A Department of Ecology Report

Palermo Wellfield Superfund Site Subdrain System and Treatment Lagoon Status Report, December 2002 and May 2003

Abstract

The Palermo Wellfield in Tumwater, Washington was found to be contaminated with trichloroethene (TCE) in the late 1980s. Groundwater contaminated with TCE and tetrachloroethene (PCE) migrated from an upland commercial area to the Deschutes River valley where the Palermo Wellfield is located. The contaminated groundwater was also found to surface at the base of the Palermo bluff and pond as surface water in the yards and crawlspaces in area homes. In 2000, a subdrain system was constructed to lower the groundwater table.

Monitoring of the subdrain system was conducted by the Department of Ecology in December 2002 and May 2003. Groundwater levels measured in piezometers near the base of the bluff were three to five feet below the ground surface near the north and central homes, and less than three feet near the two southern homes.

Total depth measurements in the subdrain system and treatment lagoon indicate that sediment deposition or scouring is not occurring, with the exception of the central station within the trunk drain, cleanout CO-4, which has had some sediment accumulation.

PCE and TCE concentrations continue to be highest in water samples collected from the south and central portion of the trunk drain, with average concentrations of 23 ppb for PCE and 24 ppb for TCE. PCE and TCE concentrations from the lagoon effluent were higher than during previous monitoring, February 2001 through April 2002. During the current monitoring, concentrations exceeded the remediation goals set for PCE and TCE for surface water that discharges to the Deschutes River. During previous monitoring, concentrations were typically below the remediation goals at the lagoon outfall.

For future monitoring, a sample station should be reestablished where surface water from the lagoon watercourse discharges to the Deschutes River. This is approximately 2,000 feet downstream from the lagoon. A station at this location would allow a better comparison of contaminant concentrations to the remediation goals.

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Author: Pamela B. Marti, Hydrogeologist
Washington State Department of Ecology
Environmental Assessment Program
E-mail: pmar461@ecy.wa.gov
Phone: (360) 407-6768
Address: PO Box 47600, Olympia WA 98504-7600

This report was prepared by a licensed hydrogeologist. A signed and stamped copy of the report is available upon request.

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Background

The city of Tumwater, Washington discovered in the late 1980s that some of the water supply wells at their Palermo Wellfield were contaminated with trichloroethene (TCE). Groundwater contaminated with TCE and tetrachloroethene (PCE) migrated from an upland commercial area to the Deschutes River valley where the Palermo Wellfield is located (Figure 1). Sources of the contaminants included several facilities located in the upland area, such as a dry cleaners and a laboratory (USEPA, 1999). In the spring of 1999, the U.S. Envionmental Protection Agency (USEPA) began the operation of an air-stripping treatment system at the Palermo Wellfield Superfund Site to remove TCE contamination from the water supply.

Groundwater contaminated with PCE and TCE was also found to surface at the base of the Palermo bluff and pond as surface water in the yards and crawlspaces of homes in the Palermo neighborhood. A subdrain system was constructed in 2000 to lower the groundwater table at the base of the bluff to prevent the contaminated groundwater from collecting in crawlspaces below the residences along Rainier Avenue. Ponded water in the crawlspaces posed an inhalation risk to human health since PCE and TCE volatilize from the water into the homes.

The subdrain system includes a subgrade perforated piping network installed around seven houses along Rainier Avenue (Figure 2). The subdrain system consists of "finger drains" between the houses connected to a "trunk drain" aligned through the backyards of the houses. Water collected by the subdrain system is routed to an unperforated "tightline" pipe aligned beneath Rainier Avenue and M Street. The water in the tightline pipe drains to a treatment lagoon located at the City of Tumwater Municipal Golf Course. The water is treated for removal of volatile organics by surface aeration. The treated water ultimately discharges to the Deschutes River via an existing water course. The PCE and TCE removed from the water are transferred to the air where they disperse and degrade naturally.

Remediation goals for shallow groundwater that ponds as surface water at the base of the bluff is to lower the static groundwater elevation beneath the homes along the west side of Rainier Avenue to a minimum depth of 18 inches below the floor of the homes crawlspaces. This is approximately equal to three feet below ground surface.

The numerical remediation goal values for treated water from the aeration lagoon are 0.8 ug/L for PCE and 2.7 ug/L for TCE for surface water that discharges to the Deschutes River.

The standard operating parameters for the subdrain system as determined during the validation monitoring (February 2001 through April 2002) are included as Appendix A.

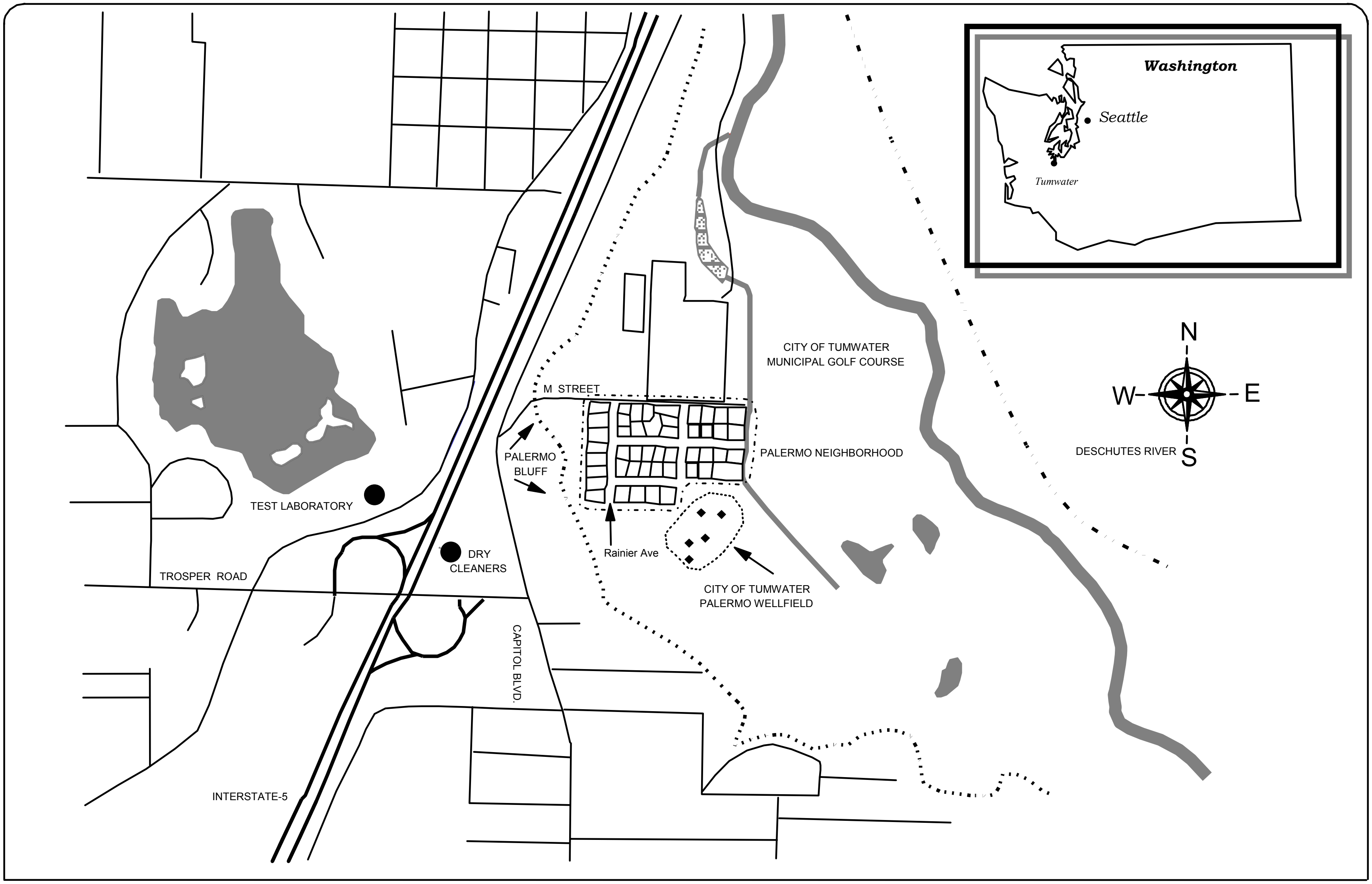
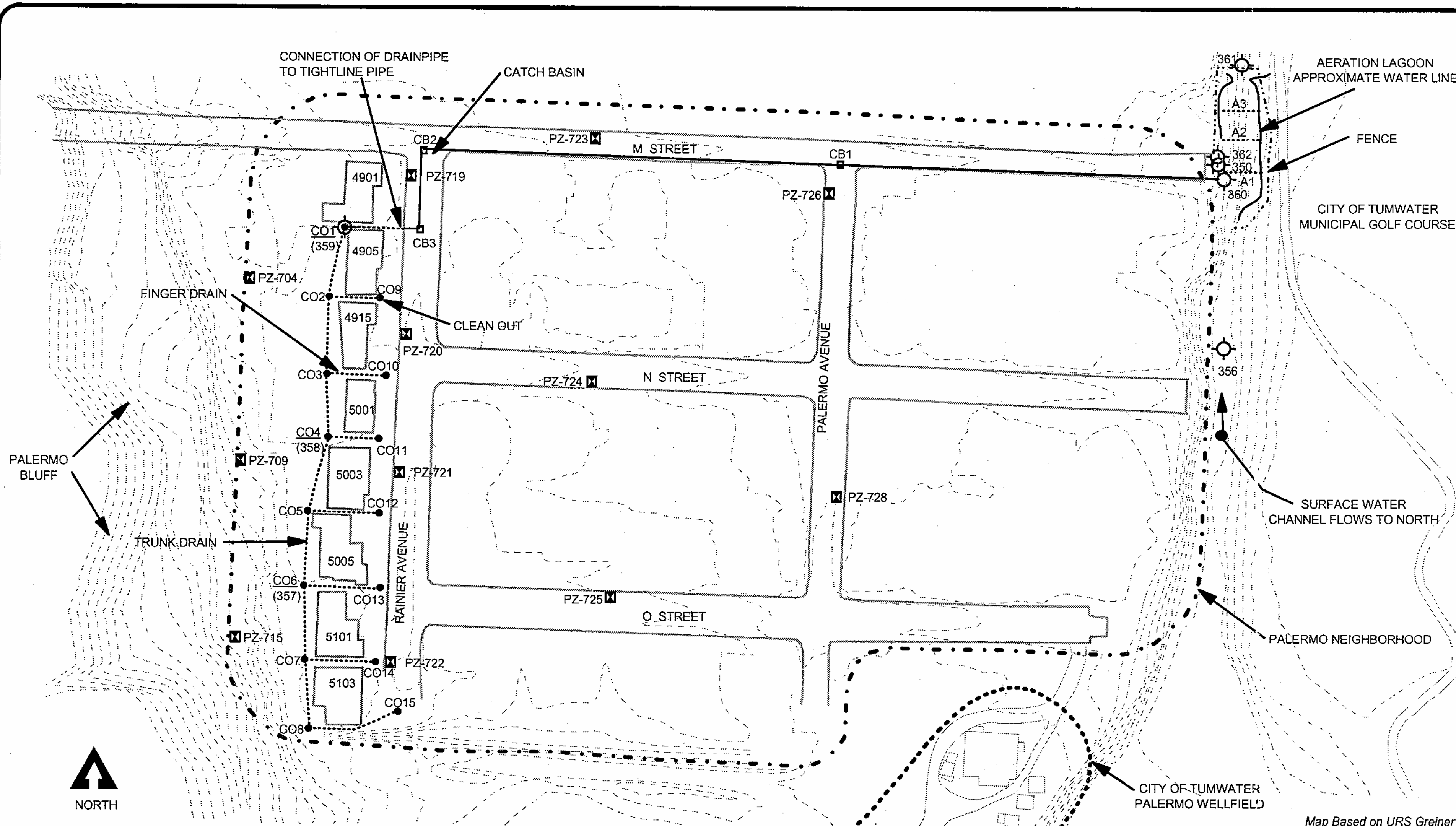


Figure 1 Palermo Wellfield and Neighborhood Site Location



Legend

PZ-722 Piezometer Location	Perforated Drainpipe
356 Water Sampling Station	Tightline Drainpipe

Scale in Feet (Approximate): 0 50 100

Sampling Station Descriptions

350	M Street Storm Drain Outfall
356	Watercourse Upstream of Lagoon
357	Cleanout CO-6
358	Cleanout CO-4
359	Cleanout CO-1
360	Tightline Pipe Outfall
361	Lagoon Effluent
362	M Street Terminus Catch Basin Outfall (Rarely Flows)

Figure 2 Palermo Wellfield Subdrain System and Treatment Lagoon Monitoring Stations

Methods

Monitoring and sampling of the subdrain system and treatment lagoon (Figure 2) was conducted by the Department of Ecology's Environmental Assessment Program on December 3-4, 2002 and May 7-8, 2003 and included the following activities:

- Depth-to-groundwater was measured in 12 piezometers and eight trunk drain cleanouts (CO-1 through CO-8) to determine if the subdrain system has lowered the static groundwater elevation beneath the homes at the base of Palermo bluff to at least three feet below the ground surface.

- Total depth was measured in eight cleanouts (CO-1 through CO-8) and three catch basins (CB-1, CB-2, and CB-3) to determine if sedimentation has occurred in the trunk drain or tightline pipe. Total depth was measured along three cross sections in the treatment lagoon (A1, A2, and A3) to determine if sedimentation or scouring has occurred in the lagoon.

- Flow rate measurements and water sampling for chemical analysis were collected from three cleanouts, three outfalls to the treatment lagoon, and two surface water stations to assess the performance of the system and compliance with remediation goals. Locations of the sample stations, as well as sample identification numbers, are described in Table 1.

Table 1: Sample Station Identification and Descriptions, Palermo Subdrain System

Sample Identification	Sample Station Description
Flow in Subdrain System – South to North	
357	Cleanout CO-6 (southernmost station within trunk drain)
358	Cleanout CO-4 (central station within trunk drain)
359	Cleanout CO-1 (northernmost station within trunk drain)
360	Tightline Pipe Outfall (influent from subdrain system to treatment lagoon)
361	Lagoon Effluent
Inflows to Treatment Lagoon Other Than the Subdrain System	
350	M Street Stormdrain Outfall
356	Watercourse flow upstream of the treatment lagoon
362	M Street Terminus Catch Basin Outfall (rarely flows)

Depth-to-Groundwater Measurements

Static water levels were measured in the 12 piezometers using a steel tape and chalk in December and a ¼-inch diameter Solinst water level meter in May. In May depth-to-water was also measured in all eight cleanouts. Measurements were recorded to 0.01 feet and are accurate to 0.03 feet. Measurements were made from a surveyed mark at the top of the piezometer casing and cleanout frame. The steel tape and probe were rinsed with deionized water and wiped clean between measurements.

Total Depth Measurements

The total depth of the cleanouts (CO-1 through CO-8) and catch basins (CB-1 through CB-3) were measured from a surveyed mark near the top of the structure, using a weighted tape measure marked in increments of 100ths (0.01) of a foot. The tape measure was rinsed with deionized water and wiped clean between measurements.

Depth of the aeration lagoon was measured along three cross sections (A3-north, A2-central, and A1-south). A measuring tape was secured between survey hubs which are located near the mooring posts for the three lagoon aerators. Depth was measured with a survey rod from the east bank to the west bank at two-foot increments from a reference elevation.

Water Flow Rate Measurement

In December and May, depth and velocity of water flow were measured from six of the eight stations within the drain system. Water velocity was measured with a Marsh-McBirney velocity meter. Depending on the station being measured, flow depth was measured using either a flow wading rod (lagoon effluent) or a graduated steel tape (pipe outfalls). For stations within the trunk drain pipe, flow depth was calculated from depth-to-water measurements collected with a water level meter (northerly rim elevation – depth to water = groundwater elevation – pipe invert elevation = flow depth). Flow in open channels was measured in accordance with standard stream gauging techniques as described in the Operation and Maintenance Plan (USEPA, 2000a).

As in previous monitoring, flow rates at station 356 were not measured. Since the installation of the lagoon, the stream at this point has become wide and slow which makes the flow difficult to measure accurately. No flow was observed from station 362 (M St. terminus catch basin) during either monitoring round.

Water Sampling and Chemical Analysis

Water samples were collected from seven of the eight sample stations. A sample was not collected from station 362 (M St. terminus catch basin) during either monitoring round because there was no flowing water.

Water samples were collected using precleaned beakers. Samples were transferred from the beaker into three 40-mL glass vials with Teflon lined septa lids for volatile organic analysis. Samples were free of headspace and preserved with 1:1 hydrochloric acid. Upon sample collection and proper labeling, all samples were stored in an ice-filled cooler. Samples were transported to the Ecology headquarters building in Lacey. Samples were kept in the walk-in cooler until picked up by the courier to Ecology/EPA Manchester Environmental Laboratory in Manchester, Washington. Chain-of-custody procedures were followed according to Manchester Environmental Laboratory protocol (Ecology, 2000).

Analysis

Analytes, methods, and reporting limits for both field and laboratory parameters are listed in Table 2. All water samples were analyzed for volatile organics.

Table 2: Analytical Methods for December 2002 and May 2003 Samples

Analytes	Method	Reference	Reporting Limit
Field			
Water Level	Solinst Water Level Meter	NA	0.01 feet
	Steel Tape with Chalk	NA	0.01 feet
Total Depth	Weighted Tape Measure	NA	0.01 feet
	Survey Rod	NA	0.01 feet
Flow Velocity	Marsh-McBirney Current Meter	NA	0.05 feet/second
Laboratory			
VOAs	SW-846 Method 8260	USEPA 1986	0.5 ug/L

In general, the quality of the data is acceptable. The detection limit for PCE and TCE did not meet the required 0.5 ug/L; however, most of the reported concentrations for these analytes were greater than 1 ug/L. Quality control samples collected in the field consisted of transport blank and blind field duplicate samples. Transport blanks were carried to and from the field to assess possible contamination from the sample containers, cross-contamination during shipment, storage, or laboratory contamination. No analytes were detected in the transport blanks. Blind field duplicate samples were obtained from the tightline pipe outfall (station 360). The numeric comparison of duplicate results is expressed as the relative percent difference (RPD). The RPD for PCE and TCE in both December and May were less than 5 percent.

In addition to field quality control samples, duplicate matrix spikes and surrogate compound recoveries were performed in the laboratory. In December, insufficient sample volume was collected to perform matrix spikes. Overall, matrix spikes and surrogate recoveries were within acceptable limits for all samples.

Quality assurance case narratives and laboratory reporting sheets are available from the author upon request.

Results

Field Observations

Summaries of depth-to-water, total depth, and flow rate measurements, as well as analytical results, are presented in Tables 3 through 6. Complete depth-to-groundwater data are presented in Appendix B, along with historical data collected prior to the drain installation. All total depth measurements for the cleanouts, catch basins, and lagoon are presented as tables and figures in Appendix C. Analytical results for PCE and TCE, as well as calculated flow rates, are presented as tables and figures in Appendix D.

Depth-to-Groundwater Measurements

Depth-to-groundwater was measured in the 12 piezometers in the Palermo neighborhood and is presented in Table 3, along with the calculated groundwater elevations and depth below ground surface. Groundwater elevations that did not meet the performance criteria of lowering the water table to three feet below the ground surface are highlighted.

Table 3: Depth to Water, Groundwater Elevations, and Depth Below Ground Surface in Piezometers for December 2002 and May 2003

Piezometer	Inner PVC Elevation (feet)	Concrete/ Ground Elevation (feet)	Depth to Water (feet)	Groundwater Elevation (feet)	Groundwater Above/Below Ground Surface (feet)	Depth to Water (feet)	Groundwater Elevation (feet)	Groundwater Above/Below Ground Surface (feet)
			December 2002			May 2003		
PZ-704	110.61	108.43	6.15	104.46	-3.97	5.84	104.77	-3.66
PZ-709	114.27	112.01	4.81	109.46	-2.55	4.40	109.87	-2.14
PZ-715	117.79	115.51	5.88	111.91	-3.60	5.65	112.14	-3.37
PZ-719	107.13	107.37	3.37	103.76	-3.61	3.09	104.04	-3.33
PZ-720	107.75	108.22	4.84	102.91	-5.31	4.70	103.05	-5.17
PZ-721	108.32	108.57	3.72	104.60	-3.97	3.72	104.60	-3.97
PZ-722	108.82	109.21	-0.10	108.92	-0.29	-0.10	108.92	-0.29
PZ-723	106.34	106.80	3.50	102.84	-3.96	3.32	103.02	-3.78
PZ-724	106.45	106.88	2.38	104.07	-2.81	2.68	103.77	-3.11
PZ-725	108.22	108.58	2.75	105.47	-3.11	3.50	104.72	-3.86
PZ-726	105.39	105.61	4.45	100.94	-4.68	4.69	100.70	-4.91
PZ-728	105.27	105.84	3.22	102.05	-3.79	4.75	100.52	-5.32

Between the December and May measurements, overall groundwater levels fluctuated less than 0.5 feet, except for PZ-725 and PZ-728 where the water level changed about 0.75 and 1.5 feet, respectively. PZ-725 and PZ-728 are located in the southeast portion of the study area.

Depth-to-groundwater below the ground surface (bgs) ranged from 0.29 to 5.31 feet in December and 0.29 to 5.32 feet in May. As in the past, lowering the water table to three feet bgs was not achieved in PZ-709 and PZ-722. In December, the water table was also less than three feet bgs in PZ-724. PZ-724 appears to be beyond the drains influence.

The reduction in groundwater elevation near the drain to three feet bgs appears to have been met for the central and northern homes along Rainier Avenue. Groundwater measured in piezometers near this portion of the trunk drain ranged from at least three feet to over five feet bgs. Based on historical data, it is assumed that groundwater was less than three feet bgs between PZ-709 and PZ-722 and therefore did not meet the performance criterion for the two most southern homes on the west side of Rainier Avenue. Groundwater levels continue to be the highest for the most southern home. In both December and May, the water level was 0.3 feet bgs in PZ-722. However, this home is located outside the mapped area of shallow groundwater contamination.

Total Depth Measurements

In December 2002 and May 2003, total depth measurements were collected in eight cleanouts, three catch basins, and along three cross sections through the treatment lagoon to assess if sedimentation or erosion is occurring within the subdrain system.

Table 4: Total Depth of Catch Basins and Cleanouts for December 2002 and May 2003

Location	Original Depth (feet)	Total Depth (feet)	Change from Original (feet)	Total Depth (feet)	Change from Original (feet)
	February 2001	December 2002		May 2003	
CB-1	7.78	7.89	-0.11	7.86	-0.08
CB-2	8.78	8.82	-0.04	8.85	-0.07
CB-3	8.81	8.95	-0.14	8.93	-0.12
CO-1	7.82	7.79	0.03	7.87	-0.05
CO-2	7.1	7.19	-0.09	7.23	-0.13
CO-3	6.84	6.84	0	6.82	0.02
CO-4	7.84	7.42	0.42	7.46	0.38
CO-5	7.84	7.83	0.01	7.85	-0.01
CO-6	7.7	7.69	0.01	7.68	0.02
CO-7	7.89	7.76	0.13	7.8	0.09
CO-8	8.1	8.0	0.1	7.97	0.13

As shown in Table 4, the range of depths in the catch basins and cleanouts were 6.84 to 8.95 feet in December and 6.82 to 8.93 feet in May. Total depth measurements in the catch basins and cleanouts were not significantly different (less than ±0.15 feet) from the original depth measured in February 2001. Cleanout CO-4 is the only exception. The total depth data since February 2001 suggest that approximately 0.4 feet of sediment has accumulated in this cleanout since construction. Each cleanout and catch basin provides a sump below the pipe invert that is a minimum of 0.5 feet deep. The sump depth in cleanout CO-4 is 0.8 feet.

Overall, lagoon depths measured in December and May are similar to the original depth measurements (February 2001) with a margin of error of ±0.5 feet. Many factors affect the depth measurements, such as how the measuring tape is secured to the survey hubs which can cause slight variations in the reference elevation. Small changes in the placement of the survey rod can also affect the depth measured due to the steep sides of the lagoon walls, the presence of riprap at the lagoon edges, and the occasional cobble on the lagoon bottom. Overall, it appears that no measurable sediment deposition or scouring has occurred.

Water Flow Rate Measurement

Water flow depth and velocity data were used to calculate flow rates at each sample station. The calculated flow rate is shown in Table 5.

Table 5: Flow Rates (cfs) for December 2002 and May 2003

Sample Station	December 2002	May 2003
Flow in Subdrain System Through Lagoon Effluent – South to North		
357	75	76
358	16	55
359	176	170
360	81	101
361	364	166
Inflows to Treatment Lagoon Other Than the Subdrain System		
350	5	11
356	FU	FU
362	NF	NF

FU : Flow was not measurable.
NF : No flow.

Average flow rates in the trunk drain at stations 357, 358, and 359 for this monitoring period were 76 gallons per minute (gpm), 35 gpm, and 173 gpm, respectively. These flow rates represent the cumulative flow of groundwater collected by the perforated pipe from the south (station 357) to the north (station 359). For December and May, the calculated flow rates at the center of the drain (station 358) were too low. This is probably the result of inaccurate flow depth or velocity measurements, since these measurements are collected approximately six feet below ground in a 15-inch diameter cleanout pipe.

Flow rates at station 360 (tightline pipe outfall), which represents the total flow of the subdrain system, did not compare well with flow rates from station 359 (northern end of the perforated pipe). Flow rates at station 360 were lower, with an average flow of 91 gpm. This is probably the result of inaccurate velocity measurements. There was some difficulty completely submerging the velocity probe head in the shallow flow that drains from the pipe.

Flow rates from station 350 (M St. stormdrain outfall) ranged from 5 to 11 gpm. As mentioned previously, the flow rate was not measurable at station 356 (upstream of lagoon), and station 362 had no flow.

Flow rates at station 361 (lagoon outfall) were 364 gpm and 166 gpm in December and May, respectively.

Analytical Results

Analytical results for volatile organics (VOAs) are summarized in Table 6. Figures 3 and 4 show PCE and TCE concentrations, respectively, from samples collected from the subdrain system and the lagoon effluent since February 2001.

Table 6: Summary of Analytical Results (ug/L) for December 2002 and May 2003

Sample Station	December 2002			May 2003		
Flow in Subdrain System Through Lagoon Effluent – South to North						
	PCE	*TCE*	*DCE*	*PCE*	*TCE*	*DCE*
357	25	20	0.32 J	25	12	0.28 J
358	22	36	0.38 J	20	27	0.32 J
359	12	23	0.24 J	11	19	0.19 J
360	13	26	0.27 J	10	18	0.18 J
361	1.3	2.8	1 U	3	5.4	1 U
Inflows to Treatment Lagoon Other Than the Subdrain System						
	PCE	*TCE*	*DCE*	*PCE*	*TCE*	*DCE*
350	1 U	0.76 J	1 U	1 U	0.44 NJ	1 U
356	1 U	2 U	1 U	1 U	1 U	1 U
362	NF	NF	NF	NF	NF	NF

U : Analyte was not detected at or above the reported value.
J : Analyte was positively identified. The associated numerical result is an estimate.
NJ : There is evidence that the analyte is present. The associated numerical result is an estimate.

PCE and TCE concentrations continue to be highest in groundwater samples collected from stations 357 and 358 which are located in the mapped area of the shallow groundwater plume. Average PCE concentrations for the monitoring period were 25 ug/L at station 357 and 21 ug/L at station 358. TCE concentrations varied more over the monitoring period with average concentrations of 16 ug/L at station 357, increasing to an average concentration of 32 ug/L at station 358. TCE concentrations continue to be higher from samples collected at station 358, at the center of the trunk drain. PCE and TCE concentrations decreased at station 359 as more groundwater was collected at the northern end of the perforated pipe. Average PCE concentrations decreased to 12 ug/L, while average TCE concentrations decreased to 21 ug/L.

PCE and TCE concentrations at stations 359 (CO-1) and 360 (tightline pipe outfall) were similar, with average concentrations for both stations over the monitoring period of 12 ug/L for PCE and 22 ug/L for TCE. The similar concentrations imply that little contaminant loss or degradation occurs within the tightline pipe, and that there is no substantial loss or introduction of water between the connection with the drain pipe and the outfall.

Cis-1,2-dichloroethene (DCE) was also detected in samples collected from the trunk drain and tightline pipe outfall, but at concentrations below the practical quantitation limit of 1 ug/L

Two of the three remaining stations which contribute flow to the treatment lagoon were sampled during both sample rounds. Station 362 (M St. terminus catch basin outfall) was not sampled because there was no flowing water. PCE and TCE were not detected at station 356 which is upstream of the lagoon. TCE was detected at station 350 (M St. stormdrain outfall) at concentrations below the practical quantitation limit of 1 ug/L during both sample rounds.

PCE and TCE concentrations in samples collected from station 361 (lagoon effluent) during December and May ranged from 1.3 ug/L to 3 ug/L for PCE and 2.8 ug/L to 5.4 ug/L for TCE. Concentrations exceeded the remediation goals set for both PCE (0.8 ug/L) and TCE (2.7 ug/L) for surface water that discharges to the Deschutes River. During the validation period (February 2001 through April 2002), PCE and TCE concentrations were typically below the remediation goals at the lagoon outfall. Since PCE and TCE concentrations at the other monitoring stations were similar or lower than those measured during the validation period, the increased concentrations at the lagoon outfall could be the result of slight variations in sample location.

Based on the lagoon effluent concentrations for PCE and TCE, the lagoon achieved a contaminant reduction of 90 percent in December and 70 percent in May as shown in Appendix E. As during the validation period, one of the three aerators was out of service. The residence time in the lagoon ranged from 5 hours in December to 11 hours in May.

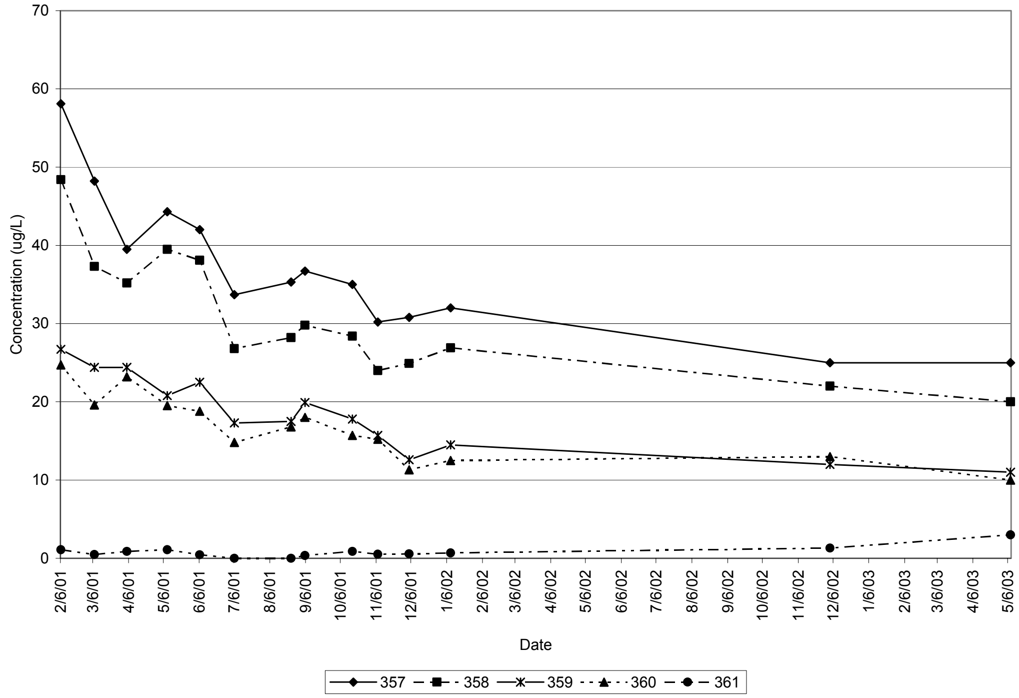


Figure 3: PCE Concentrations (ug/L) for Palermo Subdrain System and Treatment Lagoon, February 2001 to May 2003

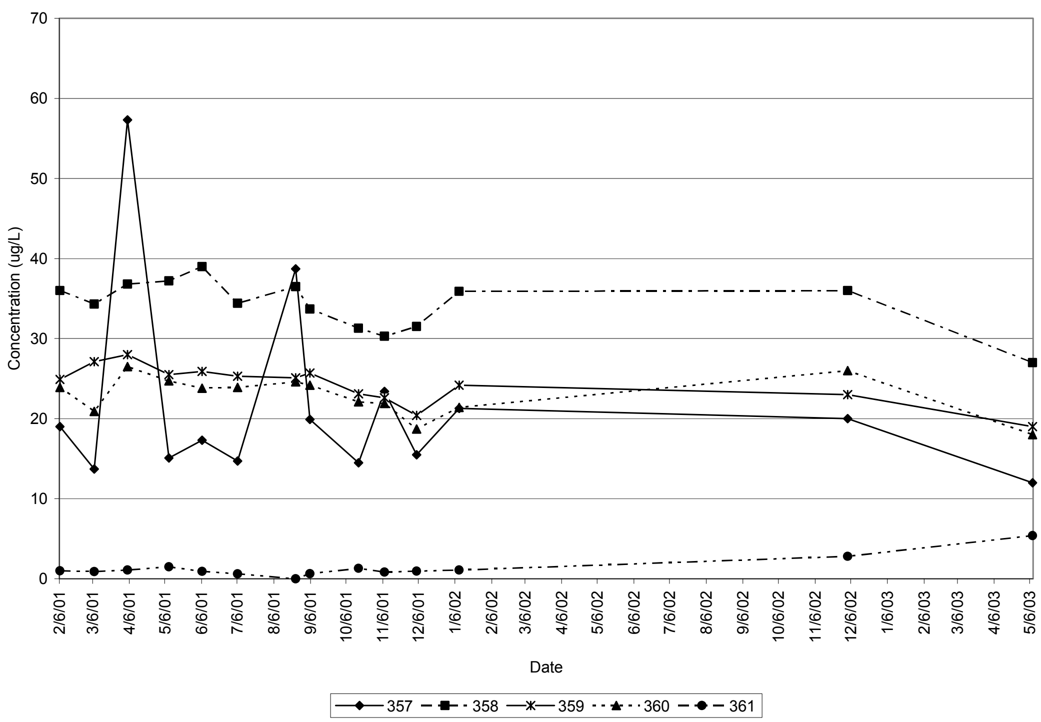


Figure 4: TCE Concentrations (ug/L) for Palermo Subdrain System and Treatment Lagoon, February 2001 to May 2003

Conclusions

- Reduction of groundwater elevations to three feet below the ground surface appear to have been met for the central and northern homes along the west side of Rainier Avenue. Groundwater measured in piezometers near this portion of the trunk drain ranged from at least three to five feet below ground.

- Groundwater was within three feet of the ground surface in piezometers PZ-709 and PZ-722 over the monitoring period. When comparing data from these piezometers to data collected during the validation period (February 2001 through April 2002), it is assumed that the performance criterion was not met for the two most southern homes on the west side of Rainier Avenue.

- Total depths measured in the trunk drain cleanouts, catch basins, and lagoon were not significantly different from the original depths measured in February 2001. Sediment has accumulated in cleanout CO-4, but is less than the sump capacity. Considering the overall trends of the total depth measurements, it does not appear that sediment deposition or scouring is occurring in the drain system.

- PCE and TCE concentrations from the lagoon effluent were higher than during the validation period. Concentrations exceeded the remediation goals set for PCE and TCE for surface water that discharges to the Deschutes River. During the validation period, concentrations were typically below the remediation goals at the lagoon outfall. Increased PCE and TCE concentrations could be the result of slight variations in sample location at the lagoon outfall.

- Reduction in contaminant concentrations after the treatment lagoon with only two aerators operating was 90 percent in December and 70 percent in May.

Recommendations

- Sample station 364 should be reestablished where surface water from the lagoon watercourse discharges to the Deschutes River. This is approximately 2,000 feet downstream from the treatment lagoon. A sample station at this location would allow a better comparison of contaminant concentrations to the remediation goals.

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Appendix A. Subdrain System Operating Parameters

Table A-1: System Operating Parameters as Established During Validation Monitoring, February 2001 through April 2002

Parameter	Representative Value	Comments
Flow rate from drain to lagoon	110 to 215 gpm	Average of 158 gpm; some low seasonal variation.
Flow rate in watercourse through lagoon	130 to 1470 gpm	High seasonal variation.
Chemicals of concern in water from drain to lagoon	PCE: 11.3 to 24.7 ug/L TCE: 18.7 to 26.5 ug/L	Overall decrease over performance validation period.
Chemicals of concern in water leaving lagoon	PCE: 0.5U to 1.1 ug/L TCE: 0.5U to 1.5 ug/L	With at least two aerators running.
Influence of drain on groundwater	*Predicted*: 3 feet of drawdown 35 feet away. *Actual*: 0.5 to 5.5 feet of drawdown, influence at 150 to 250 feet.	"*Influence*" refers to downgradient of drain. Actual is greater than predicted; however, near southern end of drain, effect is small (less than 1 foot of drawdown).

Appendix B. Groundwater Elevation Data

Table B-1: Groundwater Elevation Changes Over Time, December 1999 to May 2003

	PZ-704			PZ-709			PZ-715		
Date	GW Elev.	Delta Month	Delta Year	GW Elev.	Delta Month	Delta Year	GW Elev.	Delta Month	Delta Year
12/20/1999	107.15	--	--	111.60	--	--	**114.79**	--	--
1/31/2000	**107.49**	0.34	--	**111.83**	0.23	--	114.70	-0.09	--
2/23/2000	103.89	-3.60	--	111.75	-0.08	--	114.19	-0.51	--
3/28/2000	107.20	3.31	--	111.82	0.07	--	114.54	0.35	--
5/9/2000	107.38	0.18	--	111.77	-0.05	--	114.42	-0.12	--
5/26/2000	107.07	-0.31	--	111.75	-0.02	--	114.44	0.02	--
6/22/2000	106.81	-0.26	--	111.61	-0.14	--	113.90	-0.54	--
7/26/2000	106.61	-0.20	--	111.30	-0.31	--	113.90	0.00	--
8/21/2000	106.28	-0.33	--	111.02	-0.28	--	112.66	-1.24	--
10/2/2000	106.21	-0.07	--	111.03	0.01	--	112.17	-0.49	--
11/21/2000	102.61	-3.60	--	111.10	0.07	--	112.75	0.58	--
2/7/2001	104.26	1.65	0.37	110.99	-0.11	-0.76	111.85	-0.90	-2.34
3/6/2001	104.21	-0.05	-2.99	110.96	-0.03	-0.86	112.52	0.67	-2.02
4/3/2001	104.30	0.09	-3.08	110.95	-0.01	-0.82	112.23	-0.29	-2.19
5/8/2001	104.21	-0.09	-2.86	111.01	0.06	-0.74	112.01	-0.22	-2.43
6/6/2001	104.11	-0.10	-2.70	110.33	-0.68	-1.28	111.82	-0.19	-2.08
7/5/2001	103.86	-0.25	-2.75	110.23	-0.10	-1.07	111.40	-0.42	-2.50
8/24/2001	103.92	0.06	-2.36	110.64	0.41	-0.38	111.07	-0.33	-1.59
9/4/2001	103.73	-0.19	-2.48	110.24	-0.40	-0.79	110.58	-0.49	-1.59
10/17/2001	103.86	0.13	-2.35	109.70	-0.54	-1.40	110.89	0.31	-1.28
11/6/2001	103.56	-0.30	0.95	109.97	0.27	-1.13	110.95	0.06	-1.80
12/5/2001	104.99	1.43	2.38	111.10	1.13	0.00	112.03	1.08	-0.72
1/8/2002	105.44	0.45	1.18	111.00	-0.10	0.01	112.43	0.40	0.58
2/7/2002	105.06	-0.38	0.80	111.05	0.05	0.06	112.18	-0.25	0.33
3/7/2002	104.87	-0.19	0.66	111.04	-0.01	0.08	112.35	0.17	-0.17
4/1/2002	104.97	0.10	0.67	111.07	0.03	0.12	112.28	-0.07	0.05
12/3/2002	104.46	-0.51	-0.53	109.46	-1.61	-1.64	111.91	-0.37	-0.12
5/7/2003	104.77	0.31	-0.20	109.87	0.41	-1.20	112.14	0.23	-0.14
Average	105.12	0.70		110.94	0.26		112.61	0.39	
Maximum	107.49			111.83			114.79		
3' BGS Elev.	105.43			109.01			112.51		

2/7/2001 – Subdrain system completed, beginning of validation monitoring.
Average – arithmetic mean of data in column for both groundwater elevation and change in elevation for piezometer.
Maximum – maximum groundwater elevation recorded for each piezometer (bolded).
3' BGS Elev. – elevation for groundwater to be 3 feet below ground surface to meet performance criterion.
GW Elev. – elevation of groundwater in piezometer on date shown in feet above mean sea level.
Delta Month – change in groundwater elevation since the last measurement (typically the previous month).
Delta Year – change in groundwater elevation since the last measurement taken the same month the previous year.
NM – depth-to-groundwater not measured at this location on this date.
-- – no data available to perform calculation.
<97 – groundwater elevation was lower than the total depth of the well on this date (the well was dry). The numerical value is the approximate elevation of the bottom of the well.

Table B-1: Continued

	PZ-719			PZ-720			PZ-721		
Date	GW Elev.	Delta Month	Delta Year	GW Elev.	Delta Month	Delta Year	GW Elev.	Delta Month	Delta Year
12/20/1999	103.90	--	--	106.59	--	--	107.37	--	--
1/31/2000	104.85	0.95	--	106.45	-0.14	--	107.36	-0.01	--
2/23/2000	104.88	0.03	--	106.50	0.05	--	107.32	-0.04	--
3/28/2000	104.92	0.04	--	106.49	-0.01	--	107.33	0.01	--
5/9/2000	104.93	0.01	--	106.57	0.08	--	**107.44**	0.11	--
5/26/2000	104.82	-0.11	--	106.48	-0.09	--	107.22	-0.22	--
6/22/2000	104.57	-0.25	--	**106.60**	0.12	--	106.94	-0.28	--
7/26/2000	104.31	-0.26	--	105.89	-0.71	--	106.83	-0.11	--
8/21/2000	103.73	-0.58	--	105.38	-0.51	--	106.19	-0.64	--
10/2/2000	103.33	-0.40	--	105.41	0.03	--	105.77	-0.42	--
11/21/2000	<97	--	--	<97	--	--	NM	--	--
2/7/2001	103.50	--	-1.38	103.73	--	-2.77	104.26	--	-3.06
3/6/2001	103.19	-0.31	-1.73	102.65	-1.08	-3.84	103.94	-0.32	-3.39
4/3/2001	103.48	0.29	-1.45	102.73	0.08	-3.84	104.32	0.38	-3.12
5/8/2001	103.65	0.17	-1.17	102.91	0.18	-3.57	104.43	0.11	-2.79
6/6/2001	103.58	-0.07	-0.99	102.81	-0.10	-3.79	104.05	-0.38	-2.89
7/5/2001	102.78	-0.80	-1.53	102.42	-0.39	-3.47	103.61	-0.44	-3.22
8/24/2001	103.47	0.69	-0.26	102.61	0.19	-2.77	103.80	0.19	-2.39
9/4/2001	102.62	-0.85	-0.71	102.38	-0.23	-3.03	103.45	-0.35	-2.32
10/17/2001	102.99	0.37	-0.34	102.52	0.14	-2.89	103.72	0.27	-2.05
11/6/2001	103.49	0.50	--	102.68	0.16	--	104.15	0.43	--
12/5/2001	104.65	1.16	1.32	103.24	0.56	-2.17	104.98	0.83	-0.79
1/8/2002	**105.02**	0.37	1.52	103.85	0.61	0.12	105.44	0.46	1.18
2/7/2002	104.32	-0.70	0.82	103.12	-0.73	-0.61	104.92	-0.52	0.66
3/7/2002	104.12	-0.20	0.93	103.07	-0.05	0.42	104.74	-0.18	0.80
4/1/2002	104.21	0.09	0.73	103.12	0.05	0.39	104.85	0.11	0.53
12/3/2002	103.76	-0.45	-0.89	102.91	-0.21	-0.33	104.60	-0.25	-0.38
5/7/2003	104.04	0.28	-0.17	103.05	0.14	-0.07	104.60	0.00	-0.25
Average	103.97	0.40		104.15	0.27		105.32	0.29	
Maximum	105.02			106.60			107.44		
3' BGS Elev.	104.37			105.22			105.57		

2/7/2001 – Subdrain system completed, beginning of validation monitoring.
Average – arithmetic mean of data in column for both groundwater elevation and change in elevation for piezometer.
Maximum – maximum groundwater elevation recorded for each piezometer (bolded).
3' BGS Elev. – elevation for groundwater to be 3 feet below ground surface to meet performance criterion.
GW Elev. – elevation of groundwater in piezometer on date shown in feet above mean sea level.
Delta Month – change in groundwater elevation since the last measurement (typically the previous month).
Delta Year – change in groundwater elevation since the last measurement taken the same month the previous year.
NM – depth-to-groundwater not measured at this location on this date.
-- – no data available to perform calculation.
<97 – groundwater elevation was lower than the total depth of the well on this date (the well was dry). The numerical value is the approximate elevation of the bottom of the well.

Table B-1: Continued

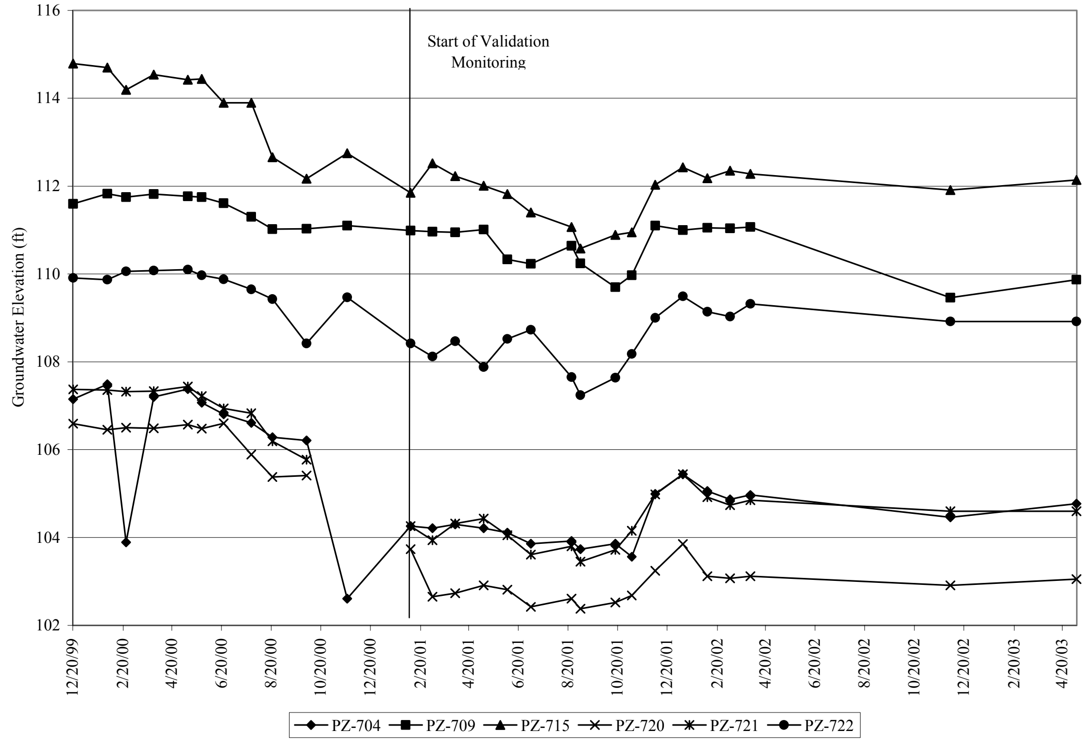
Date	PZ-722 GW Elev.	PZ-722 Delta Month	PZ-722 Delta Year	PZ-723 GW Elev.	PZ-723 Delta Month	PZ-723 Delta Year	PZ-724 GW Elev.	PZ-724 Delta Month	PZ-724 Delta Year
12/20/1999	109.91	--	--	99.47	--	--		--	--
1/31/2000	109.87	-0.04	--	103.57	4.10	--	104.89	--	--
2/23/2000	110.06	0.19	--	103.71	0.14	--	104.85	-0.04	--
3/28/2000	110.08	0.02	--	103.65	-0.06	--	105.01	0.16	--
5/9/2000	**110.10**	0.02	--	103.89	0.24	--	105.01	0.00	--
5/26/2000	109.97	-0.13	--	104.52	0.63	--	104.73	-0.28	--
6/22/2000	109.88	-0.09	--	103.36	-1.16	--	104.50	-0.23	--
7/26/2000	109.65	-0.23	--	103.01	-0.35	--	104.02	-0.48	--
8/21/2000	109.43	-0.22	--	101.82	-1.19	--	102.63	-1.39	--
10/2/2000	108.42	-1.01	--	100.85	-0.97	--	101.66	-0.97	--
11/21/2000	109.47	1.05	--	102.85	2.00	--	104.06	2.40	--
2/7/2001	108.42	-1.05	-1.64	102.89	0.04	-0.82	103.31	-0.75	-1.54
3/6/2001	108.12	-0.30	-1.96	102.62	-0.27	-1.03	103.17	-0.14	-1.84
4/3/2001	108.47	0.35	-1.63	102.91	0.29	-0.98	103.46	0.29	-1.55
5/8/2001	107.88	-0.59	-2.09	102.91	0.00	-1.61	103.57	0.11	-1.16
6/6/2001	108.52	0.64	-1.36	102.42	-0.49	-0.94	103.10	-0.47	-1.40
7/5/2001	108.73	0.21	-0.92	101.60	-0.82	-1.41	102.14	-0.96	-1.88
8/24/2001	107.65	-1.08	-1.78	102.70	1.10	0.88	102.36	0.22	-0.27
9/4/2001	107.24	-0.41	-1.18	101.69	-1.01	0.84	NM	--	--
10/17/2001	107.64	0.40	-0.78	101.97	0.28	1.12	NM	--	--
11/6/2001	108.18	0.54	-1.29	102.68	0.71	-0.17	NM	--	--
12/5/2001	109.00	0.82	-0.47	104.26	1.58	1.41	NM	--	--
1/8/2002	109.49	0.49	1.07	**105.24**	0.98	2.35	**105.97**	--	2.66
2/7/2002	109.14	-0.35	0.72	103.71	-1.53	0.82	104.43	-1.54	1.12
3/7/2002	109.03	-0.11	0.91	103.36	-0.35	0.74	104.20	-0.23	1.03
4/1/2002	109.32	0.29	0.85	103.44	0.08	0.53	104.31	0.11	0.85
12/3/2002	108.92	-0.40	-0.08	102.84	-0.60	-1.42	104.07	-0.24	--
5/7/2003	108.92	0.00	-0.40	103.02	0.18	-0.42	103.77	-0.30	-0.54
Average	108.98	0.43		102.89	0.83		103.88	0.55	
Maximum	110.10			105.24			105.97		
3' BGS Elev.	106.21			103.8			103.88		

2/7/2001 – Subdrain system completed, beginning of validation monitoring.
Average – arithmetic mean of data in column for both groundwater elevation and change in elevation for piezometer.
Maximum – maximum groundwater elevation recorded for each piezometer (bolded).
3' BGS Elev. – elevation for groundwater to be 3 feet below ground surface to meet performance criterion.
GW Elev. – elevation of groundwater in piezometer on date shown in feet above mean sea level.
Delta Month – change in groundwater elevation since the last measurement (typically the previous month).
Delta Year – change in groundwater elevation since the last measurement taken the same month the previous year.
NM – depth-to-groundwater not measured at this location on this date.
-- – no data available to perform calculation.
<97 – groundwater elevation was lower than the total depth of the well on this date (the well was dry). The numerical value is the approximate elevation of the bottom of the well.

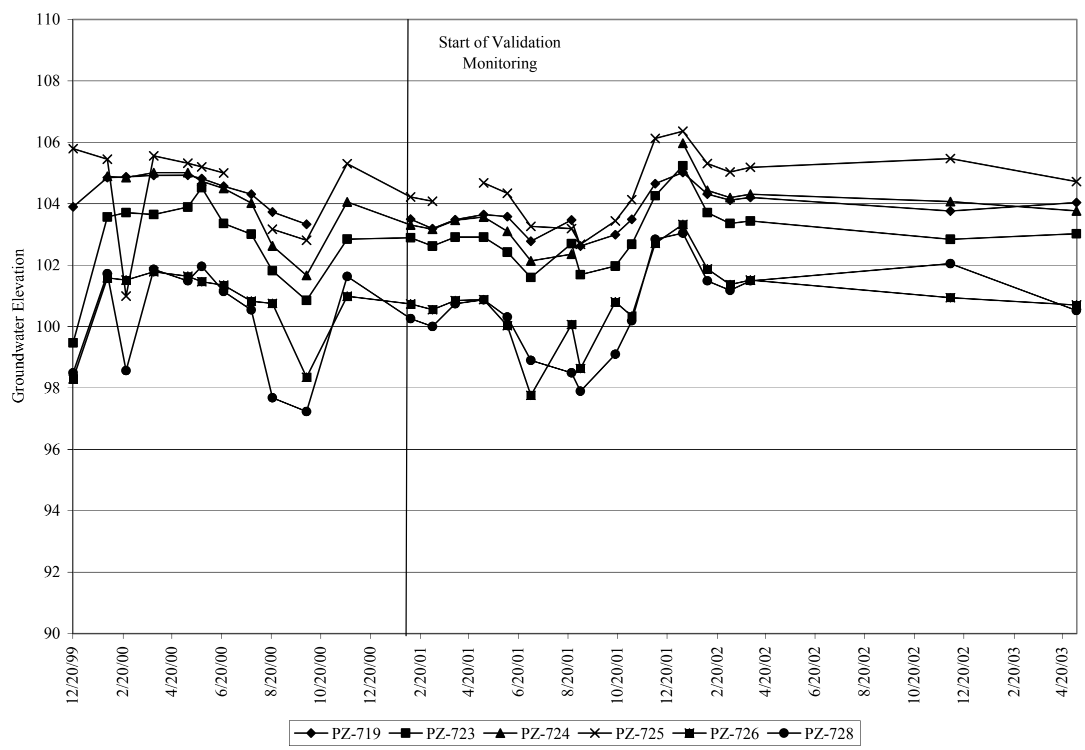
Table B-1: Continued

	PZ-725			PZ-726			PZ-728		
Date	GW Elev.	Delta Month	Delta Year	GW Elev.	Delta Month	Delta Year	GW Elev.	Delta Month	Delta Year
12/20/1999	105.79	--	--	98.30	--	--	98.49	--	--
1/31/2000	105.45	-0.34	--	101.59	3.29	--	101.72	3.23	--
2/23/2000	100.99	-4.46	--	101.52	-0.07	--	98.56	-3.16	--
3/28/2000	105.56	4.57	--	101.79	0.27	--	101.86	3.30	--
5/9/2000	105.32	-0.24	--	101.64	-0.15	--	101.49	-0.37	--
5/26/2000	105.20	-0.12	--	101.47	-0.17	--	101.96	0.47	--
6/22/2000	105.00	-0.20	--	101.35	-0.12	--	101.14	-0.82	--
7/26/2000	--	--	--	100.83	-0.52	--	100.54	-0.60	--
8/21/2000	103.17	-1.83	--	100.76	-0.07	--	97.68	-2.86	--
10/2/2000	102.81	-0.36	--	98.35	-2.41	--	97.23	-0.45	--
11/21/2000	105.30	2.49	--	100.99	2.64	--	101.63	4.40	--
2/7/2001	104.22	-1.08	3.23	100.74	-0.25	-0.78	100.26	-1.37	1.70
3/6/2001	104.08	-0.14	-1.48	100.55	-0.19	-1.24	100.00	-0.26	-1.86
4/3/2001	NM	--	--	100.85	0.30	-0.79	100.74	0.74	-0.75
5/8/2001	104.68	--	-0.52	100.88	0.03	-0.59	100.87	0.13	-1.09
6/6/2001	104.34	-0.34	-0.66	100.03	-0.85	-1.32	100.31	-0.56	-0.83
7/5/2001	103.26	-1.08	--	97.76	-2.27	-3.07	98.90	-1.41	-1.64
8/24/2001	103.19	-0.07	0.02	100.07	2.31	-0.69	98.49	-0.41	0.81
9/4/2001	102.68	-0.51	-0.13	98.64	-1.43	0.29	97.89	-0.60	0.66
10/17/2001	103.44	0.76	0.63	100.81	2.17	2.46	99.10	1.21	1.87
11/6/2001	104.13	0.69	-1.17	100.34	-0.47	-0.65	100.19	1.09	-1.44
12/5/2001	106.13	2.00	0.83	102.72	2.38	1.73	102.84	2.65	1.21
1/8/2002	**106.36**	0.23	2.14	**103.33**	0.61	2.59	**103.04**	0.20	2.78
2/7/2002	105.31	-1.05	1.09	101.88	-1.45	1.14	101.49	-1.55	1.23
3/7/2002	105.03	-0.28	0.95	101.37	-0.51	0.81	101.18	-0.31	1.18
4/1/2002	105.19	0.16	0.97	101.52	0.15	0.67	101.49	0.31	0.75
12/3/2002	105.47	0.28	-0.66	100.94	-0.58	-1.78	102.05	0.56	-0.79
5/7/2003	104.72	-0.75	-0.47	100.70	-0.24	-0.81	100.52	-1.53	-0.97
Average	104.49	1.14		100.77	0.99		100.42	1.27	
Maximum	106.36			103.33			103.04		
3' BGS Elev.	105.58			102.61			102.84		

2/7/2001 – Subdrain system completed, beginning of validation monitoring.
Average – arithmetic mean of data in column for both groundwater elevation and change in elevation for piezometer.
Maximum – maximum groundwater elevation recorded for each piezometer (bolded).
3' BGS Elev. – elevation for groundwater to be 3 feet below ground surface to meet performance criterion.
GW Elev. – elevation of groundwater in piezometer on date shown in feet above mean sea level.
Delta Month – change in groundwater elevation since the last measurement (typically the previous month).
Delta Year – change in groundwater elevation since the last measurement taken the same month the previous year.
NM – depth-to-groundwater not measured at this location on this date.
-- – no data available to perform calculation.
<97 – groundwater elevation was lower than the total depth of the well on this date (the well was dry). The numerical value is the approximate elevation of the bottom of the well.



Groundwater Elevations for Piezometers Influenced by the Drain from December 1999 to May 2003



Groundwater Elevations for Piezometers Beyond the Drains Influence from December 1999 to May 2003

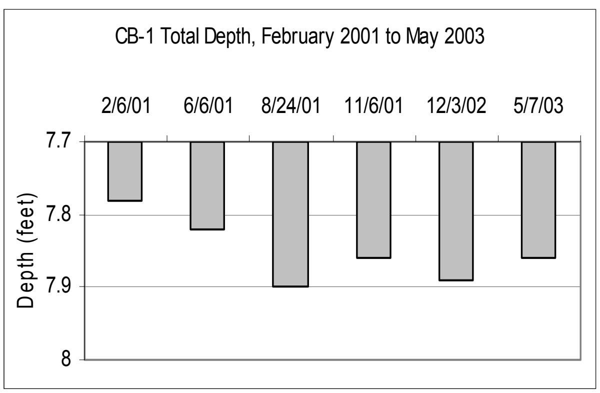
Table B-2: Depth to Water and Groundwater Elevations in Cleanouts for December 2002 and May 2003

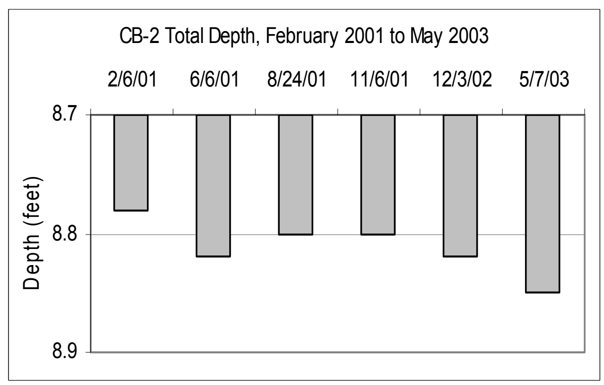
Cleanout	North Rim Elevation (feet)	Depth to Water (feet)	Groundwater Elevation (feet)	Depth to Water (feet)	Groundwater Elevation (feet)
		December 2002		May 2003	
CO-1	108.39	6.38	102.01	6.38	102.01
CO-2	108.04	--	--	5.95	102.09
CO-3	107.96	--	--	5.72	102.24
CO-4	108.73	6.42	102.31	6.22	102.51
CO-5	109.32	--	--	6.69	102.63
CO-6	109.78	6.59	103.19	6.58	103.20
CO-7	110.73	--	--	6.72	104.01
CO-8	110.96	--	--	6.85	104.11

Appendix C. Total Depth Data for Catch Basins, Cleanouts, and Treatment Lagoon

Table C-1: Total Depth of Catch Basins, February 2001 to May 2003

	CB-1		CB-2		CB-3	
Date	Depth Below Survey Elevation	Change from Original	Depth Below Survey Elevation	Change from Original	Depth Below Survey Elevation	Change from Original
2/6/2001	7.78	--	8.78	--	8.81	--
6/6/2001	7.82	-0.04	8.82	-0.04	8.92	-0.11
8/24/2001	7.9	-0.12	8.8	-0.02	8.96	-0.15
11/6/2001	7.86	-0.08	8.8	-0.02	8.41	0.4
12/2/2002	7.89	-0.11	8.82	-0.04	8.95	-0.14
5/7/2003	7.86	-0.08	8.85	-0.07	8.93	-0.12





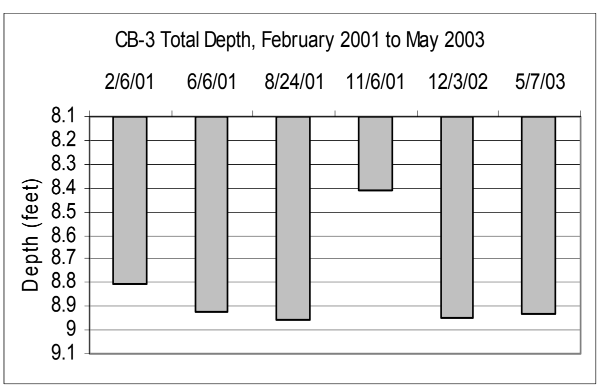
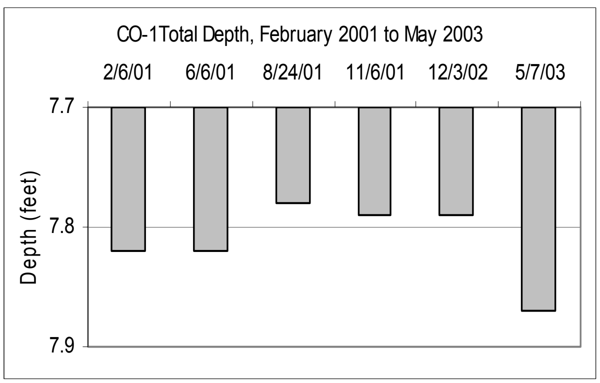
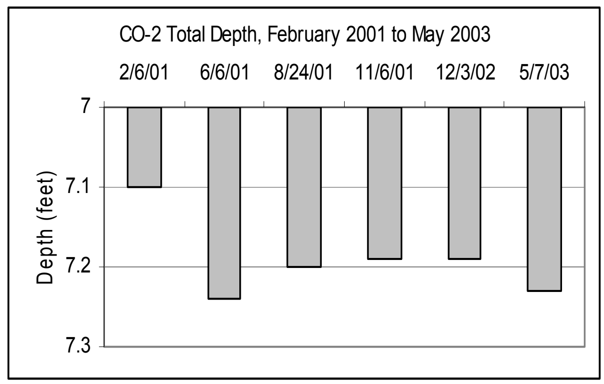
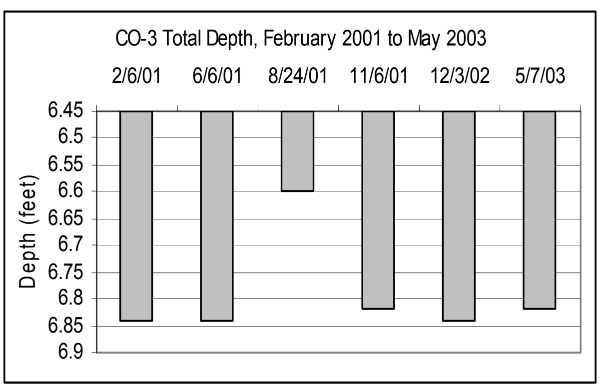


Table C-2: Total Depth of Cleanouts CO-1 to CO-4, February 2001 to May 2003

	CO-1		CO-2		CO-3		CO-4	
Date	Depth Below Survey Elevation	Change from Original	Depth Below Survey Elevation	Change from Original	Depth Below Survey Elevation	Change from Original	Depth Below Survey Elevation	Change from Original
2/6/2001	7.82	--	7.1	--	6.84	--	7.84	--
6/6/2001	7.82	0.00	7.24	-0.14	6.84	0.00	7.44	0.4
8/24/2001	7.78	0.04	7.2	-0.1	6.6	0.24	7.41	0.43
11/6/2001	7.79	0.03	7.19	-0.09	6.82	0.02	7.43	0.41
12/2/2002	7.79	0.03	7.19	-0.09	6.84	0.00	7.42	0.42
5/7/2003	7.87	-0.05	7.23	-0.13	6.82	0.02	7.46	0.38







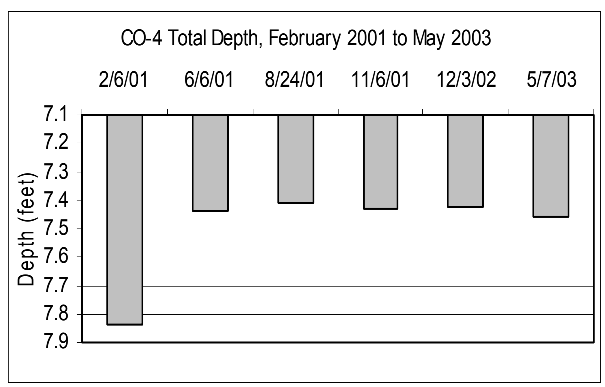
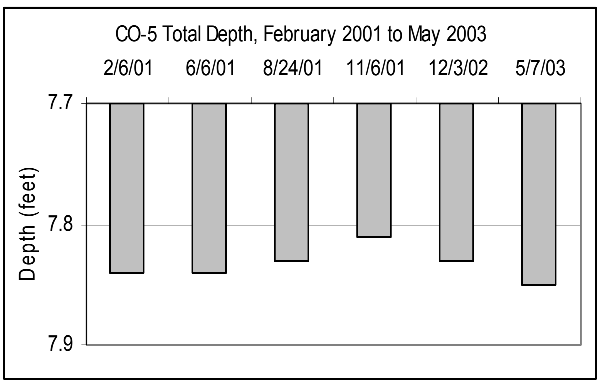
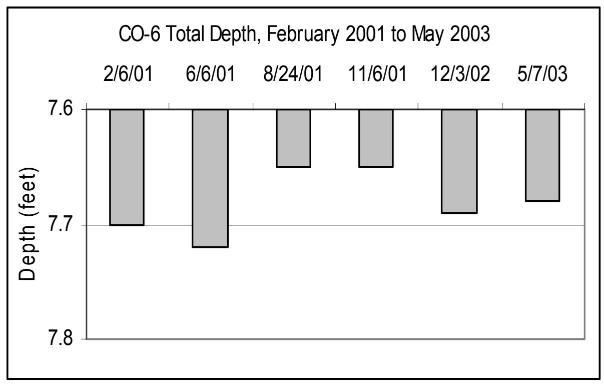
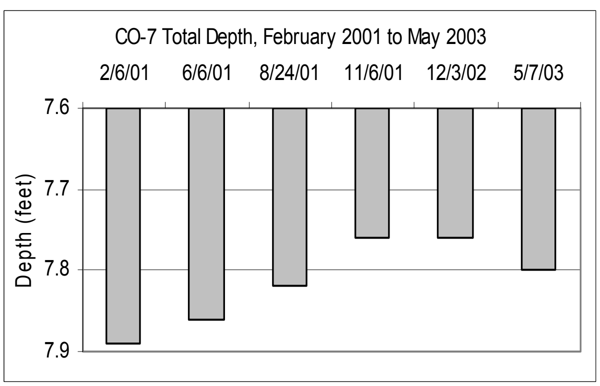


Table C-3: Total Depth of Cleanouts CO-5 to CO-8, February 2001 to May 2003

	CO-5		CO-6		CO-7		CO-8	
Date	Depth Below Survey Elevation	Change from Original	Depth Below Survey Elevation	Change from Original	Depth Below Survey Elevation	Change from Original	Depth Below Survey Elevation	Change from Original
2/6/2001	7.84	--	7.7	--	7.89	--	8.1	--
6/6/2001	7.84	0.00	7.72	-0.02	7.86	0.03	8.12	-0.02
8/24/2001	7.83	0.01	7.65	0.05	7.82	0.07	8.0	0.1
11/6/2001	7.81	0.03	7.65	0.05	7.76	0.13	7.99	0.11
12/2/2002	7.83	0.01	7.69	0.01	7.76	0.13	8.0	0.1
5/7/2003	7.85	-0.01	7.68	0.02	7.8	0.09	7.97	0.13







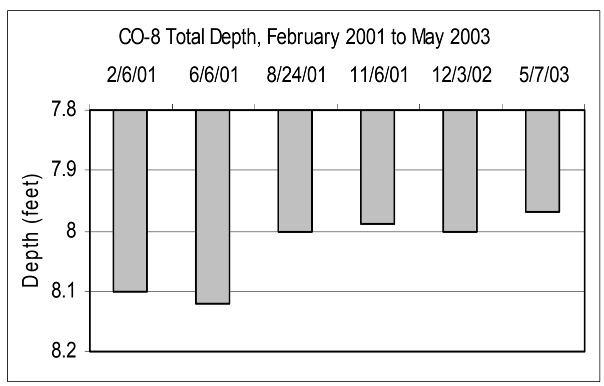
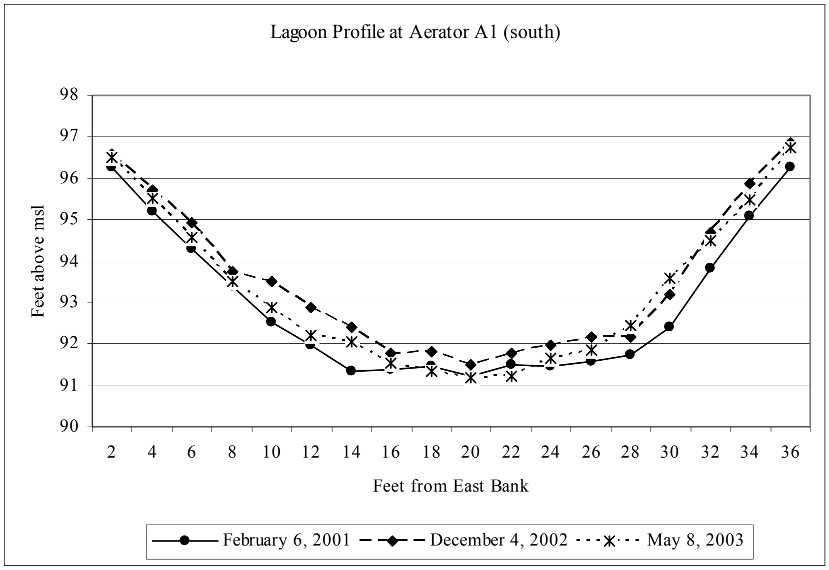


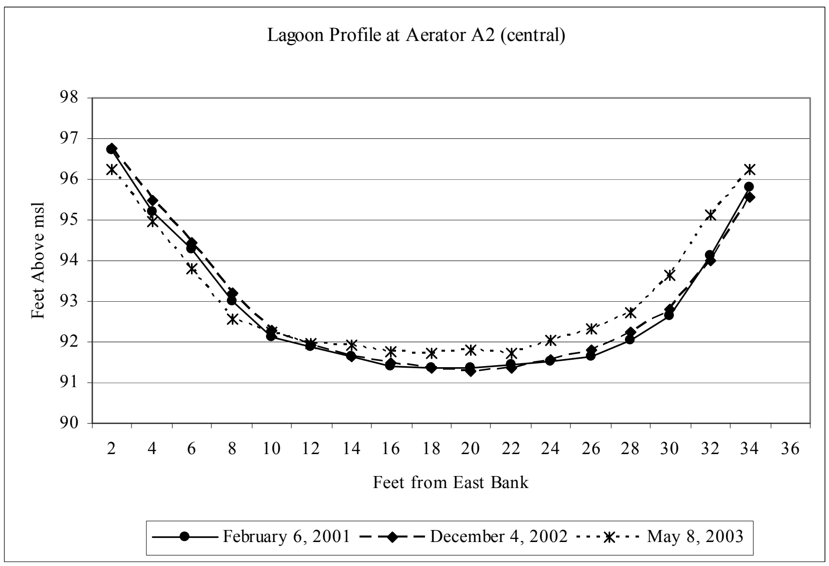
Table C-4: Treatment Lagoon Total Depth Measurements, December 2002

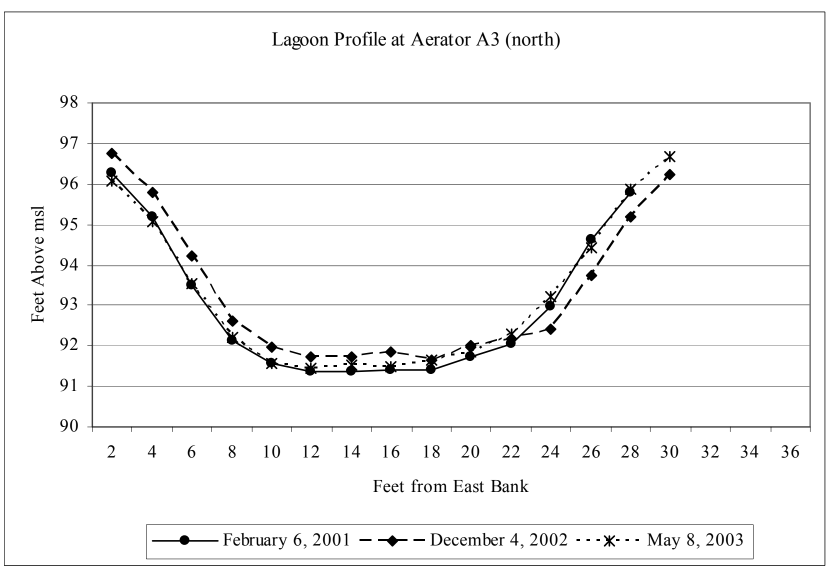
	Aerator A1 (south)			Aerator A2 (central)			Aerator A3 (north)		
Feet From East Bank	Depth Below Survey Elev.	Elev. Above Datum	Change from Original	Depth Below Survey Elev.	Elev. Above Datum	Change from Original	Depth Below Survey Elev.	Elev. Above Datum	Change from Original
2	2.42	96.58	0.32	2.24	96.76	0.02	2.24	96.76	0.5
4	3.27	95.73	0.51	3.53	95.47	0.27	3.23	95.77	**0.57**
6	4.07	94.93	0.63	4.56	94.44	0.14	4.76	94.24	0.76
8	5.25	93.75	0.35	5.78	93.22	0.24	6.4	92.6	0.46
10	5.5	93.5	0.96	6.74	92.26	0.14	7.02	91.98	0.43
12	6.13	92.87	0.89	7.06	91.94	0.06	7.27	91.73	0.35
14	6.61	92.39	1.05	7.36	91.64	-0.02	7.28	91.72	**0.34**
16	7.22	91.78	0.4	7.51	91.49	0.09	7.17	91.83	0.43
18	7.2	91.8	0.34	7.65	91.35	-0.03	7.35	91.65	**0.23**
20	7.52	91.48	0.26	7.74	91.26	-0.1	6.97	92.03	0.29
22	7.22	91.78	0.3	7.63	91.37	-0.09	6.82	92.18	0.14
24	7.03	91.97	0.51	7.45	91.55	0.03	6.58	92.42	-0.56
26	6.85	92.15	0.57	7.22	91.78	0.12	5.25	93.75	-0.89
28	6.84	92.16	0.42	6.76	92.24	0.2	3.8	95.2	-0.58
30	5.8	93.2	0.8	6.22	92.78	0.14	2.76	96.24	
32	4.33	94.67	0.85	5.02	93.98	-0.14			
34	3.12	95.88	0.8	3.43	95.57	-0.23			
36	2.15	96.85	0.57						

Table C-5: Treatment Lagoon Total Depth Measurements, May 2003

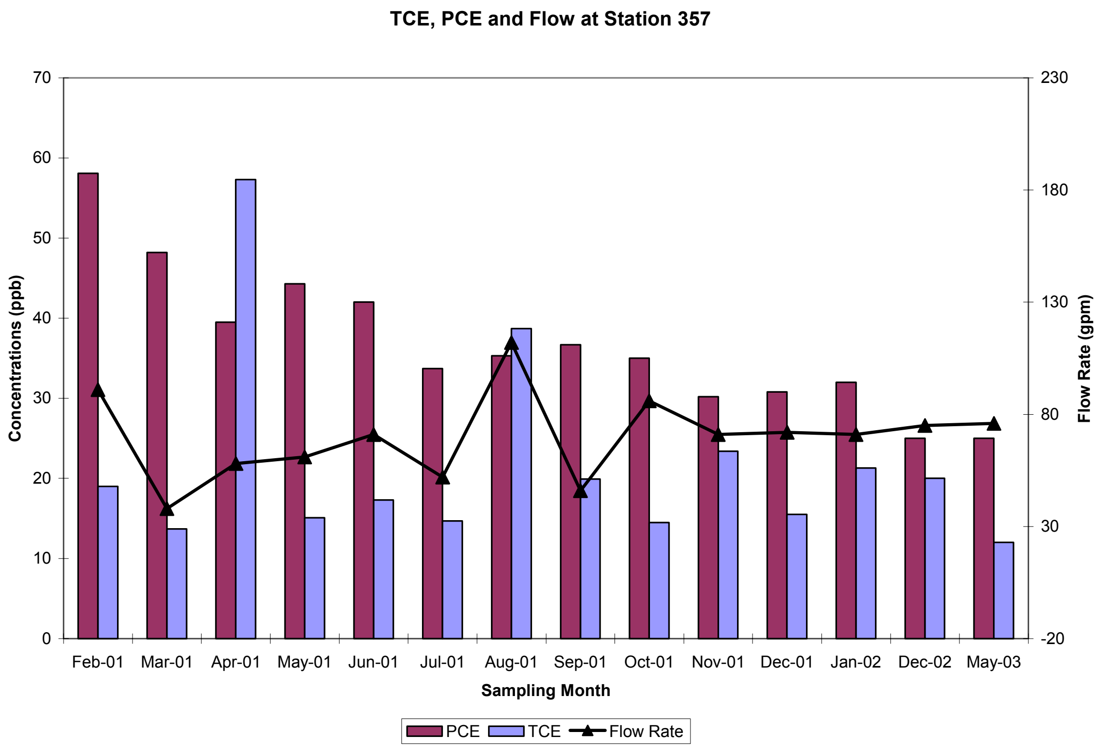
	Aerator A1 (south)			Aerator A2 (central)			Aerator A3 (north)		
Feet From East Bank	Depth Below Survey Elev.	Elev. Above Datum	Change from Original	Depth Below Survey Elev.	Elev. Above Datum	Change from Original	Depth Below Survey Elev.	Elev. Above Datum	Change from Original
2	2.5	96.5	0.24	2.77	96.23	-0.51	2.91	96.09	-0.17
4	3.47	95.53	0.31	4.05	94.95	-0.25	3.94	95.06	-0.14
6	4.42	94.58	0.28	5.2	93.8	-0.5	5.46	93.54	0.06
8	5.48	93.52	0.12	6.46	92.54	-0.44	6.77	92.23	0.09
10	6.11	92.89	0.35	6.75	92.25	0.13	7.44	91.56	0.01
12	6.78	92.22	0.24	7.03	91.97	0.09	7.54	91.46	0.08
14	6.94	92.06	0.72	7.09	91.91	0.25	7.48	91.52	0.14
16	7.48	91.52	0.14	7.23	91.77	0.37	7.52	91.48	0.08
18	7.66	91.34	-0.12	7.26	91.74	0.36	7.35	91.65	0.23
20	7.8	91.2	-0.02	7.2	91.8	0.44	7.17	91.83	0.09
22	7.77	91.23	-0.25	7.26	91.74	0.28	6.72	92.28	0.24
24	7.34	91.66	0.2	6.96	92.04	0.52	5.78	93.22	0.24
26	7.16	91.84	0.26	6.96	92.31	0.65	4.57	94.43	-0.21
28	6.54	92.46	0.72	6.26	92.74	0.7	3.13	95.87	0.09
30	5.43	93.57	1.17	5.35	93.65	1.01	2.31	96.69	
32	4.5	94.5	0.68	3.89	95.11	0.99			
34	3.52	95.48	0.4	2.75	96.25	0.45			
36	2.28	96.72	0.44						

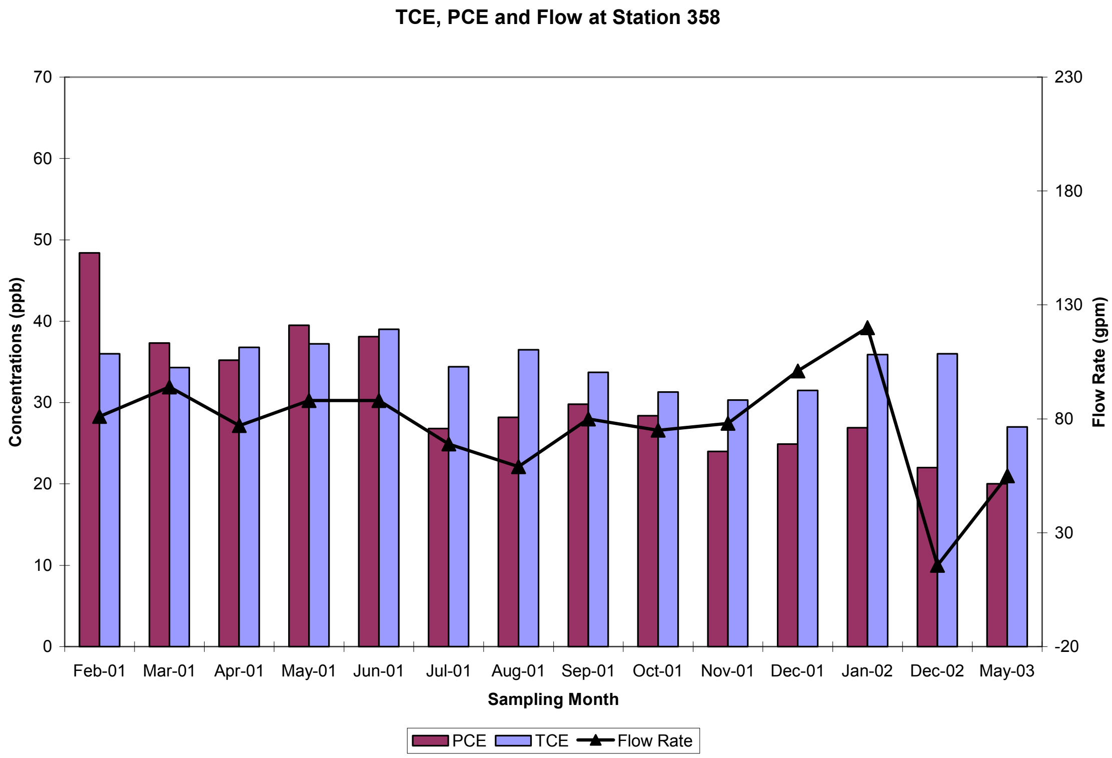

Lagoon Profile at Aerator A1 (south)
Feet above msl
Feet from East Bank
February 6, 2001
December 4, 2002
May 8, 2003


Lagoon Profile at Aerator A2 (central)
Feet Above msl
Feet from East Bank
February 6, 2001
December 4, 2002
May 8, 2003

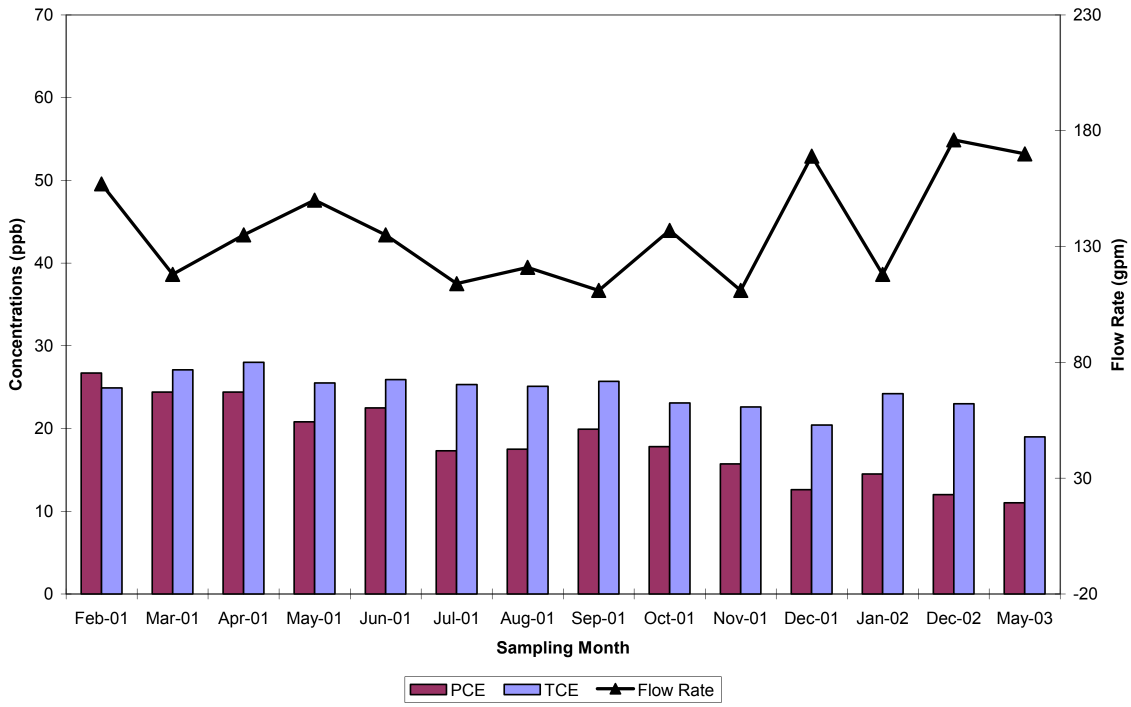

Lagoon Profile at Aerator A3 (north)
Feet Above msl
Feet from East Bank
February 6, 2001
December 4, 2002
May 8, 2003

Appendix D. PCE and TCE Concentrations with Flow Rates from February 2001 to May 2003

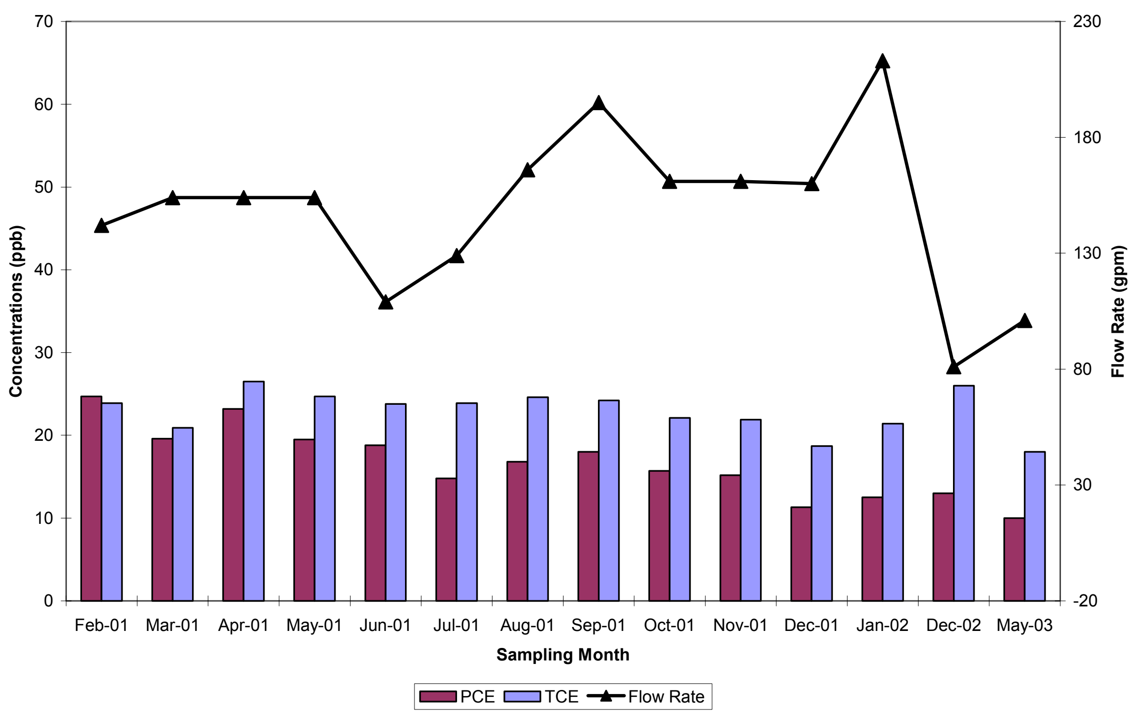


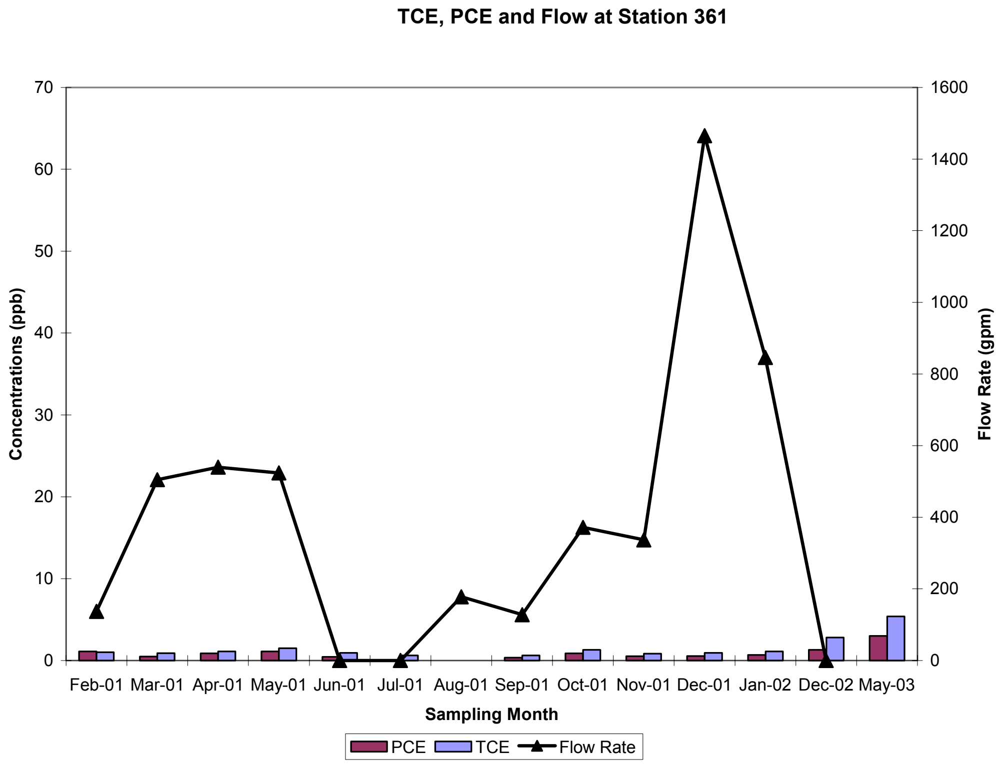


TCE, PCE, and Flow at Station 359



TCE, PCE and Flow at Station 360




TCE, PCE and Flow at Station 361
Concentrations (ppb)
70
60
50
40
30
20
10
0
1600
1400
1200
1000
800
600
400
200
0
Flow Rate (gpm)
Feb-01 Mar-01 Apr-01 May-01 Jun-01 Jul-01 Aug-01 Sep-01 Oct-01 Nov-01 Dec-01 Jan-02 Dec-02 May-03
Sampling Month
PCE
TCE
Flow Rate

Appendix E. Lagoon Performance Calculations

Find: Percent contaminant reduction by lagoon for December 4, 2002

Measured parameters

Lagoon influent:		
PCE:	13	ug/L
TCE:	26	ug/L
Flow:	81	gpm
Lagoon effluent:		
PCE:	1.3	ug/L
TCE:	2.8	ug/L
Flow:	364	gpm

Overall percent reduction

$$\frac{\text{Effluent Concentration}}{\text{Influent Concentration}} \times 100\%$$

PCE: 90%
TCE: 89%

Residence time

Lagoon volume = 556.3 cyds

Convert to gallons: 112,350 gallons

Calculate residence time:

$$\frac{112{,}350 \text{ gal}}{364 \text{ gal/min}}$$

Residence time = 308 minutes or 5 hours

Find: Percent contaminant reduction by lagoon for May 8, 2003

Measured parameters

Lagoon influent:		
PCE:	10	ug/L
TCE:	18	ug/L
Flow:	101	gpm
Lagoon effluent:		
PCE:	3	ug/L
TCE:	5.4	ug/L
Flow:	166	gpm

Overall percent reduction

$$\frac{\text{Effluent Concentration}}{\text{Influent Concentration}} \times 100\%$$

PCE: 70%
TCE: 70%

Residence time

Lagoon volume = 556.3 cyds

Convert to gallons: 112,350 gallons

Calculate residence time:

$$\frac{112{,}350 \text{ gal}}{166 \text{ gal/min}}$$

Residence time = 677 minutes or 11 hours