WASHINGTON STATE DEPARTMENT OF ECOLOGY

Palermo Wellfield Superfund Site Subdrain System and Treatment Lagoon, Status Report, October 2003 and May 2004

Abstract

In the late 1980s, groundwater contaminated with trichloroethene (TCE) and tetrachloroethene (PCE) migrated from an upland commercial area to the city of Tumwater's Palermo Wellfield in the Deschutes River valley. The contaminated groundwater also surfaced at the base of Palermo bluff and ponded as surface water in the yards and crawlspaces of area homes. In 2000 a subdrain system was constructed to reduce the human health risk from the contaminated water by lowering the groundwater table.

Monitoring of the subdrain system was conducted by the Washington State Department of Ecology's Environmental Assessment Program in October 2003 and May 2004. The goal of the monitoring is to collect water level and PCE/TCE data to determine if the subdrain system is operating within the remediation goals set for the project.

Groundwater levels measured in piezometers were three to five feet below the ground surface near the north and central homes, which meets the remediation goals. As in the past, groundwater levels were 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 cleanout CO-4 which has had some sediment accumulation.

PCE and TCE concentrations continue to be highest from water samples collected from the south and central portion of the trunk drain, with average concentrations of 25 ppb for PCE and 23 ppb for TCE. PCE and TCE concentrations from the lagoon effluent continue to be higher than during the validation period monitoring. TCE concentrations in May were twice as high as concentrations reported the previous year. PCE and TCE concentrations at station 364, where the treated water discharges to the Deschutes River, were below the remediation goals of 0.8 ug/L for PCE and 2.7 ug/L for TCE.

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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 (US EPA 1999). In the spring of 1999, the U.S. Environmental Protection Agency (EPA) began operation of an air-stripping treatment system at the Palermo Wellfield Superfund Site to remove TCE contamination from the water supply.

Contaminated groundwater was also found to surface at the base of the Palermo bluff and pond in the yards and crawlspaces of homes in the Palermo neighborhood. Ponded water in the crawlspaces posed an inhalation risk to human health since PCE and TCE volatilize from the water into the homes. To alleviate this situation a subdrain system and treatment lagoon was constructed in 2000 to lower the groundwater table at the base of the bluff and remove the contaminants from the collected water.

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 before being discharged 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.

The remediation goal (RG) 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 3 feet below ground surface.

The numerical RG 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 period of February 2001 to April 2002, have been included as Appendix A. The Department of Ecology (Ecology) took over the lead in monitoring the subdrain system from EPA in December 2002 (Marti 2003).

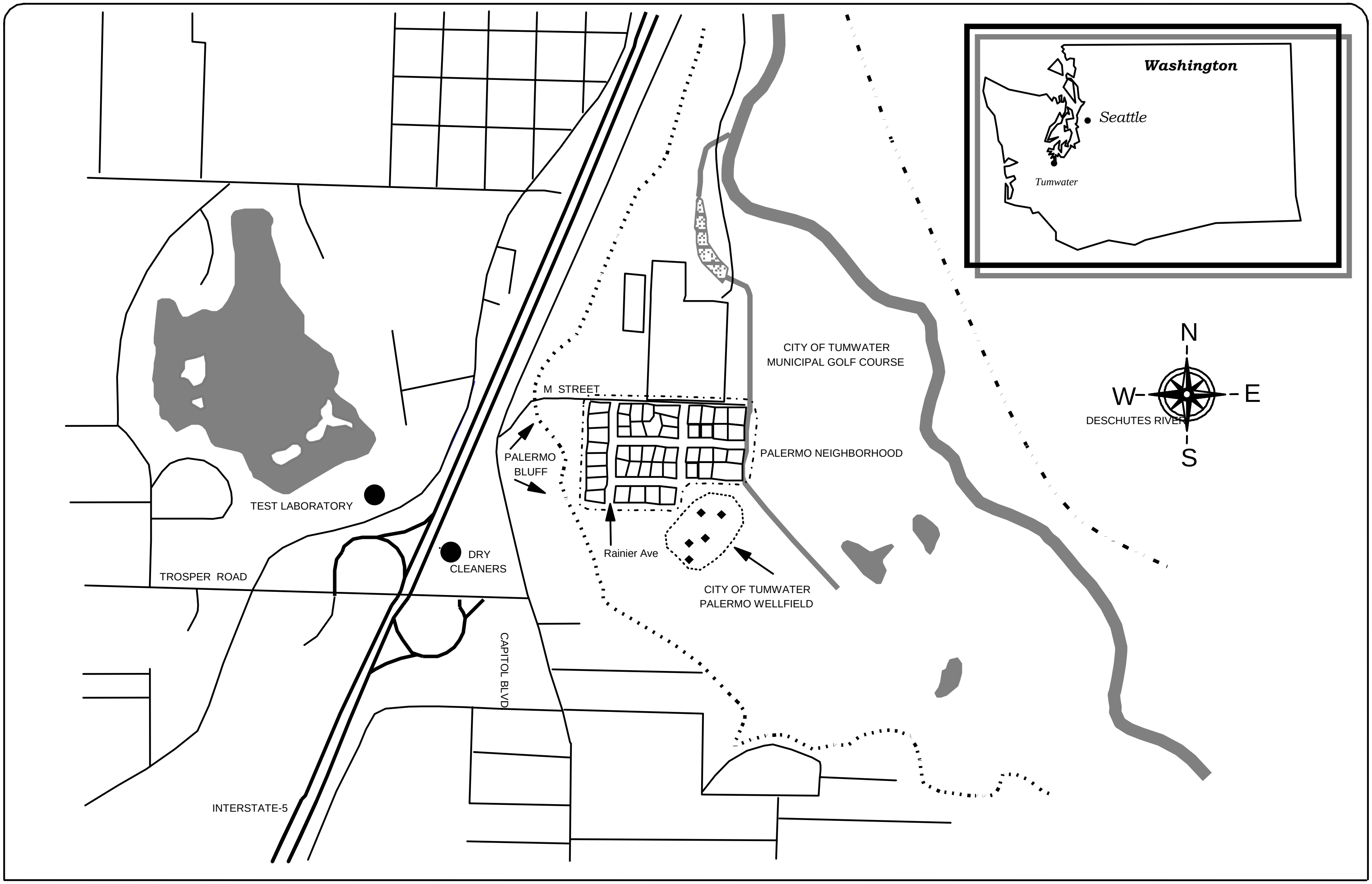


Figure 1	Palermo Wellfield and Neighborhood Site Location

Methods

The goal of this project is to provide Ecology's Toxics Cleanup Program (TCP) with water level data and PCE/TCE concentrations on a semi-annual basis to determine if the subdrain system and treatment lagoon is operating within the remediation goals. Monitoring and sampling of the system (Figure 2) was conducted by the Environmental Assessment Program on October 27-28, 2003 and May 12-13, 2004 and included the following activities:

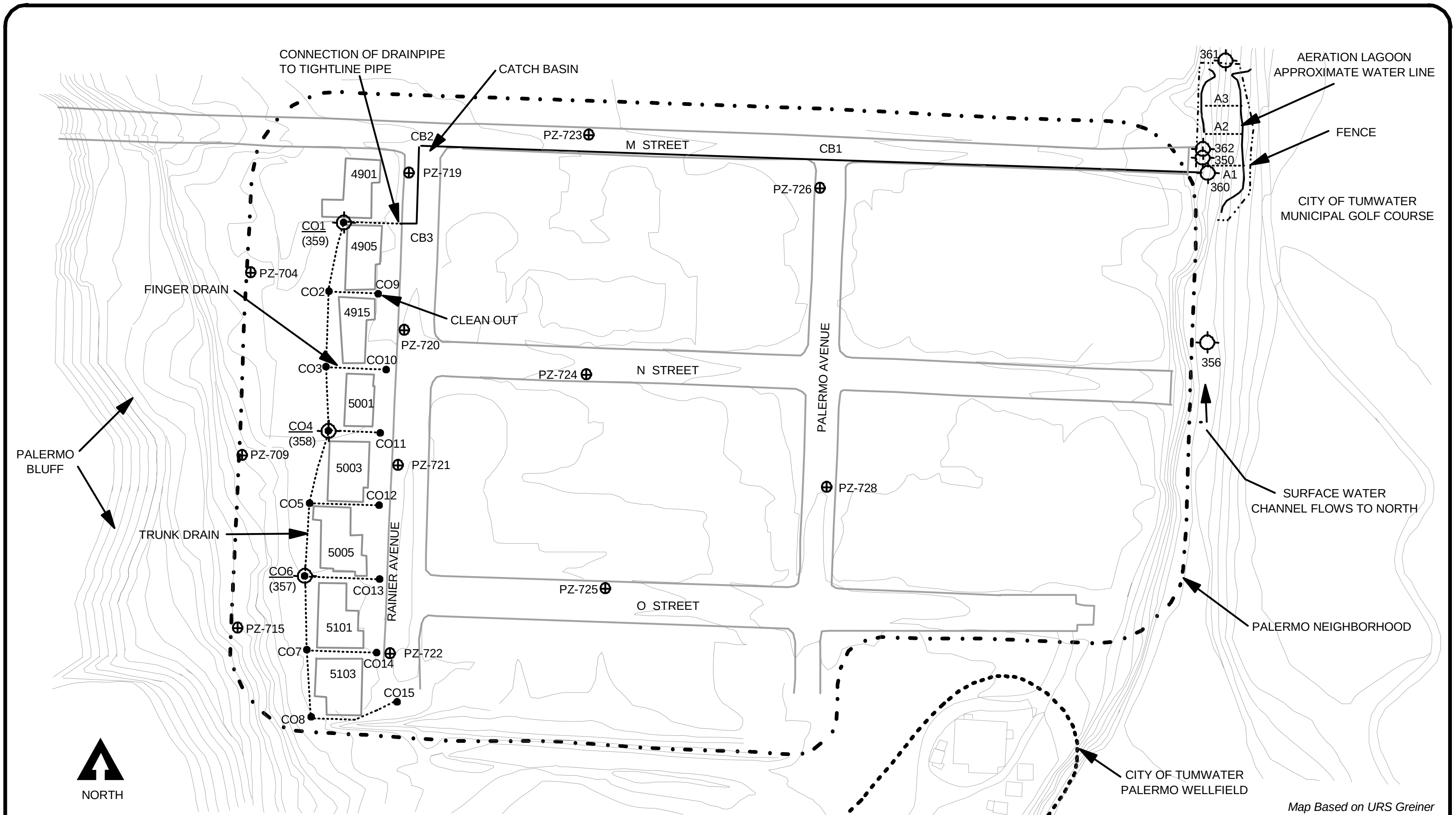
- Measure depth-to-groundwater in 12 piezometers (PZ-704 through PZ-728) and eight cleanouts (CO-1 through CO-8) to determine if the subdrain system has lowered the static groundwater elevation beneath the homes at the base of Palermo bluff to at least three feet below the ground surface.

- Measure total depth in eight trunk drain 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. Measure total depth of the treatment lagoon along three cross sections (A1, A2, and A3) to determine if sedimentation or scouring has occurred in the lagoon.

- Measure flow rates and collect water samples for chemical analysis from three drain cleanouts (stations 357, 358, 359), three outfalls to the treatment lagoon (stations 360, 350, 362), and three surface water stations (stations 356, 361, 364) to assess the contaminant removal performance of the system and compliance with remediation goals. Station 364, which is where the lagoon watercourse discharges to the Deschutes River, was added to the monitoring program in October to allow better comparison of contaminant concentrations to the remediation goals. Locations of the sample stations as well as the sample identification numbers are described in Table 1 and shown in Figure 2.

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
364	Lagoon watercourse discharge to Deschutes River
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)



Legend

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

0 50 100
Scale in Feet
(Approximate)

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

Depth-to-Groundwater Measurements

Static water levels were measured in the 12 piezometers (PZ-704 through PZ-728) using a ¼-inch diameter Solinst water level meter. Depth-to-groundwater was also measured in the subdrain cleanouts (CO-1 through CO-8). 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 or cleanout frame. The water level probe was rinsed with deionized water and wiped clean between measurements.

In May, static water levels were not measured in piezometer PZ-709 because the homeowner could not be reached to grant access and piezometer PZ-725 was under a parked car.

Total Depth Measurements

The total depth of the trunk drain 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 and are accurate to 0.03 feet. The tape measure was rinsed with deionized water and wiped clean between measurements. In October and May, total depth of CO-7 was not measured because the bolts and lid of the cleanout have rusted shut. Total depth was not measured in cleanout CO-5 in May because the homeowner could not be reached to grant access.

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 from the east bank to the west bank at two foot increments from a reference elevation with a survey rod.

Water Flow Rate Measurement

In October and May, depth and velocity of water flow were measured from six of the nine 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 rounds, flow rates at station 356 were not measured. Since the installation of the lagoon, the watercourse 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. Flow rates were not measured at station 364 because of the difficulty of reaching either end of the culvert through which the lagoon watercourse flows before discharging to the Deschutes River.

Water Sampling

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

Water samples were collected using precleaned glass 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, 2003).

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, which includes the target analytes of tetrachloroethene, trichloroethene and dichloroethene.

Table 2: Field and Laboratory Measurements for October 2003 and May 2004 Samples.

Parameter	Method	Reference	Reporting Limit
Field			
Water Level	Solinst Water Level Meter	NA	0.03 feet
Total Depth	Weighted Tape Measure	NA	0.03 feet
	Survey Rod	NA	0.01 feet
Flow Velocity	Marsh-McBirney Current Meter	NA	0.05 feet/second
Laboratory			
VOAs	EPA SW-846 Method 8260B	U.S. EPA 1996	0.5-5 ug/L

In general, the quality of the data is good. Quality control samples collected in the field consisted of blind field duplicate samples, which 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 October and May were less than 10%. In addition to field quality control samples, duplicate matrix spikes and surrogate compound recoveries were performed in the laboratory. In May, 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, with the complete list of volatile organics analyzed, are available upon request. Project data will be located on the website for Ecology's Environmental Information Management (EIM) database at http://apps.ecy.wa.gov/eimreporting/

Results

Depth-to-Groundwater Measurements

Depth-to-groundwater data measured in the piezometers in the Palermo neighborhood is listed in Table 3, along with the calculated groundwater elevations and depth below ground surface. Groundwater elevations and depth below ground surface are also shown in Figure 3. Historical depth-to-groundwater data are presented in Appendix B, including data collected prior to the drain installation.

Table 3: Depth-to-Groundwater, Groundwater Elevations, and Groundwater Depth Below Ground Surface in Piezometers for October 2003 and May 2004.

Piezometer	Inner PVC Elevation (feet)	Concrete/ Ground Elevation (feet)	Depth-to-Groundwater (feet)	Ground-water Elevation (feet)	Groundwater Below Ground Surface (feet)	Depth-to-Groundwater (feet)	Ground-water Elevation (feet)	Groundwater Below Ground Surface (feet)
			October 2003			May 2004		
PZ-704	110.61	108.43	5.87	104.74	-3.69	5.68	104.93	-3.50
PZ-709	114.27	112.01	3.69	110.58	-1.43	--	--	--
PZ-715	117.79	115.51	5.87	111.92	-3.59	5.72	112.07	-3.44
PZ-719	107.13	107.37	2.94	104.19	-3.18	2.85	104.28	-3.09
PZ-720	107.75	108.22	4.56	103.19	-5.03	4.49	103.26	-4.96
PZ-721	108.32	108.57	3.60	104.72	-3.85	3.65	104.67	-3.90
PZ-722	108.82	109.21	0.17	108.65	-0.56	0.07	108.75	-0.46
PZ-723	106.34	106.80	2.86	103.48	-3.32	2.96	103.38	-3.42
PZ-724	106.45	106.88	1.92	104.53	-2.35	2.24	104.21	-2.67
PZ-725	108.22	108.58	2.91	105.31	-3.27	--	--	--
PZ-726	105.39	105.61	3.27	102.12	-3.49	3.77	101.62	-3.99
PZ-728	105.27	105.84	3.24	102.03	-3.81	3.67	101.60	-4.24

-- = Not measured

[box] = Did not meet performance criteria of lowering the water table 3' below the ground surface.

Between the October and May measurements, overall groundwater levels fluctuated less than 0.5 feet. Depth-to-groundwater below the ground surface ranged from 0.56 to 5.03 feet in October and 0.46 to 4.96 feet in May. As in the past, lowering the water table to three feet below the ground surface (bgs) was not achieved in PZ-709, PZ-722, and PZ-724.

The remediation goal of reducing the groundwater elevation near the drain to three feet below the ground surface (bgs) appears to have been met for the central and northern homes along Rainier Avenue. Groundwater levels measured in piezometers near this portion of the trunk drain ranged from three feet to about five feet bgs. Based on historical data, it is assumed that groundwater was less than three feet below the ground surface 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 October and May, the water level was about one-half foot below the ground surface in PZ-722. However, this home is located outside the mapped area of shallow groundwater contamination.

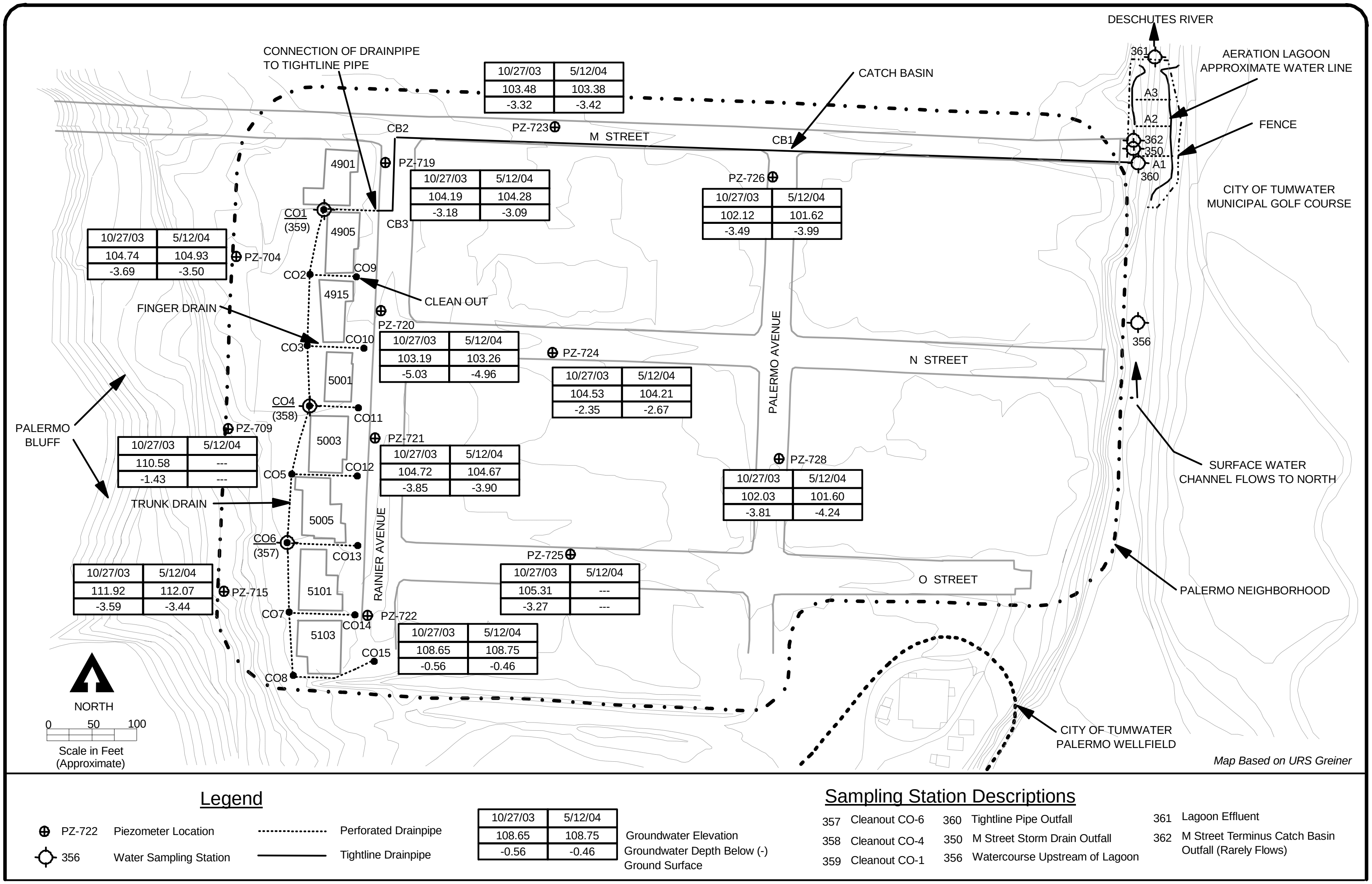


Figure 3 Palermo Wellfield Subdrain System and Treatment Lagoon Groundwater Depth

Total Depth Measurements

In October 2003 and May 2004, total depth measurements were collected in the cleanouts, catch basins, and along three cross sections through the treatment lagoon to assess if sedimentation or erosion is occurring within the subdrain system. Historical total depth measurements for the cleanouts, catch basins, and lagoon are presented as tables and figures in Appendix C.

Table 4: Total Depth of Cleanouts and Catch Basins for October 2003 and May 2004.

Location	Original Depth (feet)	Total Depth (feet)	Change from Original (feet)	Total Depth (feet)	Change from Original (feet)
	February 2001	October 2003		May 2004	
CB-1	7.78	7.79	-0.01	7.79	-0.01
CB-2	8.78	8.80	-0.02	8.81	-0.03
CB-3	8.81	8.93	-0.12	8.93	-0.12
CO-1	7.82	7.81	0.01	7.81	0.01
CO-2	7.1	7.21	-0.11	7.21	-0.11
CO-3	6.84	6.84	0	6.82	0.02
CO-4	7.84	7.42	0.42	7.43	0.41
CO-5	7.84	7.83	0.01	---	---
CO-6	7.7	7.67	0.03	7.68	0.02
CO-7	7.89	---	---	---	---
CO-8	8.1	7.98	0.12	8.02	0.08

-- = Not measured

As shown in Table 4, the range of depths in the catch basins and cleanouts were 6.84 to 8.93 feet in October and 6.82 to 8.93 feet in May. Total depth measurements in the catch basins and cleanouts were not significantly different (less than ±0.12 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 October and May are similar to the original depth measurements (February, 2001) with a margin of error of ±0.5 feet (Appendix C). 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.

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. Flow rates measured since February 2001 are presented in Appendix D.

Table 5: Flow Rates (cfs) for October 2003 and May 2004.

Sample Station	October 2003	May 2004
Flow in Subdrain System Through Discharge to Deschutes River		
357	81	71
358	76	79
359	197	201
360	111	120
361	755	52*
364	NM	NM
Inflows to Treatment Lagoon Other Than the Subdrain System		
350	28	32
356	FU	FU
362	NF	NF

NM: Not measured
FU : Flow rate was unmeasureable.
NF : No flow.
* : Flow rate is under reported.

Average flow rates in the trunk drain at stations 357, 358, and 359 for this monitoring period were 76 gallons per minute (gpm), 77 gpm, and 199 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).

Flow rates at station 360 (tightline pipe outfall), which represent 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 115 gpm, as compared to an average flow of 199 gpm at station 359. 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) averaged 30 gpm. As mentioned previously, the flow rate was unmeasurable at station 356 (upstream of lagoon) and station 362 had no flow. Flow rates were not measured at station 364.

In October 2003, the flow rate at station 361 (lagoon outfall) was 755 gpm, which is higher than previous measurements. The October monitoring occurred one week after heavy rains and flooding of the lagoon watercourse. By May the lagoon outfall had been covered by a thick grass mat which was removed. Riprap at the lagoon outfall made it difficult to collect accurate flow depth and velocity measurements; therefore, the measured flow rate of 52 gpm is probably under reported.

Volatile Organics

Analytical results for PCE, TCE, and DCE are summarized in Table 6. PCE and TCE results for October and April are shown in Figure 4. Figures 5 and 6 show PCE and TCE concentrations, respectively, from samples collected from the subdrain system and the lagoon effluent since February 2001. PCE and TCE results for each station, as well as calculated flow rates, are also presented in Appendix D.

Table 6: Summary of Target Analyte Results (ug/L) for October 2003 and May 2004.

Sample Station	October 2003			May 2004		
Flow in Subdrain System – South to North						
	PCE	*TCE*	*DCE*	*PCE*	*TCE*	*DCE*
357	32	13	0.19 NJ	28	12	0.22 J
358	22	34	0.31 J	20	34	0.26 NJ
359	13	24	0.17 J	11	21	0.23 NJ
360	12	23	0.17 NJ	10	26	1 U
361	1.7	3.5	1 U	3.9	11	1 U
Inflows to Treatment Lagoon Other Than the Subdrain System						
	PCE	*TCE*	*DCE*	*PCE*	*TCE*	*DCE*
350	0.5 U	0.61 NJ	1 U	0.5 U	0.78 NJ	1 U
356	0.5 U	0.5 U	1 U	0.5 U	0.5 U	1 U
362	NF	NF	NF	NF	NF	NF
Lagoon watercourse discharge to Deschutes River						
	PCE	*TCE*	*DCE*	*PCE*	*TCE*	*DCE*
364	0.30 J	0.70	1 U	0.5 U	0.61 NJ	1 U
Remediation Goals	0.8	2.7	--	0.8	2.7	--

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.

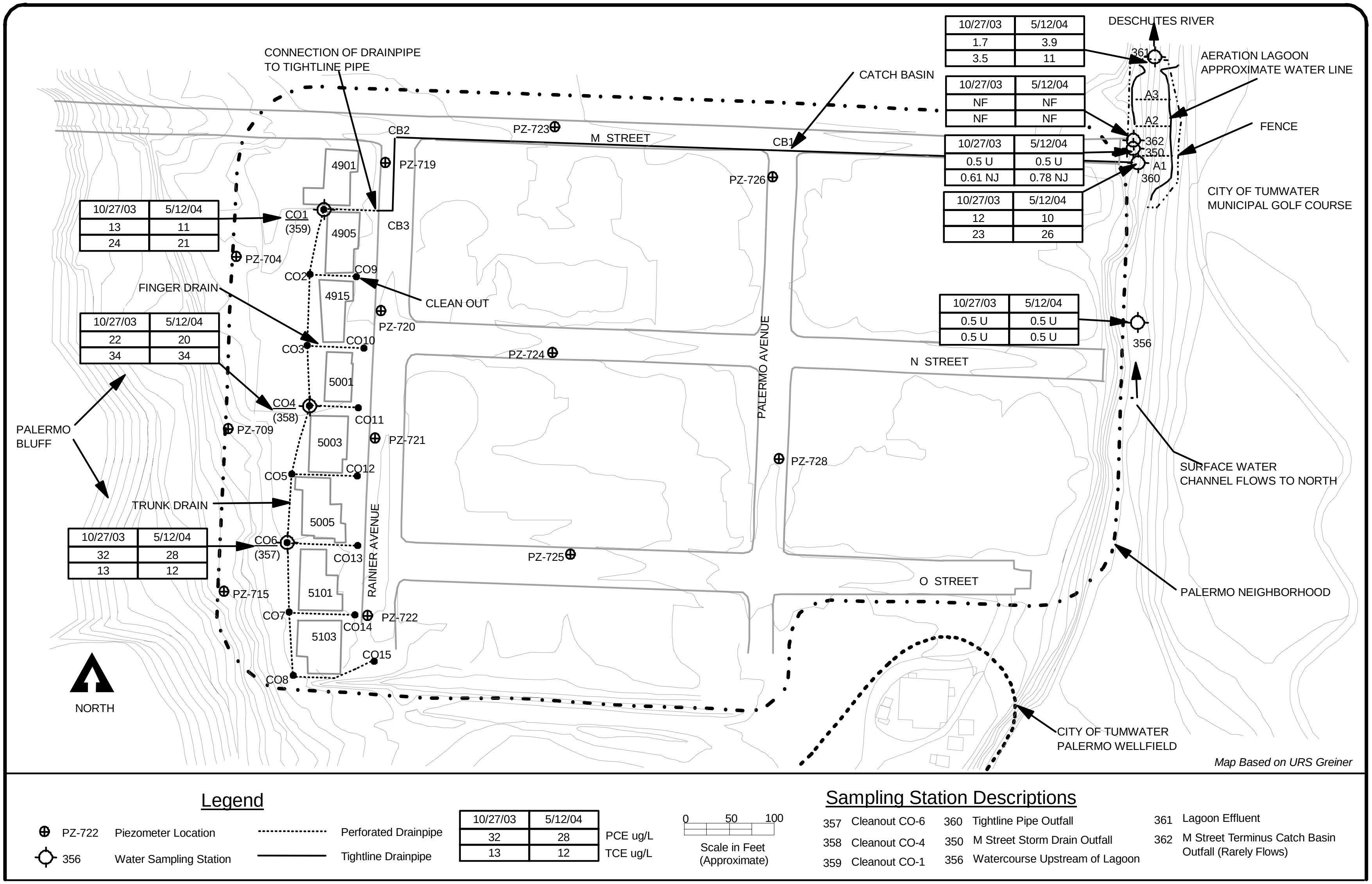


Figure 4 — Palermo Wellfield Subdrain System and Treatment Lagoon PCE/TCE Concentrations

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 30 ug/L at station 357 and 21 ug/L at station 358. TCE concentrations varied more over the monitoring period with average concentrations of 13 ug/L at station 357, increasing to an average concentration of 34 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 23 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 24 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 near the practical quantitation limit of 0.5 ug/L during both sample rounds.

PCE and TCE concentrations in samples collected from station 361 (lagoon effluent) during October and May ranged from 1.7 ug/L to 3.9 ug/L for PCE and 3.5 ug/L to 11 ug/L for TCE. TCE concentrations in May were twice as high as concentrations measured at this station the previous year. During the validation period, PCE and TCE concentrations at the lagoon outfall were typically below the remediation goals (RGs) of 0.8 ug/L (PCE) and 2.7 ug/L (TCE) for water discharging to the Deschutes River. Because PCE and TCE concentrations exceeded the RGs in the previous year of monitoring, sample station 364 was added to the monitoring network to allow a true comparison to the RGs. This station is approximately 2000 feet downstream of the lagoon where the treated water discharges to the Deschutes River. PCE was detected at this station in October at an estimated concentration of 0.3 ug/L, while TCE was detected in October and May at an average estimated concentration of 0.65 ug/L. PCE and TCE concentrations at station 364 were below the remediation goals.

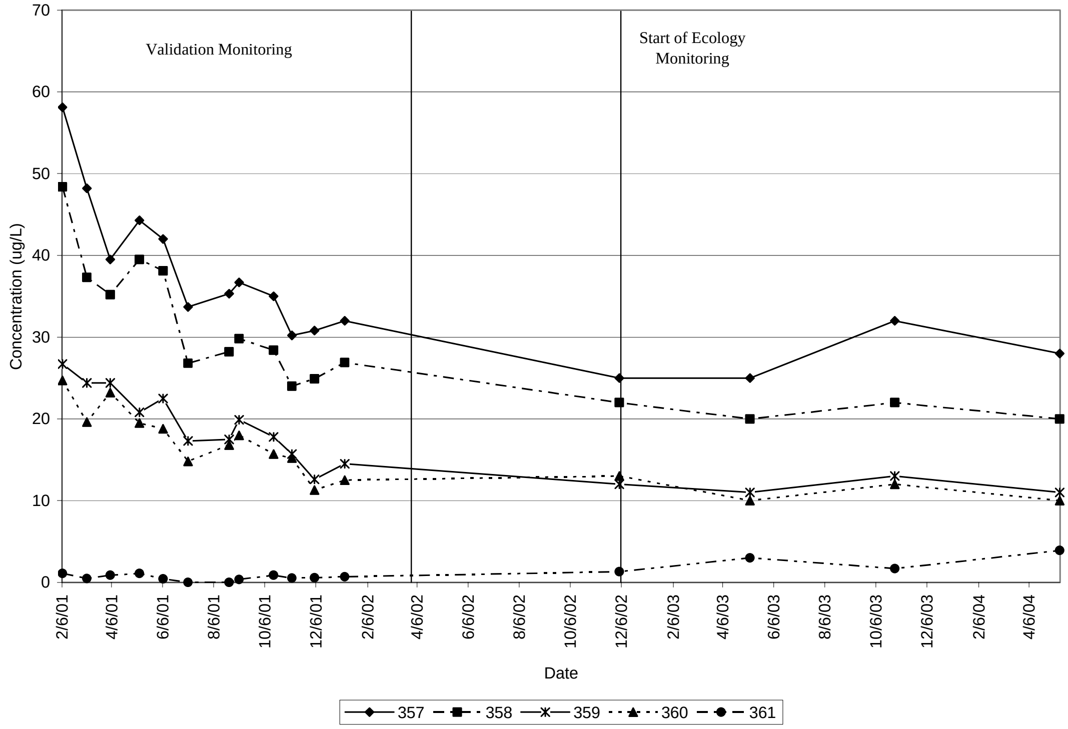


Figure 5: PCE Concentrations (ug/L) for Palermo Subdrain System and Treatment Lagoon, February 2001 to May 2004.

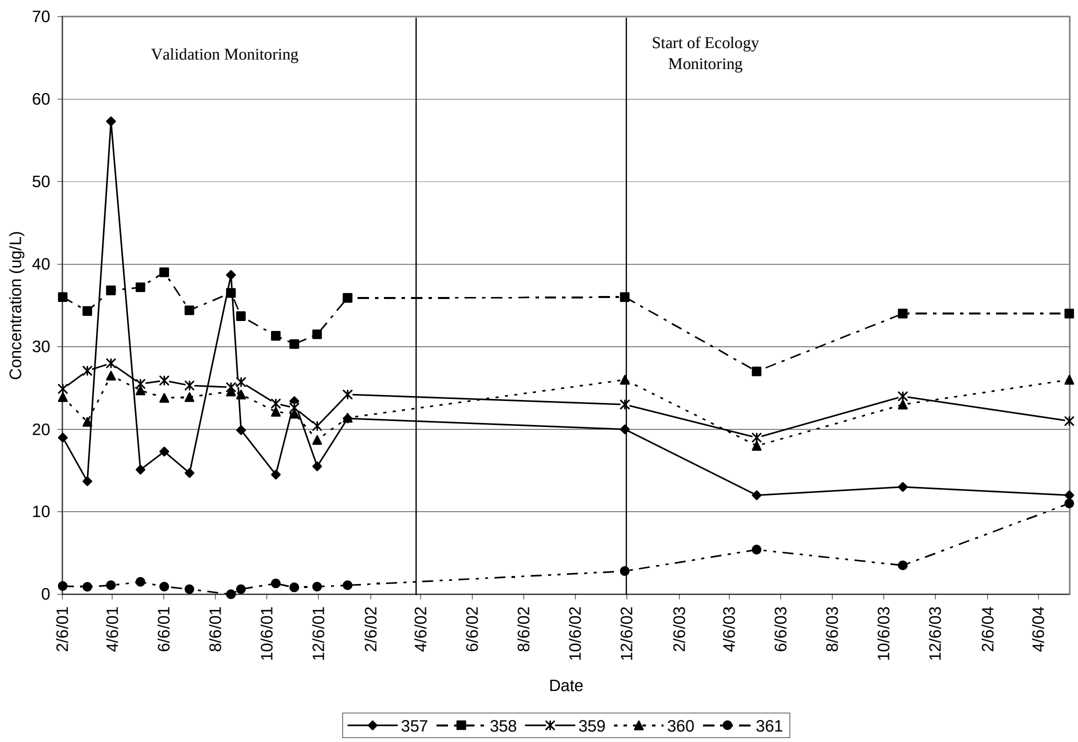


Figure 6: TCE Concentrations (ug/L) for Palermo Subdrain System and Treatment Lagoon, February 2001 to May 2004.

Based on the lagoon effluent concentrations for PCE and TCE, the lagoon achieved a contaminant reduction of about 85 percent in October and 60 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 was less than three hours in October. However, the October monitoring occurred when flows were higher due to recent flooding. In May the residence time in the lagoon was calculated to be 36 hours. However, due to the difficulty of collecting accurate flow depth and velocity measurements at the lagoon outfall, the flow rate used to calculate residence time is too low; therefore, the time the water is in the lagoon is probably shorter.

Conclusions

- Reduction of groundwater elevations to three feet below the ground surface appears 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 about five feet below ground.

- Groundwater was less than three feet below the ground surface in PZ-709 and PZ-722 over the monitoring period. When comparing data from these piezometers to data collected during the validation period, 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 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 continue to be higher than during the validation period. TCE concentrations in May were twice as high as concentrations reported the previous year. Increased PCE and TCE concentrations could be the result of slight variations in sample location at the lagoon outfall.

- PCE and TCE were detected in samples collected from station 364 which is where the treatment lagoon watercourse enters the Deschutes River (approximately 2,000 feet downstream from the lagoon). PCE and TCE concentrations were below the RGs set for both PCE (0.8 ug/L) and TCE (2.7 ug/L) for surface water that discharges to the Deschutes River.

- Reduction in contaminant concentrations after the treatment lagoon was about 85 percent in October and 60 percent in May with only two aerators operating.

Recommendations

- The lid to cleanout CO-7 has rusted shut. This will need to be repaired before the next scheduled monitoring in October 2004.
- The southern-most aerator (A1) should be repaired or replaced. This aerator has not operated properly since Ecology took the lead in monitoring the system in December 2002.
- Improve flow depth and velocity measurement techniques at stations 360 and 361 to get more accurate flow data.
- Sample station 364, where surface water from the lagoon watercourse discharges to the Deschutes River, should continue to be monitored. Results from this station allow for better comparison of contaminant concentrations to the remediation goals.

References

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Appendix A. Subdrain System Operating Parameters

Table A-1: System Operating Parameters as Established During Validation Monitoring February 2001 to 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 2004.

	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
12/20/99	107.15	--	--	111.60	--	--	114.79	--	--
1/31/00	107.49	0.34	--	111.83	0.23	--	114.70	-0.09	--
2/23/00	103.89	-3.60	--	111.75	-0.08	--	114.19	-0.51	--
3/28/00	107.20	3.31	--	111.82	0.07	--	114.54	0.35	--
5/9/00	107.38	0.18	--	111.77	-0.05	--	114.42	-0.12	--
5/26/00	107.07	-0.31	--	111.75	-0.02	--	114.44	0.02	--
6/22/00	106.81	-0.26	--	111.61	-0.14	--	113.90	-0.54	--
7/26/00	106.61	-0.20	--	111.30	-0.31	--	113.90	0.00	--
8/21/00	106.28	-0.33	--	111.02	-0.28	--	112.66	-1.24	--
10/2/00	106.21	-0.07	--	111.03	0.01	--	112.17	-0.49	--
11/21/00	102.61	-3.60	--	111.10	0.07	--	112.75	0.58	--
2/7/01	104.26	1.65	0.37	110.99	-0.11	-0.76	111.85	-0.90	-2.34
3/6/01	104.21	-0.05	-2.99	110.96	-0.03	-0.86	112.52	0.67	-2.02
4/3/01	104.30	0.09	-3.08	110.95	-0.01	-0.82	112.23	-0.29	-2.19
5/8/01	104.21	-0.09	-2.86	111.01	0.06	-0.74	112.01	-0.22	-2.43
6/6/01	104.11	-0.10	-2.70	110.33	-0.68	-1.28	111.82	-0.19	-2.08
7/5/01	103.86	-0.25	-2.75	110.23	-0.10	-1.07	111.40	-0.42	-2.50
8/24/01	103.92	0.06	-2.36	110.64	0.41	-0.38	111.07	-0.33	-1.59
9/4/01	103.73	-0.19	-2.48	110.24	-0.40	-0.79	110.58	-0.49	-1.59
10/17/01	103.86	0.13	-2.35	109.70	-0.54	-1.40	110.89	0.31	-1.28
11/6/01	103.56	-0.30	0.95	109.97	0.27	-1.13	110.95	0.06	-1.80
12/5/01	104.99	1.43	2.38	111.10	1.13	0.00	112.03	1.08	-0.72
1/8/02	105.44	0.45	1.18	111.00	-0.10	0.01	112.43	0.40	0.58
2/7/02	105.06	-0.38	0.80	111.05	0.05	0.06	112.18	-0.25	0.33
3/7/02	104.87	-0.19	0.66	111.04	-0.01	0.08	112.35	0.17	-0.17
4/1/02	104.97	0.10	0.67	111.07	0.03	0.12	112.28	-0.07	0.05
12/3/02	104.46	-0.51	-0.53	109.46	-1.61	-1.64	111.91	-0.37	-0.12
5/7/03	104.77	0.31	-0.20	109.87	0.41	-1.20	112.14	0.23	-0.14
10/27/03	104.74	-0.03	0.28	110.58	0.71	1.12	111.92	-0.22	0.01
5/12/04	104.93	0.19	0.16	--	--	--	112.07	0.15	-0.07
Average:	105.10	0.64	--	110.92	0.28	--	112.57	0.37	--
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 (shaded).
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 for this cell.
<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-719			PZ-720			PZ-721		
	GW Elev.	Delta Month	Delta Year	GW Elev.	Delta Month	Delta Year	GW Elev.	Delta Month	Delta Year
12/20/99	103.90	--	--	106.59	--	--	107.37	--	--
1/31/00	104.85	0.95	--	106.45	-0.14	--	107.36	-0.01	--
2/23/00	104.88	0.03	--	106.50	0.05	--	107.32	-0.04	--
3/28/00	104.92	0.04	--	106.49	-0.01	--	107.33	0.01	--
5/9/00	104.93	0.01	--	106.57	0.08	--	107.44	0.11	--
5/26/00	104.82	-0.11	--	106.48	-0.09	--	107.22	-0.22	--
6/22/00	104.57	-0.25	--	106.60	0.12	--	106.94	-0.28	--
7/26/00	104.31	-0.26	--	105.89	-0.71	--	106.83	-0.11	--
8/21/00	103.73	-0.58	--	105.38	-0.51	--	106.19	-0.64	--
10/2/00	103.33	-0.40	--	105.41	0.03	--	105.77	-0.42	--
11/21/00	<97	--	--	<97	--	--	NM	--	--
2/7/01	103.50	--	-1.38	103.73	--	-2.77	104.26	--	-3.06
3/6/01	103.19	-0.31	-1.73	102.65	-1.08	-3.84	103.94	-0.32	-3.39
4/3/01	103.48	0.29	-1.45	102.73	0.08	-3.84	104.32	0.38	-3.12
5/8/01	103.65	0.17	-1.17	102.91	0.18	-3.57	104.43	0.11	-2.79
6/6/01	103.58	-0.07	-0.99	102.81	-0.10	-3.79	104.05	-0.38	-2.89
7/5/01	102.78	-0.80	-1.53	102.42	-0.39	-3.47	103.61	-0.44	-3.22
8/24/01	103.47	0.69	-0.26	102.61	0.19	-2.77	103.80	0.19	-2.39
9/4/01	102.62	-0.85	-0.71	102.38	-0.23	-3.03	103.45	-0.35	-2.32
10/17/01	102.99	0.37	-0.34	102.52	0.14	-2.89	103.72	0.27	-2.05
11/6/01	103.49	0.50	--	102.68	0.16	--	104.15	0.43	--
12/5/01	104.65	1.16	1.32	103.24	0.56	-2.17	104.98	0.83	-0.79
1/8/02	105.02	0.37	1.52	103.85	0.61	0.12	105.44	0.46	1.18
2/7/02	104.32	-0.70	0.82	103.12	-0.73	-0.61	104.92	-0.52	0.66
3/7/02	104.12	-0.20	0.93	103.07	-0.05	0.42	104.74	-0.18	0.80
4/1/02	104.21	0.09	0.73	103.12	0.05	0.39	104.85	0.11	0.53
12/3/02	103.76	-0.45	-0.89	102.91	-0.21	-0.33	104.60	-0.25	-0.38
5/7/03	104.04	0.28	-0.17	103.05	0.14	-0.07	104.60	0.00	-0.25
10/27/03	104.19	0.15	0.43	103.19	0.14	0.28	104.72	0.12	0.12
5/12/04	104.28	0.09	0.24	103.26	0.07	0.21	104.67	-0.05	0.07
Average:	103.99	0.38	--	104.09	0.25	--	105.28	0.27	--
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 (shaded).
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 for this cell.
<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-722			PZ-723			PZ-724		
Date	**GW Elev.**	**Delta Month**	**Delta Year**	**GW Elev.**	**Delta Month**	**Delta Year**	**GW Elev.**	**Delta Month**	**Delta Year**
12/20/99	109.91	--	--	99.47	--	--		--	--
1/31/00	109.87	-0.04	--	103.57	4.10	--	104.89	--	--
2/23/00	110.06	0.19	--	103.71	0.14	--	104.85	-0.04	--
3/28/00	110.08	0.02	--	103.65	-0.06	--	105.01	0.16	--
5/9/00	110.10	0.02	--	103.89	0.24	--	105.01	0.00	--
5/26/00	109.97	-0.13	--	104.52	0.63	--	104.73	-0.28	--
6/22/00	109.88	-0.09	--	103.36	-1.16	--	104.50	-0.23	--
7/26/00	109.65	-0.23	--	103.01	-0.35	--	104.02	-0.48	--
8/21/00	109.43	-0.22	--	101.82	-1.19	--	102.63	-1.39	--
10/2/00	108.42	-1.01	--	100.85	-0.97	--	101.66	-0.97	--
11/21/00	109.47	1.05	--	102.85	2.00	--	104.06	2.40	--
2/7/01	108.42	-1.05	-1.64	102.89	0.04	-0.82	103.31	-0.75	-1.54
3/6/01	108.12	-0.30	-1.96	102.62	-0.27	-1.03	103.17	-0.14	-1.84
4/3/01	108.47	0.35	-1.63	102.91	0.29	-0.98	103.46	0.29	-1.55
5/8/01	107.88	-0.59	-2.09	102.91	0.00	-1.61	103.57	0.11	-1.16
6/6/01	108.52	0.64	-1.36	102.42	-0.49	-0.94	103.10	-0.47	-1.40
7/5/01	108.73	0.21	-0.92	101.60	-0.82	-1.41	102.14	-0.96	-1.88
8/24/01	107.65	-1.08	-1.78	102.70	1.10	0.88	102.36	0.22	-0.27
9/4/01	107.24	-0.41	-1.18	101.69	-1.01	0.84	NM	--	--
10/17/01	107.64	0.40	-0.78	101.97	0.28	1.12	NM	--	--
11/6/01	108.18	0.54	-1.29	102.68	0.71	-0.17	NM	--	--
12/5/01	109.00	0.82	-0.47	104.26	1.58	1.41	NM	--	--
1/8/02	109.49	0.49	1.07	105.24	0.98	2.35	105.97	--	2.66
2/7/02	109.14	-0.35	0.72	103.71	-1.53	0.82	104.43	-1.54	1.12
3/7/02	109.03	-0.11	0.91	103.36	-0.35	0.74	104.20	-0.23	1.03
4/1/02	109.32	0.29	0.85	103.44	0.08	0.53	104.31	0.11	0.85
12/3/02	108.67	-0.65	-0.33	102.84	-0.60	-1.42	104.07	-0.24	--
5/7/03	108.67	0.00	-0.65	103.02	0.18	-0.42	103.77	-0.30	-0.54
10/27/03	108.65	-0.02	-0.02	103.48	0.46	0.64	104.53	0.76	0.46
5/12/04	108.75	0.10	0.08	103.38	-0.10	0.36	104.21	-0.32	0.44
Average:	108.95	0.39	--	102.93	0.77	--	103.92	0.54	--
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 (shaded).
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 for this cell.
<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
12/20/99	105.79	--	--	98.30	--	--	98.49	--	--
1/31/00	105.45	-0.34	--	101.59	3.29	--	101.72	3.23	--
2/23/00	100.99	-4.46	--	101.52	-0.07	--	98.56	-3.16	--
3/28/00	105.56	4.57	--	101.79	0.27	--	101.86	3.30	--
5/9/00	105.32	-0.24	--	101.64	-0.15	--	101.49	-0.37	--
5/26/00	105.20	-0.12	--	101.47	-0.17	--	101.96	0.47	--
6/22/00	105.00	-0.20	--	101.35	-0.12	--	101.14	-0.82	--
7/26/00	--	--	--	100.83	-0.52	--	100.54	-0.60	--
8/21/00	103.17	-1.83	--	100.76	-0.07	--	97.68	-2.86	--
10/2/00	102.81	-0.36	--	98.35	-2.41	--	97.23	-0.45	--
11/21/00	105.30	2.49	--	100.99	2.64	--	101.63	4.40	--
2/7/01	104.22	-1.08	3.23	100.74	-0.25	-0.78	100.26	-1.37	1.70
3/6/01	104.08	-0.14	-1.48	100.55	-0.19	-1.24	100.00	-0.26	-1.86
4/3/01	NM	--	--	100.85	0.30	-0.79	100.74	0.74	-0.75
5/8/01	104.68	--	-0.52	100.88	0.03	-0.59	100.87	0.13	-1.09
6/6/01	104.34	-0.34	-0.66	100.03	-0.85	-1.32	100.31	-0.56	-0.83
7/5/01	103.26	-1.08	--	97.76	-2.27	-3.07	98.90	-1.41	-1.64
8/24/01	103.19	-0.07	0.02	100.07	2.31	-0.69	98.49	-0.41	0.81
9/4/01	102.68	-0.51	-0.13	98.64	-1.43	0.29	97.89	-0.60	0.66
10/17/01	103.44	0.76	0.63	100.81	2.17	2.46	99.10	1.21	1.87
11/6/01	104.13	0.69	-1.17	100.34	-0.47	-0.65	100.19	1.09	-1.44
12/5/01	106.13	2.00	0.83	102.72	2.38	1.73	102.84	2.65	1.21
1/8/02	106.36	0.23	2.14	103.33	0.61	2.59	103.04	0.20	2.78
2/7/02	105.31	-1.05	1.09	101.88	-1.45	1.14	101.49	-1.55	1.23
3/7/02	105.03	-0.28	0.95	101.37	-0.51	0.81	101.18	-0.31	1.18
4/1/02	105.19	0.16	0.97	101.52	0.15	0.67	101.49	0.31	0.75
12/3/02	105.47	0.28	-0.66	100.94	-0.58	-1.78	102.05	0.56	-0.79
5/7/03	104.72	-0.75	-0.47	100.70	-0.24	-0.81	100.52	-1.53	-0.97
10/27/03	105.31	0.59	-0.16	102.12	1.42	1.18	102.03	1.51	-0.02
5/12/04	--	--	--	101.62	-0.50	0.92	101.63	-0.43	1.08
Average:	104.52	1.14	--	100.84	0.96	--	100.51	1.26	--
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 (shaded).
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 for this cell.
<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.

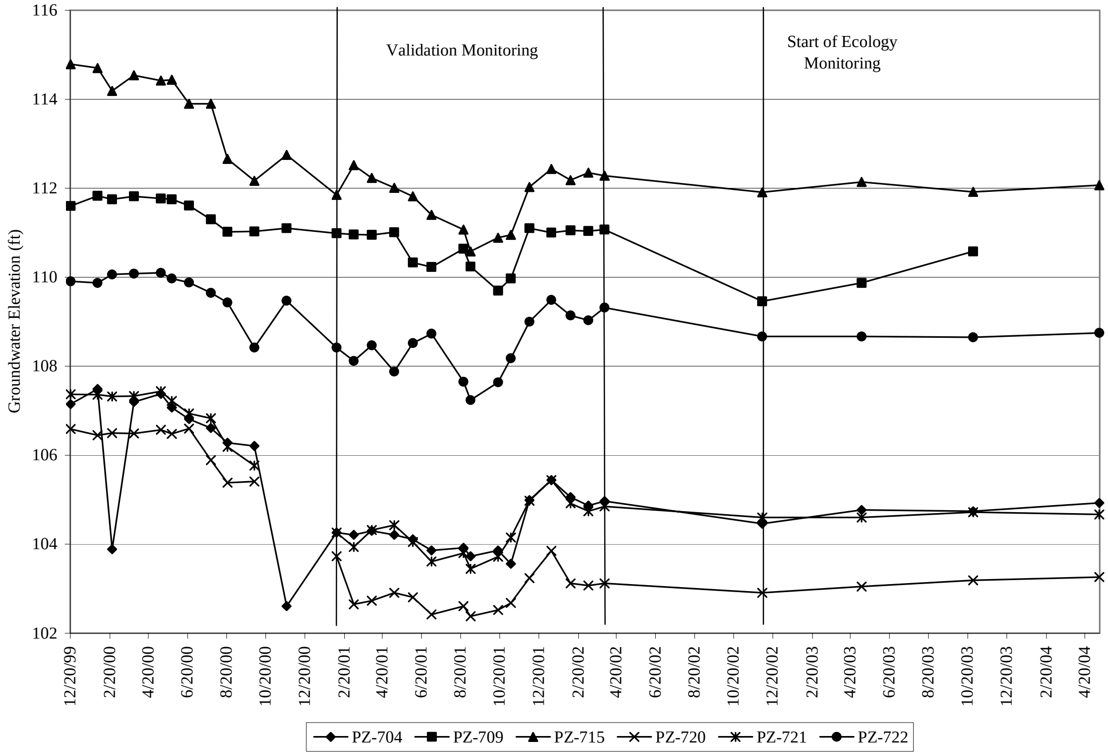


Figure B-1. Groundwater Elevations for Piezometers Influenced by the Drain from December 1999 to May 2004.

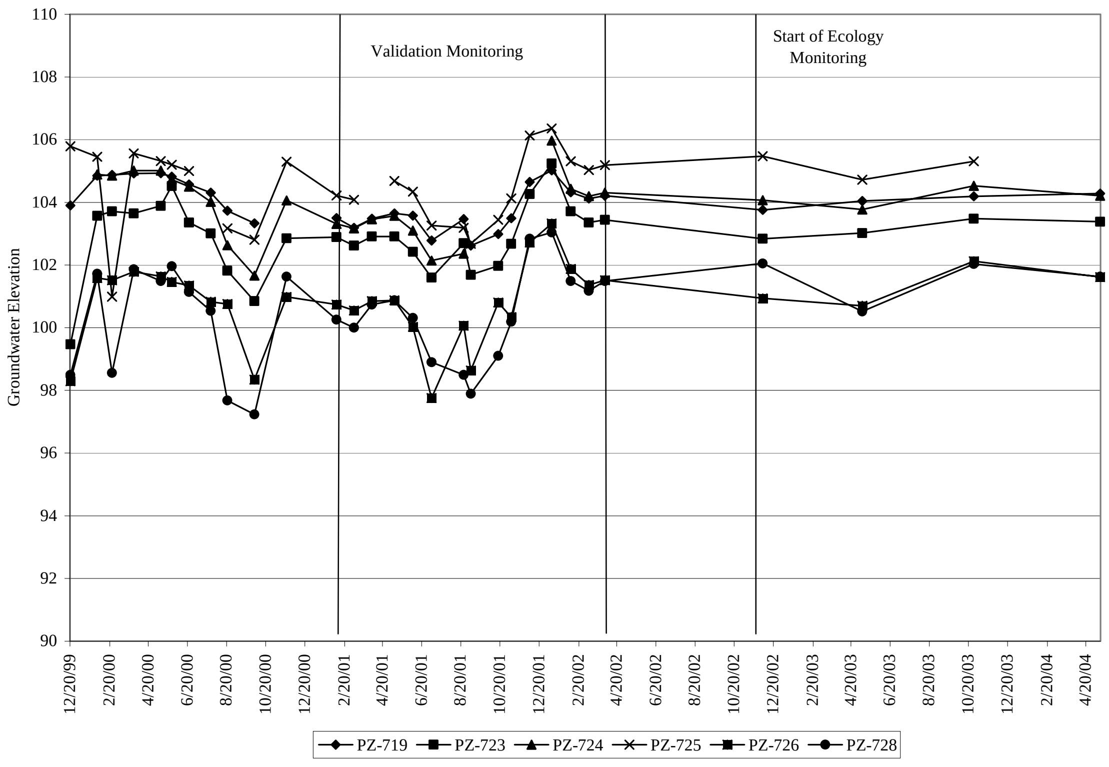


Figure B-2. Groundwater Elevations for Piezometers Beyond the Drains Influence from December 1999 to May 2004.

Table B-2: Depth-to-Water and Water Elevations in Cleanouts from December 2002 to May 2004.

Cleanout	North Rim Elevation (feet)	Depth to Water (feet)	Water Elevation (feet)	Depth to Water (feet)	Water 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

-- - not measured.

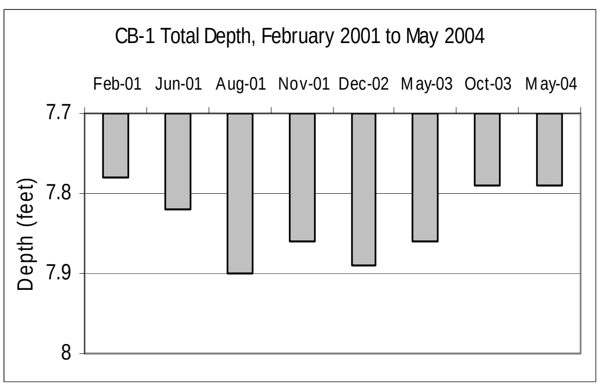
Cleanout	North Rim Elevation (feet)	Depth to Water (feet)	Water Elevation (feet)	Depth to Water (feet)	Water Elevation (feet)
		October 2003		May 2004	
CO-1	108.39	6.36	102.03	6.35	102.04
CO-2	108.04	5.91	102.13	5.91	102.13
CO-3	107.96	5.71	102.25	5.72	102.24
CO-4	108.73	6.22	102.51	6.21	102.52
CO-5	109.32	6.68	102.64	--	--
CO-6	109.78	6.55	103.23	6.58	103.20
CO-7	110.73	--	--	--	--
CO-8	110.96	6.85	104.11	6.85	104.11

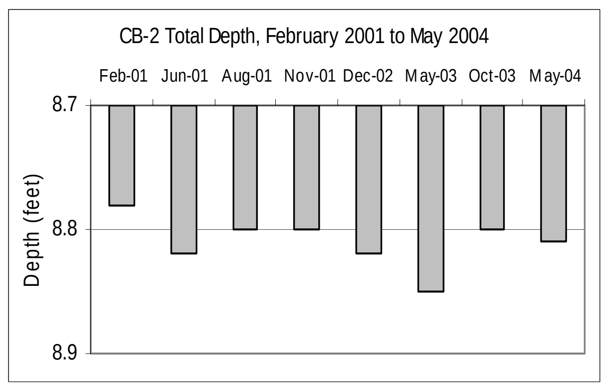
-- - not measured.

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

Table C-1: Total Depth of Catch Basins, February 2001 to May 2004.

	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
2/6/01	7.78	--	8.78	--	8.81	--
6/6/01	7.82	-0.04	8.82	-0.04	8.92	-0.11
8/24/01	7.9	-0.12	8.8	-0.02	8.96	-0.15
11/6/01	7.86	-0.08	8.8	-0.02	8.41	0.4
12/2/02	7.89	-0.11	8.82	-0.04	8.95	-0.14
5/7/03	7.86	-0.08	8.85	-0.07	8.93	-0.12
10/27/03	7.79	-0.01	8.80	-0.02	8.93	-0.12
5/12/04	7.79	-0.01	8.81	-0.03	8.93	-0.12





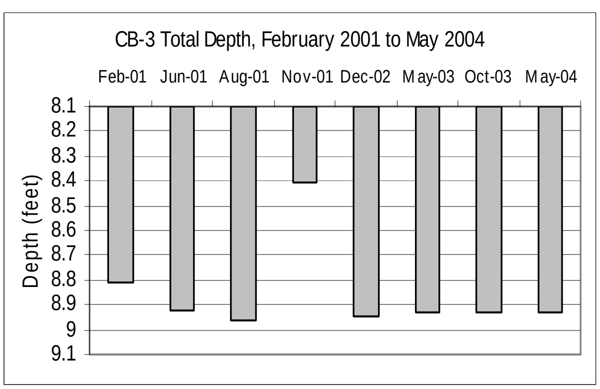
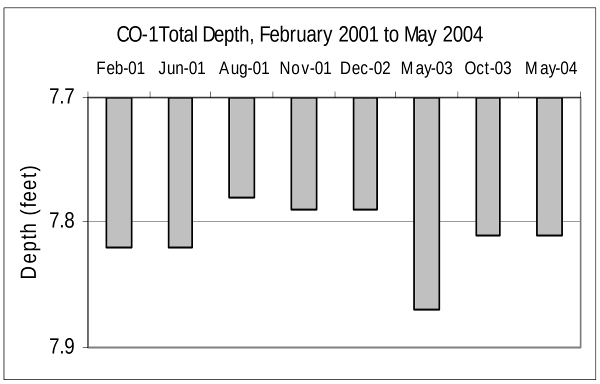
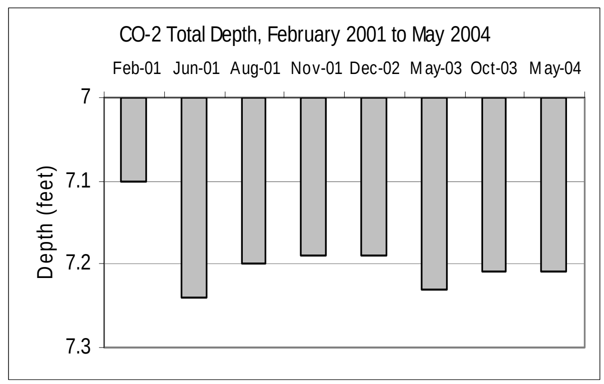
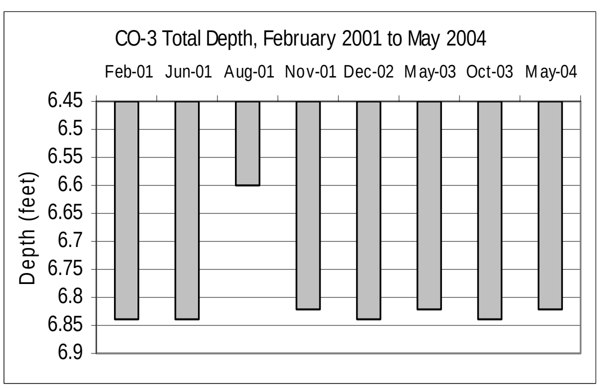


Table C-2: Total Depth of Cleanouts CO-1 to CO-4, February 2001 to May 2004

	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
2/6/01	7.82	--	7.1	--	6.84	--	7.84	--
6/6/01	7.82	0.00	7.24	-0.14	6.84	0.00	7.44	0.4
8/24/01	7.78	0.04	7.2	-0.1	6.6	0.24	7.41	0.43
11/6/01	7.79	0.03	7.19	-0.09	6.82	0.02	7.43	0.41
12/2/02	7.79	0.03	7.19	-0.09	6.84	0.00	7.42	0.42
5/7/03	7.87	-0.05	7.23	-0.13	6.82	0.02	7.46	0.38
10/27/03	7.81	0.01	7.21	-0.11	6.84	0	7.42	0.42
5/12/04	7.81	0.01	7.21	-0.11	6.82	0.02	7.43	0.41







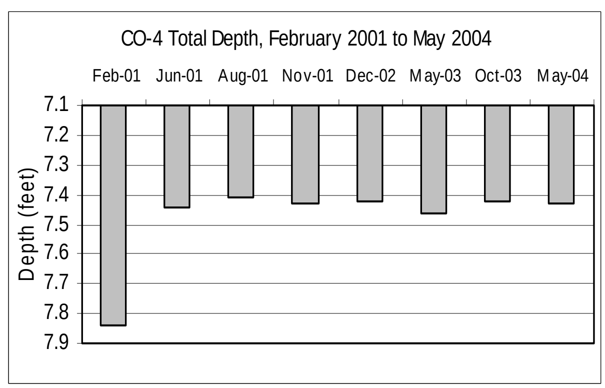
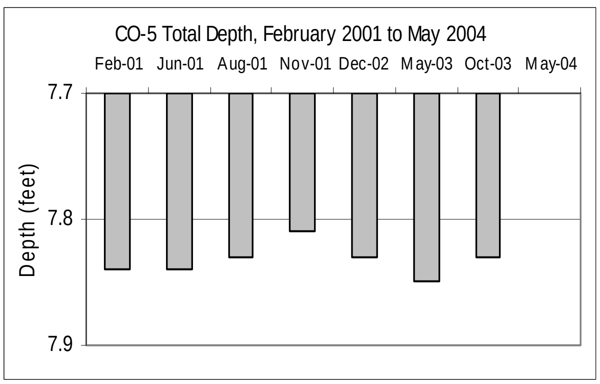
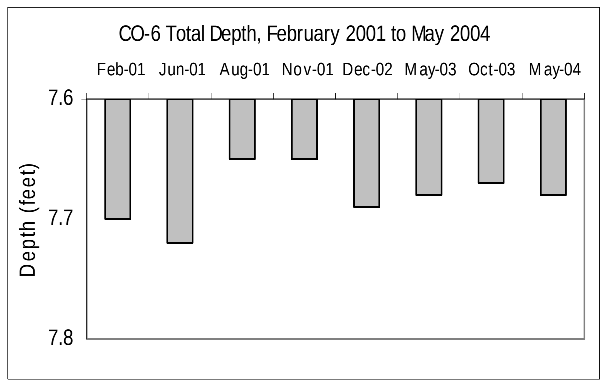


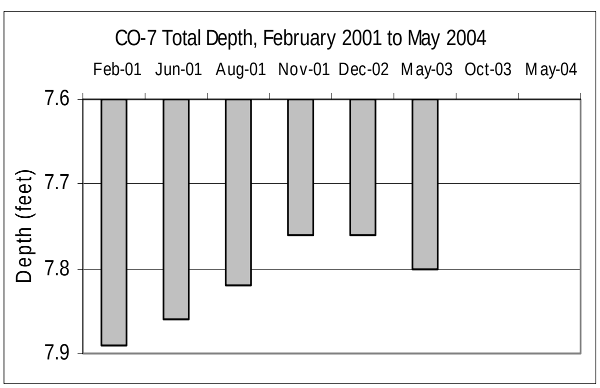
Table C-3: Total Depth of Cleanouts CO-5 to CO-8, February 2001 to May 2004.

	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
2/6/01	7.84	--	7.7	--	7.89	--	8.1	--
6/6/01	7.84	0.00	7.72	-0.02	7.86	0.03	8.12	-0.02
8/24/01	7.83	0.01	7.65	0.05	7.82	0.07	8.0	0.1
11/6/01	7.81	0.03	7.65	0.05	7.76	0.13	7.99	0.11
12/2/02	7.83	0.01	7.69	0.01	7.76	0.13	8.0	0.1
5/7/03	7.85	-0.01	7.68	0.02	7.8	0.09	7.97	0.13
10/27/03	7.83	0.01	7.67	0.03	--	--	7.98	0.12
5/12/04	--	--	7.68	0.02	--	--	8.02	0.08

-- - not measured.







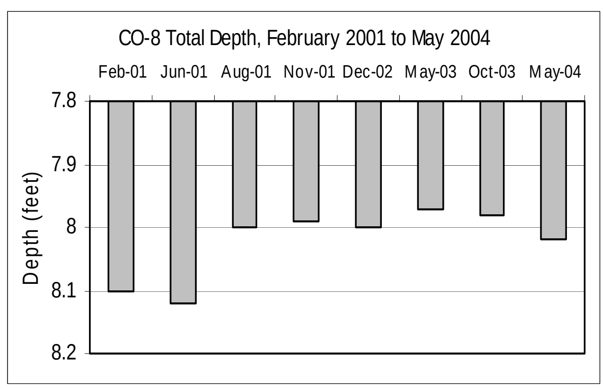
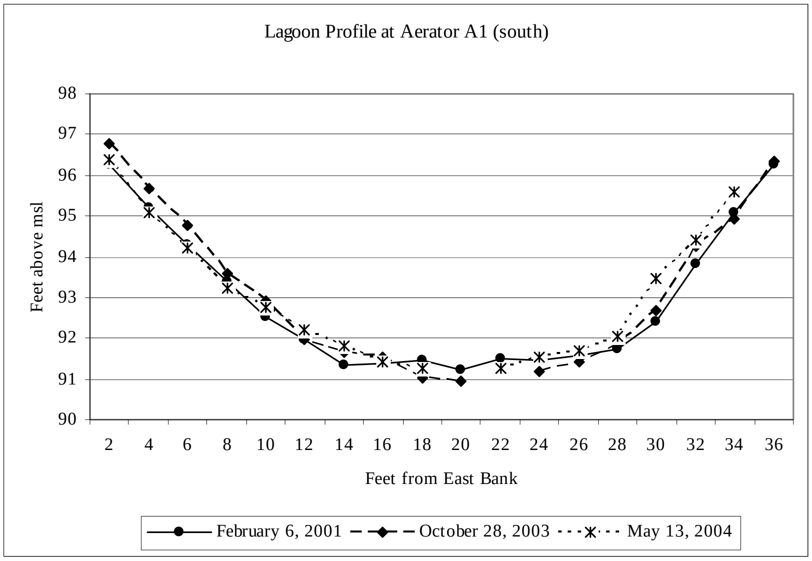


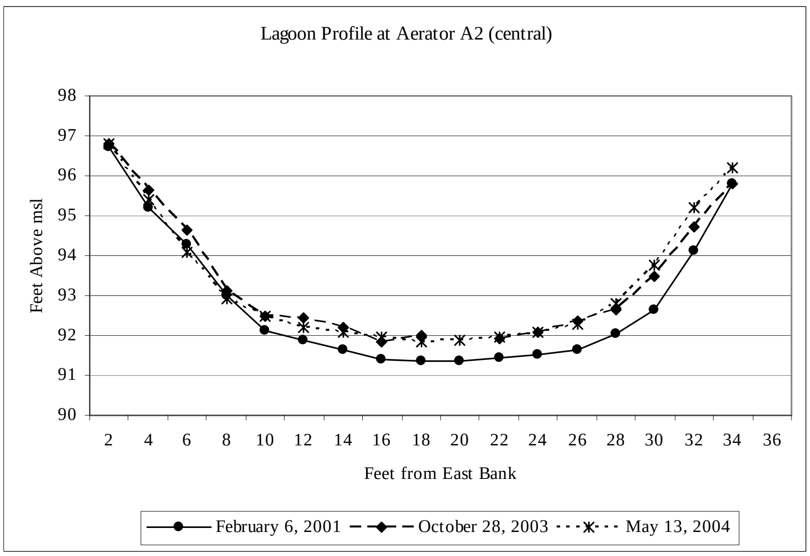
Table C-4: Treatment Lagoon Total Depth Measurements October 2003.

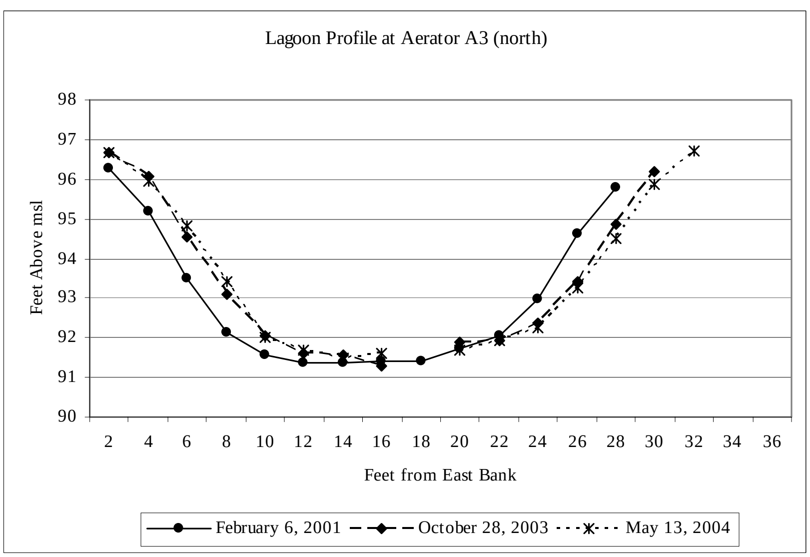
	Aerator A1 (south)			Aerator A2 (central)			Aerator A3 (north)		
Feet From East Bank	Depth Below Survey Elev.	Elev. Above Datum	Change from Original	Depth Below Survey Elev.	Elev. Above Datum	Change from Original	Depth Below Survey Elev.	Elev. Above Datum	Change from Original
2	2.21	96.79	0.53	2.2	96.8	0.06	2.33	96.67	0.41
4	3.32	95.68	0.46	3.35	95.65	0.45	2.93	96.07	0.87
6	4.22	94.78	0.48	4.36	94.64	0.34	4.44	94.56	1.08
8	5.41	93.59	0.19	5.88	93.12	0.14	5.9	93.1	0.96
10	6.09	92.91	0.37	6.5	92.5	0.38	6.96	92.04	0.49
12	7.02	91.98	0	6.56	92.44	0.56	7.38	91.62	0.24
14	7.35	91.65	0.31	6.81	92.19	0.53	7.44	91.56	0.18
16	7.45	91.55	0.17	7.15	91.85	0.45	7.7	91.3	-0.1
18	7.98	91.02	-0.44	6.99	92.01	0.63	--	--	--
20	8.07	90.93	-0.29	--	--	--	7.12	91.88	0.14
22	--	--	--	7.06	91.94	0.48	7.06	91.94	-0.1
24	7.83	91.17	-0.29	6.9	92.1	0.58	6.61	92.39	-0.59
26	7.58	91.42	-0.16	6.66	92.34	0.68	5.58	93.42	-1.22
28	7.16	91.84	0.1	6.38	92.62	0.58	4.13	94.87	-0.91
30	6.31	92.69	0.29	5.52	93.48	0.84	2.81	96.19	
32	4.76	94.24	0.42	4.27	94.73	0.61			
34	4.08	94.92	-0.16	3.19	95.81	0.01			
36	2.64	96.36	0.08						

Table C-5: Treatment Lagoon Total Depth Measurements May 2004.

	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	2.61	96.39	0.13	2.21	96.79	0.05	2.32	96.68	0.42
4	3.93	95.07	-0.15	3.61	95.39	0.19	3.05	95.95	0.75
6	4.77	94.23	-0.07	4.9	94.1	-0.2	4.18	94.82	1.34
8	5.75	93.25	-0.15	6.07	92.93	-0.05	5.57	93.43	1.29
10	6.25	92.75	0.21	6.51	92.49	0.37	7.0	92.0	0.45
12	6.78	92.22	0.24	6.8	92.2	0.32	7.33	91.67	0.29
14	7.19	91.81	0.47	6.93	92.07	0.41	7.52	91.48	0.1
16	7.6	91.4	0.02	7.05	91.95	0.55	7.4	91.6	0.2
18	7.73	91.27	-0.19	7.14	91.86	0.48	--	--	--
20	--	--	--	7.13	91.87	0.51	7.31	91.69	-0.05
22	7.74	91.26	-0.22	7.05	91.95	0.49	7.09	91.91	-0.13
24	7.45	91.55	0.09	6.9	92.1	0.58	6.73	92.27	-0.71
26	7.31	91.69	0.11	6.74	92.26	0.6	5.75	93.25	-1.39
28	6.96	92.04	0.3	6.22	92.78	0.74	4.48	94.52	-1.26
30	5.52	93.48	1.08	5.23	93.77	1.13	3.14	95.86	
32	4.6	94.4	0.58	3.79	95.21	1.09	2.3	96.7	
34	3.41	95.59	0.51	2.8	96.2	0.4			
36									


Lagoon Profile at Aerator A1 (south)
Feet above msl
Feet from East Bank
February 6, 2001
October 28, 2003
May 13, 2004


Lagoon Profile at Aerator A2 (central)
Feet Above msl
Feet from East Bank
February 6, 2001
October 28, 2003
May 13, 2004


Lagoon Profile at Aerator A3 (north)
Feet Above msl
Feet from East Bank
February 6, 2001
October 28, 2003
May 13, 2004

Appendix D. PCE and TCE Concentrations with Flow Rates from February 2001 to May 2004

Table D-1.

Sample		Sampling Month															
Station	COC	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	Oct-03	May-04
350	PCE (ppb)	1.0 U	0.5 U	0.5 U	0.5 U	NF	NF	0.5 U	NF	NF	0.5 U	0.5 U	0.5 U	1 U	1 U	0.5 U	0.5 U
(M St. SD)	TCE (ppb)	1.0 U	0.5 U	0.5 U	0.5 U	NF	NF	0.5 U	NF	NF	0.5 U	1.5	1.7	0.76 J	0.44 NJ	0.61 NJ	0.78 NJ
	Flow (gpm)	2.6	1.3	1.6	0.04	0	0	126	0	0	Trace	39	72	5	11	28	32
356	PCE (ppb)	1.0 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.50 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U	0.5 U	0.5 U
(Ustrm)	TCE (ppb)	1.0 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.38 J	0.5 U	0.5 U	0.5 U	0.5 U	2 U	1 U	0.5 U	0.5 U
	Flow (gpm)	FU	FU	FU	FU	FU	FU	FU	FU	FU	FU	FU	FU	FU	FU	FU	FU
357	PCE (ppb)	58.1	48.2	39.0	44.3	42.0	33.7	35.3	36.7	35	30.2	30.8	32.0	25	25	32	28
(CO-6)	TCE (ppb)	19.0	13.7	57.3	15.1	17.3	14.4	38.7	19.9	14.5	23.4	15.5	21.3	20	12	13	12
	Flow (gpm)	91	38	58	61	71	52	112	46	86	71	72	71	75	76	81	71
358	PCE (ppb)	48.4	37.3	35.2	39.5	38.1	26.8	28.2	32.7	28.4	24.0	24.9	26.9	22	20	22	20
(CO-4)	TCE (ppb)	36	34.3	36.8	37.2	39.0	34.4	36.5	36.3	31.3	30.3	31.5	25.9	36	27	34	34
	Flow (gpm)	81	94	77	88	88	69	59	80	75	78	101	120	16	55	76	79
359	PCE (ppb)	26.7	24.4	24.4	20.8	22.5	17.3	17.5	19.9	17.8	15.7	12.6	14.5	12	11	13	11
(CO-1)	TCE (ppb)	24.9	27.1	28.0	25.5	25.9	25.3	25.1	25.7	23.1	22.6	20.4	24.2	23	19	24	21
	Flow (gpm)	157	118	135	150	135	114	121	111	137	111	169	118	176	170	197	201
360	PCE (ppb)	24.7	19.6	23.2	19.5	18.8	14.8	16.8	18	15.7	15.2	11.3	12.5	13	10	12	10
(TPO)	TCE (ppb)	23.9	20.9	26.5	24.7	23.8	23.9	24.6	24.2	22.1	21.9	18.7	21.4	26	18	23	26
	Flow (gpm)	142	154	154	154	109	129	166	195	161	161	160	213	81	101	111	121
361	PCE (ppb)	1.1	0.48	0.87	1.1	0.44	0.39 J	0.5 U	0.4	0.88	0.52	0.56	0.68	1.3	3	1.7	3.9
(LE)	TCE (ppb)	1.0	0.90	1.1	1.5	0.92	0.62	0.5 U	0.6	1.3	0.83	0.94	1.1	2.8	5.4	3.5	11
	Flow (gpm)[a]	0 (137)	505	0 (540)	159 (524)	FU	FU	FU (178)	FU (128)	FU (372)	FU (337)	359 (1,465)	668 (846)	364	166	755	52
362	PCE (ppb)	NF	NF	NF	NF	NF	NF	0.5 U	NF	NF	NF	0.5 U	NF	NF	NF	NF	NF
(MSt.CBO)	TCE (ppb)	NF	NF	NF	NF	NF	NF	0.5 U	NF	NF	NF	0.5 U	NF	NF	NF	NF	NF
	Flow (gpm)	NF	NF	NF	NF	NF	NF	Trace	0	0	NF	Trace	NF	NF	NF	NF	NF
364	PCE (ppb)															0.30 J	0.5 U
Deschutes	TCE (ppb)															0.70 J	0.61 NJ
	Flow (gpm)															NM	NM

[a] - Flow for Station 361, the water flow was difficult or impossible to measure using the stream cross section technique. Numbers in parentheses are flow rate measurements at a pair of parallel culverts downstream of station 361 and considered to be representative of flow at station 361.

FU - Water flow rate was unmeasurable with the available instrument.

NF - No water flow at this station on this date.

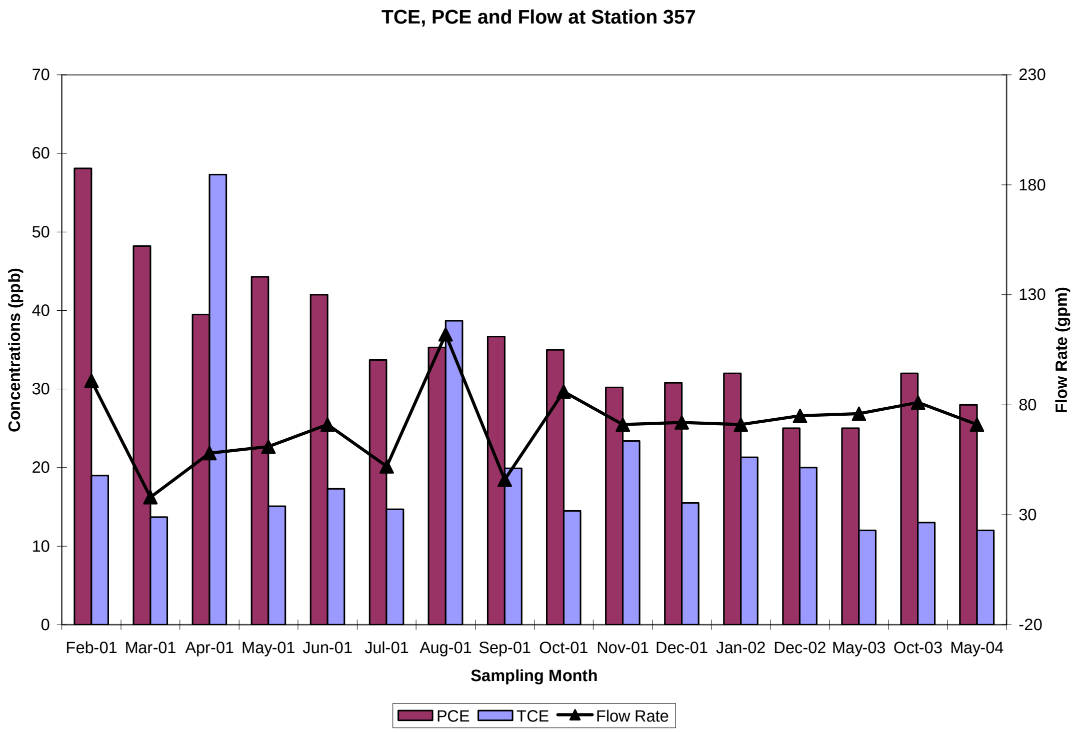
NM - Flow at this station was not measured.

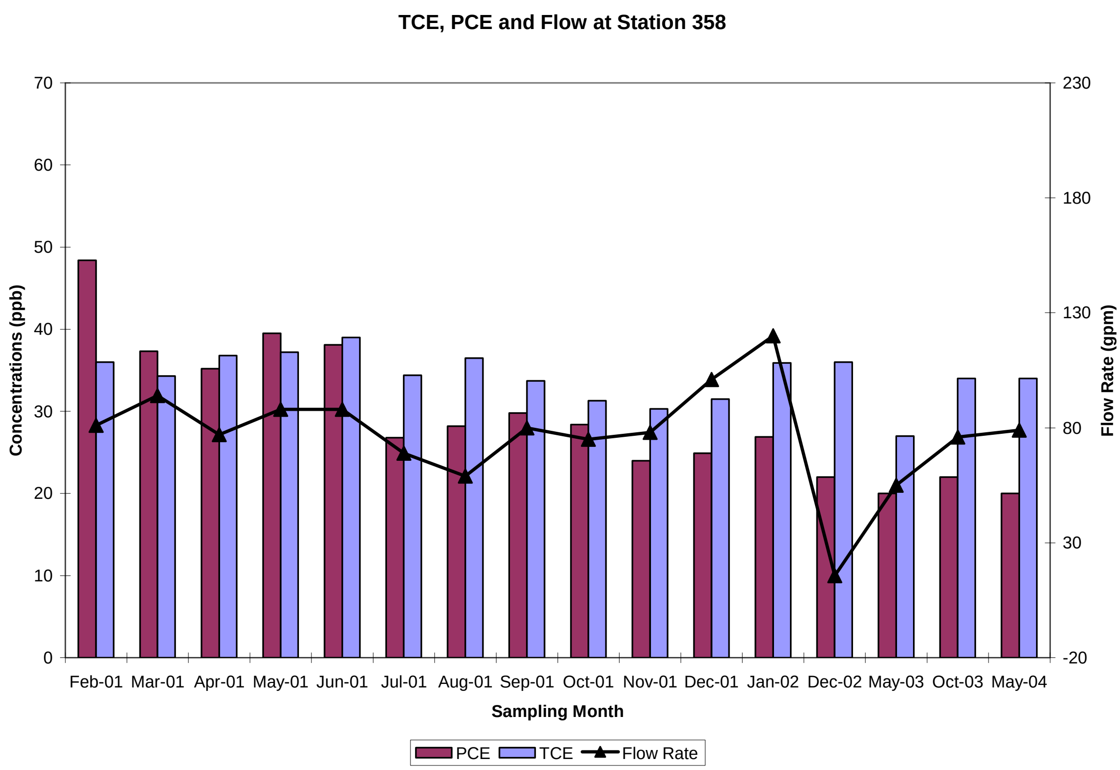
U - The analyte was not detected at or above the reported result.

J - The analyte was positively identified. The associated numerical result is an estimate.

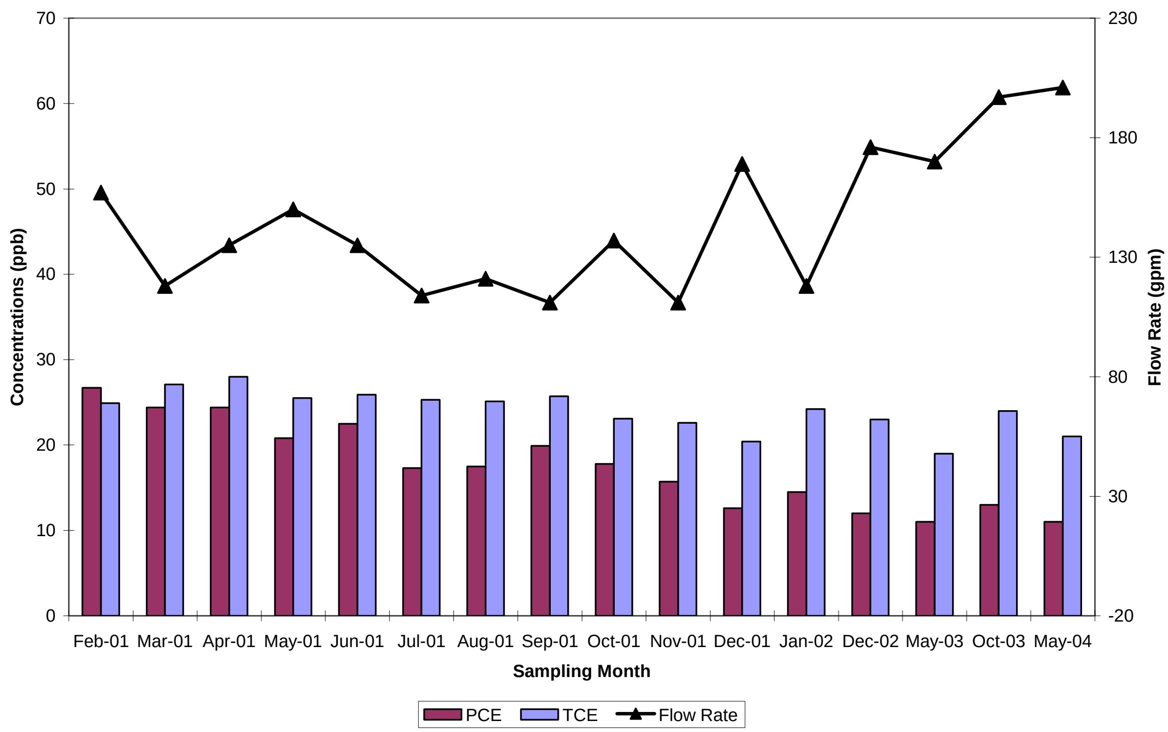
NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.

Figure D-1. PCE and TCE Concentrations with Flow Rates from February 2001 to May 2004.

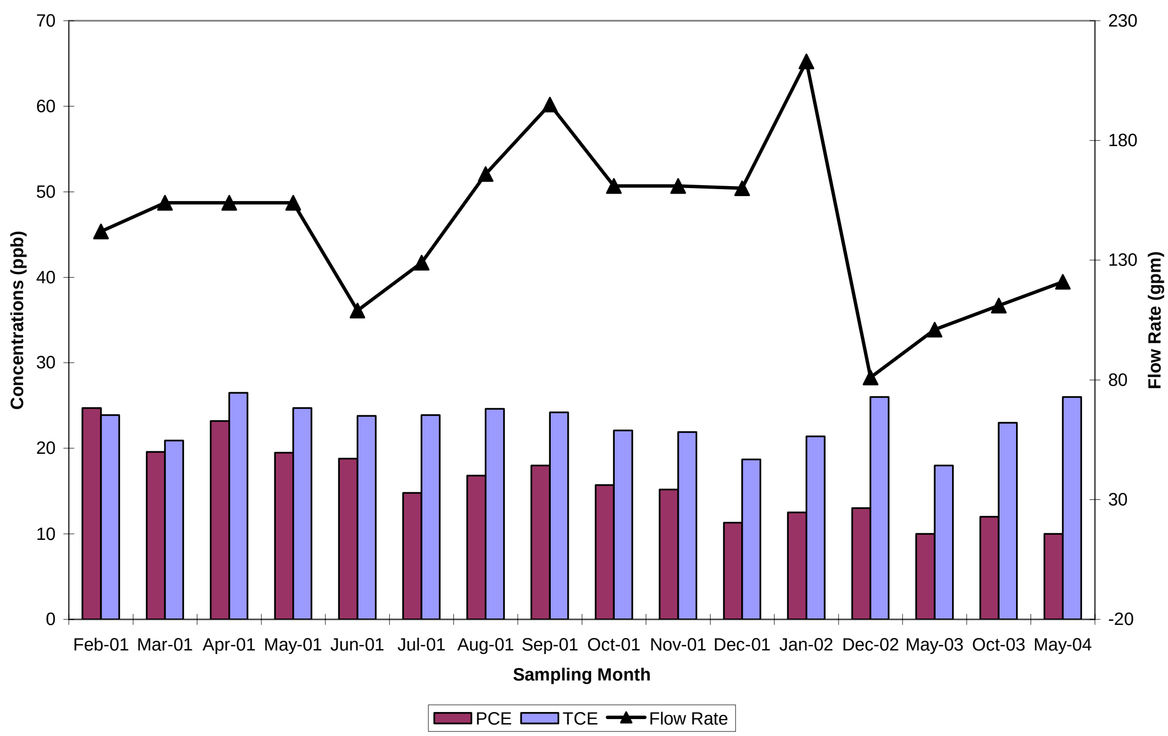




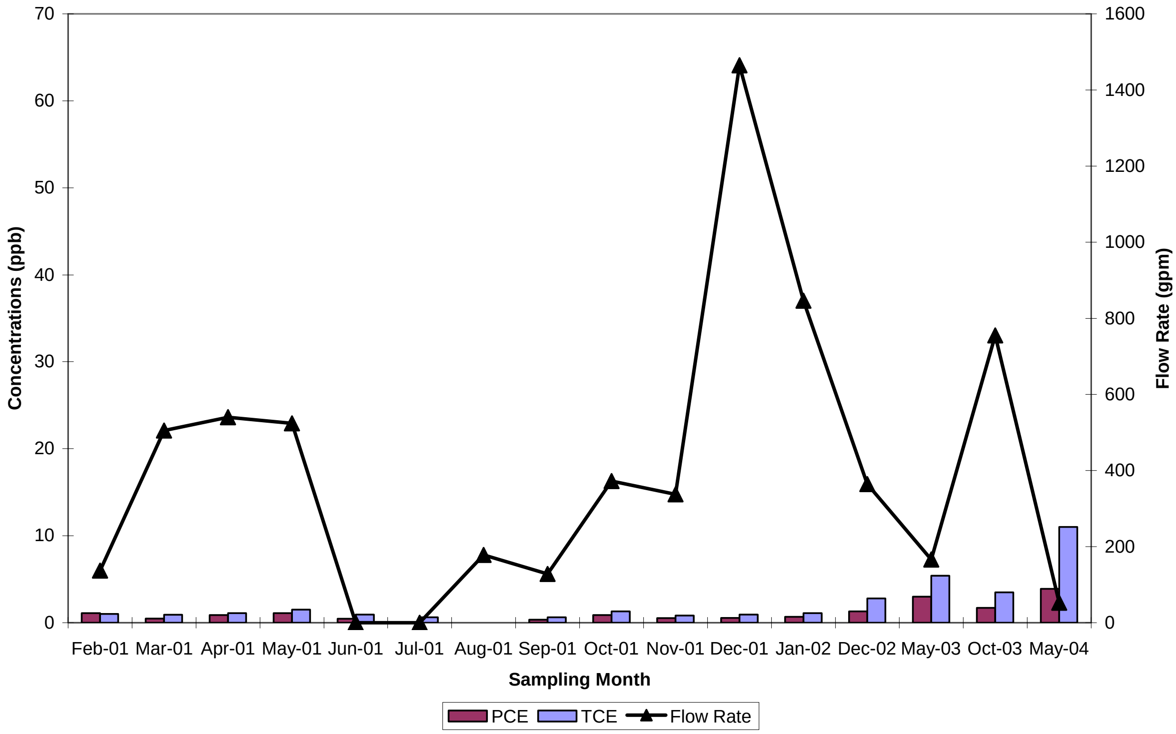
TCE, PCE, and Flow at Station 359



TCE, PCE and Flow at Station 360



TCE, PCE and Flow at Station 361



Appendix E. Lagoon Performance Calculations

Percent contaminant reduction by lagoon for October 28, 2003

Measured Parameters

Lagoon influent		
PCE	12	ug/L
TCE	23	ug/L
Flow	111	gpm
Lagoon effluent		
PCE	1.7	ug/L
TCE	3.5	ug/L
Flow	755	gpm

Overall Percent Reduction

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

PCE: 86%
TCE: 85%

Residence Time

Lagoon volume = 556.3 cyds

Convert to gallons: 112,350 gallons

Calculate residence time:

$$\frac{112{,}350 \text{ gal}}{755 \text{ gal/min}}$$

Residence time = 149 minutes or 2.5 hours

Percent contaminant reduction by lagoon for May 12, 2004

Measured Parameters

Lagoon influent		
PCE	10	ug/L
TCE	26	ug/L
Flow	121	gpm
Lagoon effluent		
PCE	3.9	ug/L
TCE	11	ug/L
Flow	52*	gpm

* Flow rate is too low

Overall Percent Reduction

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

PCE: 61%
TCE: 58%

Residence Time

Lagoon volume = 556.3 cyds

Convert to gallons: 112,350 gallons

Calculate residence time:

$$\frac{112{,}350 \text{ gal}}{52 \text{ gal/min}}$$

Residence time = 2160 minutes or 36 hours