Results for CY2002 Sampling Event	30
Table 14	Volume of Water Treated in the Present Landfill Passive Seep Interception and Treatment System During CY2002	32
Table 15	Present Landfill Treatment System Water Analytes and Performance Standards	33
Table 16	Benzene Concentrations in Present Landfill Treatment System Effluent	34
Table 17	Preliminary Treatability Study Results	38

4

ACRONYMS & ABBREVIATIONS

AL	Action Level
ALF	Action Level Framework
CAD/ROD	Corrective Action Decision/Record of Decision
CWTF	Consolidated Water Treatment Facility
CY	calendar year
DCE	dichloroethene
DOE	U S Department of Energy
EPA	U S Environmental Protection Agency
ft	feet
FY	fiscal year
gpm	gallons per minute
HRC [®]	Hydrogen Release Compound [®]
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
ITS	Interceptor Trench System
K-H	Kaiser-Hill Company, L L C
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
MIP	material insertion point
MST	modular storage tank
ORP	oxidation reduction potential
OU	operable unit
PCE	tetrachloroethene
pCi/l	picocuries per liter
POC	point of compliance
PU&D	Property Utilization and Disposal
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RMRS	Rocky Mountain Remediation Services
SAP	sampling and analysis plan
SCFA	Subsurface Contaminant Focus Area

SITE	Superfund Innovative Technology Evaluation
SPP	Solar Ponds Plume
TCE	trichloroethene
ug/kg	micrograms per kilogram
ug/l	micrograms per liter
VOC	volatile organic compound

6

1.0 INTRODUCTION

This report describes calendar year (CY) 2002 activities and performance monitoring data for five groundwater collection and treatment systems and a treatability study at the Rocky Flats Environmental Technology Site (RFETS) Table 1 summarizes these six projects and the groundwater treatment processes employed

Table 1. Groundwater Treatment Projects at RFETS

Project	Contaminant Type	Treatment Process
Mound Site Plume Treatment System	VOCs Radionuclides	Passive collection trench with submerged zero-valent iron treatment cells
East Trenches Plume Treatment System	VOCs	Passive collection trench with submerged zero-valent iron treatment cells
Solar Ponds Plume Treatment System	Nitrates Uranium	Passive collection trench with solar-powered pump and submerged bio-reactors containing wood chips and zero-valent iron
OU1, 881 Hillside Groundwater Treatment System	VOCs Radionuclides	Collection well with ultraviolet light / hydrogen peroxide treatment followed by an ion exchange process*
OU7, Present Landfill Passive Seep Interception and Treatment System	VOCs	Passive seep interception system with passive aeration treatment
PU&D Yard Plume Treatability Study	VOCs	<i>In situ</i> bioremediation using HRC [®] , a polylactate ester

* The modified treatment system can now treat a variety of components (see Section 5) The process units listed represent those components from the original treatment system that were designed to treat this contaminant stream.

This report provides information on the performance of each of these systems from January 2002 through December 2002 The primary purpose of these groundwater treatment projects is to prevent contaminants in groundwater from entering surface water and affecting downstream receptors

The passive barrier treatment systems are designed to intercept a groundwater plume at its distal end, either before it reaches the surface (i.e., the Mound Site, East Trenches Plume, and OU1 Treatment Systems) or at the point where it actually reaches the surface (i.e., the OU7 Treatment System) These systems are effective in low-flow, low-permeability regimes With the exception of the OU1 Treatment System, all of these collection/treatment systems are essentially passive, low-maintenance/low-profile systems that are designed for long-term treatment

The Property Utilization and Disposal (PU&D) Treatability Study differs from the groundwater treatment systems in that it is an *in situ* process that treats the source area of the plume rather than capturing a plume front It also addresses both soil and groundwater contamination

2.0 MOUND SITE PLUME TREATMENT SYSTEM

The Mound Site Plume Treatment System uses reactive barrier technology to collect and treat contaminated groundwater derived from the Mound Site area. The source area was excavated as an accelerated action in 1997. Installation of the 220-foot-long collection system and two treatment cells containing reactive iron was completed in 1998 (Figure 1). The system is designed to meet the Tier II Groundwater Action Levels (ALs) defined in the Rocky Flats Cleanup Agreement (RFCA) (DOE, CDPHE, EPA 1996). The Mound Site Plume Treatment System employs innovative technology to treat groundwater contaminated with chlorinated organic compounds and low levels of radionuclides. The effectiveness and feasibility of using this technology at the Site was demonstrated by this project.

The Mound Site Plume Treatment System project was a cooperative effort between RFETS and the U.S. Department of Energy (DOE) Subsurface Contaminant Focus Area (SCFA), with support from the U.S. Environmental Protection Agency (EPA) Superfund Innovative Technology Evaluation (SITE) Program. Funds were provided by SCFA in fiscal year (FY) 2000 for additional sampling beyond that required by the Mound Site Plume Decision Document (DOE 1997a). This additional sampling provided extensive data regarding the feasibility and effectiveness of reactive barriers.

2.1 Project Activities

During CY2002, system maintenance included raking the media in the reaction vessels about 14 times over the course of the year. Media raking has been reduced because the crust formation continues to be minimal. In addition, the flow measurement flumes and lines were cleaned about four times. Site personnel performed quarterly water level monitoring and semiannual analytical sample collection.

2.2 Treatment Effectiveness

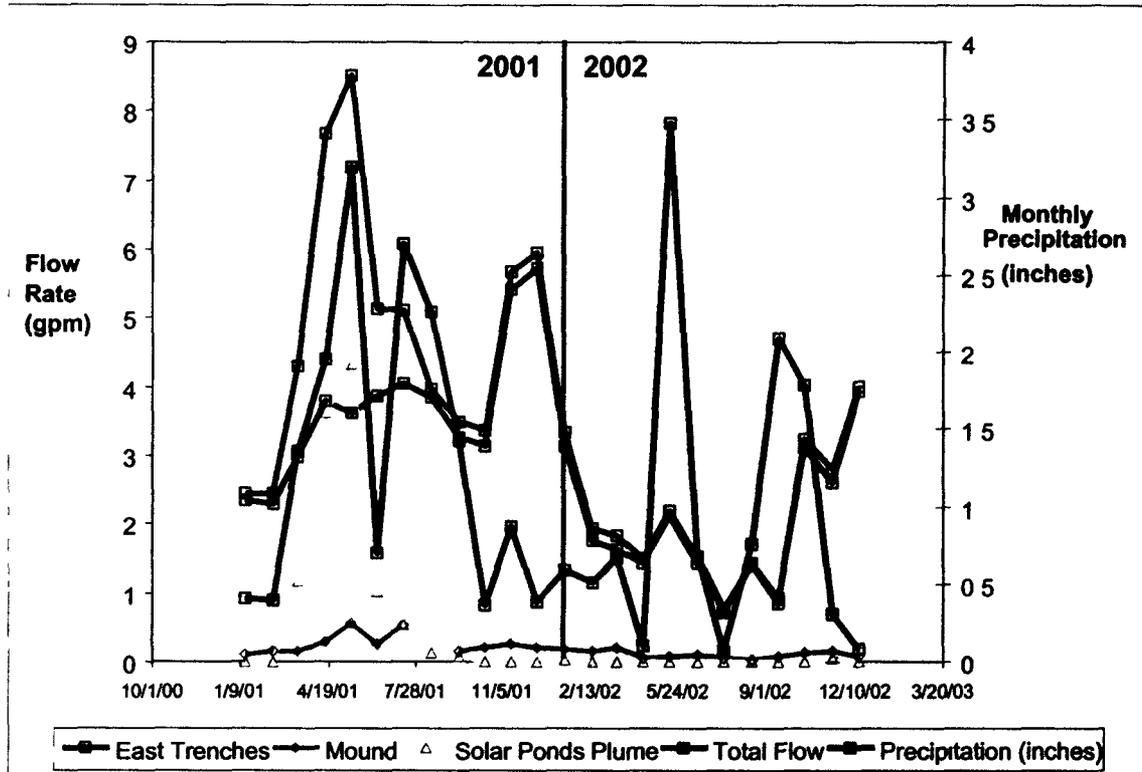
The volume of water treated at the Mound Site Plume Treatment System was significantly influenced by the ongoing drought. For the period January 2002 through mid-December 2002, 53,000 gallons of contaminated water flowed through the treatment system. In 2001, 119,000 gallons were treated. The total volume of groundwater treated as of December 16, 2002 was approximately 833,000 gallons. Measured flow rates ranged from below 0.01 gallons per minute (gpm) in July and August, to a high flow rate of 0.99 gpm on March 4, which is probably associated with a precipitation event. Monthly average flow rates range from 0.034 to 0.24 gpm.

Figure 2 shows the average monthly flow rate for the Mound Site Plume, East Trenches, and Solar Ponds Treatment Systems compared to precipitation. The effects of the drought can be seen. Although in the past the Mound Site Plume Treatment System was responsive to precipitation events, as can be seen from Figure 2, the response might have been dampened due to effects of the drought. This is particularly noticeable in July, when there were some significant rainstorms but little was seen going into the treatment systems. This may be a result of more runoff and less infiltration due to the dry soils and lack of vegetation, plus absorption by the dry soils.

Groundwater levels within the collection trench were monitored quarterly at five piezometers. The piezometer at the west end of the collection trench (Piezometer 16199) was dry throughout the year, as it has been in the past. Due to the drought, water levels measured in the remaining piezometers were not as constant as they have been in the past. Three of these piezometers (Piezometers 16299, 16499, and 16599) were dry at different times throughout CY2002. Only the piezometer near the center of the trench (Piezometer 16399) had water throughout the year.

8

Figure 2. Comparison of Monthly Precipitation to the Average Monthly Flow Rate for Mound Site Plume, East Trenches Plume, and Solar Ponds Plume Treatment Systems



Groundwater levels were also monitored quarterly at seven locations surrounding the collection trench (three upgradient, three downgradient, and one to the east) as shown in Table 2. Groundwater elevations in wells upgradient of the collection trench ranged from 5913 to 5917 feet above mean sea level (msl), about one to four feet lower than in CY2001. The groundwater elevation downgradient of the collection trench was about 10 feet lower in Well 15699. The other two downgradient wells were dry throughout the year. These data indicate that the collection system is working as designed and that flow is toward the trench when water is present. Seasonal water level fluctuations are approximately two to three feet at both upgradient and downgradient wells. Groundwater elevations in Well 3586, near South Walnut Creek, were at an elevation of 5905 feet above msl, similar to the creek elevation of 5,903 feet. However, in July, this well also was dry.

Table 2. Mound Site Plume Upgradient and Downgradient Water Elevations (feet above msl)

Well #	Location	1/8/02	4/8/02	7/2/02	10/2/02
15199	Eastern	5917.38	5918.27	5918.88	5917.06
15299	Upgradient	Dry	Dry	Dry	Dry
15399	Upgradient	5916.75	5916.90	5916.27	5913.15
15499	Upgradient	5917.35	Dry	5915.57	5915.57
15599	Downgradient	Dry	Dry	Dry	Dry
15699	Downgradient	Dry	Technically Dry	Dry	Technically Dry
15799	Downgradient	Dry	Dry	Dry	Dry

2.2.1 Treatment System Effectiveness

Analytical results continue to show that the treatment system is effectively removing the volatile organic compounds (VOCs) and radionuclides. Semiannual analytical sample results are summarized in Table 3. The contaminants of concern are chlorinated solvents and uranium.

Table 3. Summary of Mound Site Plume CY2002 Sampling Events

Contaminant	Influent (R1I) Concentration Range	Reactor 2 Effluent (R2E) Concentration Range	RFCA Tier II Groundwater AL	Unit
Acetone	ND	9.4	3,650	ug/l
Benzene	ND	0.38	5	ug/l
Bromomethane	ND	1.1	51.1	ug/l
2-Butanone	ND	3.2	21,900	ug/l
Carbon Tetrachloride	110-155	ND	5	ug/l
Carbon Disulfide	1.31	ND	3,650	ug/l
Chloroform	26-27.5	ND	100	ug/l
Chloromethane	ND	31	6.55	ug/l
Cis 1,2-Dichloroethene	11.3-24	1.8	70	ug/l
Dibromochloromethane	24	ND	1.01	ug/l
1,1-Dichloroethene	1.06-4.5	ND	7	ug/l
1,1-Dichloroethane	0.49J-1.2J	1.4	5	ug/l
1,2-Dichloroethane	0.51J	ND	5	ug/l
1,3-Dichloropropane	0.6J	ND	-	ug/l
1,2-Dimethyl Cyclopropane	ND	3.1	-	ug/l
2-Methyl-1-Propene	ND	4	-	ug/l
Propene	ND	7.6	200	ug/l
1,1,1-Trichloroethane	2.9	ND	200	ug/l
Trichloroethene	46.8-76	ND	5	ug/l
Tetrachloroethene	33.6-41	ND	5	ug/l
Americium-241	ND	0.0063J	0.145	pCi/l
Total Uranium	6.91-7.51	ND	2.84	pCi/l

Notes

J = detected at concentrations below the detection limit for this analysis
ND = not detected at the detection limit for this analysis

11

The principal organic contaminants entering the treatment system are tetrachloroethene, trichloroethene, carbon tetrachloride, and their degradation products. Uranium isotopes are present in the influent but are removed below detection limits in the effluent. Americium-241 was present in one effluent sample.

A number of additional compounds are found in trace concentrations. Carbon disulfide and 1,3-dichloropropane are either contaminants that are present in trace quantities or the result of cross-contamination at the laboratory. If they are present, it appears likely that the treatment process is effective in removing these as they do not appear in the effluent. Bromomethane and dibromochloromethane are probably laboratory surrogates, since these are unlikely to be found in this environment. The sample collected in April 2002 contained low concentrations of acetone, benzene, 2-butanone, chloromethane, 1,2-dimethyl cyclopropane, 2-methyl-1-propene, and propene. These are likely a result of laboratory cross-contamination because these do not appear in the influent and, with the exception of chloromethane, are not degradation products. The sample taken six months later did not contain any of these constituents.

At this time, there does not appear to be any evidence that the iron is being depleted. Removal efficiencies for tetrachloroethene, trichloroethene, and carbon tetrachloride continue to be greater than 99 percent. This demonstrates the long-term treatment capability that was anticipated when the project was initiated.

Influent concentrations increased slightly this reporting period, most likely because of the extended dry conditions.

As part of the investigation of Individual Hazardous Substance Site (IHSS) Group 900-2, an area of soils with elevated levels of chlorinated solvents has been found to the southwest, at IHSS 153, Oil Burn Pit No. 2. This area appears to be an additional source for the Mound Site Plume. The identification of this source area will not have an impact on the operation of the Mound Site Plume Treatment System, since the collection trench already intercepts the distal end of the plume. Additional information on this potential source area can be found in the Characterization Data Summary for IHSS Group 900-2 (DOE 2002).

2.2.2 Downgradient Water Quality

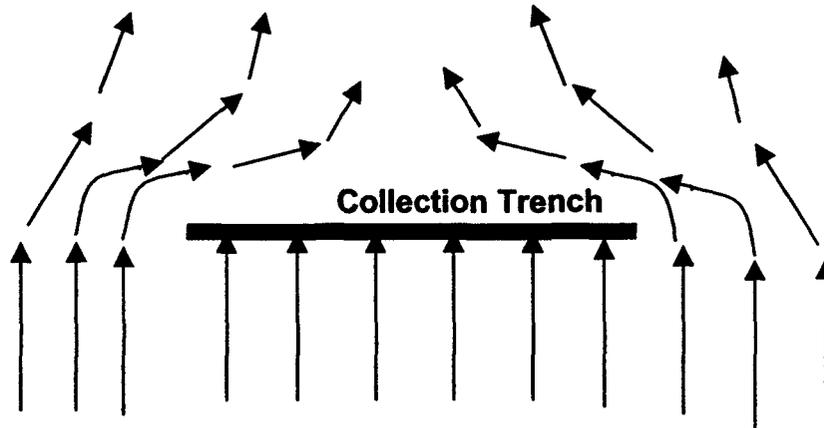
As stated in the Final Mound Site Plume Decision Document (DOE 1997a), the collection system was installed near South Walnut Creek "to capture the contaminated groundwater to the extent practicable." The wells downgradient of the collection system are located within the cut-off, downgradient portion of the plume, which was not intended to be treated.

Groundwater contaminants in the downgradient area may persist at approximately the same concentrations as before the system was installed because migration of upgradient contaminants has been cut off and there is less groundwater flow into the area to flush out residual contaminants. A minor amount of clean groundwater from outside the capture area of the collection trench may flow into the downgradient area once it has passed the trench due to the hydraulic gradient that the collection trench induces. Eventually, some contaminants could move downgradient or degrade, but this will likely be a relatively slow process.

Figure 3 is a schematic model of downgradient flow. Water elevations are shown graphically in Figure 4. The hydraulic gradient induced by the trench can be seen in the difference in water elevations driving the water from the edges of the capture area, toward the center of the downgradient portion of the plume.

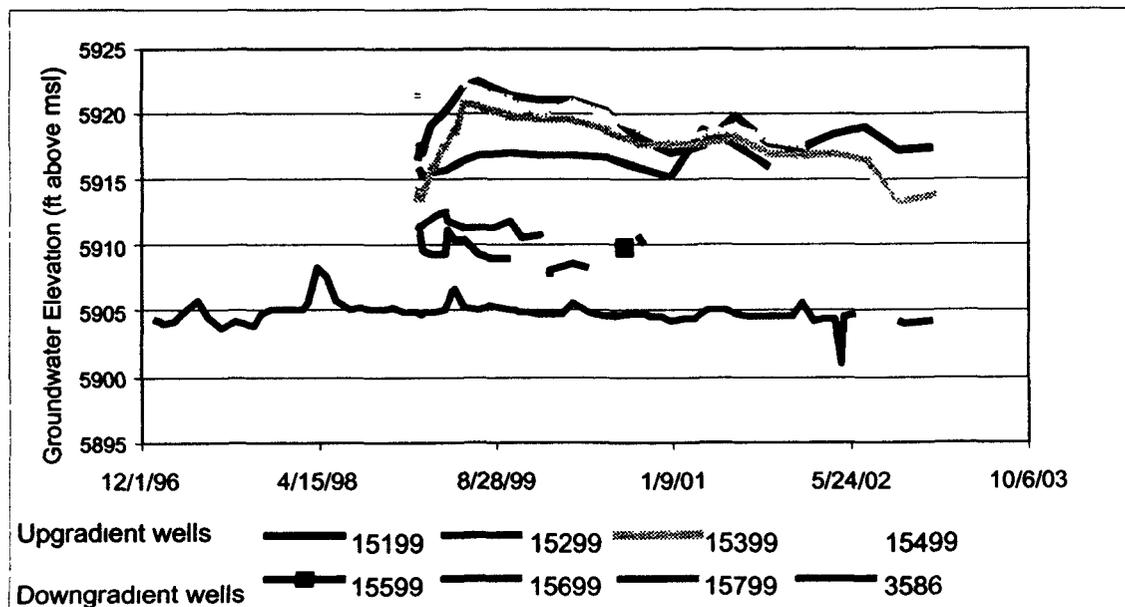
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Figure 3. Conceptual Model of Flow Downgradient from Mound Collection Trench



The groundwater elevation in Well 15199, at the eastern edge of the collection trench, is about seven to 10 feet higher than downgradient Wells 15799 and 15599. At the center of the downgradient area, Well 15699 has a lower groundwater elevation, indicating that a gradient exists from the outside edge of the capture area toward the center of the downgradient area. Although there is a steep hydraulic gradient, groundwater flow is minimal because there is little groundwater in the area. Based on groundwater elevation differences, the collection system appears to be working as designed.

Figure 4. Mound Site Plume Water Elevations



13

As shown on Figure 1, the plan is to collect analytical samples from four wells located downgradient of the collection trench. However, during CY2002, only Well 3586 contained sufficient water for sampling. Analytical results from this well are provided in Table 4.

Table 4. Downgradient Well Analytical Results

Analyte	Well 3586		RFCA Tier II AL	Unit
	Sample Date 4/25/02	Sample Date 10/21/02		
1,1,1-Trichloroethane	ND	ND	200	ug/l
1,1-Dichloroethane	ND	15.8	3650	ug/l
1,1-Dichloroethene	ND	ND	7	ug/l
1,2-Dichloroethane	ND	ND	5	ug/l
Benzene	ND	ND	5	ug/l
Chloroethane	ND	ND	29.4	ug/l
Cis-1,2-Dichloroethene	ND	0.91 J	70	ug/l
Tetrachloroethene	ND	ND	5	ug/l
Trans-1,2-Dichloroethene	ND	ND	70	ug/l
Trichloroethene	ND	ND	5	ug/l
Vinyl Chloride	ND	ND	2	ug/l
Plutonium-239/240	0.0108 J	ND		pCi/l
Uranium-233,234	0.364 J	1.77	1.06	pCi/l
Uranium-235	ND	ND	1.01	pCi/l
Uranium-238	ND	1.67	0.768	pCi/l

Notes

J = detected at concentrations below the detection limit for this analysis

ND = not detected at the detection limit for this analysis

Previous elevated contaminant concentrations downgradient of the Mound Site Plume Treatment System appear to be the result of residual contamination rather than contamination that has bypassed the system. Downgradient Well 15699 is located within the preferential flow path for the Mound Site Plume and along the trend of the highest plume concentrations defined in the pre-remedial investigation (DOE 1997a). The analytical results from the pre-remedial groundwater investigation from nearby Geoprobe™ Hole 10797 were 844 micrograms per liter (ug/l) trichloroethene, and 261 ug/l tetrachloroethene. As shown in Figures 5 and 6, these analytical results are roughly the same order of magnitude as those seen in Well 15699. By comparison, the historical concentration of trichloroethene within the collection trench ranges from 67 to 160 ug/l. The trench concentrations are lower because groundwater is collected from across the plume area, including lower concentration areas.

Based on the similarity between downgradient water quality and the pre-remedial downgradient concentrations, and the disparity between downgradient and collection trench water quality, the contaminant concentrations observed in Well 15699 are most likely due to residual contamination as opposed to contaminants bypassing the collection system. There is no clear trend shown in Figures 5 and 6 due to the variations in contaminant levels. Continued monitoring should provide enough information to determine whether some of these values are anomalous or other factors are causing these erratic results.

Well 3586 is downgradient of the collection system near South Walnut Creek. VOC concentrations at this location have been consistently below the RFCA Tier II Groundwater ALs throughout the year, as shown in Table 4. Uranium activities were elevated above the RFCA Tier II Groundwater ALs at Well 3586, only in October. As with the VOC concentrations, these are likely the result of residual contaminants, and it is anticipated that over time these activities will eventually decrease.

Figure 5. Trichloroethene Concentrations in Mound Site Plume Downgradient Wells

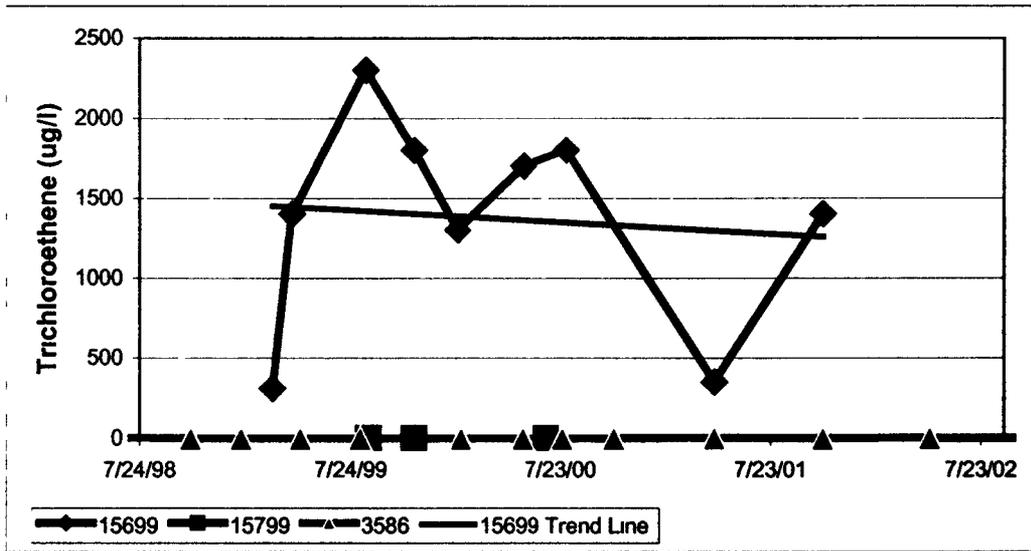
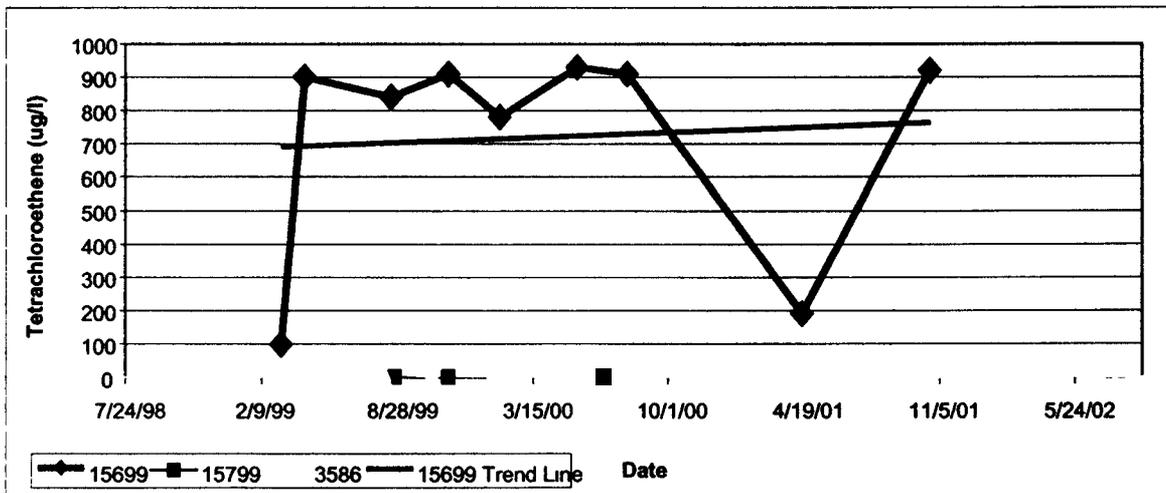


Figure 6. Tetrachloroethene Concentrations in Mound Site Plume Downgradient Wells



2.3 Conclusions and Planned Changes

The Mound Site Plume Treatment System is fully operational and treating contaminated groundwater to below specified system performance concentrations. The collection trench continues to be effective in cutting off and recovering contaminated water. The ongoing treatment system maintenance, raking the iron media, retrieving flow rate and water level data, and monitoring water quality, are the only necessary operational activities. Both the treatment system and downgradient wells will continue to be sampled on a semiannual basis, and water levels will be measured quarterly.

The presence of VOCs in downgradient areas is expected to persist. It does not appear that contaminants will be flushed out of these areas, since the collection trench has cut off the majority of the groundwater flow in this area. Degradation of the contaminants also does not appear to be impacting contaminant levels significantly. This is most likely due to lack of sufficient nutrients necessary to sustain a viable microbial community at this location.

3.0 EAST TRENCHES PLUME TREATMENT SYSTEM

The East Trenches Plume Treatment System collects and treats contaminated groundwater derived from the Trench 3 and Trench 4 area. These trenches were the primary sources for the contaminated groundwater plume and were remediated in 1996 as an accelerated action.

Installation of the 1,200-foot-long collection system and two reactive iron treatment cells, similar to the Mound Site Plume Treatment System, was completed in September 1999. Locations are shown in Figure 7. VOCs are reduced in the treatment cells to the RFCA Tier II Groundwater ALs. This system requires little maintenance and provides long-term protection of surface water by collecting and treating the contaminated groundwater before it reaches South Walnut Creek.

3.1 Project Activities

During CY2002, system maintenance included raking the media in the reaction vessels about 14 times over the course of the year. Media raking has been reduced because the crust formation continues to be minimal. Site personnel performed quarterly water level monitoring and semiannual analytical sample collection. In addition, the discharge line to South Walnut Creek and the flow measurement flume were cleaned about four times to eliminate bacterial buildup. The buildup allows water to back up into the flume, resulting in erroneous water level readings. Because the flow rate is based on the height of the water in the flume, the presence of standing water resulted in higher than actual flow rate readings. While the problem has been corrected, it is expected the flume will need to be cleaned on a quarterly basis if accurate flow measurements are required.

3.2 Treatment Effectiveness

Total volume of groundwater treated by the system as of December 16, 2002 was approximately 5.7 million gallons, with a little less than 1 million gallons of groundwater treated in CY2002. This is about half the volume of what was treated in CY2001 (i.e., 1.9 million gallons), due to effects of the ongoing drought.

Daily average flow rates ranged from 0.08 to 6.74 gpm, and averaged 1.66 gpm. Peak flow rates did not appear to be associated with precipitation events. As discussed above, higher flow rates are attributable to water backing up into the flume.

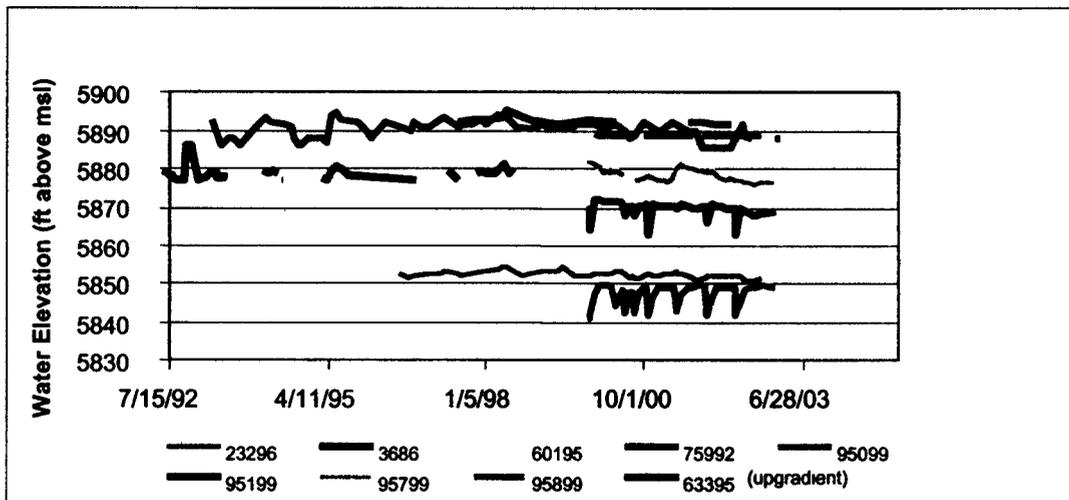
Water levels within the collection trench, and wells and piezometers downgradient of the collection trench, were measured monthly for most of CY2002. Due to the consistent water level elevations, as of the 4th quarter of CY2002, the wells and piezometers are now on a quarterly water level measurement schedule. Monitoring results are presented in Table 5. Historical water elevations are shown graphically in Figure 8.

**Table 5. CY2002 East Trenches Plume Piezometer and Well Water Levels
 (feet above msl)**

Well	Jan	Feb	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
23296	5852 17	5852 17	5852 23	5852 16	5852 16	5852 2	5851 14	5850 72	5850 8	5851 52	NM	NM
60195	Dry	Dry	Dry									
63395	5891 83	NM	NM	5891 71	NM	NM	Dry	NM	NM	Dry	NM	NM
75992	Dry	Dry	NM	5885 72	NM	Dry	NM	5888 19	NM	Dry	NM	NM
95099	5849 05	5849 24	5849 25	5849 15	5841 83	5844 7	5848 25	5848 92	5849 18	5849 42	NM	NM
95199	5870 47	5870 2	5869 99	5869 78	5862 76	5869 61	5868 95	5868 23	5868 04	5868 48	NM	NM
95299	Dry	Dry	NM									
95699	Dry	NM	NM									
95799	5877 95	5877 57	5877 11	5877 51	5876 77	5876 89	5876 17	5876 12	5876 04	5876 18	NM	NM
95899	5888 59	5888 61	5888 58	5888 6	5888 6	5888 59	5888 59	5888 61	5888 58	5888 75	NM	NM

Note
 NM = not measured

Figure 8. East Trenches Plume System Water Elevations



18

North of the trench, water elevations continue to demonstrate a strong downgradient trend to the north and east, with the groundwater elevations at the piezometers within the collection trench generally 10 feet higher than the corresponding piezometers downgradient of the collection trench. As can be seen in Figure 8, the groundwater elevation difference between Piezometers 95799 and 95899 show that there is a strong hydraulic gradient to the east, toward the collection sump. While Piezometer 95699 is dry all of the time, it is evident from treatment system flow rates that water is flowing through this part of the collection trench.

The collection trench appears to be effective in cutting off downgradient flow. Well 95299 is always dry, proving that there is no groundwater flow from the ponds or from groundwater bypassing the trench. Toward the middle of the collection trench, at Well 95199, groundwater elevations are influenced by Pond B-2 and the nearby South Walnut Creek. Pond B-2 is isolated from the main drainage system and only collects local area drainage. Pond water is usually not discharged but is allowed to evaporate or infiltrate into the ground. Because of this, the Pond B-2 water level rises when there are precipitation events. The fluctuations seen in the groundwater elevations for Well 95199 also appear to be the result of precipitation events and reflect influence of Pond B-2 on this area.

Farther downstream, Pond B-3 collects stream water, which is held at a near constant elevation by its discharge pipe. Well 23296 is adjacent to Pond B-3 and shows less fluctuation (as shown in Figure 8) because its water level is dominated by the water levels in Pond B-3. During trench installation, water flowed into the excavation in this area from the north side, indicating that the hydraulic gradient north of the trench is toward the trench because of the ponded water. Based on these wells, it appears that there is a direct connection between groundwater and surface water downgradient of the collection trench, and groundwater elevations in this area are dominated by the stream channel flow and the B-Series ponds as opposed to water flow under or around the collection trench.

The groundwater elevation at Well 95099, located east of the collection trench, fluctuated the most, from 5,842 to 5,850 feet above msl. It is evident that this well is influenced strongly by precipitation events.

Water level data from wells and piezometers, together with the volume of water recovered in the collection system, indicate that the collection trench is working as designed.

3.2.1 Treatment System Effectiveness

Analytical samples were collected semiannually at the influent and effluent locations of the treatment system to monitor treatment effectiveness. A summary of these sampling events is provided in Table 6. The contaminants of concern for this plume are primarily trichloroethene, tetrachloroethene, and carbon tetrachloride.

With the exception of one instance of tetrachloroethene, all contaminants were reduced to levels below the RFCA Tier II Groundwater ALs. Some of the compounds in the effluent, such as dichloroethane and dichloroethene, may be the result of incomplete chemical reduction of trichloroethene and tetrachloroethene. The cause for other alkenes, such as hexene and pentene, is unknown but is likely an anomaly.

It is anticipated that eventually the effluent concentrations will increase as the iron is oxidized, however, the effluent concentrations are still relatively low. The system will continue to be monitored to determine when the iron will need to be replaced. However, current data indicate that removal of the iron is not warranted at this time.

Table 6. Summary of East Trenches Plume CY2002 Sample Results

Compound	Influent Concentration (ug/l)		Effluent Concentration (ug/l)		RFCA Tier II Groundwater AL (ug/l)
	4/24/02	10/22/02	4/24/02	10/22/02	
Acetone	ND	ND	ND	13.7	3650
Benzene	ND	ND	0.5 J	ND	5
Carbon Tetrachloride	200	151	ND	ND	5
Chloroform	88	61.2	ND	ND	100
Chloromethane	10	ND	ND	ND	6.55
1,1-Dichloroethane	ND	ND	1.7	ND	3650
1,1-Dichloroethene	5.9 J	1.43	0.53 J	ND	7
Cis-1,2-Dichloroethene	35	20.1	20	0.34 J	70
1,2-Dichloropropane	ND	5.49	ND	ND	5
1,1,1-Trichloroethane	6.2 J	4.25	ND	ND	200
1-Hexene	ND	ND	1.6 J	ND	
Methylene chloride	ND	ND	ND	ND	5
2-Methyl,1-Propene	ND	ND	1.7 J	ND	
1-Pentene	ND	ND	2 J	ND	
Propene	ND	ND	9.3 J	ND	
Tetrachloroethene	280	367 D	12	1.45	5
Toluene	ND	ND	ND	2.23	1,000
1,1,1-Trichloroethane	6.2 J	4.25	ND	ND	200
Trichloroethene	3,200 *	1,880 D *	3.9	1.02	5

Notes

D = diluted

J = detected at concentrations below the detection limit for this analysis

ND = not detected at the detection limit for this analysis

* = concentration exceeds RFCA Tier I Groundwater AL

3.2.2 Upgradient Water Quality

Well 11891 is located upgradient of the collection and treatment system. In CY2002, the concentrations of carbon tetrachloride, tetrachloroethene, and trichloroethene ranged between 337 to 452 ug/l, 157 to 229 ug/l, and 28.3 to 43.4 ug/l respectively. As compared to the influent concentrations presented in Table 6, this well had higher concentrations of carbon tetrachloride but lower concentrations of trichloroethene and tetrachloroethene. This is interpreted as the result of variations in contaminant concentrations across the plume due to the multiple contaminant sources at the East Trenches. However, it is clear from the treatment system influent concentrations, that the collection system is recovering significant VOC concentrations from groundwater within this plume.

3.2.3 Downgradient Water Quality

Analytical samples are collected, where possible, from the three downgradient wells and one well east of the collection trench. Results for CY2002 are shown in Table 7. As noted above, Well 95299 was dry throughout the year. Wells 23296, 95099 and 95199 contained sufficient water for the scheduled semiannual sampling. However, if insufficient groundwater was present to collect the full suite of samples at one time, the VOC analyses were prioritized over the radiological sampling because of the smaller sample volume required.

Table 7. Downgradient Well Analytical Results

Analyte	Well Location						RFCA Tier II Groundwater AL	Unit
	23296		95099		95199			
	4/29/02	10/22/02	4/29/02	10/22/02	4/29/02	10/22/02		
1,1,1-Trichloroethane	0.82 J	ND	ND	ND	ND	ND	200	ug/l
1,1-Dichloroethane	ND	ND	ND	ND	1.39	1.26	3650	ug/l
1,1-Dichloroethene	ND	ND	ND	ND	1.49	ND	7	ug/l
Carbon Tetrachloride	9.8	35.8	ND	ND	ND	0.48 J	5	ug/l
Chloroform	24	27.1	ND	ND	0.22 J	ND	100	ug/l
Cis-1,2-Dichloroethene	100	70.6	ND	ND	1.69	ND	70	ug/l
Tetrachloroethene	17	20.5	ND	ND	2.02	1.87	5	ug/l
Toluene	ND	ND	0.67 J	ND	ND	ND	1,000	ug/l
Trichloroethene	700 *	628 D *	ND	ND	54.8	68.6	5	ug/l
Plutonium-239/240	0.0124 J	ND	-	-	0.0108 J	ND	0.151	pCi/l
Uranium-233,234	18.1	18.7	-	-	-	-	1.06	pCi/l
Uranium-235	0.886 J	0.877 J	-	-	-	-	1.01	pCi/l
Uranium-238	13.8	12.4	-	-	-	-	0.768	pCi/l

Notes

- = not sampled
- D = diluted
- J = detected at concentrations below the detection limit for this analysis
- ND = not detected at the detection limit for this analysis
- * = concentration exceeds RFCA Tier I Groundwater AL

Well 95099 is located east of the collection system and outside the East Trenches Plume. It was installed in that location to determine whether the plume was spreading to the east as a result of the collection system. Water quality at this location has remained substantially unchanged, both historically and for the current reporting period. Contaminant concentrations for this well are close to or lower than detection limits.

Well 23296 is located near South Walnut Creek, where the East Trenches Plume exits to surface water. Higher VOC concentrations observed at this well were an early indication that a remedial action should be considered for this plume. VOC concentrations in Well 23296 exceed RFCA Tier I Groundwater ALs. VOC concentrations in Well 95199 exceed the RFCA Tier II Groundwater ALs. However, contaminant concentrations in both wells are much lower than the concentrations seen in the influent. These two downgradient wells are located within the downgradient portion of the plume, not intended to be collected or treated.

21

As shown in Figure 9, there is an increasing trend in trichloroethene concentrations in Well 23296, which is primarily attributable to an initial spike in concentration after startup. The cause of this spike is unknown. When the initial spike is removed, as shown on Figure 10, the concentration trend is relatively constant, with a smaller increasing trend. Based on the prolonged drought conditions, with minor increasing contaminant trends seen in many wells and declining water levels in both wells and the stream, it does not appear that the concentration increase in Well 23296 is due to leakage or underflow from the trench.

Figure 9. Historical Trichloroethene Trend in Well 23296

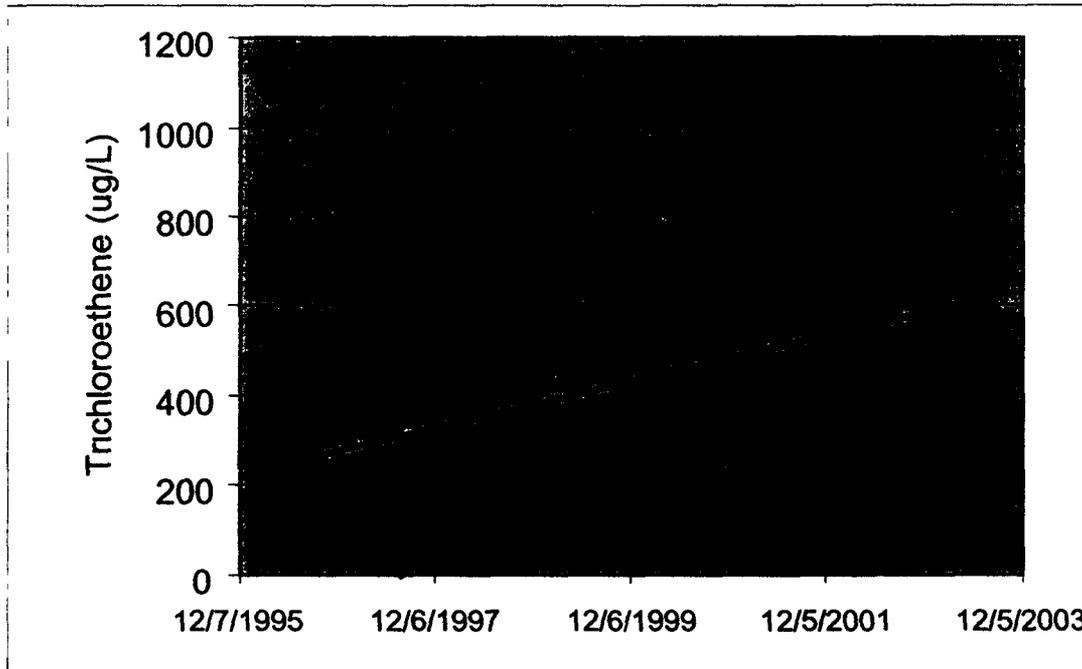
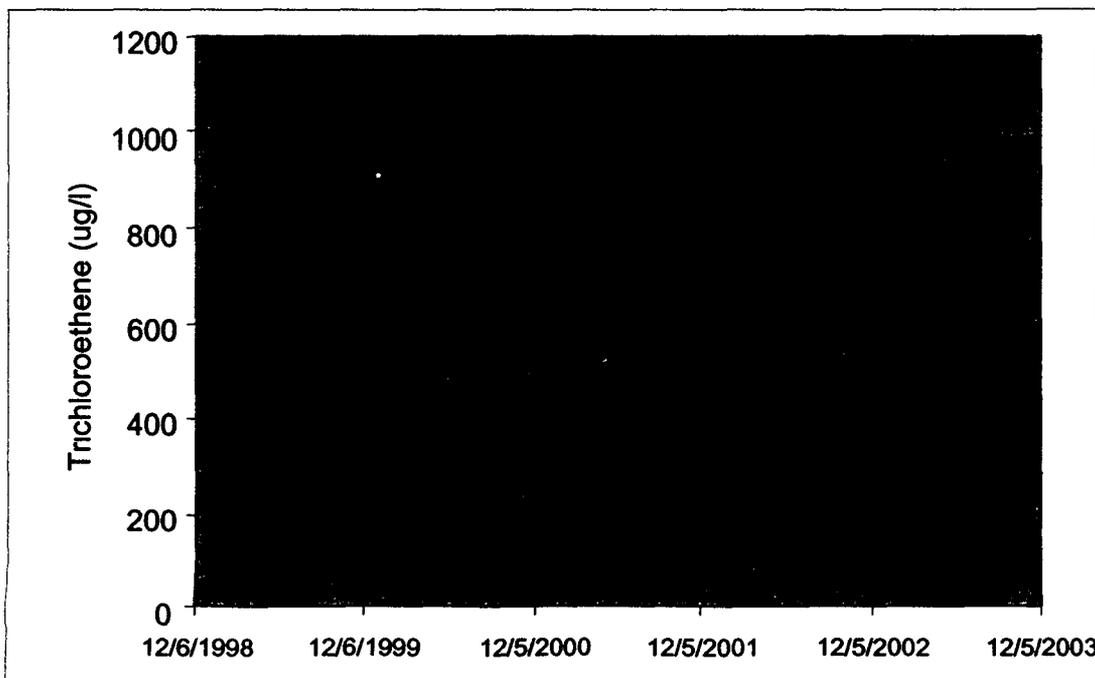


Figure 10. Trichloroethene Levels in Well 23296 During System Operation



22

Figures 11 and 12 show similar trends with tetrachloroethene concentrations, although there is a very slight decreasing trend in tetrachloroethane concentrations when the initial spike is removed

Figure 11. Historical Tetrachloroethene Trend in Well 23296

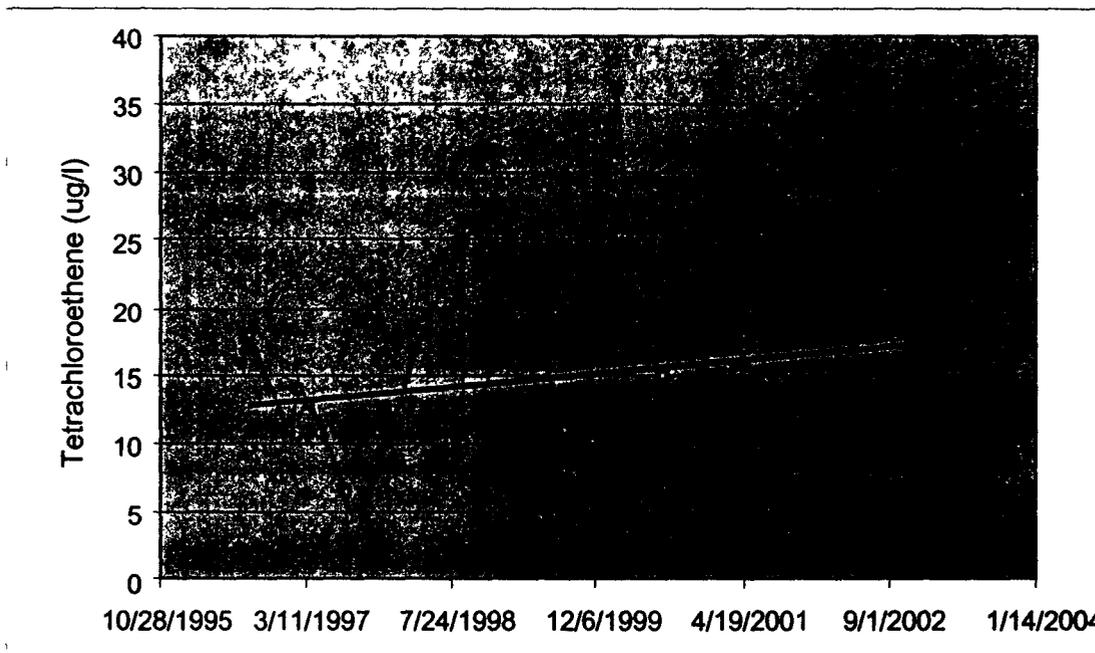
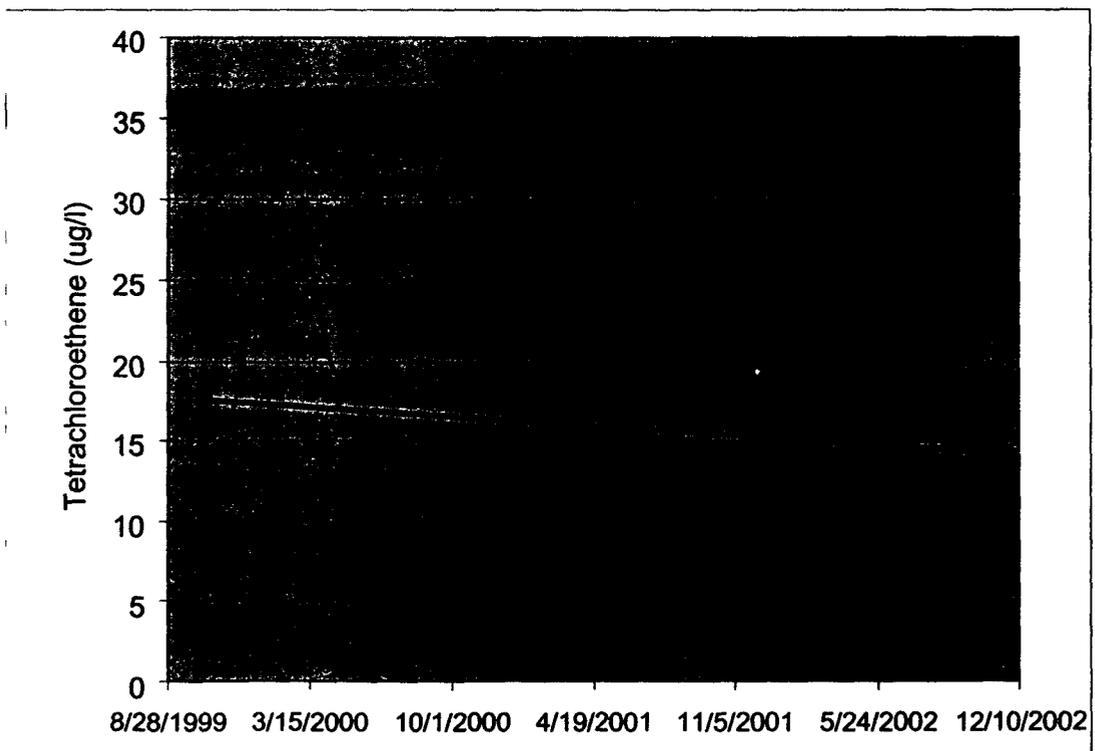


Figure 12. Tetrachloroethene Levels in Well 23296 During System Operation



Some concentration fluctuation in downgradient wells appears to be the result of precipitation, with periods of increased precipitation and infiltration resulting in lower concentrations. The proximity of these wells to the ponds is probably also influencing concentrations because lower levels in the ponds could also be decreasing groundwater flow in these areas, resulting in higher concentrations. Decreasing groundwater flow because of the upgradient dewatering by the collection system could also contribute to the increasing concentrations.

3.3 Conclusions and Planned Changes

The East Trenches Plume Treatment System is fully operational and treating contaminated groundwater to specified system performance requirements. Ongoing maintenance (i.e., raking the iron filings and monitoring) will continue. In addition, periodic cleaning of the discharge line from the flow meter is necessary due to the buildup of iron bacteria. Sampling of the treatment system is expected to continue semiannually. Analytical results will be monitored to indicate when the iron needs to be replaced.

Modifications to the line between the flow meter and the outfall at South Walnut Creek may be necessary to prevent iron bacteria from building up. These modifications would likely include installation of a larger line and/or ensuring that the line has a sufficient grade to prevent holdup, and to keep the line cleaner. The iron bacteria develop in this part of the line due to the presence of reduced iron in the effluent, combined with oxygen introduced in the flow meter flume.

Similar to the areas downgradient of the Mound Site Plume Treatment System, the areas of higher concentrations downgradient of the East Trenches Plume Treatment System are expected to persist. There is insufficient groundwater flow to move contaminants, and it does not appear that degradation is having a significant effect in this area.

4.0 SOLAR PONDS PLUME TREATMENT SYSTEM

The Solar Ponds groundwater plume contains low levels of nitrate and uranium, generally attributed to the storage and evaporation of radioactive and hazardous liquid wastes in the Solar Evaporation Ponds from 1953 to 1986. These ponds were drained and the sludge was removed by 1995. Six interceptor ditches were installed in 1971 to de-water the hillside north and downgradient of the ponds. The original six ditches were abandoned in place, and the Interceptor Trench System (ITS) was installed in 1981. The ITS was replaced with a 1,100-foot-long collection system and passive treatment cell containing iron and wood chips in September 1999. The system components are shown on Figure 13. This system intercepts the water previously collected by the ITS.

The Solar Ponds Plume Treatment System is different from the passive, flow-through systems installed for the Mound Site Plume and East Trenches Plume. As originally designed, the treatment cell was to be located near North Walnut Creek. Water was expected to be intercepted and flow by gravity to the treatment cell without detention in the collection trench.

Because the Preble's Meadow Jumping Mouse (a federally listed threatened species under the Endangered Species Act) is present at the optimal location for a flow-through treatment cell, the treatment cell was located immediately adjacent to the collection trench, not 400 feet downgradient as was originally planned. As a result, the collection trench for this system was required to hold approximately 11 feet of groundwater within a several-hundred-foot section of the collection trench to develop sufficient hydraulic head for the groundwater to flow into the treatment cell. During CY2002, a solar-powered collection pump was installed to allow the system to operate more as it was originally intended, by reducing the hydraulic head in the collection trench.

Maintenance for the Solar Ponds Plume Treatment System consists of water level monitoring, solar-powered pump inspection, and sample collection. Because the iron is more dispersed within the treatment media, the media does not require raking or other maintenance. Based on vendor experience, it is expected that media replacement will be required 10 years after installation.

4.1 Project Activities

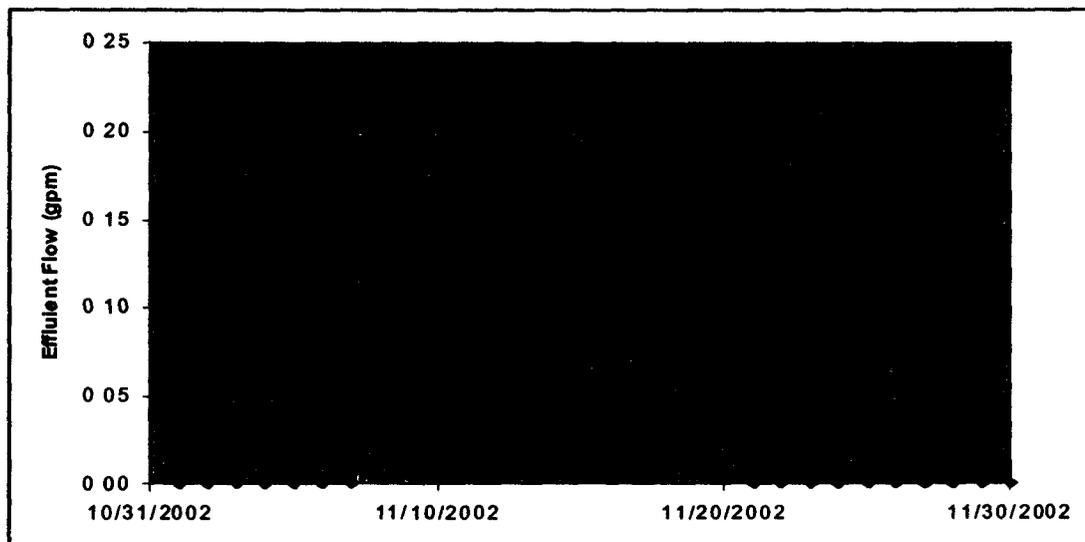
New piezometers were installed in September of 2002 at two locations (Piezometers 71102 and 71202) (Figure 13)

The Solar Ponds Plume Treatment System is collecting groundwater containing nitrate and uranium from the plume. However, untreated groundwater is also reaching surface water at the discharge gallery. This results in higher nitrate and uranium levels in North Walnut Creek than were observed prior to system installation. Based on piezometer data, water in the collection trench was maintaining a constant head lower than the discharge line to the treatment system. The most likely explanations for this were that water was leaking through the impermeable barrier or into the underlying bedrock.

In October 2002, a solar-powered pump was installed within the collection trench to pump the collection trench water into the treatment cell and to maintain a lower level of groundwater within the collection trench. This allows the collection trench to operate more as it was originally designed and eliminates the need for water to be stored within the collection trench. By maintaining a lower water level in the trench, more water will be collected and it should reduce or prevent water from bypassing the treatment system. Installation of the solar-powered pump is expected to reduce the amount of untreated groundwater reaching the stream.

After installation of the pump, it took three to four weeks for the treatment cell to fill because water was being lost within the cell. System flow rates then increased, as shown in Figure 14. While initial flow rates were small, in the past there has not been any flow in November. Based on observed pump operation, flow continued but was not recorded as effluent because the flow rate was too low to be measured.

Figure 14. Effluent Flow Rates From the Solar Ponds Plume Treatment System



26

The drop off in flow was eventually determined to result from the well screen in the sump becoming plugged with fine-grained materials. In March 2003, the sump was redeveloped and much of the fine material was removed. The fines recovered from sump appear to be native material that collected in the trench over time, as opposed to bentonite used in installation of both the collection trench and the sump. This indicates that clogging of the well screen was due to site conditions rather than improper sump design or installation. As a result, the screen may need to be cleaned again to maintain optimum system operations.

In January and February 2002, water from the modular storage tanks (MSTs) was treated in the Solar Ponds Plume Treatment System. Based on what was known of the uranium and nitrate concentrations of this water, it appeared to be acceptable for treatment. During treatment, elevated levels of uranium were detected at the discharge gallery. As a result, addition of the MST water into the treatment cell was stopped, the water was resampled, and it was found to have uranium activities in excess of 400 picocuries per liter (pCi/l). Although the reason for these higher levels is uncertain, it is possible that the water discharged to the treatment system might have had higher uranium levels due to the disturbance of sediments within the tanks during draining, or that uranium activities were concentrated because of continued evaporation of the MST water. No additional water was treated from these tanks.

In the past, the flow meter flume sometimes backed up, producing erroneous readings. The flow meter flume on the Solar Evaporation Ponds is now cleaned and the calibration checked quarterly to improve the accuracy of these measurements. During CY2002, no other maintenance activities or system modifications were performed for this collection and treatment system. Site staff performed regular water level monitoring and sample collection.

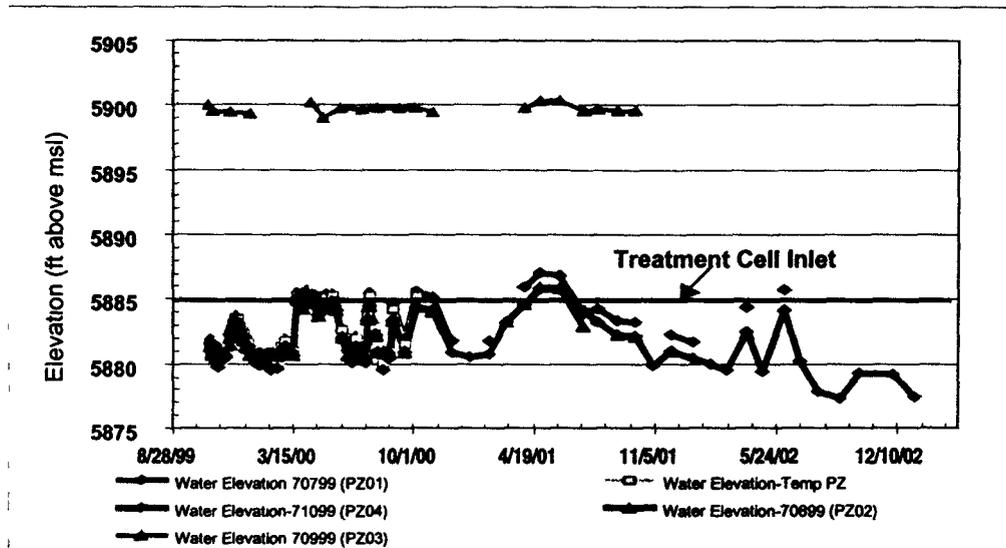
4.2 Treatment Effectiveness

The total volume of water treated by the Solar Ponds Plume Treatment System between March 2000 and December 22, 2002 was 458,448 gallons. Approximately 5,568 gallons, or about 1 percent of the water treated to date, was treated in CY2002. Most of this water was from the MSTs, which contain water collected from the Solar Ponds Plume by the ITS. The rest of the water was treated after the installation of the pump in the collection trench. Prior to installation of the pump, the treatment system only received water during high precipitation events. Due to drought conditions, there was insufficient water to induce measurable flow prior to pump installation. Flow rates ranged from 0 to 0.32 gpm.

Water levels within the collection trench are monitored at five piezometers. The inlet to the treatment cell is 5,885 feet above msl and the bottom of the collection trench is approximately 5,875 feet above msl. As shown in Figure 15, water levels in four of the piezometers fluctuate between 5,880 and 5,885 feet above msl. The fifth piezometer, located at the east end of the trench, has a water elevation of 5,900 feet. By design, water collected in this part of the trench drains to the west. This piezometer is generally dry when the water level of the other piezometers drops to 5,880 feet. As shown below, water in the trench was lower than in past years, and it was below the inlet most of the year.

Prior to pump installation, it was evident that groundwater was bypassing the treatment system. Water levels in the collection trench fluctuated rather than hold a constant level of 11 feet, the height of the treatment cell inlet. Elevated nitrate and uranium levels in North Walnut Creek indicate that untreated groundwater was reaching surface water. Water quality in North Walnut Creek continues to be well below applicable standards for nitrate and uranium despite the apparent bypass of the treatment system. Water levels in the downgradient wells of the system were monitored monthly. These data are provided in Table 8. Quarterly monitoring was initiated in October 2002.

Figure 15. Solar Ponds Plume Collection Trench Piezometer Water Levels



**Table 8. Groundwater Elevations in Downgradient Solar Ponds System Wells
 (feet above msl)**

Well	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1786	5863 9	5863 78	5863 93	5863 92	5863 68	5863 96	5860 59	5863 42	5863 4	5863 85	NM	NM
70099	5876 86	5874 84	5875 48	5876 28	5874 88	5876 01	5876 58	5875 16	5876 47	5877 48	NM	NM
70299	5877 32	5876 69	5876 95	5876 71	5875 76	5876 18	5876 04	5875 41	5875 88	5876.38	NM	NM
71102	-	-	-	-	-	-	-	-	-	5860.29	5863 22	5866 35
71202	-	-	-	-	-	-	-	-	-	5862 7	5866 02	5872 2

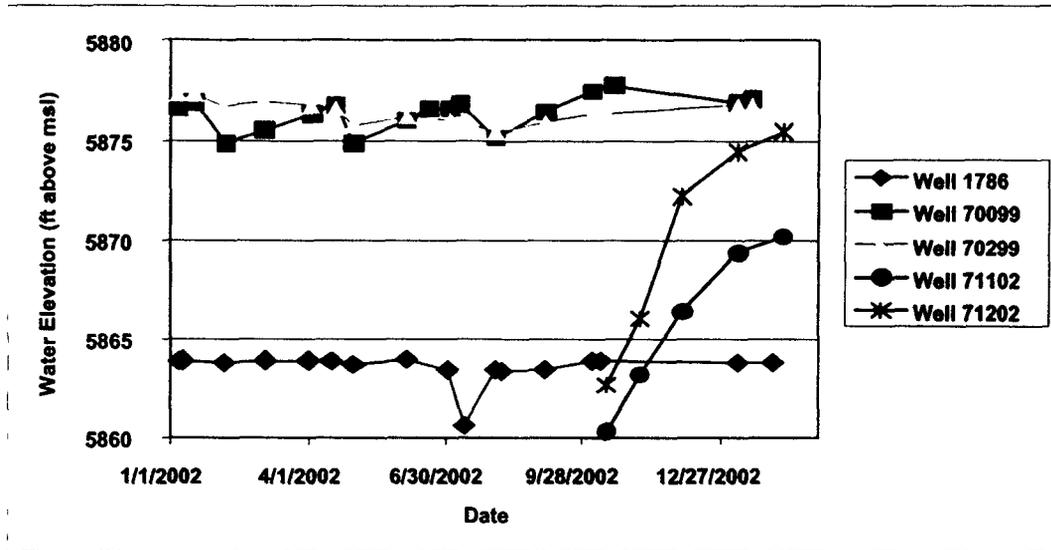
Notes

NM = water elevation not measured

- = not yet installed

As show in Table 8, and on Figure 16, the groundwater elevations in the downgradient wells, colluvial Well 70099, bedrock Well 70299, and Well 1786 adjacent to South Walnut Creek, were relatively stable during CY2002. Groundwater elevations in the two new piezometers (Piezometers 71102 and 71202) increased six to 10 feet since installation. This initial rise may be a result of the water levels equilibrating in the tight formations after well installation. By December 2002, the groundwater elevations in the new piezometers were still lower than those seen within the collection trench and the immediately downgradient wells (Wells 70099 and 70299).

Figure 16. Solar Ponds Plume System 2002 Downgradient Well Water Elevations



4.2.1 Treatment System Effectiveness

Monthly samples for nitrate and uranium collected from the treatment system influent, effluent, and discharge gallery are provided in Table 9. Because of the depth of the collection cell and the influent lines, the influent groundwater concentrations are measured at the piezometer within the collection trench, closest to the treatment cell.

Table 9. Solar Ponds Plume Treatment System CY2002 Analytical Results

Collection Date	SPP Influent		SPP Effluent		SPP Discharge Gallery	
	Nitrate mg/l	Total Uranium pCi/l	Nitrate mg/l	Total Uranium pCi/l	Nitrate mg/l	Total Uranium pCi/l
29-Jan-02	162	25.19	No flow	No flow	209	68
28-Feb-02	198	23.48	No flow	No flow	236	112.86
28-Mar-02	157	24.92	No flow	No flow	165	50.1
5-Apr-02	-	-	0.39	0.217	-	41.5
30-Apr-02	179	24.73	No flow	No flow	230	33.16
28-May-02	182	23.6	0.1	0.03	96.9	18
27-Jun-02	171	3.18	No flow	No flow	247	4.58
30-Jul-02	194	20.94	No flow	No flow	263	32.39
28-Aug-02	170	23.87	No flow	No flow	230	47.41
23-Sep-02	170	38.4	No flow	No flow	230	12.8
28-Oct-02	200	9.55	No flow	No flow	240	28.94
25-Nov-02	140	22.1	No flow	No flow	150	29
30-Dec-02	200	24.056	No flow	No flow	230	34.385

Notes

- = not sampled
 SPP = Solar Ponds Plume

29

Figures 17 and 18 show the changes in uranium and nitrate since the system was installed. Influent and discharge gallery nitrate concentrations were above average for the year, most likely because of drought conditions. Uranium influent activities ranged widely, between 3.18 and 38.4 pCi/l. Although the higher values might be attributable to drought, the cause for the lower values is uncertain, but may indicate a problem with laboratory analysis. The discharge gallery uranium activities ranged between 4.58 and 112.86 pCi/l. The higher values appear to be attributable to the addition of the MST water. The lowest value corresponds to the lowest value in the influent.

Figure 17. Solar Ponds Plume Treatment System Nitrate Concentrations

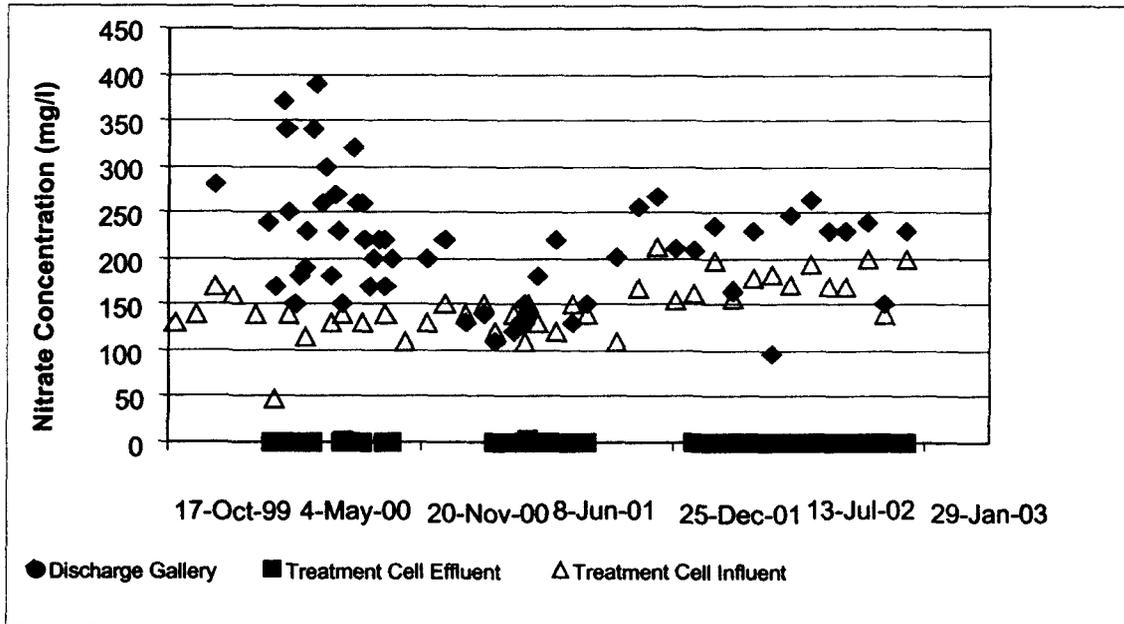
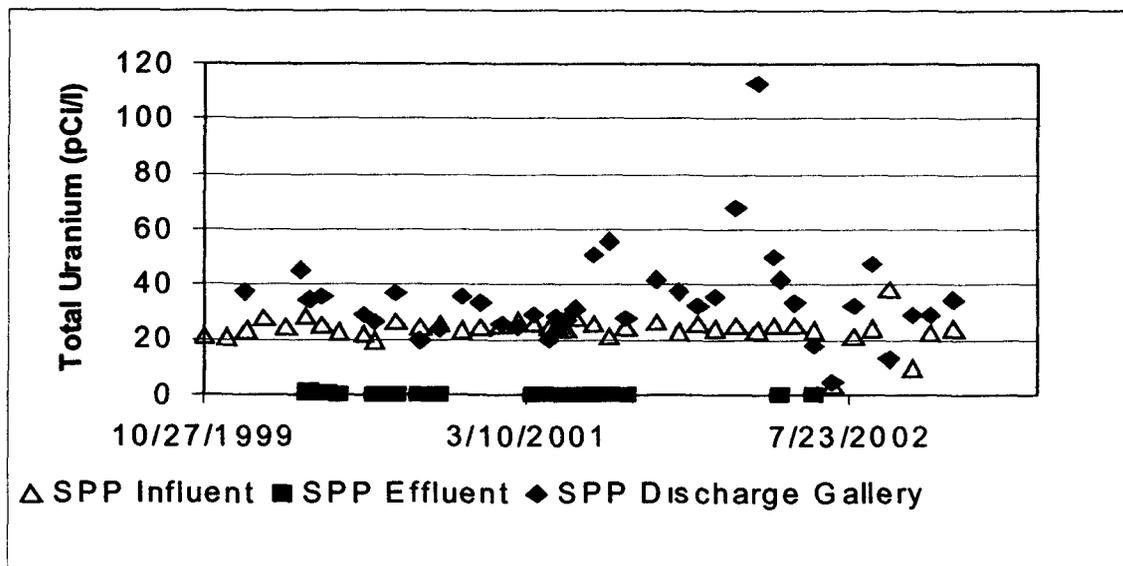


Figure 18. Solar Ponds Plume Treatment System Uranium Activities



When there is effluent flow, the effluent concentrations continue to be much lower than predicted. It was previously thought that this was most likely a result of the increased residence time due to low flow rates, however, higher flow rates have been achieved and the system continues to remove over 99 percent of the nitrates and uranium in the influent. At startup, it was likely that most of the uranium removal and possibly the nitrate reduction was due to the zero-valence iron, however, since a viable bacteria community has developed it is possible that reduction is being controlled by microbes and that iron is not having as much of an effect. This could explain why the results appear to be better than what bench-scale testing would predict.

As described earlier, when water is added to the treatment cell, there is a delay between influent flow and effluent flow of anywhere from a few days to a month, which appears to be due to the cell refilling. At this time, there does not appear to be a leak in the cell because of the way it was constructed and the efforts made to ensure that it was watertight. One possibility is that the organic media over the top of the cell might be wicking water out of the cell, bringing it near the surface where it undergoes evapotranspiration. The top of the treatment cell is filled with wood chips covered by soil. While there is a liner over the treatment cell, this liner is not watertight. It is also possible that siphoning is occurring during discharge, dropping the water in the treatment cell below the level of the discharge line. Although the effluent lines are vented, if one or more of the vents are clogged then siphoning is possible. The vents could have become clogged with an aerobic bacteria (as opposed to the anaerobic bacteria that fills the cell), since the water inside the cell is rich with nutrients and this is the one location in the cell where oxygen might be introduced.

The discharge gallery is most likely discharging both groundwater that is bypassing the treatment cell and groundwater derived from the pre-existing downgradient part of the plume that contains nitrate concentrations consistently above 500 mg/l (milligrams per liter). This downgradient part of the plume is contributing higher nitrate and uranium contaminated groundwater to the discharge gallery, resulting in higher concentrations than are observed at the influent to the system. The addition of the pump is expected to reduce this problem by adding more treated water to the discharge gallery, diluting the contribution from the distal portion of the plume.

The nitrate concentration observed at Well 209489, upgradient of the collection system, was 183 mg/l and the activities in this well for uranium-233/234, 235 and 238 were 33.3 pCi/l, 0.953 pCi/l and 28.7 pCi/l, respectively. The nitrate concentrations are about the same as the influent concentrations to the treatment system and the uranium levels are about twice as high, indicating that uranium is not as mobile as nitrate.

4.2.2 Downgradient Water Quality

Analytical samples were collected quarterly from the three downgradient wells. The data for these wells are provided in Table 10. The new piezometers were not sampled. Wells 70099 and 70299 are twinned wells in the colluvium and the bedrock, respectively. In the past, the bedrock well has sometimes contained sufficient water for sampling, while the adjacent colluvial well has not. However, in CY2002, there was sufficient water to sample both wells quarterly even though drought conditions were dominant throughout the year.

As indicated in Table 10, nitrate concentrations in the immediately downgradient wells are lower than those observed at both the collection trench and the discharge gallery. As previously observed, the uranium activity in the colluvial well (Well 70099) exceeds background activities and is higher than elsewhere in the collection and treatment system. In addition, the uranium activity is much higher than that of the adjacent bedrock well, indicating a pre-existing higher activity in the colluvium.

Table 10. Solar Ponds Plume Downgradient Well Analytical Results

Well	Date	Nitrate/Nitrite (mg/l)	Uranium-233,-234 (pCi/l)	Uranium-235 (pCi/l)	Uranium-238 (pCi/l)
1786	1/9/02	415	39.6	1.56	29.2
	4/16/02	315	37.4	1.06	26.8
	7/12/02	301	27.2	2.14	24.2
	8/6/02	320	34.9	1.23	25.2
	10/10/02	342	30.9	2.31	24.2
70099	1/17/02	1.3	99.8	4.13	81.9
	4/19/02	0.57	110	4.08	68
	7/10/02	1.3	107	5.89	65
	10/18/02	1.4	95.6	4.72	72.4
70299	1/17/02	0.099	5.32	0.189	2.66
	4/19/02	0.03	5.79	0.189	3.07
	7/11/02	0.02	3.79	0.164	2.53
	10/14/02	0.038	5.91	0.549	3.16

Well 1786 is located downgradient, within the same part of the nitrate plume that influences the discharge gallery. Nitrate concentrations at this location are currently 300 to 400 mg/l, much higher than what is observed in the treatment system influent or at the discharge gallery. Uranium activities in this area are also consistently elevated. The source for this downgradient plume is believed to be leakage of historically higher uranium- and nitrate-contaminated groundwater from the ITS sump. Observations of this sump have shown that it was not watertight and historical data from this location have high nitrate levels in the water and sediment. The sediment sample collected from the sump in March 2003 had a nitrate concentration of 159 milligrams per kilogram (mg/kg), showing that the sump is no longer a significant source of contamination.

Water quality was measured at the Solar Ponds Plume discharge gallery, surface water station GS13, located in North Walnut Creek immediately downgradient of the Solar Ponds Plume, and downgradient Pond A-3, which accepts the water that passes through GS13. GS13 and Pond A-3 were monitored frequently to verify that concentrations at both locations are well below the temporary stream standard for nitrate of 100 mg/l. The 100 mg/l nitrate standard is a temporary modification of the underlying stream standard of 10 mg/l nitrate in North Walnut Creek (DOE 1999). Table 11 provides a summary of these analytical data.

32

Table 11. Solar Ponds Plume Summary of Downgradient Surface Water Locations

Date	SPP Discharge Gallery	GS13	Pond A-3	SPP Discharge Gallery	GS13
	Nitrate (mg/l)			Total Uranium (pCi/l) *	
29-Jan-02	209	24.9	7	68	12.18
28-Feb-02	236	25.3	9.6	112.86	10.66
28-Mar-02	165	15	7.6	50.1	8.7
5-Apr-02**				41.5	
30-Apr-02	230	35.7	5.3	33.16	13.7
28-May-02	96.9	7.8	2.4	18	4.78
27-Jun-02	247	46.8	0.97	4.58	1.56
30-Jul-02	263	No flow	<0.05	32.39	No flow
28-Aug-02	230	No flow	0	47.41	No flow
23-Sep-02	230	20	0.14	12.8	0.71
28-Oct-02	240	26	1	28.94	20.19
25-Nov-02	150	14	2.7	29	7.11
30-Dec-02	230	23	3.3	34.385	10.102
Minimum	96.9	7.8	0	4.58	0.71
Maximum	263	46.8	9.6	112.86	20.19
Average	210.6	23.85	3.6	39.5	8.97

Notes

* = Uranium is not measured at Pond A-3

** = Only the discharge gallery was sampled for uranium on this date

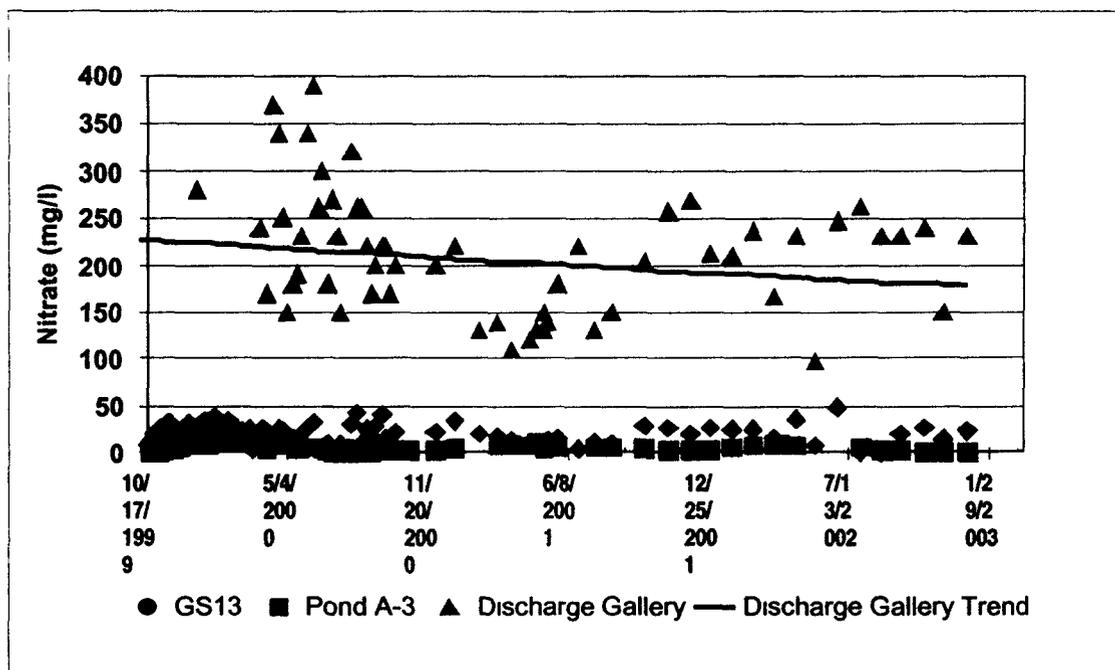
SPP = Solar Ponds Plume

As discussed above, the concentrations of nitrate at the discharge gallery are higher than the treatment system influent because the pre-existing, higher concentration portion of the plume is adjacent to the discharge gallery. As shown in Figure 19, there is a downward trend in nitrate concentrations at the discharge gallery, partly attributable to the lower concentration groundwater flowing into this area from the treatment cell.

GS13, located in North Walnut Creek, is the performance monitoring location for the Solar Ponds Plume Treatment System (DOE 1999). In CY2002, the nitrate concentrations were generally higher than in CY2001. For CY2002, the 85th percentile concentration of nitrate is 32.3 mg/l. This is about a 25 percent increase over the CY2001 85th percentile nitrate concentration of 25.9 mg/l. This apparent increase is likely due to decreased flows in North Walnut Creek as a result of persistent drought conditions. There was no flow at all during the July and August sampling events. Precipitation measured at Rocky Flats in CY2002 was 7.9 inches, almost half of the Site's normal average.

33

Figure 19. Nitrate Concentrations in Solar Ponds Surface Water Locations



The nitrate concentrations still remain well below the applicable surface water standard of 100 mg/l (DOE 1999) At Pond A-3, located downstream of GS13, nitrate concentrations have been declining steadily since March 2000, and they were below 10 mg/l throughout CY2002, even with less dilution from surface water than in past years, due to a lack of stream flow The concentrations are lower in Pond A-3 than GS13, probably due to dilution from downstream water sources and phytoremediation within the pond

As indicated in Table 11 and depicted in Figure 20, uranium activities at GS13 varied greatly during the year and were sporadically above 10 pCi/l However, sample results from the outfall to Pond A-4 (i.e., GS11, the RFCA point-of-compliance [POC] for uranium), remained below 10 pCi/L throughout the year Outfall sampling occurs during discharge events, which occurred only three times in CY2002 Samples were collected May 16th, May 20th and October 24th Total uranium activities were 3 059 pCi/l, 2 662 pCi/l and 1 475 pCi/l, respectively, well below the standard and within the range of historical uranium activities for this location

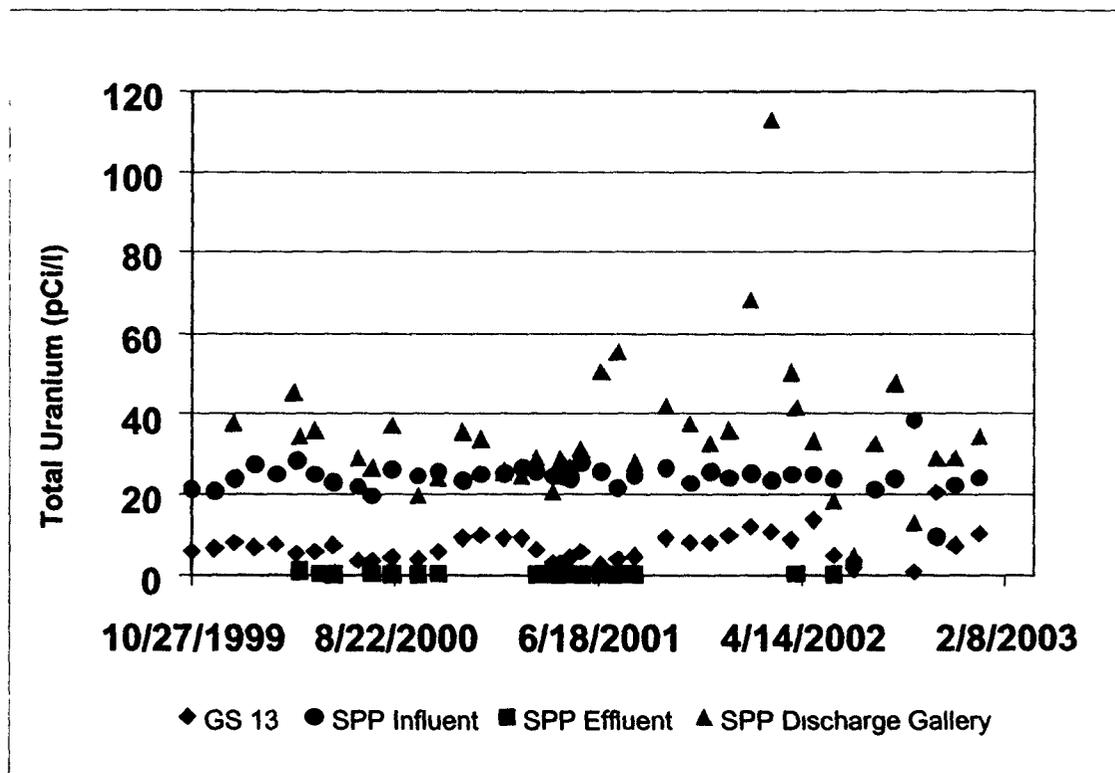
4.2.3 Conclusions and Planned Changes

The Solar Ponds Plume Treatment System is currently collecting groundwater containing nitrate and uranium from the Solar Ponds Plume and the treatment cell is providing treatment for nitrate and uranium as designed Performance monitoring data show that the surface water is well below the applicable standards of 10 pCi/l uranium and 100 mg/l nitrate, as specified in the Final Solar Ponds Plume Decision Document (DOE 1999) The 100 mg/l nitrate standard is a temporary modification of the underlying stream standard for nitrate (10 mg/l) in North Walnut Creek (DOE 1999)

System performance continues to be evaluated by monitoring water levels and collecting samples Because water levels within the collection trench and nearby wells remain stable, these are monitored quarterly The treatment system influent, effluent, discharge gallery, and GS13 are sampled monthly to monitor system performance and impacts to surface water

Additional maintenance will be performed on the collection sump if fines build up again, and maintenance will be repeated until the sump and the materials around it are fully developed

Figure 20. Uranium Activities in Solar Ponds Surface Water Locations



5.0 OUI, 881 HILLSIDE GROUNDWATER TREATMENT SYSTEM

The OUI, 881 Hillside groundwater collection and treatment system was installed in 1992. It consisted of a 1,435-foot-long French drain and a separate upgradient Collection Well. The French drain was installed to prevent potential downgradient contaminant migration with collected water treated in the Consolidated Water Treatment Facility (CWTF). The Collection Well previously collected VOC-contaminated groundwater from within the contaminant plume.

Groundwater collected by the French drain was consistently below RFCA Tier II Groundwater ALs. Therefore, the OUI Corrective Action Decision/Record of Decision (CAD/ROD) (DOE 1997b) included decommissioning the French drain. The French drain was decommissioned in CY2000. Data are no longer collected at this location.

Declining concentrations were also seen at the Collection Well. The Final Major Modification to the OUI CAD/ROD, signed in January 2001 (DOE 2001), included continued extraction and treatment of groundwater from the Collection Well for an additional one-year period to verify this downward trend. In accordance with the terms of the Final Major Modification, water recovery and treatment from the Collection Well were terminated in April 2002, because of the continued decline in contaminant concentrations.

Water sampled from the Collection Well between January and March 2002 was treated at the CWTF. The water volume treated was 1,305 gallons. Table 12 shows the volume of water collected during these three months.

Table 12. Volume of Groundwater Collected from the OU1 Collection Well

Month	January	February	March	Total
Water collected (gallons)	835	370	100	1,305

5.1 Project Activities and Status

The Collection Well continues to be sampled quarterly. The CY2002 VOC analytes that are above detection limits are provided in Table 13. Figure 21 shows the trichloroethene concentrations relative to time. Figure 21 also illustrates the general trend of higher concentrations during dryer periods and the overall downward trend. Even with the continued drought, trichloroethene and other contaminants remained below the RFCA Tier I Groundwater ALs throughout the year.

Table 13. OU1 Collection Well Analytical Results for CY2002 Sampling Event

Analyte	Concentration (ug/l)	RFCA Tier I Groundwater AL (ug/l)
Tetrachloroethene	36.5 - 41.8	500
Trichloroethene	297 E - 473	500
Carbon Tetrachloride	14.4 - 22.1	500
Chloroform	0.92 J - 2.51	10,000
Methylene Chloride	2.5 B - 13.4 B	500
1,1,2-Trichlorotrifluoroethane	3.4 - 5.76	-
1,1-Dichloroethene	16 - 17	700
1,1,1-Trichloroethane	2.01 - 3	20,000
1- Methyl Naphthalene	19 J	-
2- Methyl Naphthalene	13 J	146,000
Methyl tert-Butyl Ether	1.32	-

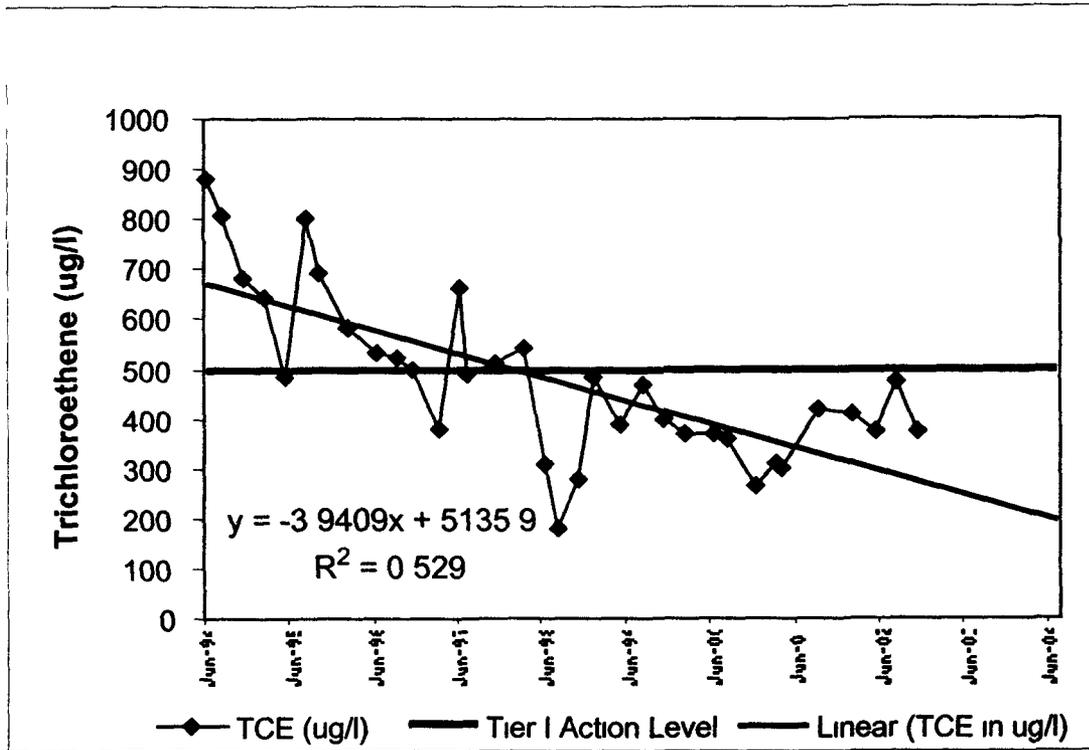
Notes

B = Detected in sample blank

E = Estimated value

J = Detected at concentrations below the detection limit for this analysis

Figure 21. Trichloroethene Concentrations in the OU1 Collection Well



5.2 Conclusions and Planned Changes

Consistent with the modified CAD/ROD, the Collection Well was operated for one year after the signing of the Final Modification (DOE 2001). As of April 2002, collection of groundwater from the Collection Well ceased. Per the modified CAD/ROD, monitoring of the Collection Well will continue in order to verify that levels are below RFCA Tier I Groundwater ALs.

Other wells in the area of the Collection Well were sampled recently and were shown to have concentrations that exceeded RFCA Tier I Groundwater ALs. This will not affect the OU1 CAD/ROD Final Modification because:

- There is no impact to surface water from this groundwater and the description of the pathway to surface water in the OU1 CAD/ROD Final Modification is still accurate, and
- Collection of water from the Collection Well is not likely to improve water quality in these wells since clay and possibly some organic material in the soil continue to act as reservoirs for VOCs. Since equilibrium relationships favor materials in the soil versus the groundwater, these will only very slowly be removed through groundwater extraction technologies.

6.0 OU7, PRESENT LANDFILL PASSIVE SEEP INTERCEPTION AND TREATMENT SYSTEM

Groundwater contaminated with low concentrations of vinyl chloride and benzene discharges at a seep at the eastern end of the Present Landfill (OU7) These contaminants are periodically above RFCA Surface Water ALs

The current passive seep interception and treatment system has operated since October 1998 The water is collected in a settling basin, flows through a pipe to a set of stepped flagstones, and then flows over a six-foot-long bed of gravel before discharging into the East Landfill Pond Flow is measured at the point of discharge In accordance with the Proposed Action Memorandum (PAM) for the OU7 Passive Seep Interception and Treatment System (DOE, 1998), water quality samples are collected from the treatment system discharge endpoint (SW00196), defined as the point six feet downstream from the last aeration step Water released from the treatment system is collected in the East Landfill Pond, which is periodically pumped into Pond A-3 in North Walnut Creek All water in North Walnut Creek passes through two RFCA POCs before it is discharged from the Rocky Flats Site

6.1 Volume of Seep Water Treated

The total volume of seep flow measured and treated in CY2002 was 648,217 gallons The volume treated by month is shown in Table 14

Table 14. Volume of Water Treated in the Present Landfill Passive Seep Interception and Treatment System During CY2002

Month	Volume (gallons)
January	70,867
February	59,777
March	68,051
April	64,167
May	50,288
June	55,232
July	67,309
August	59,896
September	42,031
October	40,441
November	37,998
December	32,160

6.2 Treatment Effectiveness

Samples are collected and analyzed semiannually, in June and December. Sampling requirements are based on the Performance Evaluation Report (K-H 2000) and the Sampling and Analysis Plan (SAP) for the OU7 Passive Aeration System (K-H 2001a). Analytical results are compared to RFCA Surface Water ALs to assess treatment system performance.

In accordance with the SAP, only VOC samples are currently collected and analyzed. All parameters analyzed in CY2001 were within RFCA standards, except benzene. The benzene concentration was between 0.94 to 1.6 ug/l for all sampling events. The RFCA standard for Segment 4 is 1 ug/l. The other standards are shown in the Table 15.

Table 15. Present Landfill Treatment System Water Analytes and Performance Standards

VOC Analytes	RFCa Surface Water Standard (ug/l)
Cis 1,2-Dichloroethene	70
Benzene	1
Chloromethane	5.7
Ethylbenzene	680
Methylene Chloride	5
Tetrachloroethene	5
Toluene	1,000
Trichloroethene	2.7
Vinyl Chloride	2
Xylene (Total)	10,000

RFCa values are based on RFCa Attachment 5 Table 1, Surface Water Action Levels & Standards, March 2000

The SAP states that if a RFCa standard is exceeded in the semiannual monitoring, then a sample will be collected and analyzed the month following receipt of validated data. Preliminary data are received from the analytical laboratory within a month of sampling and validated results are received one month later. A sample taken in December was 1.6 ug/l and a followup sample was taken in January of 1.3 ug/l. These values are so close to the detection limit of 1 ug/l for benzene that they might not actually be over the surface water standard. The result of the February sample was 1 ug/l. Based on these analytical results, sampling was performed quarterly in CY2001 for benzene. The results are shown in Table 16 for the period June 2000 through February 2003.

The water discharging from the Present Landfill Passive Seep Interception and Treatment System generally meets all RFCa Surface Water ALs, except for minor, intermittent exceedances of benzene. As stated in the RFCa Action Level Framework (ALF), the Segment 5 temporary modification to the stream standard for benzene is 5 ug/l, and the Segment 4 stream standard is 1 ug/l (the RFCa AL is applied as a standard in Segment 4). The temporary modification is in place until December 31, 2009. While the East Landfill Pond is located in Segment 4, water from the pond is transferred about once a year to the A-Series ponds in Segment 5. Benzene is not an analyte of interest at the POCs at Pond A-4 or Walnut Creek and Indiana Street.

Table 16. Benzene Concentrations in Present Landfill Treatment System Effluent

Month	Benzene Concentration (ug/l)
June 2000	1
July 2000	1 (special sample)
December 2000	2
March 2001	1
June 2001	2 (duplicate sample concentration was 1 ug/l)
September 2001	1 4
December 2001	0 3 J
June 2002	0 94 J
December 2002	1 6
January 2003	1 3
February 2003	1

Notes

J = Estimated below detection limit

The results for September and December 2001 were reported to the tenth of a microgram due to differences in protocols and reporting between different laboratories

6.3 Conclusions and Planned Changes

Monitoring will continue under the PAM (DOE, 1998) until post closure monitoring begins upon closure of the Present Landfill in FY2004, as described in the Interim Measure/Interim Remedial Action (IM/IRA) Decision Document and Closure Plan for the Present Landfill (DOE, in progress)

7.0 PU&D YARD PLUME TREATABILITY STUDY

A plume of VOC-contaminated groundwater originates from a contaminant source located in the PU&D Yard at RFETS. Investigation results indicate that subsurface VOC contamination is present in only a few locations and the primary contaminant is tetrachloroethene (K-H 2001b)

A treatability study was conducted to evaluate the effectiveness of Hydrogen Release Compound (HRC[®]) for enhancing natural attenuation of the VOCs in the groundwater and soil at the PU&D Yard Plume (K-H 2001b, K-H2001c). HRC[®] is a proprietary, environmentally safe, food quality, polylactate ester formulated for slow release of lactic acid upon hydration.

The HRC[®] stimulated rapid degradation of chlorinated VOCs found in groundwater and soil at this location by making low concentrations of hydrogen available to the resident microbes to use for dechlorination. The HRC[®] was a one-time application that, according to the manufacturer, Regensis, was expected to stimulate contaminant degradation at the project site for approximately one and a half years. However, because some of the HRC[®] was inserted above the water table and the water table fluctuated considerably, it appears that additional degradation of contaminants within the vadose zone occurred through CY2002 and will likely continue through CY2003. This project was a cooperative effort between RFETS and the DOE SCFA. Funding was provided by DOE SCFA.

7.1 Project Activities

The treatability study is located within the source area and that portion of the PU&D Yard Plume exhibiting the highest contaminant concentrations (Figure 22). A monitoring (Well 30900) was installed in this area immediately adjacent to Borehole 17497, where the highest concentrations of VOCs in soils were detected. An additional monitoring well (Well 31001) was installed slightly downgradient of the source area in January 2001 as part of this study. Baseline samples were collected from these two monitoring wells prior to insertion of the HRC®.

Beginning in February 2001, 16 material insertion points (MIPs) were used to place over 800 pounds of HRC® into the subsurface within a 10-foot by 6-foot area within the source area of the plume (Figure 23). The initial grid consisted of nine points. Additional Geoprobe™ boreholes used as MIPs were spaced between these initial locations, biased to the upgradient part of the source area. HRC® insertion was completed on March 1, 2001. Subsurface conditions were allowed to stabilize for two months, before monthly sampling was initiated April 30, 2001.

7.2 Treatment Effectiveness

Results from the initial baseline samples and the monthly sampling events through late November 2001 are reported in Table 17. The previous samples from the pre-existing monitoring well (Well 30900) in the source area are included for completeness. In addition, results from the one-time-only groundwater sample from MIP3 are also provided in Table 17.

As shown in Table 17 and on Figure 24, concentrations of tetrachloroethene, trichloroethene, and cis 1,2-dichloroethene in the source area well (Well 30900) increased after insertion of the HRC®, then decreased. Trichloroethene and cis 1,2-dichloroethene are common degradation products of tetrachloroethene. According to Regensis, approximately 70 to 80 percent of project sites see an initial increase in VOC concentrations before a downward trend is observed. It was anticipated that this downward trend would continue, however, the cycle repeated itself when the water table rose again in the Spring of 2002. It is anticipated that the cycle will repeat again in CY2003, especially since the water table did not rise as much in CY2002 as it does in normal precipitation years, due to the drought. As indicated on Figure 25, data from the downgradient well (Well 31001) show a similar overall pattern.

The initial, expected increase in tetrachloroethene in groundwater was most likely due to one or a combination of the following conditions:

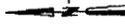
- A change in the surface tension of free phase solvents in the pores that would cause more solvent to be released from the pores
- A change in the relative solubility of the individual VOCs due to the presence of lactic acid in the aqueous phase that would allow more VOCs to go into solution
- Other changes in liquid and organic phases caused by changes in pH, temperature, oxidation reduction potential (ORP), etc. caused by addition of lactic acid or by increases in biological activity
- A seasonal increase due to the rising water table and release of additional contaminants from the vadose zone

Figure 23
FU&D Yard
Groundwater VOC Plume
Material Insertion Point Configuration

- EXPLANATION**
- PUSD Well Monitoring Well
 - Groundwater Monitor Well
 - UMSU (See Field Manual)
 - ⊕ Groundwater Monitor Well
 - ⊕ UMSU (See Field Manual)
 - Groundwater Monitor Well
 - UMSU (See Field Manual)
 - Bertha's Locations
 - × Abandoned Monitor Well
 - ◆ Material Insertion Point
 - Composite VOC Groundwater Plume (concentration equal to MCL)
 - PUSD Well PHS

- Standard Map Features**
- ▭ Buildings and other structures
 - ▭ Landfill Pond
 - ▭ Streamline ditches or other drainage features
 - ▭ Fences and other barriers
 - ▭ Topographic Contour (5-Foot)
 - ▭ Paved roads
 - ▭ Dirt roads

NOTES
 See Appendix 1 for abbreviations.



Scale = 1" = 70'
 1 inch represents approximately 6 feet



State Plane Coordinate Projection
 Colorado North Zone
 Datum: NAD27

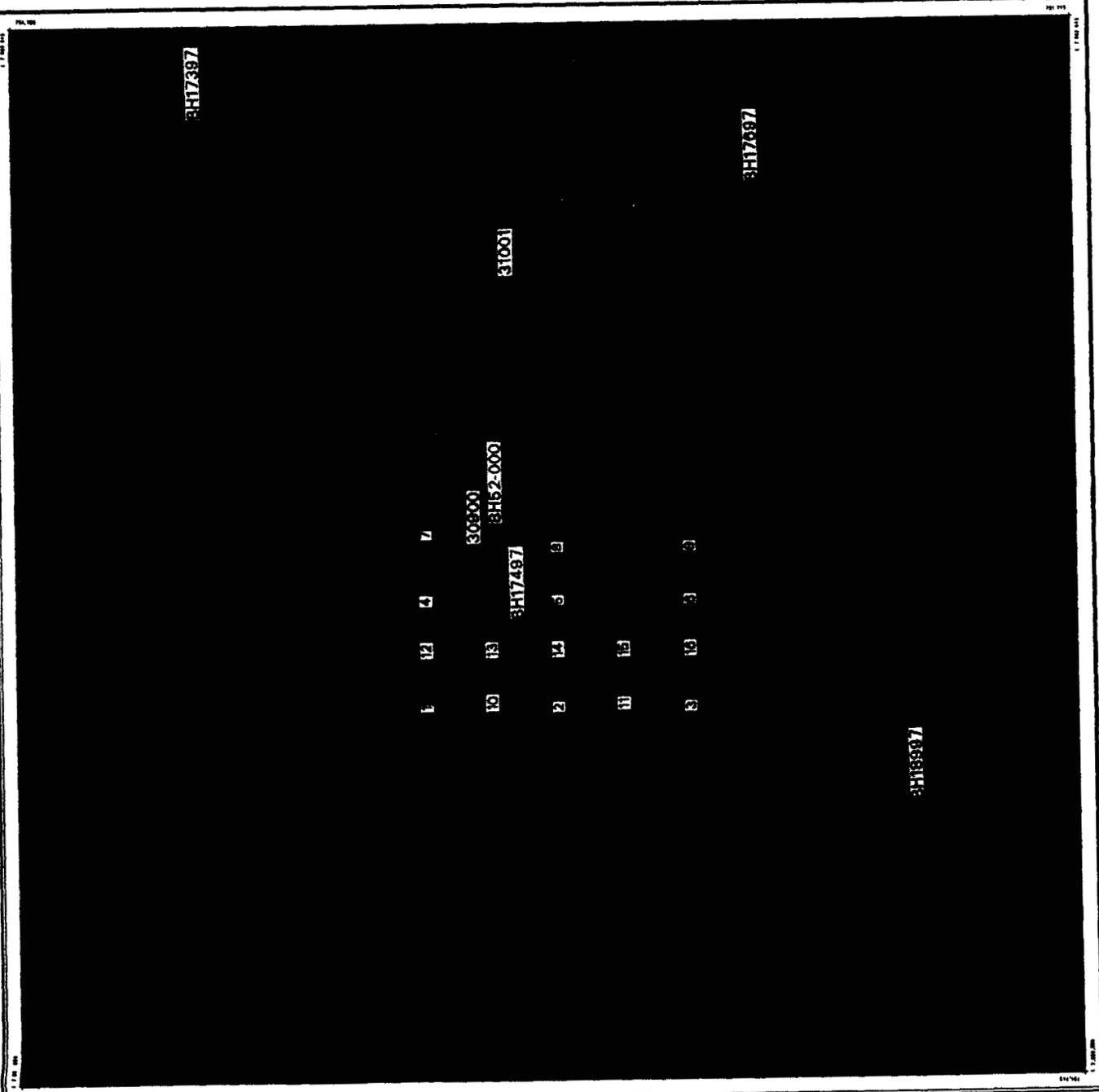
U.S. Department of Energy
 Rocky Flats Environmental Technology Site

OSD Draw: 88-000-707

Prepared for



March 27, 2009



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Table 17. Preliminary Treatability Study Results (ug/l)

Location	Sample Date	Tetrachloro-ethene	Trichloro-ethene	Cis 1,2 Dichloro-ethene	Trans 1,2, Dichloro-ethene	1,1-Dichloro-ethene	Vinyl Chloride
MIP3	2/20/01	49	ND	ND	ND	ND	ND
30900	10/21/00	96	74	531	ND	ND	ND
	2/7/01	120	7	78	05	05	ND
	4/30/01	180	11	110	01	04	ND
	5/30/01	350	23	210	ND	ND	ND
	6/27/01	240	15	140	02	05	ND
	7/31/01	936	106	914	019	031	021
	8/28/01	116	15	100	ND	039	ND
	10/1/01	50	5	77	ND	ND	ND
	10/31/01	34	31	36	ND	ND	ND
	11/29/01	30	36	45	ND	028	ND
	1/7/02	185	292	886	0212J	ND	ND
	2/18/02	98	19	140	ND	038	ND
	3/4/02	825	137	188	0568J	051J	ND
	4/1/02	15	27	160	ND	042	ND
	5/2/02	75	16	200	ND	045	ND
	7/1/02	46	9	460	058	15	ND
	10/3/02	23	61	31	ND	1	ND
1/7/03	7	096	540	087	11	ND	
31001	2/7/01	18	55	12	ND	26	ND
	4/30/01	130	20	52	01	4	ND
	5/30/01	41	18	4	ND	ND	ND
	6/27/01	120	25	38	ND	1	ND
	7/31/01	105	163	189	013	149	012
	8/29/01	81	22	93	ND	ND	ND
	10/1/01	67	77	71	ND	06	ND
	11/1/01	18	48	30	ND	065	ND
	11/30/01	15	37	24	ND	047	ND
	1/07/02	12	378	121	ND	088	ND
	2/18/02	37	94	13	ND	33	ND
	3/4/02	34	923	927	ND	167	ND
	4/1/02	30	67	10	ND	26	ND
	5/2/02	25	66	12	ND	23	ND
7/1/02	35	16	85	ND	22	ND	
10/3/02	27	24	79	ND	ND	ND	
1/7/03	16	42	36				
Groundwater Tier I AL		500	500	700	700	700	200
Groundwater Tier II AL		5	5	7	7	7	2

ND - not detected

44

Figure 24. Tetrachloroethene and Degradation Products Concentration versus Time in Well 30900

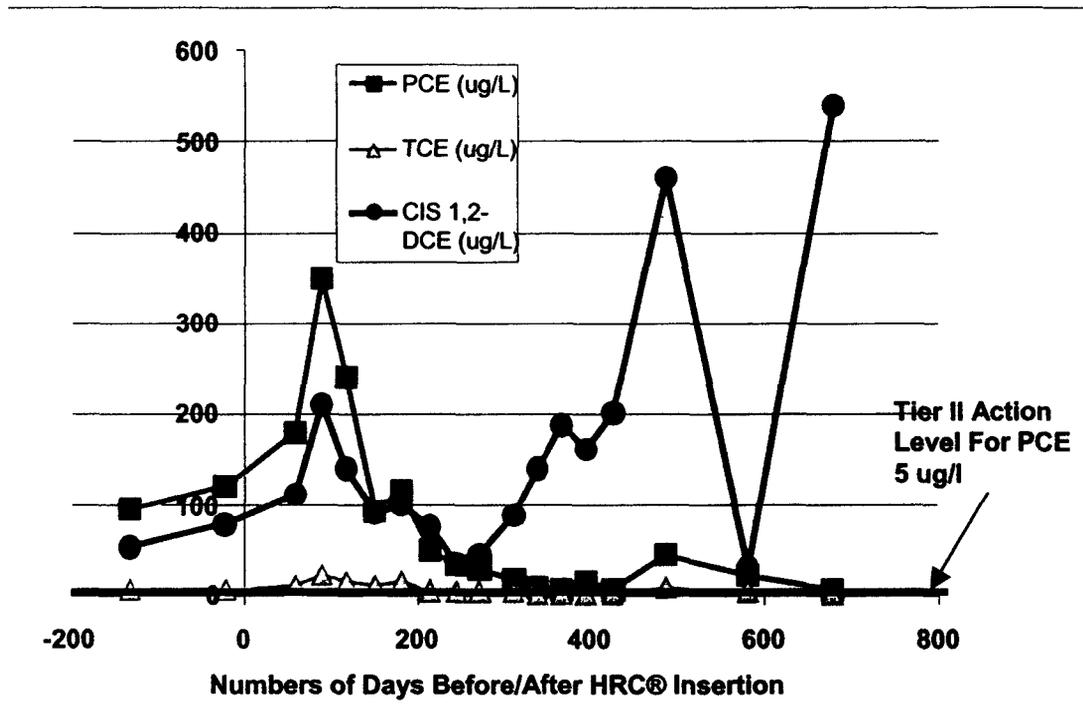


Figure 25. Tetrachloroethene and Degradation Products Concentration versus Time in Well 31001

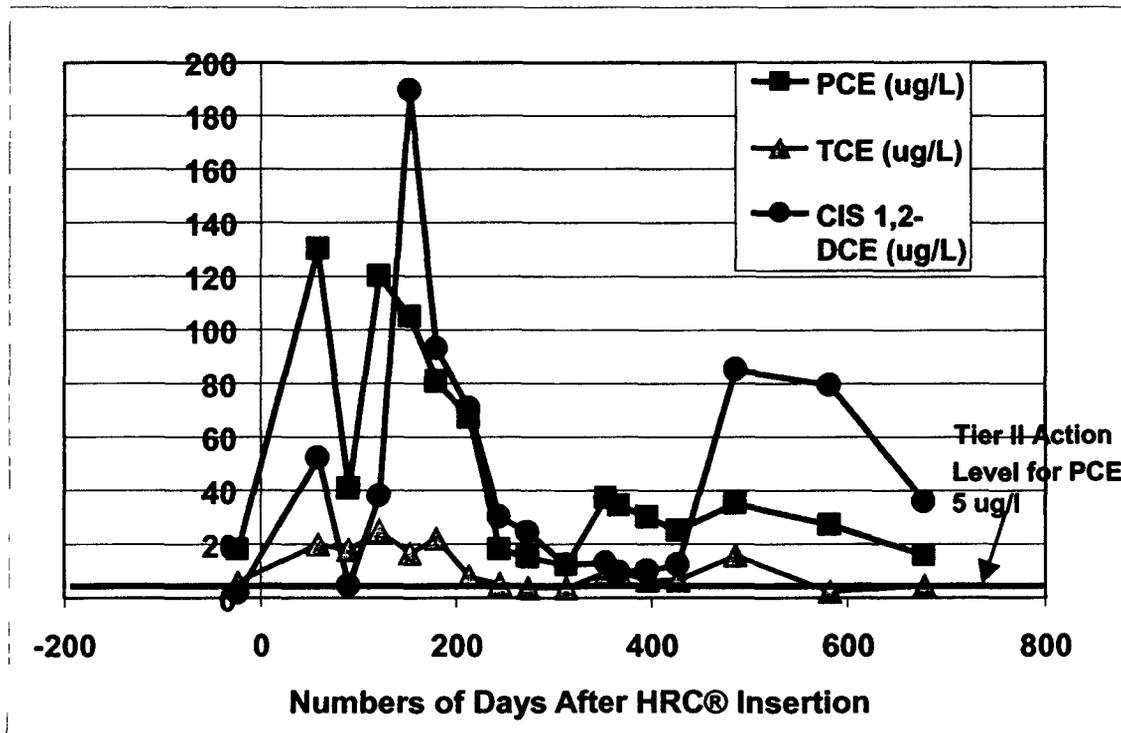
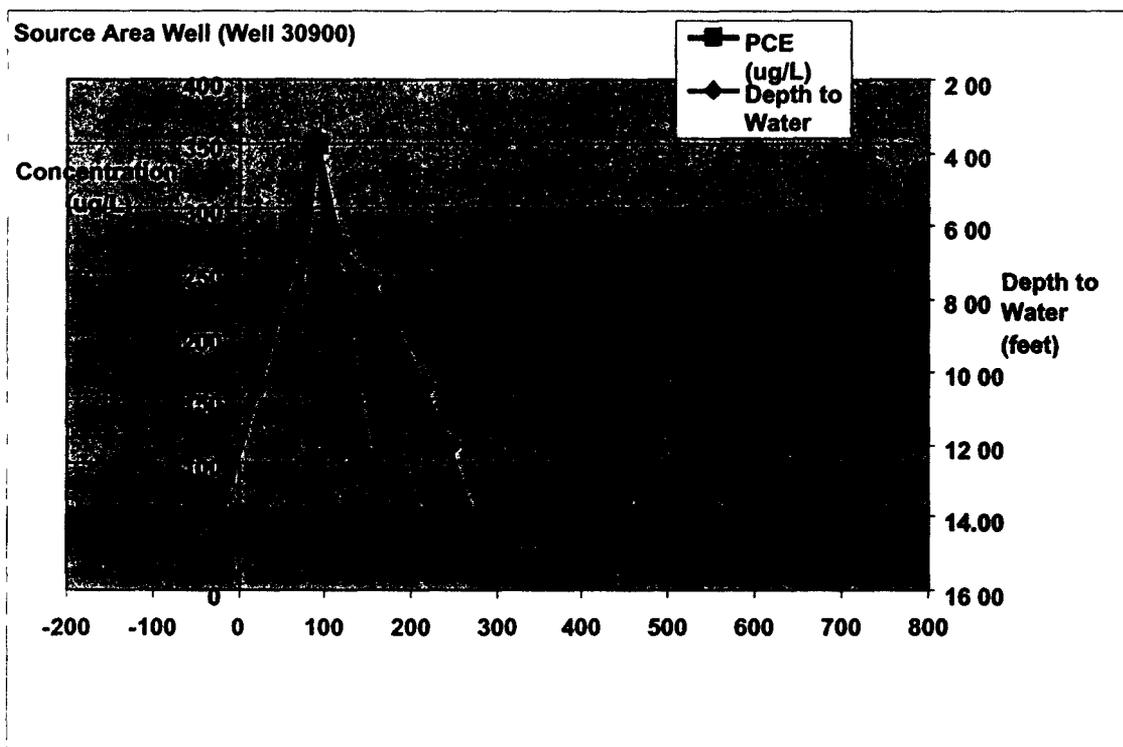


Figure 26 better demonstrates the relationship between the depth to water and the tetrachloroethene concentration in the source area well (Well 30900). When the HRC[®] was inserted, much of it appears to have been inserted into the vadose zone rather than below the water table. As the water table rises into the vadose zone, HRC[®] is released, inducing more biological activity. At the same time, additional contaminants are available since more contaminated soil is now below the water table and available for biological and chemical degradation. Figures 27 and 28 show the same phenomenon as a mole fraction. The relative amounts of degradation byproducts increase as additional degradation occurs and the zone of anaerobic degradation increases. Eventually these byproducts are also degraded and their mole fraction decreases.

Figure 26. Tetrachloroethene Concentration and Depth to Water in Source Area Well 30900 versus Time



Figures 24 and 27 also show that in the source area the Cis 1,2-dichloroethene is in much higher concentrations in the source area well than in the downgradient well. Cis 1,2-dichloroethene is more resistant to anaerobic bacterial degradation than tetrachloroethene and its other byproducts. However, according to Regenesys, aerobic bacteria can more readily degrade it. In the downgradient well, as conditions become more aerobic, the Cis 1,2-dichloroethene appears to be readily degraded to vinyl chloride and then to ethane. Vinyl chloride is so readily degraded that it only appears occasionally in very low concentrations.

The initial increases in concentrations indicate that VOCs are being transferred from the soil to an aqueous phase, potentially accelerating both soil and water remediation. Typically, the VOCs trapped in the saturated and vadose zones have been the most difficult phase to remediate and continue to act as a contaminant source. If these are being mobilized and then biologically degraded along with the dissolved phase, this is a much more robust treatment methodology than simply biologically degrading the dissolved fraction.

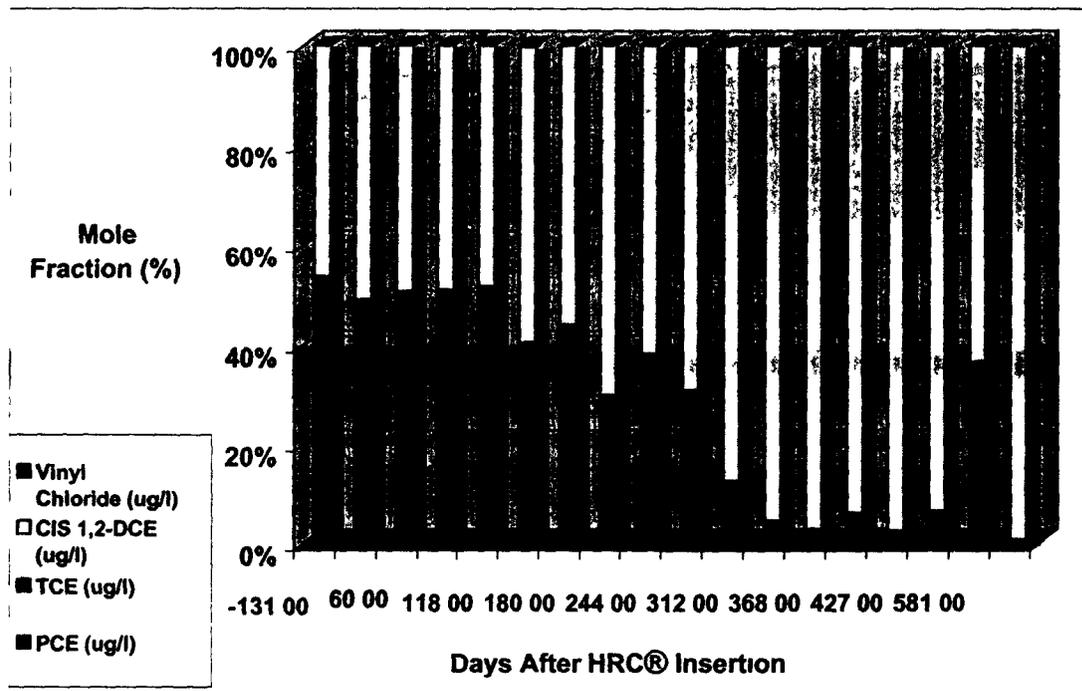
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As shown in Table 17, the presence of other degradation products such as trans 1,2-dichloroethene, 1,1-dichloroethene and vinyl chloride demonstrates that degradation is occurring because these contaminants were not associated with releases at the PU&D Yard. The increase in the ratio of degradation products relative to tetrachloroethene concentrations confirms that degradation is occurring. Figures 27 and 28 show this increase in degradation products over time.

Vinyl chloride is the last degradation product generated prior to the degradation to ethene. The small quantities of ethene produced are expected to offgas rather than be detected.

The area of anaerobic degradation appears to expand and contract with water table fluctuations. The area expands as the HRC[®] is released and contracts as it is consumed. Figure 29 shows how oxidation potential changes with time in both the source area well (Well 30900) and in the downgradient well (Well 31001). Reduced conditions in the source area well increased as the anaerobic bacterial community developed. Since it is at the center of the community, it has remained in a reduced state.

Figure 27. Mole Fraction Percent of Tetrachloroethene in Source Area Well 30900 Relative to its Degradation Products Over Time



**Figure 28. Mole Fraction Percent of Tetrachloroethene in Downgradient Well 31001
Relative to its Degradation Products Over Time**

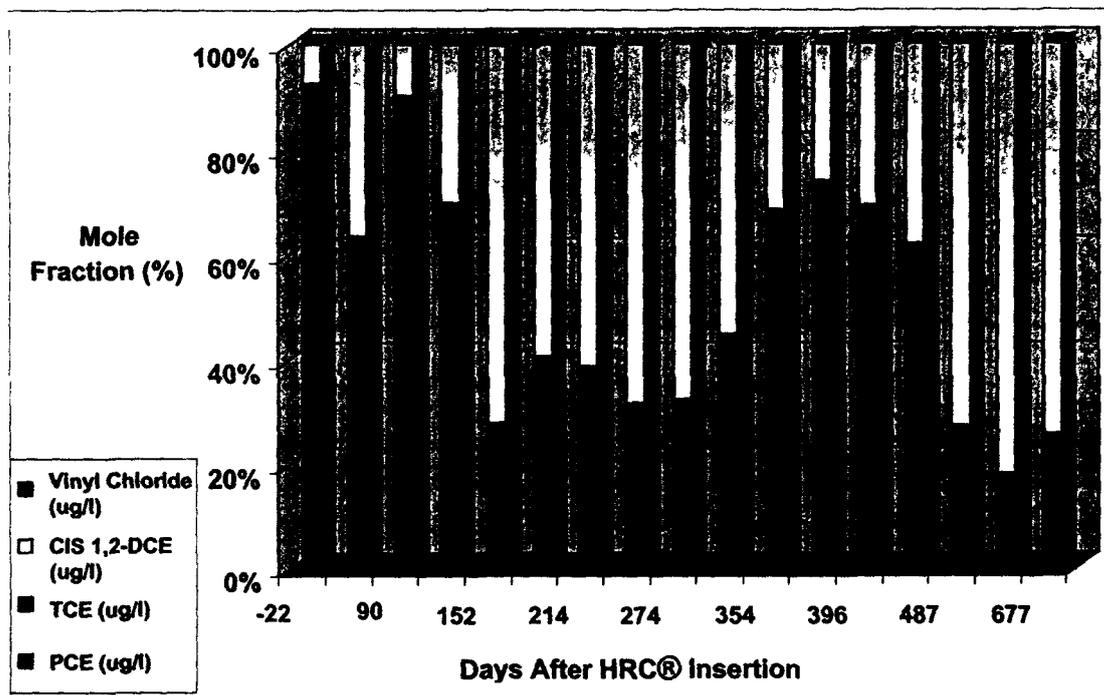
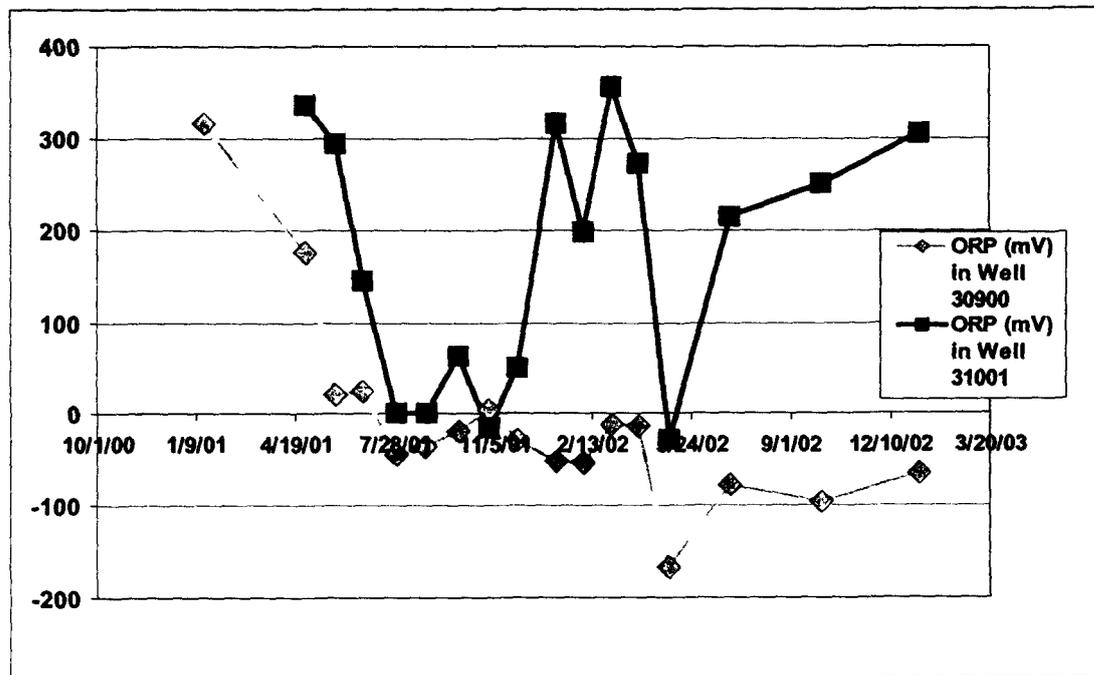


Figure 29. Oxidation Reduction Potential in PU&D Yard Wells versus Time



48

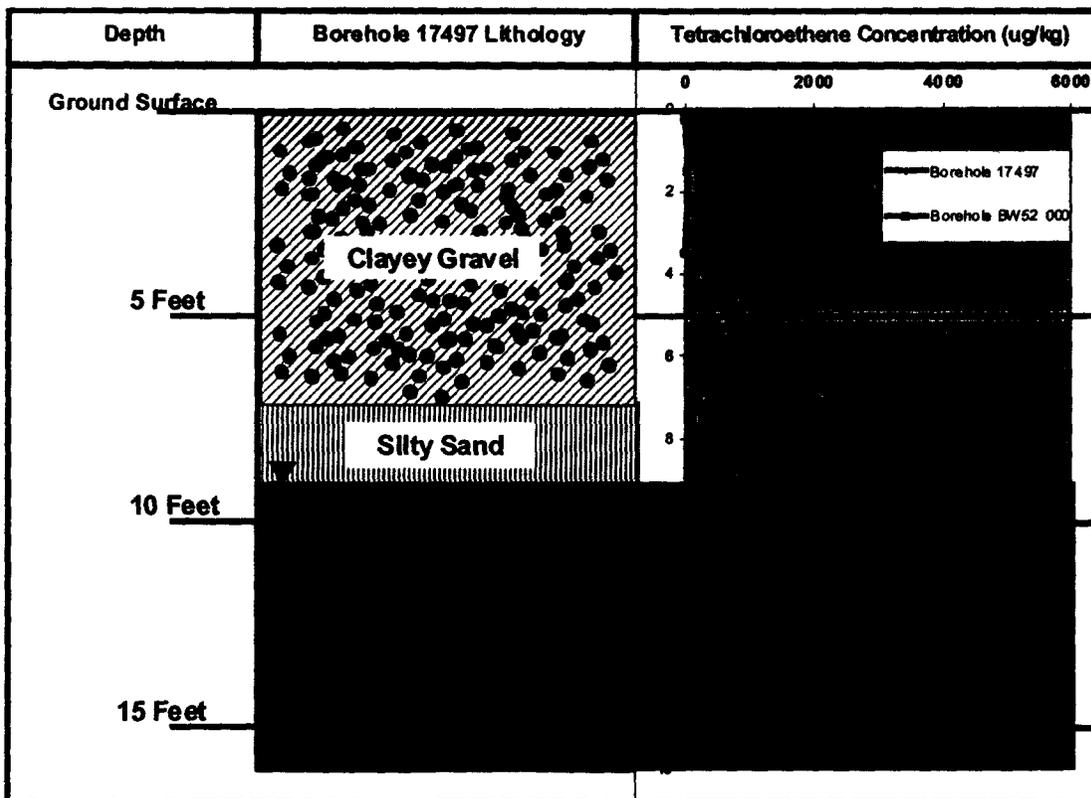
Downgradient, the area of reduced conditions increased but then contracted when the HRC[®] was consumed and the area of anaerobic degradation shrank. When the water table rose, and more HRC[®] became available, the area of reduced conditions again expanded. Figure 29 also shows seasonal variations in the downgradient well. When more HRC[®] was released in the Spring of 2002, the area of anaerobic bacteria expanded to include this well and the oxidation-reduction potential again dropped.

The most promising thing about this technology is not so much effectiveness on contaminants in the dissolved phase but its effectiveness on the organics trapped in the soil that would normally act as a continuous source of contaminants. Pump and treat systems and passive systems such as the Mound Site Plume and East Trenches Plume treatment systems only treat the groundwater plume. These systems are expected to operate for many years since the trapped organics will continue to feed these plumes. With *in situ* biodegradation, organic compounds are liberated from micropores and consumed over a relatively short period of time.

In September 2002, Borehole 17497 was twinned with a new borehole (Borehole BW52-000) to determine whether soil concentrations were significantly reduced. Samples were taken at two-foot intervals from 0.5 feet below the surface down to 15.5 feet below the surface and analyzed for VOCs.

Figure 30 shows the differences in tetrachloroethene concentration with depth between the original sample and the sample after treatment. Prior to HRC[®] insertion, the highest concentration of tetrachloroethene was 5,700 ug/kg occurring below the water table at a depth of 11.25 feet. The more recent sample from the corresponding borehole interval had a tetrachloroethene concentration of 140 ug/kg or a 97.5 percent reduction in concentration. As can be seen in Figure 30, there appears to have been a reduction in tetrachloroethene both above and below the water table.

Figure 30. Lithology and Soil Concentrations of Tetrachloroethene in the Source Area



7.3 Conclusions and Work Planned

The continued decrease in tetrachloroethene and appearance of its byproducts provide direct evidence that the contaminant plume is being degraded. However, quarterly monitoring will continue until sufficient data are collected to establish the effectiveness of the HRC®. Other than monitoring, no additional work is planned for this site. A treatability study report was completed in October 2001. It provides additional information on the treatability study (K-H 2001c).

In situ biodegradation appears to be one of the most viable technologies for future groundwater remediation at Rocky Flats. It appears to be best suited for areas with organic compounds trapped below the water table although it could be a viable technology above the water table. In areas where there are large quantities of free phase organic compounds, other technologies might be more viable or might be combined with *in situ* biodegradation.

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51/51

