



## Palermo Wellfield Superfund Site Subdrain System and Treatment Lagoon, Status Report, September 2005 and June 2006

### 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.

In December 2002, the Department of Ecology took over the lead from EPA for monitoring the subdrain system. The goal of the project 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.

The most recent monitoring was conducted in September 2005 and June 2006. Groundwater levels were three to five feet below the ground surface near the northern and central homes; this meets the remediation goals. As in the past, groundwater levels were less than three feet near the two southern homes.

Total depths measured in subdrain cleanouts CO-3 through CO-8 appear to have decreased, indicating that sediment may be accumulating in the central and southern parts of the trunk drain. If sediment has accumulated in the perforated pipe, the sediment should be removed so the subdrain system continues to operate within the parameters established during the validation monitoring. It does not appear that sediment deposition or scouring is occurring in the catch basins and lagoon.

PCE and TCE concentrations continue to be highest in water samples from the southern and central portion of the trunk drain, with average concentrations of 26 ppb for PCE and 25 ppb for TCE. PCE and TCE concentrations from stations 361 (lagoon effluent) and 364 (treated water discharge 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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For more information contact:

Publications Coordinator  
Environmental Assessment Program  
P.O. Box 47600  
Olympia, WA 98504-7600

E-mail: [jlet461@ecy.wa.gov](mailto:jlet461@ecy.wa.gov)

Phone: (360) 407-6764

Author: Pamela B. Marti, Hydrogeologist  
Washington State Department of Ecology  
Environmental Assessment Program  
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, including 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. Pooled 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 main perforated pipe or “trunk drain” is aligned through the backyards of the houses. Water collected by the perforated pipes is routed to an unperforated “tightline” pipe 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. PCE and TCE are removed from the water by surface aeration before the water is discharged to the Deschutes River via an existing water course. The volatilized PCE and TCE disperse to the air and degrade naturally.

The remediation goal 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 at least 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 period of February 2001 to April 2002, have been included as Appendix A. The Washington State Department of Ecology (Ecology) took over the lead for monitoring the subdrain system from EPA in December 2002 (Marti, 2003b).

Results since December 2002 indicate that groundwater elevations have been lowered three or more feet below the ground surface for the homes in the central and northern portion of the trunk drain. However, the performance criteria appear to not have been met for the two homes at the southern end of the trunk drain. Overall, total depths measured in the cleanouts, catch basins, and lagoon have not been significantly different from the original depths, with the exception of cleanout CO-4 which has had some sediment accumulation. PCE and TCE concentrations in the treated surface water samples have been below the remediation goals.

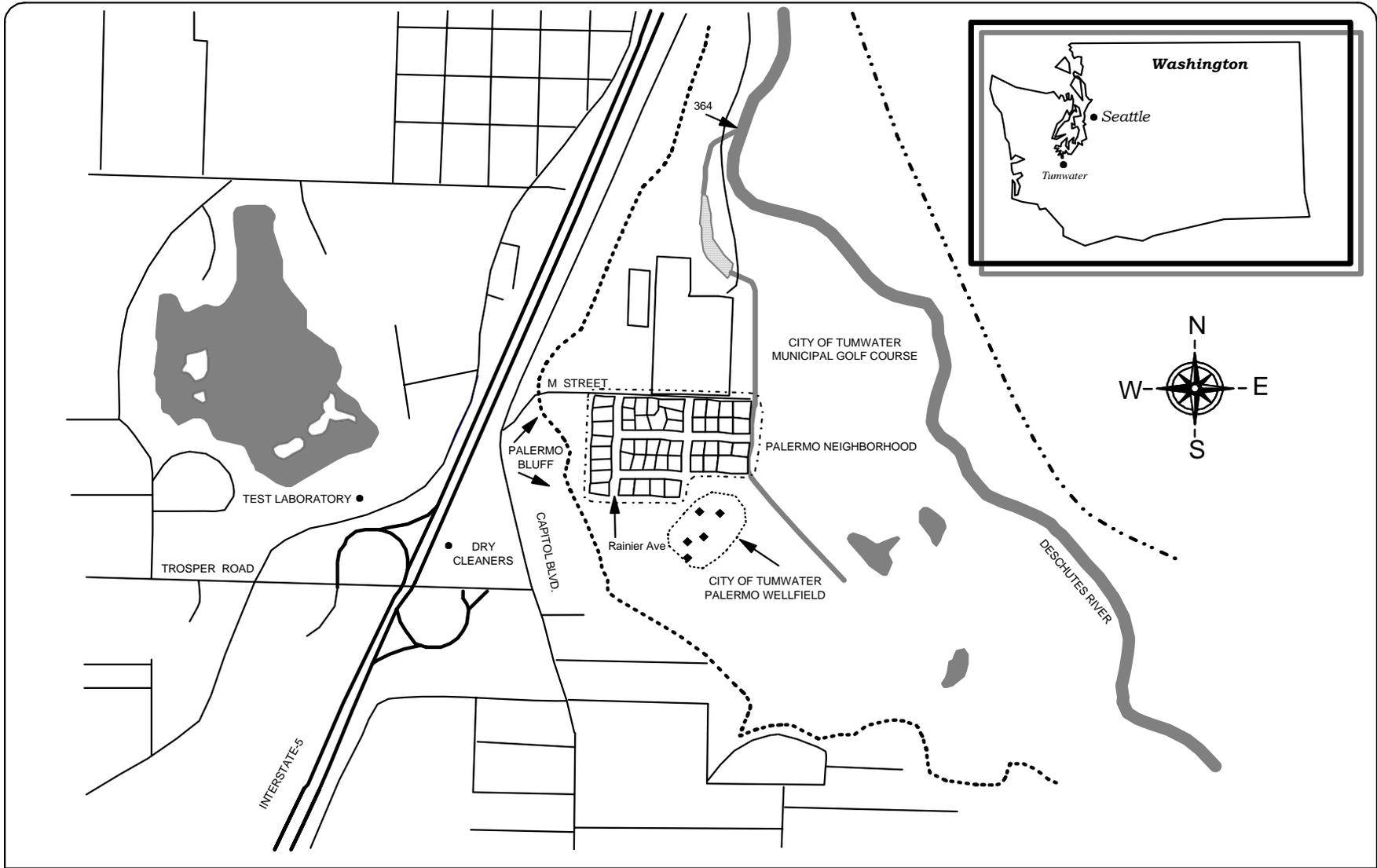


Figure 1

Palermo Wellfield and Neighborhood Site Location

## Methods

The goal of this project is to provide Ecology’s Toxics Cleanup Program with water level data and PCE/TCE concentrations on a semi-annual basis to determine if the subdrain system and treatment lagoon are operating within the remediation goals. Monitoring and sampling of the system (Figure 2) were conducted by Ecology’s Environmental Assessment Program on September 27-28, 2005 and June 5-6, 2006, and included the following activities:

- Measure depth-to-groundwater in 12 piezometers (PZ-704 through PZ-728) 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.
- Measure total depth in CO-1 through CO-8 and three catch basins (CB-1, CB-2, 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, 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 (357, 358, 359), three outfalls to the treatment lagoon (360, 350, 362), and three surface water stations (356, 361, 364) to assess the contaminant removal performance of the system and compliance with remediation goals. Station 364, where the lagoon watercourse discharges to the Deschutes River, was added to the monitoring program in October 2003 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 Figures 1 and 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 storm drain outfall
356	Watercourse flow upstream of the treatment lagoon
362	M Street terminus catch basin outfall (rarely flows)

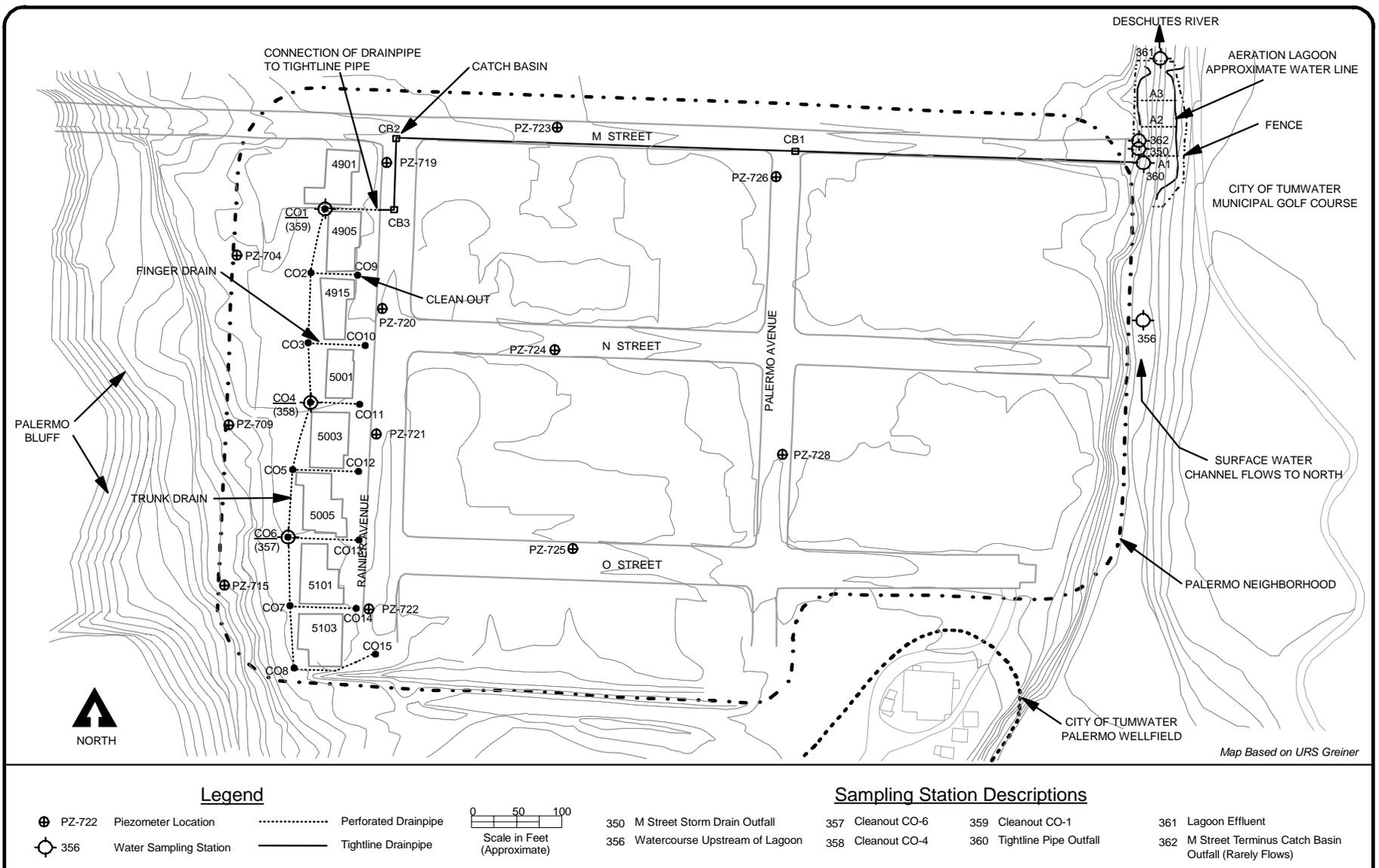


Figure 2

Palermo Wellfield Subdrain System and Treatment Lagoon Monitoring Stations

## Depth-to-Groundwater

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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 September, the static water level was not measured in piezometer PZ-709 because it could not be located in the thick undergrowth. In June, the static water level was not measured in piezometer PZ-715 because it could not be accessed.

## Total Depth

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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 0.01 foot, and were accurate to 0.03 feet. 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 100-foot measuring tape was secured between survey hubs 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

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In September and June, depth and velocity of water flow were measured from six of the nine stations within the drain system (357, 358, 359, 360, 361, and 350). Water velocity was measured with a Marsh-McBirney velocity meter. Depending on the station, 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 the standard area-velocity method of measuring streamflows as described in the Operation and Maintenance Plan (US EPA, 2000).

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 an accurate flow measurement difficult. 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

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Water samples were collected from eight of the nine sample stations (357, 358, 359, 360, 361, 350, 356, and 364). 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 from each station using a pre-cleaned glass beaker. 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. After sample collection and proper labeling, all samples were stored in an ice-filled cooler. Samples were transported to Ecology's Operation Center in Lacey. Samples were kept in the walk-in cooler until picked up by the courier to the Ecology/EPA Manchester Environmental Laboratory in Manchester. Chain-of-custody procedures were followed according to Manchester Environmental Laboratory protocol (Ecology, 2005).

## Laboratory

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Analytes, methods, and reporting limits for both field and laboratory parameters are listed in Table 2. All water samples were analyzed for volatile organics, including the target analytes of PCE, TCE, and dichloroethene (DCE).

Table 2: Field and Laboratory Measurements for September 2005 and June 2006 Samples.

Parameter	Method	Reference	Reporting Limit
<i>Field</i>			
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
<i>Laboratory</i>			
VOAs	EPA SW-846 Method 8260B	U.S. EPA 1996	0.5-5 ug/L

VOAs - volatile organics analysis

## Data Quality

Quality control samples collected in the field consisted of blind field duplicates obtained from the tightline pipe outfall (station 360). Field duplicates were collected by splitting the water collected in a pre-cleaned glass beaker between two sets of sample bottles. This provides a measure of the overall sampling and analytical precision. Precision estimates are influenced not only by the random error introduced by collection and measurement procedures, but are also influenced by the natural variability of the concentrations in the media being sampled.

The numeric comparison of duplicate results is expressed as the relative percent difference (RPD). RPD is calculated as the difference between sample results, divided by the mean and

expressed as a percent. The RPD in September was 0% for PCE and 4% for TCE. The RPD in June was 1% for PCE and 8% for TCE.

Overall, a review of the data quality control and quality assurance from laboratory case narratives indicates analytical performance was good. The reviews include descriptions of analytical methods, holding times, instrument calibration checks, blank results, surrogate recoveries, and laboratory control samples. No problems were reported that compromised the usefulness or validity of the sample results. No data were rejected, and all results were usable as qualified. Quality assurance case narratives and laboratory reporting sheets are available upon request.

All field measurements and analytical result data are available in electronic format from Ecology’s EIM data management system: [www.ecy.wa.gov/eim/index.htm](http://www.ecy.wa.gov/eim/index.htm)

## Results

### Depth-to-Groundwater

Depth-to-groundwater data measured in the piezometers in the Palermo neighborhood are listed in Table 3, along with 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, including data collected prior to the drain installation, are presented in Appendix B.

Table 3: Depth-to-Groundwater, Groundwater Elevations, and Groundwater Depth Below Ground Surface in Piezometers for September 2005 and June 2006 (measured in feet).

Piezometer	Inner PVC Elevation	Concrete/ Ground Elevation	September 2005			June 2006		
			Measured Depth to Groundwater <sup>1</sup>	Groundwater Elevation	Groundwater Depth Below Ground Surface	Measured Depth to Groundwater <sup>1</sup>	Groundwater Elevation	Groundwater Depth Below Ground Surface
PZ-704	110.61	108.43	6.17	104.44	-3.99	5.23	105.38	-3.05
PZ-709	114.27	112.01	--	--	--	3.41	110.86	<b>-1.15</b>
PZ-715	117.79	115.51	6.33	111.46	-4.05	--	--	--
PZ-719	107.13	107.37	3.54	103.59	-3.78	2.71	104.42	<b>-2.95</b>
PZ-720	107.75	108.22	4.80	102.95	-5.27	rej	--	--
PZ-721	108.32	108.57	4.15	104.17	-4.40	3.28	105.04	-3.53
PZ-722	108.82	109.21	0.21	108.61	<b>-0.60</b>	0.02	108.80	<b>-0.41</b>
PZ-723	106.34	106.80	3.82	102.52	-4.28	6.36	99.98	-6.82
PZ-724	106.45	106.88	3.18	103.27	-3.61	2.01	104.44	<b>-2.44</b>
PZ-725	108.22	108.58	4.28	103.94	-4.64	3.10	105.12	-3.46
PZ-726	105.39	105.61	4.89	100.50	-5.11	3.50	101.89	-3.72
PZ-728	105.27	105.84	5.00	100.27	-5.57	3.59	101.68	-4.16

<sup>1</sup> = Measured from top of PVC

-- = Not measured

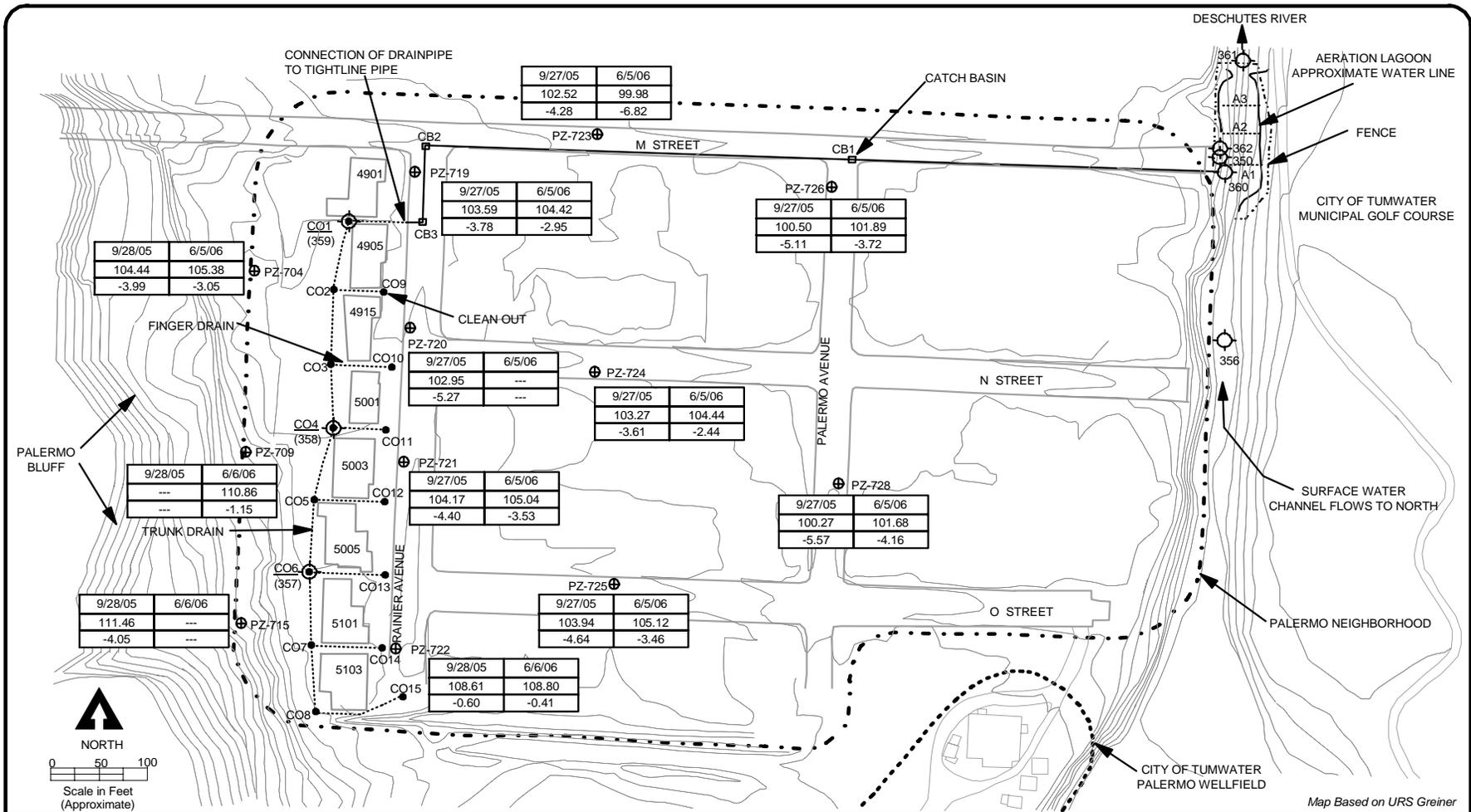
rej = Depth-to-groundwater measurement has been rejected because an accurate measurement could not be recorded.

**Bold** = Did not meet performance criteria of lowering the water table to 3 feet below the ground surface.

Depth-to-groundwater below the ground surface ranged from 0.60 to 5.57 feet in September and 0.41 to 6.82 feet in June, fluctuating less than two feet. As in the past, lowering the water table to three feet below the ground surface (bgs) was not achieved in PZ-722 in September; and PZ-709, PZ-719, PZ-722, and PZ-724 in June.

The remediation goal of reducing the groundwater elevation near the drain to three feet 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 September and June, 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.



**Legend**

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

10/27/03	5/12/04
108.65	108.75
-0.56	-0.46

Groundwater Elevation  
Groundwater Depth Below (-)  
Ground Surface

**Sampling Station Descriptions**

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

**Figure 3**

**Palermo Wellfield Subdrain System and Treatment Lagoon Groundwater Depth**

## Total Depth

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In September 2005 and June 2006, total depth measurements were collected in the cleanouts, catch basins, and along three cross-sections through the treatment lagoon to determine 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 September 2005 and June 2006 (feet).

Location	February 2001	September 2005		June 2006	
	Original Depth	Total Depth	Change from Original	Total Depth	Change from Original
CB-1	7.78	7.79	-0.01	7.77	0.01
CB-2	8.78	8.80	-0.02	8.77	0.01
CB-3	8.81	8.91	-0.1	8.93	-0.12
CO-1	7.82	7.81	0.01	7.81	0.01
CO-2	7.1	7.21	-0.11	7.17	-0.07
CO-3	6.84	6.81	0.03	6.14	0.7
CO-4	7.84	7.38	0.46	6.71	1.13
CO-5	7.84	7.71	0.13	7.04	0.8
CO-6	7.7	7.64	0.06	7.12	0.58
CO-7	7.89	7.02	0.87	7.07	0.82
CO-8	8.1	6.92	1.18	6.88	1.22

As shown in Table 4, the average range of depths in the catch basins and cleanouts in September and June were 6.47 to 8.92 feet. In the three catch basins, the total depth measurements were not significantly different (less than  $\pm 0.12$  feet) from the original depths measured in February 2001. Total depths varied more in the eight cleanouts between September and June. In September, five of the cleanouts were less than  $\pm 0.13$  feet from the original depth. In June, only two cleanouts (CO-1 and CO-2) were near the original depths.

Since construction, cleanout CO-4 has consistently been about +0.4 feet less than the original depth, suggesting sediment accumulation. In June, the measured total depth in CO-4 was +1.13 feet less than the original depth. Each cleanout provides a sump below the pipe invert. The sump depth in cleanout CO-4 is 0.8 feet. The June measurement indicates that sediment may have accumulated above the sump capacity. Total depths measured in CO-7 and CO-8 since September 2004 also indicate that sediment has accumulated in these cleanouts. The average changes in depths for this monitoring period were +0.85 feet in CO-7, and +1.2 feet in CO-8, which are similar to measurements from the previous year. The sump depths in these cleanouts, located at the southern end of the perforated drain pipe, are approximately 0.9 feet.

Total depths also appear to have decreased in cleanouts CO-3 (+0.7), CO-5 (+0.8), and CO-6 (+0.58) in June 2006, nearing their sump capacities which are approximately 0.9 feet.

Lagoon depths were similar to the original depth measurements (February 2001) with a margin of error of  $\pm 0.5$  feet (Appendix C). Many factors affect 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 occasional cobbles on the lagoon bottom. Vegetation growth along the lagoon banks also makes it difficult to collect measurements near the bank edges. Overall, it appears that no measurable sediment deposition or scouring has occurred.

## Water Flow Rate

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Water flow depth and velocity data were used to calculate flow rates at each sample station. Calculated flow rates are shown in Table 5. Flow rates measured since February 2001 are presented in Appendix D.

Table 5: Flow Rates (gpm) for September 2005 and June 2006.

Sample Station	Location	September 2005	June 2006
Flow in Subdrain System Through Discharge to Deschutes River			
357	Cleanout CO-6	72	39
358	Cleanout CO-4	73	69
359	Cleanout CO-1	164	166
360	Tightline pipe outfall	97	107
361	Lagoon effluent	347	234
364	Lagoon watercourse discharge to Deschutes River	--	--
Inflows to Treatment Lagoon Other Than the Subdrain System			
350	M Street storm drain outfall	--	19
356	Watercourse flow upstream of	--	--
362	M Street catch basin outfall	No Flow	No Flow

-- Not measured

In September 2005, flow rates in the trunk drain at stations 357, 358, and 359 were 72 gallons per minute (gpm), 73 gpm, and 164 gpm, respectively. In June 2006, flow rates at these stations were 39 gpm, 69 gpm, and 166 gpm. 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 102 gpm, as compared to an average flow of 165 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. storm drain outfall) were too low to measure in September and were 19 gpm in June. As mentioned previously, the flow rate was not measurable at station 356 (upstream of lagoon), and station 362 had no flow. Flow rates were not measured at station 364.

In September, the flow rate at station 361 (lagoon outfall) was 347 gpm, and in June it was 234 gpm. During both monitoring events, the lagoon outfall was covered by a thick grass mat. Riprap at the lagoon outfall also made it difficult to collect accurate flow depth and velocity measurements.

## Volatile Organics

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Analytical results for PCE, TCE, and DCE are summarized in Table 6. PCE and TCE results for September and June are shown in Figure 4. Figures 5 and 6 show PCE and TCE concentrations in 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.

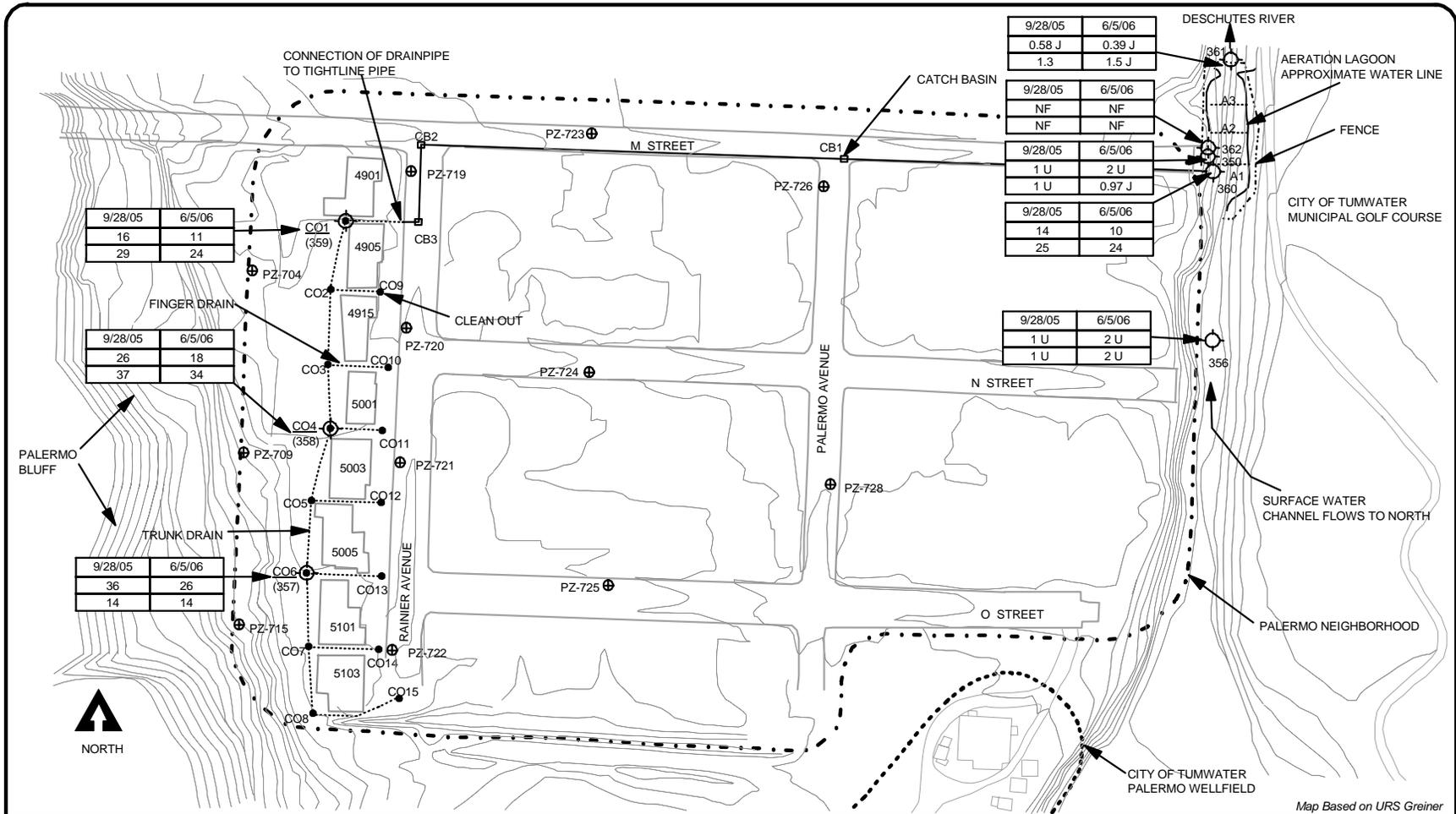
Table 6: Summary of Target Analyte Results (ug/L) for September 2005 and June 2006.

Sample Station	September 2005			June 2006		
	PCE	TCE	DCE	PCE	TCE	DCE
Flow in Subdrain System – South to North						
357	36	14	1 U	26	14	1 U
358	26	37	1 U	18	34	1 U
359	16	29	1 U	11	24	1 U
360	14	25	1 U	10	24	1 U
361	0.58 J	1.3	1 U	0.39 J	1.5 J	1 U
Inflows to Treatment Lagoon Other Than the Subdrain System						
350	1 U	1 U	1 U	2 U	0.97 J	1 U
356	1 U	1 U	1 U	2 U	2 U	1 U
362	NF	NF	NF	NF	NF	NF
Lagoon watercourse discharge to Deschutes River						
364	1 U	1 U	1 U	2 U	0.98 J	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.

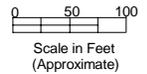
NF: No Flow.



**Legend**

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

9/28/05	6/5/06
36	26
14	14



**Sampling Station Descriptions**

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

**Figure 4**

**Palermo Wellfield Subdrain System and Treatment Lagoon PCE/TCE Concentrations**

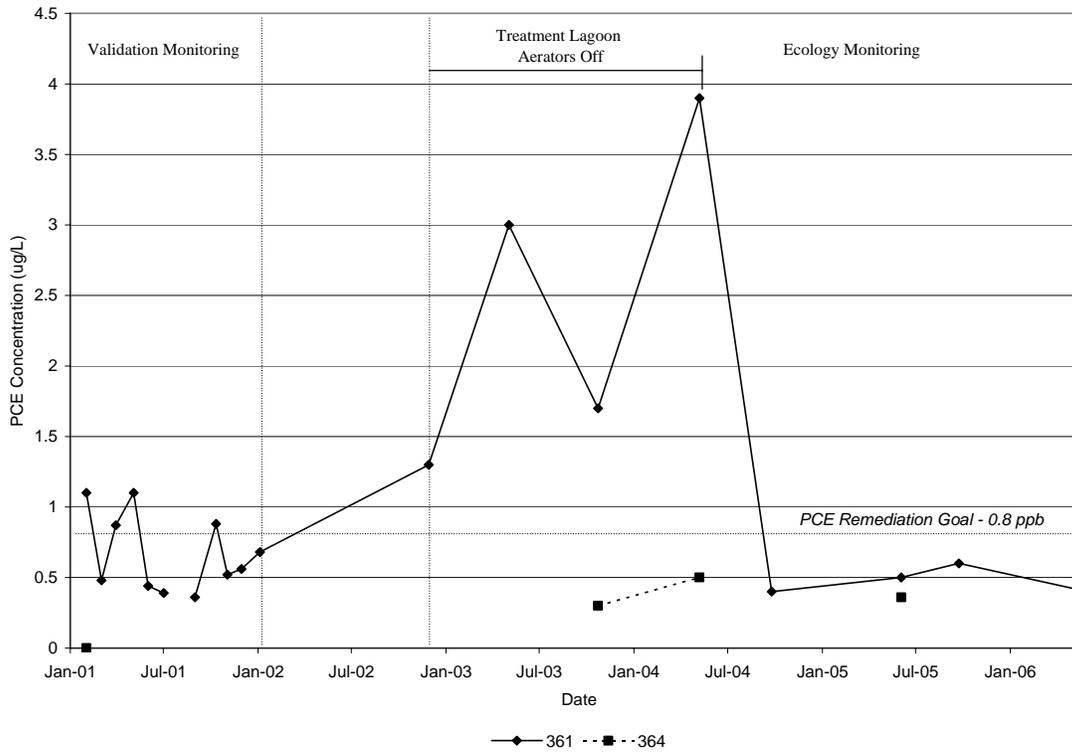
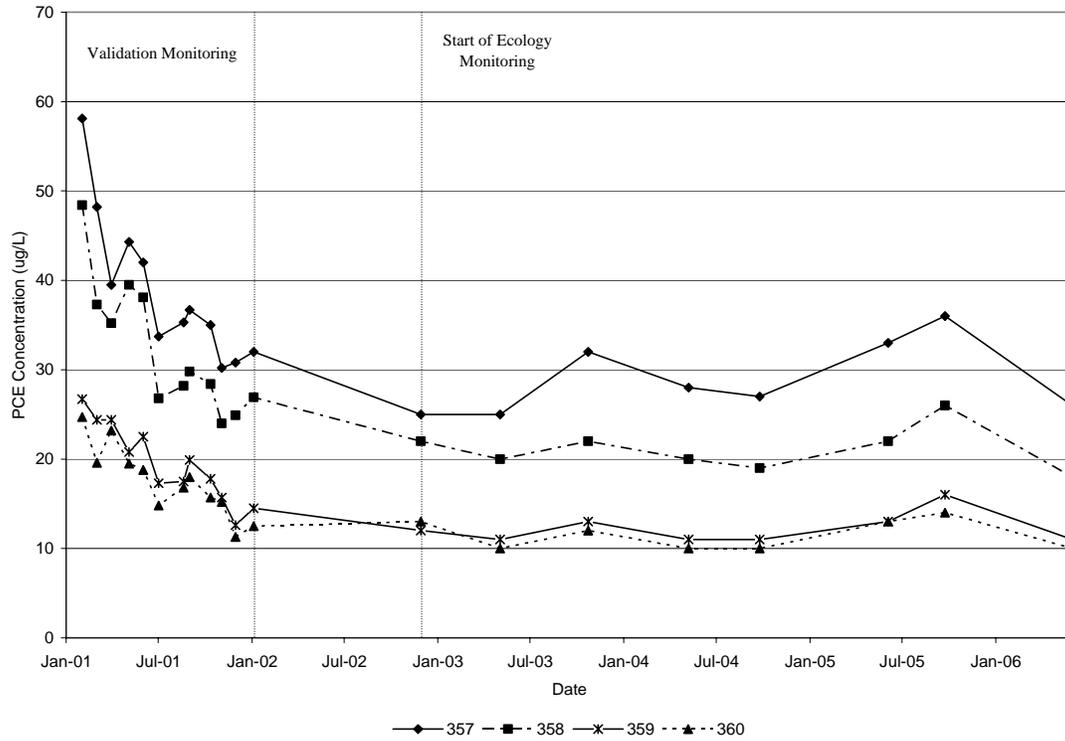


Figure 5: PCE Concentrations (ug/L) for Palermo Subdrain System and Treatment Lagoon, February 2001 through June 2006.

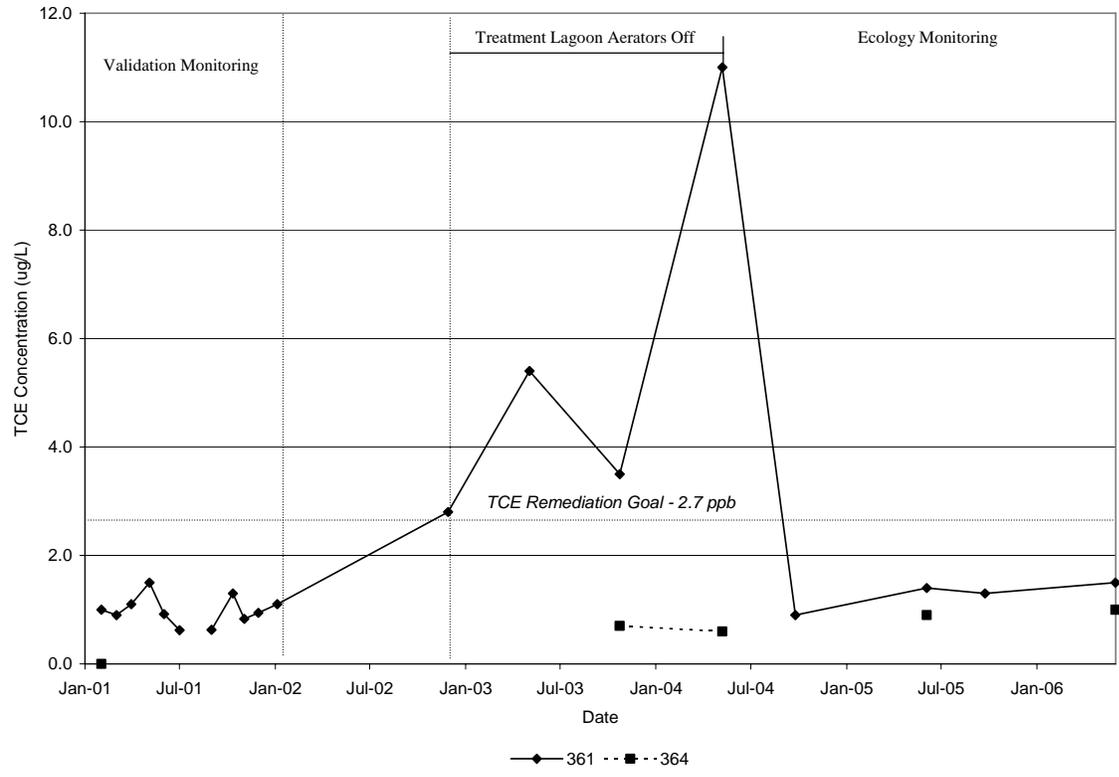
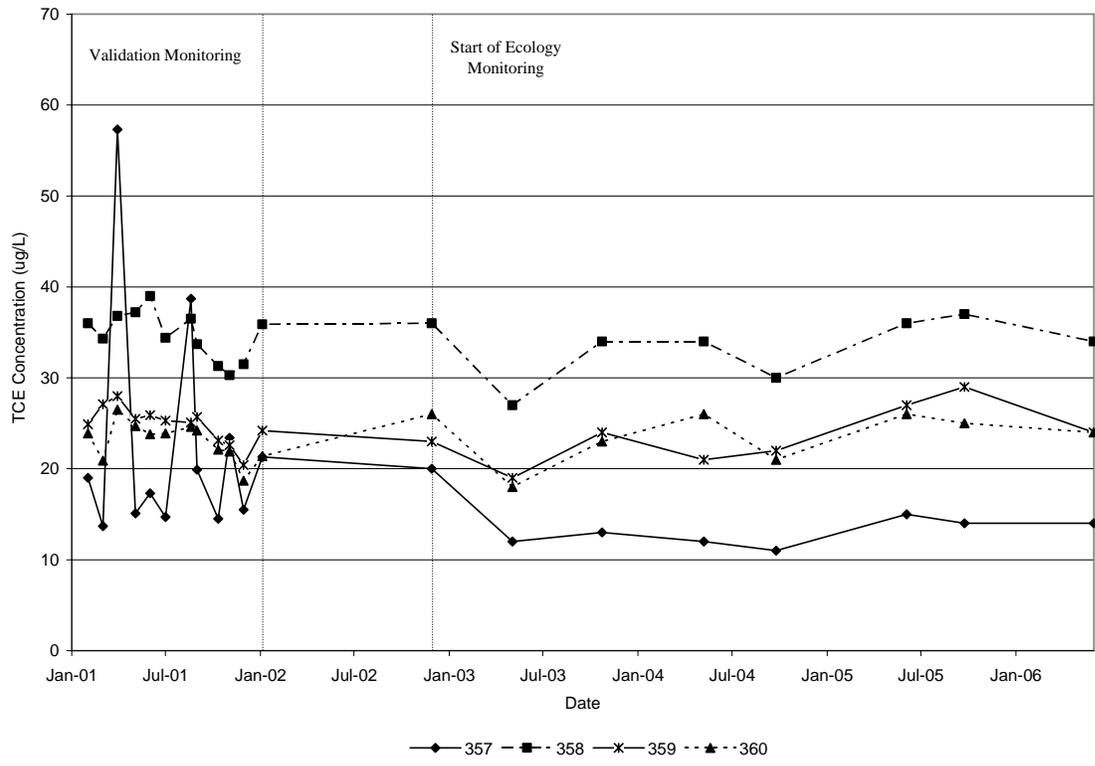


Figure 6: TCE Concentrations (ug/L) for Palermo Subdrain System and Treatment Lagoon, February 2001 through June 2006.

PCE and TCE concentrations continue to be highest in groundwater samples from stations 357 and 358 which are located in the mapped area of the shallow groundwater plume. Average PCE concentrations for September 2005 and June 2006 were 31 ug/L at station 357 and 22 ug/L at station 358. TCE concentrations varied more during the same two monitoring periods, with average concentrations of 14 ug/L at station 357, increasing to an average concentration of 36 ug/L at station 358. TCE concentrations continue to be higher in samples from 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 14 ug/L, while average TCE concentrations decreased to 27 ug/L.

PCE and TCE concentrations at stations 359 (CO-1) and 360 (tightline pipe outfall) were similar, with average concentrations for both stations during this 2005-06 monitoring period of 13 ug/L for PCE and 26 ug/L for TCE. The similar concentration implies that little contaminant loss or degradation occurs within the tightline pipe, and that there is no substantial loss or gain of water between the connection with the drain pipe and the outfall.

Two of the three remaining stations which contribute flow to the treatment lagoon were sampled during September 2005 and June 2006. PCE and TCE were not detected at station 356 which is upstream of the lagoon. TCE was detected at station 350 (M St. storm drain outfall) at concentrations below the practical quantitation limit of 2 ug/L in June. Station 362 (M St. terminus catch basin outfall) was not sampled because there was no flowing water.

PCE and TCE concentrations in samples from station 361 (lagoon effluent) during September 2005 and June 2006 averaged 0.48 ug/L for PCE and 1.4 ug/L for TCE. These concentrations at the lagoon outfall are below the remediation goals of 0.8 ug/L (PCE) and 2.7 ug/L (TCE) for water discharging to the Deschutes River. It should be noted that samples from station 361 (lagoon effluent) collected between December 2002 and May 2004, as shown in Figures 5 and 6, were collected while the treatment lagoon aerators were turned off. PCE and TCE results for this period are higher than during the 2001-2002 validation monitoring.

Station 364 was added to the monitoring network in 2003 to allow a true comparison to the remediation goals. This station is located where the treated water discharges to the Deschutes River, approximately 2,000 feet downstream from the lagoon. TCE was detected here in June 2006 at an estimated concentration of 0.98 ug/L, which is below the remediation goal.

Based on the lagoon effluent concentrations for PCE and TCE, the lagoon achieved a contaminant reduction of about 95% in September 2005 and June 2006, as shown in Appendix E. The calculated residence time in the lagoon was about five hours in September and eight hours in June.

## Conclusions

- Reduction of groundwater elevations to three feet below the ground surface was 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 less than three feet below the ground surface in piezometers PZ-709 and PZ-722 during this 2005-06 monitoring period. When comparing data from these piezometers to data collected during the 2001-2002 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 most of the cleanouts appear to have decreased from the original depths measured in February 2001. Sediment has accumulated in cleanouts CO-4, CO-7, and CO-8 and is near or exceeding the sump capacity for each cleanout. Total depths measured in CO-3, CO-5, and CO-6 in June 2006 indicate that sediment may also be accumulating in these cleanouts which are located at the central part of the perforated pipe. It appears that sediment deposition is occurring in the central and southern parts of the subdrain system.
- Total depths measured in the catch basins and lagoon were not significantly different from the original depths measured in February 2001.
- PCE and TCE were detected in samples collected from station 364, where the treatment lagoon watercourse enters the Deschutes River (approximately 2,000 feet downstream from the lagoon). PCE and TCE concentrations were below 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.
- Reduction in contaminant concentrations after the treatment lagoon was about 95% in September 2005 and June 2006.

## Recommendations

- Because of sediment accumulation in the perforated pipe, total depths of cleanouts CO-3, CO-4, CO-5, CO-6, CO-7 and CO-8 should continue to be closely monitored.
- Sediment that has accumulated in the perforated pipe between cleanouts CO-3 and CO-8 should be removed so that the subdrain system continues to operate within the parameters established during the 2001 validation monitoring.

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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	<u>Predicted</u> : 3 feet of drawdown 35 feet away. <u>Actual</u> : 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 through June 2006.

Date	PZ-704			PZ-709			PZ-715		
	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	NM	--	--	112.07	0.15	-0.07
9/29/04	104.54	-0.39	-0.20	109.87	--	-0.71	111.74	-0.33	-0.18
6/8/05	NM	--	--	NM	--	--	112.08	0.34	0.01
9/27/05	104.44	--	-0.10	NM	--	--	111.46	-0.62	-0.28
6/5/06	105.38	0.94	--	110.86	--	--	NM	--	--
Average:	105.07	0.65	--	110.89	0.28	--	112.50	0.38	--
Maximum:	107.49	--	--	111.83	--	--	114.79	--	--
3' BGS Elev.	105.43	--	--	109.01	--	--	112.51	--	--

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
9/29/04	103.75	-0.53	-0.44	103.00	-0.26	-0.19	104.28	-0.39	-0.44
6/8/05	104.23	0.48	-0.05	--	--	--	104.59	0.31	-0.08
9/27/05	103.59	-0.64	-0.16	102.95	--	-0.05	104.17	-0.42	-0.11
6/5/06	104.42	0.83	0.19	--	--	--	105.04	0.87	0.45
Average:	103.99	0.41	--	104.02	0.25	--	105.18	0.30	--
Maximum:	105.02	--	--	106.60	--	--	107.44	--	--
3' BGS Elev.	104.37	--	--	105.22	--	--	105.57	--	--

Table B-1: Continued.

Date	PZ-722			PZ-723			PZ-724		
	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
9/29/04	108.48	-0.27	-0.17	99.72	-3.66	-3.76	103.37	-0.84	-1.16
6/8/05	108.76	0.28	0.01	99.71	-0.01	-3.67	104.17	0.80	-0.04
9/27/05	108.61	-0.15	0.13	102.52	2.81	2.80	103.27	-0.90	-0.10
6/5/06	108.80	0.19	0.04	99.98	-2.54	0.27	104.44	1.17	0.27
Average:	108.91	0.37	--	102.64	0.95	--	103.90	0.60	--
Maximum:	110.10	--	--	105.24	--	--	105.97	--	--
3' BGS Elev.	106.21	--	--	103.8	--	--	103.88	--	--

Table B-1: Continued.

Date	PZ-725			PZ-726			PZ-728		
	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	NM	--	--	101.62	-0.50	0.92	101.60	-0.43	1.08
9/29/04	104.23	--	-1.08	100.70	-0.92	-1.42	100.66	-0.94	-1.37
6/8/05	104.89	0.66	--	100.53	-0.17	-1.09	101.42	0.76	-0.18
9/27/05	103.94	-0.95	-0.29	100.50	-0.03	-0.20	100.27	-1.15	-0.39
6/5/06	105.12	1.18	--	101.89	1.39	1.36	101.68	1.41	0.26
Average:	104.53	1.07	--	100.85	0.92	--	100.57	1.23	--
Maximum:	106.36	--	--	103.33	--	--	103.04	--	--
3' BGS Elev.	105.58	--	--	102.61	--	--	102.84	--	--

<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.

Notes for Table B-1:

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.

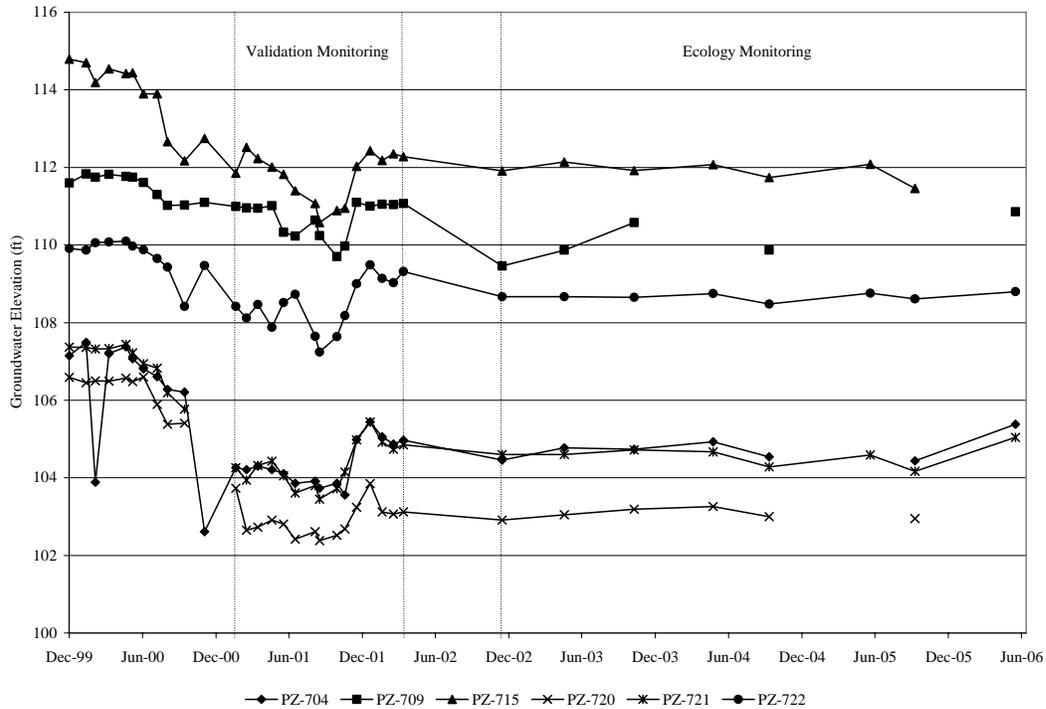


Figure B-1. Groundwater Elevations for Piezometers Influenced by the Subdrain System, December 1999 through June 2006

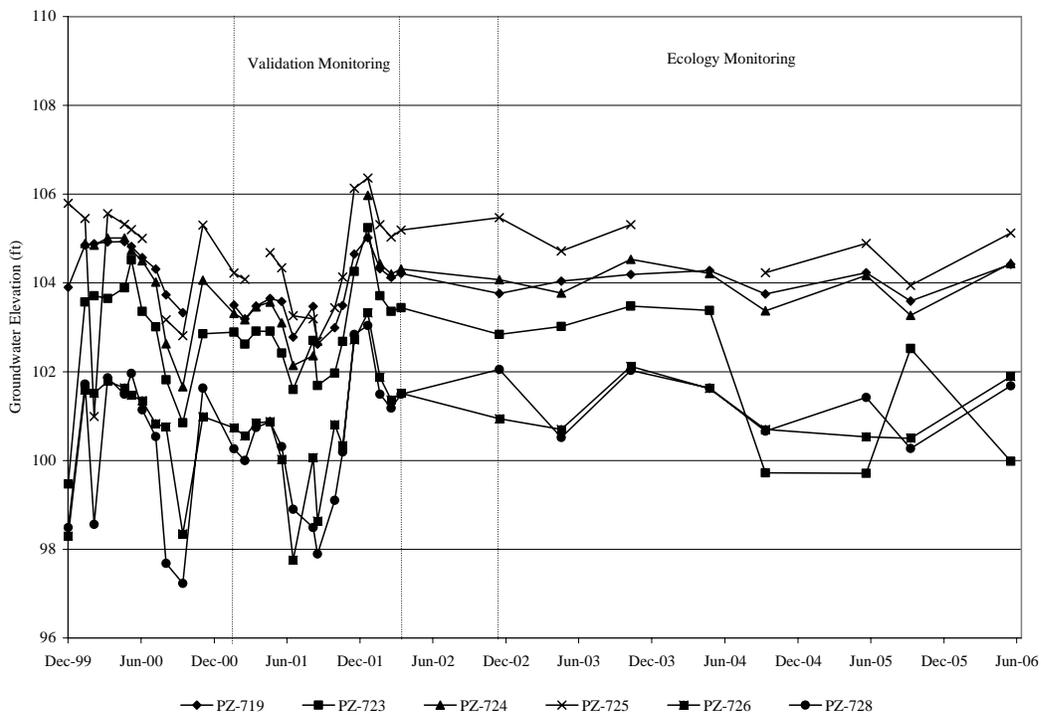


Figure B-2. Groundwater Elevations for Piezometers Beyond the Influence of the Subdrain System, December 1999 through June 2006

Table B-2: Depth-to-Water and Water Elevations (feet) in Cleanouts from December 2002 through June 2006.

Cleanout	North Rim Elevation	Depth to Water	Water Elevation	Depth to Water	Water Elevation
		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
		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
		September 2004		June 2005	
CO-1	108.39	6.37	102.02	6.30	102.09
CO-2	108.04	5.95	102.09	5.90	102.14
CO-3	107.96	5.72	102.24	5.72	102.24
CO-4	108.73	6.22	102.51	6.19	102.54
CO-5	109.32	6.68	102.64	--	--
CO-6	109.78	6.59	103.19	6.58	103.20
CO-7	110.73	6.71	104.02	6.69	104.04
CO-8	110.96	--	--	6.76	104.20
		September 2005		June 2006	
CO-1	108.39	6.36	102.03	6.22	102.17
CO-2	108.04	5.94	102.10	5.75	102.29
CO-3	107.96	5.75	102.21	5.64	102.32
CO-4	108.73	6.21	102.52	6.23	102.50
CO-5	109.32	6.69	102.63	6.68	102.64
CO-6	109.78	6.60	103.18	6.62	103.16
CO-7	110.73	6.71	104.02	6.73	104.00
CO-8	110.96	6.77	104.19	6.76	104.20

-- not measured

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

Table C-1: Total Depth (feet) of Catch Basins, February 2001 through June 2006.

Date	CB-1		CB-2		CB-3	
	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
9/29/04	7.82	-0.04	8.82	-0.04	8.91	-0.1
6/8/05	7.78	0.0	8.79	-0.01	8.92	-0.11
9/28/05	7.79	-0.01	8.80	-0.02	8.91	-0.1
6/5/06	7.77	0.01	8.77	0.01	8.93	-0.12

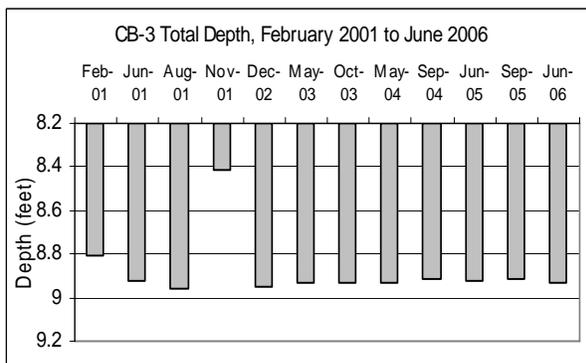
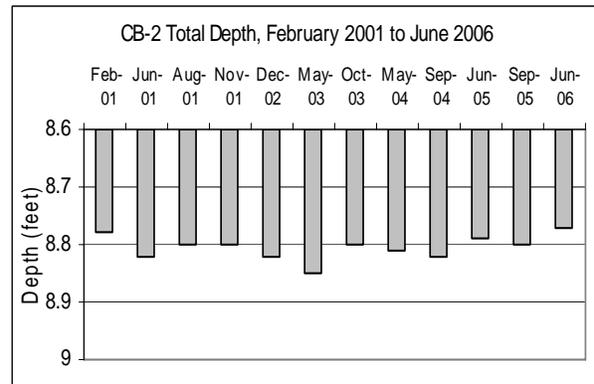
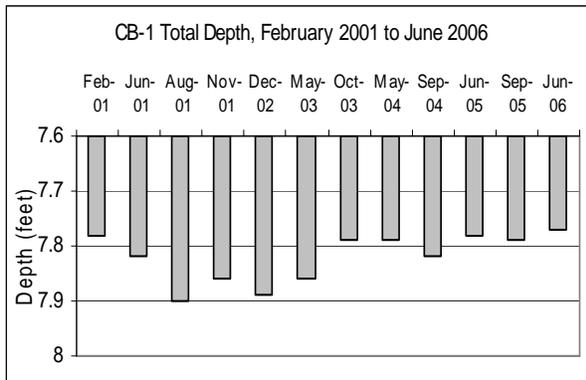


Figure C-1: Total Depth of Catch Basins, February 2001 through June 2006

Table C-2: Total Depth (feet) of Cleanouts CO-1 to CO-4, February 2001 through June 2006

Date	CO-1		CO-2		CO-3		CO-4	
	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
9/29/04	7.79	0.03	7.20	-0.1	6.81	0.03	7.39	0.45
6/8/05	7.79	0.03	7.19	-0.09	6.83	0.01	7.37	0.47
9/28/05	7.81	0.01	7.21	-0.11	6.81	0.03	7.38	0.46
6/5/06	7.81	0.01	7.17	-0.07	6.14	0.7	6.71	1.13

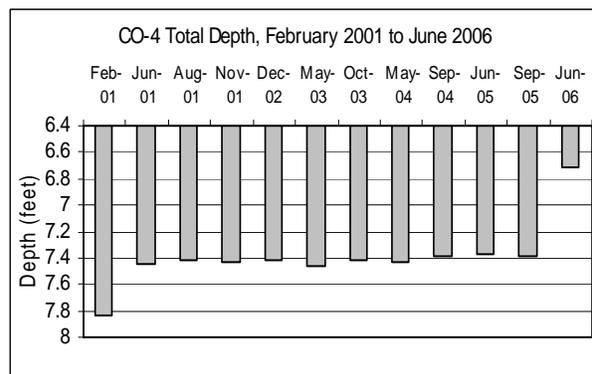
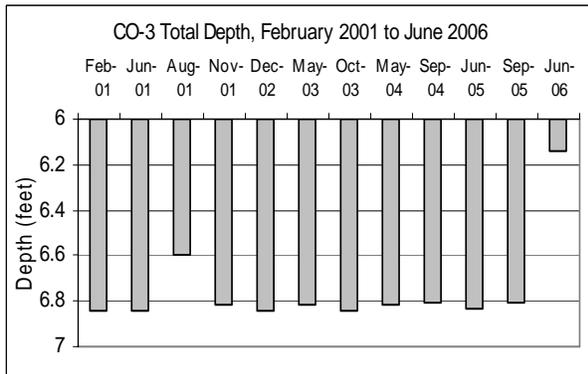
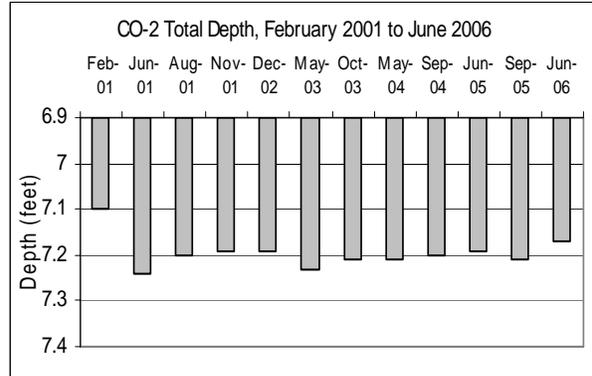
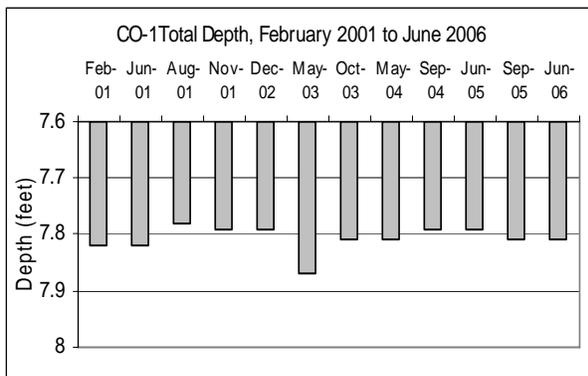


Figure C-2: Total Depth of Cleanouts CO-1 to CO-4, February 2001 through June 2006

Table C-3: Total Depth (feet) of Cleanouts CO-5 to CO-8, February 2001 through June 2006.

Date	CO-5		CO-6		CO-7		CO-8	
	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
9/29/04	7.81	0.03	7.67	0.03	7.22	0.67	6.85	1.25
6/8/05	--	--	7.61	0.09	7.04	0.85	6.86	1.24
9/28/05	7.71	0.13	7.64	0.06	7.02	0.87	6.92	1.18
6/5/06	7.04	0.8	7.12	0.58	7.07	0.82	6.88	1.22

-- not measured

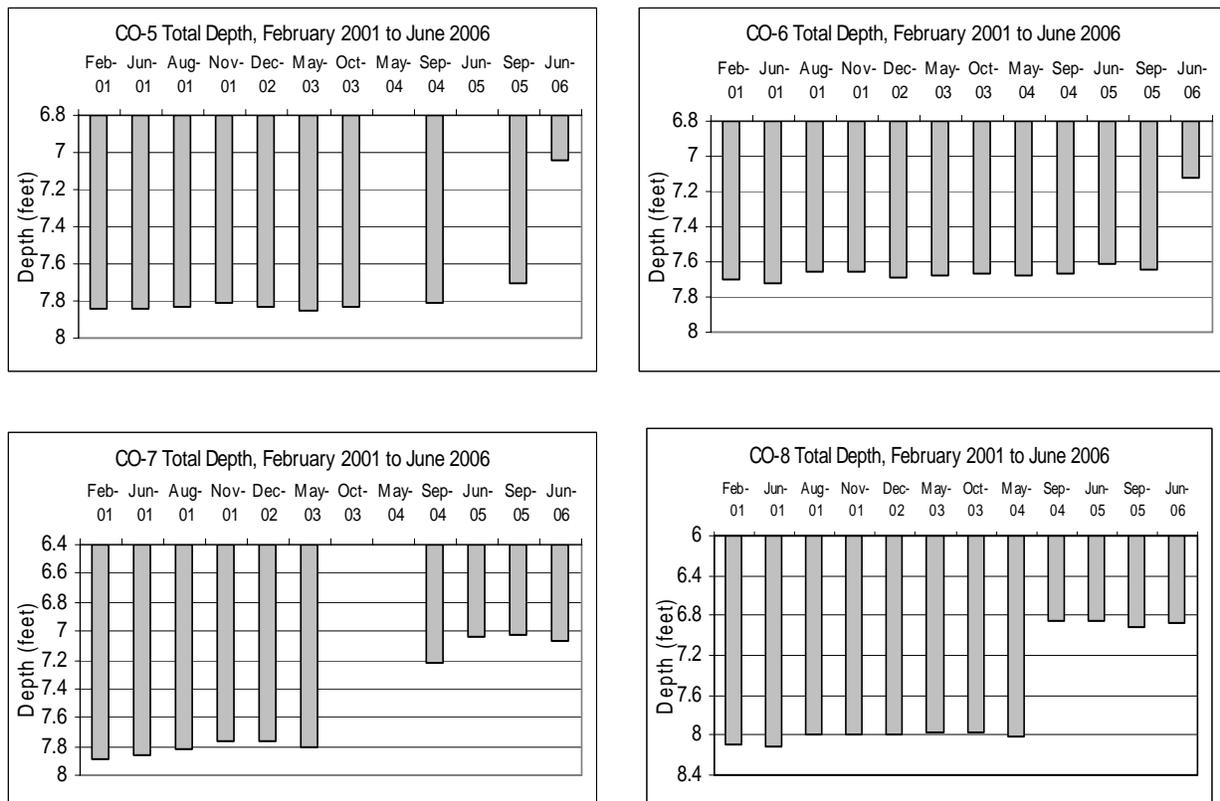


Figure C-3: Total Depth of Cleanouts CO-5 to CO-8, February 2001 through June 2006

Table C-4: Treatment Lagoon Total Depth (feet), September 2005.

Feet From East Bank	Aerator A1 (south)			Aerator A2 (central)			Aerator A3 (north)		
	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	2.45	96.55	0.29	2.35	96.65	-0.09	3.3	95.70	-0.56
4	3.12	95.88	0.66	4.04	94.96	-0.24	4.49	94.51	-0.69
6	4.47	94.53	0.23	5.43	93.57	-0.73	5.75	93.25	-0.23
8	5.38	93.62	0.22	6.50	92.50	-0.48	7.22	91.78	-0.36
10	6.08	92.92	0.38	6.78	92.22	0.1	7.56	91.44	-0.11
12	6.6	92.40	0.42	7.1	91.90	0.02	7.77	91.23	-0.15
14	6.85	92.15	0.81	7.38	91.62	-0.04	7.8	91.20	-0.18
16	7.29	91.71	0.33	7.65	91.35	-0.05	--	--	--
18	7.51	91.49	0.03	7.75	91.25	-0.13	7.73	91.27	-0.15
20	--	--	--	7.72	91.28	-0.08	7.42	91.58	-0.16
22	7.28	91.72	0.24	7.79	91.21	-0.25	6.9	92.10	0.06
24	6.76	92.24	0.78	7.42	91.58	0.06	6.2	92.80	-0.18
26	7.05	91.95	0.37	7.21	91.79	0.13	4.99	94.01	-0.63
28	6.11	92.89	1.15	6.7	92.30	0.26	3.45	95.55	-0.23
30	5.0	94.00	1.6	5.84	93.16	0.52			
32	3.95	95.05	1.23	4.5	94.50	0.38			
34	3.04	95.96	0.88	3.05	95.95	0.15			
36									

-- not measured

Table C-5: Treatment Lagoon Total Depth (feet), June 2006.

Feet From East Bank	Aerator A1 (south)			Aerator A2 (central)			Aerator A3 (north)		
	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	2.66	96.34	0.08	2.75	96.25	-0.49	2.91	96.09	-0.17
4	2.81	96.19	0.97	3.99	95.01	-0.19	3.96	95.04	-0.16
6	4.17	94.83	0.53	4.79	94.21	-0.09	5.34	93.66	0.18
8	5.05	93.95	0.55	6.16	92.84	-0.14	6.79	92.21	0.07
10	6.27	92.73	0.19	6.52	92.48	0.36	7.42	91.58	0.03
12	6.42	92.58	0.6	6.78	92.22	0.34	7.45	91.55	0.17
14	6.84	92.16	0.82	6.95	92.05	0.39	7.55	91.45	0.07
16	7.27	91.73	0.35	7.19	91.81	0.41	7.65	91.35	-0.05
18	7.46	91.54	0.08	7.24	91.76	0.38	7.44	91.56	0.14
20	7.5	91.50	0.28	7.23	91.77	0.41	7.32	91.68	-0.06
22	7.43	91.57	0.09	7.24	91.76	0.3	6.9	92.10	0.06
24	7.56	91.44	-0.02	7.01	91.99	0.47	6.0	93.00	0.02
26	7.49	91.51	-0.07	6.95	92.05	0.39	4.92	94.08	-0.56
28	7.25	91.75	0.01	6.46	92.54	0.5	3.49	95.51	-0.27
30	5.82	93.18	0.78	5.58	93.42	0.78	2.66	96.34	
32	4.86	94.14	0.32	4.2	94.80	0.68			
34	4.25	94.75	-0.33	2.97	96.03	0.23			
36	3.19	95.81	-0.47						

-- not measured

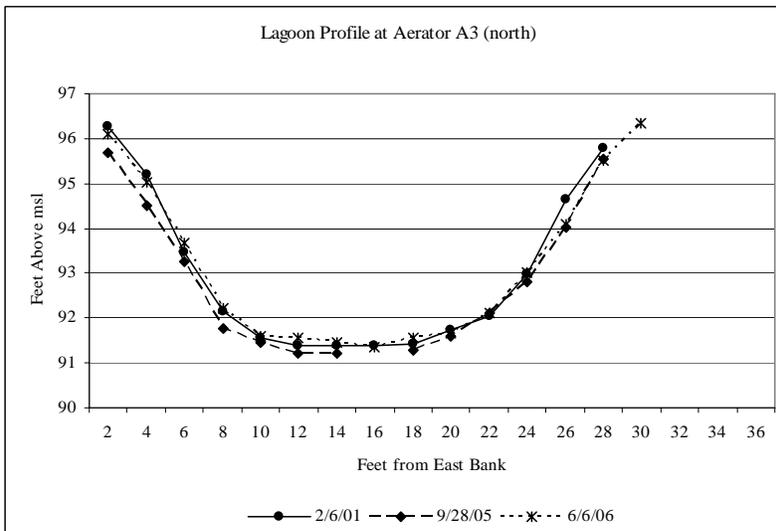
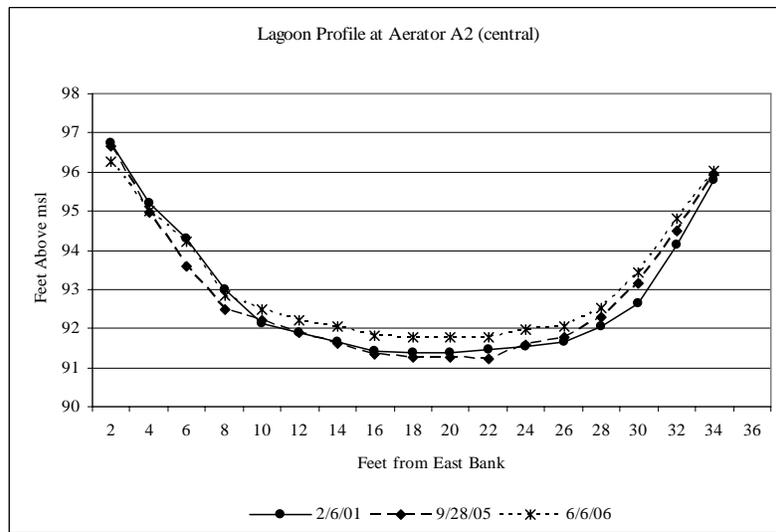
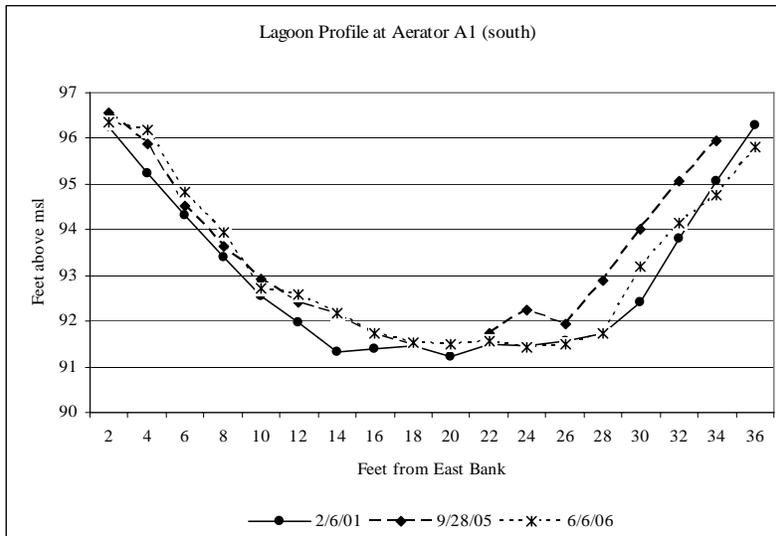


Figure C-4: Treatment Lagoon Total Depth for September 2005 and June 2006, Compared to Original Depth of February 2001.

**Appendix D. PCE and TCE Concentrations with Flow Rates  
from February 2001 through June 2006**

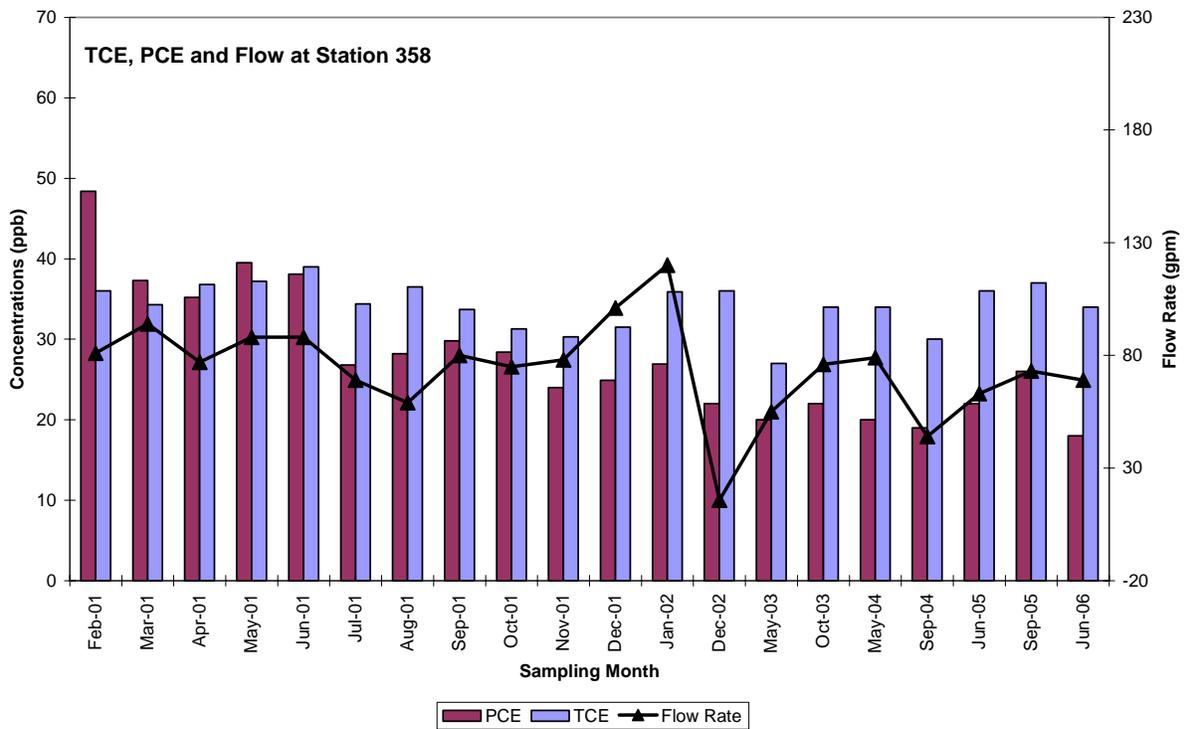
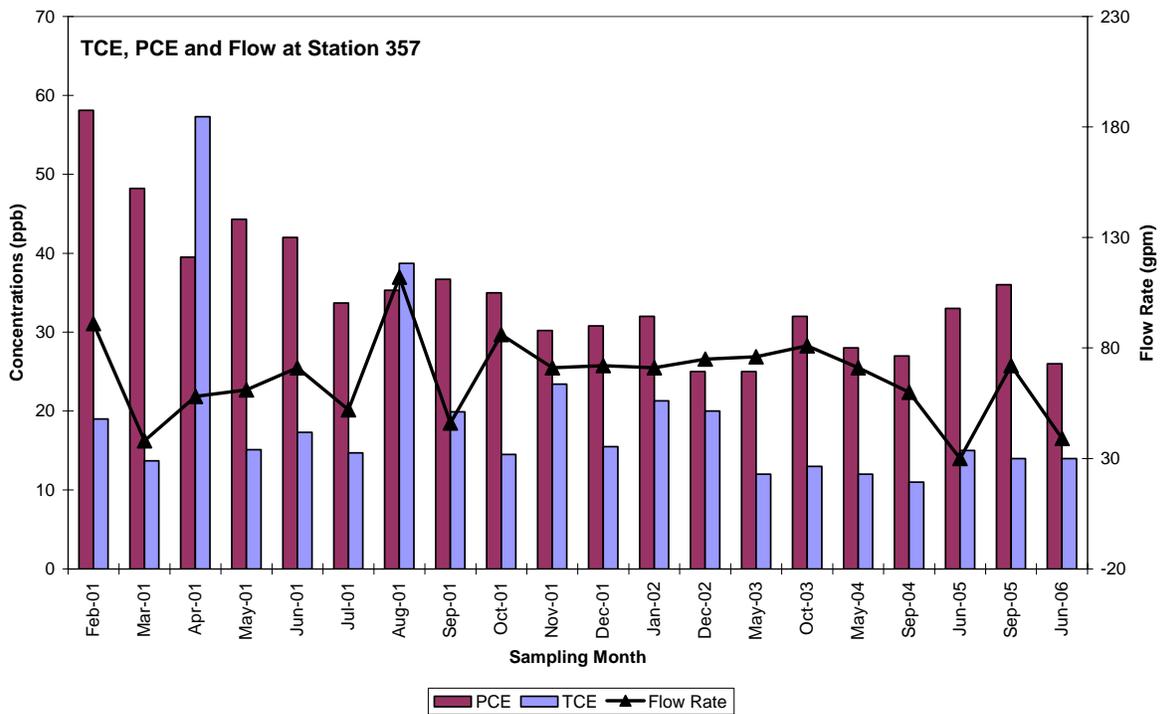


Figure D-1. PCE and TCE Concentrations with Flow Rates from February 2001 through June 2006.

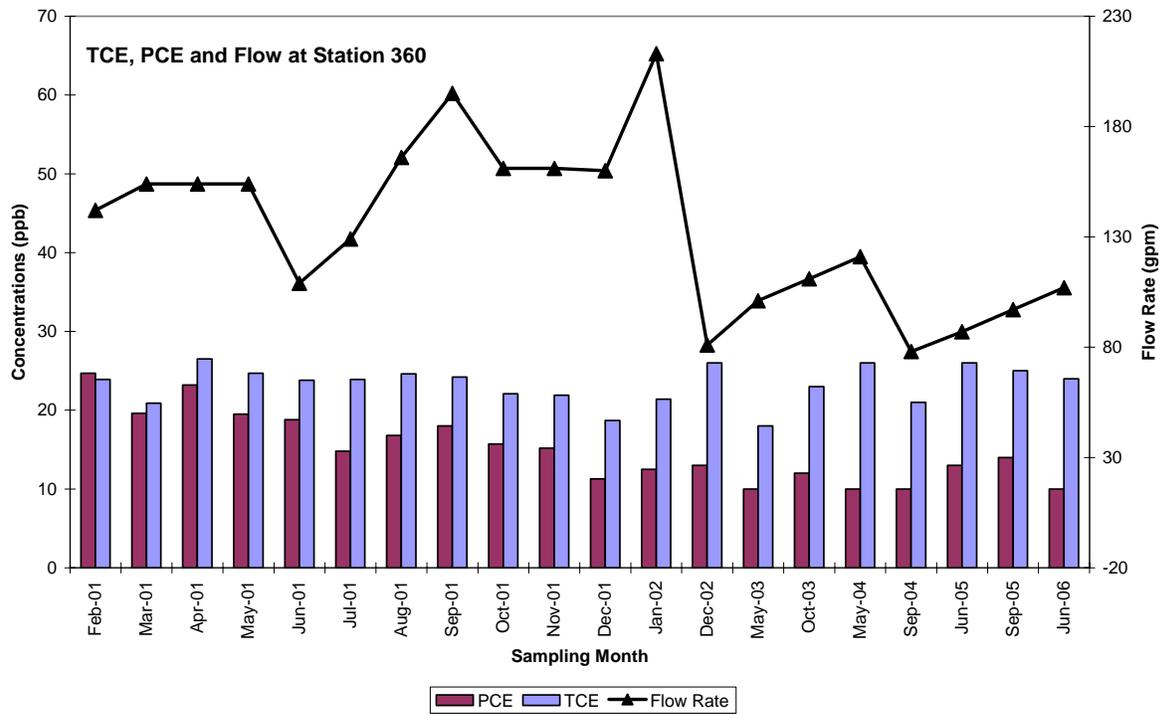
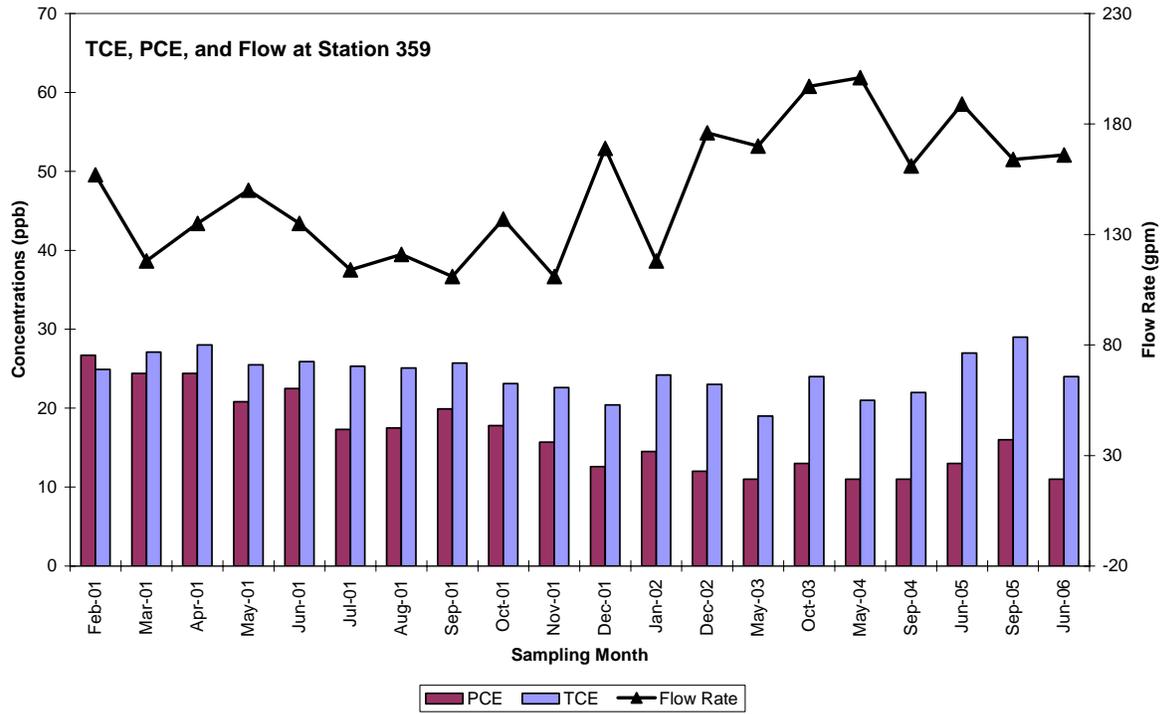


Figure D-1 (continued).

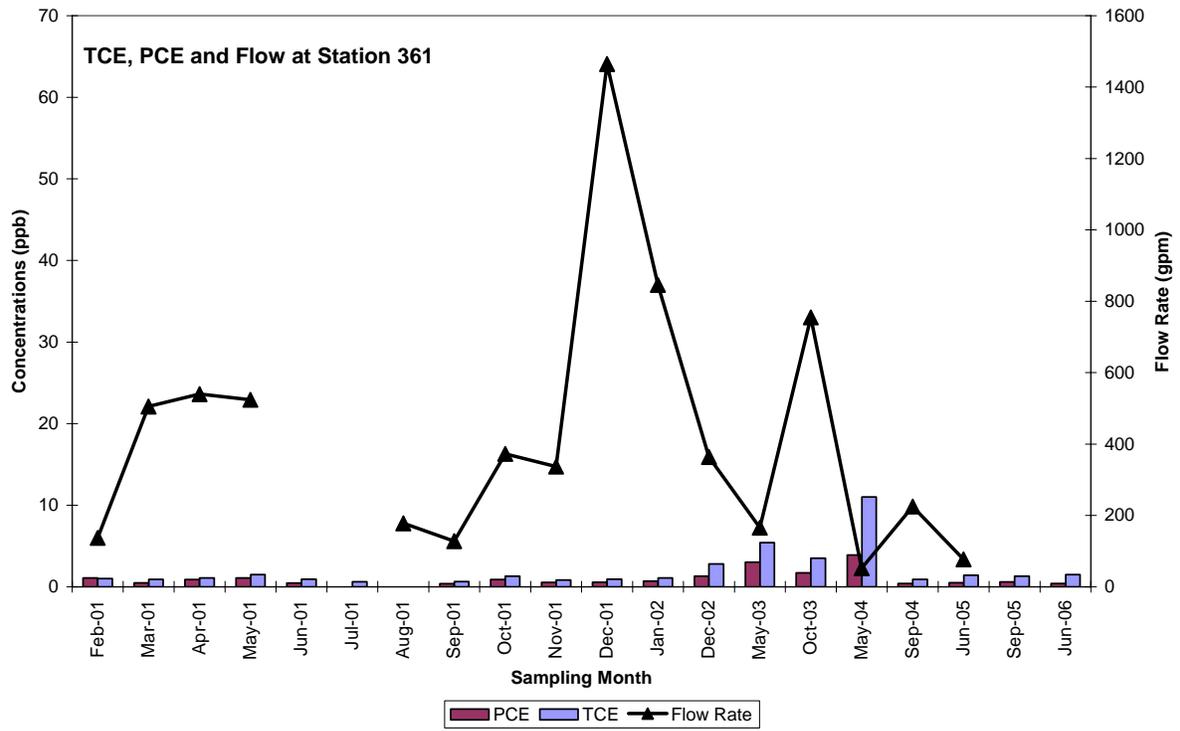


Figure D-1 (continued).

## Appendix E. Lagoon Performance Calculations

### Percent Contaminant Reduction by Lagoon for September 28, 2005

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#### Measured Parameters

Lagoon influent		
PCE	14	ug/L
TCE	25	ug/L
Flow	97	gpm
Lagoon effluent		
PCE	0.58	ug/L
TCE	1.3	ug/L
Flow	347	gpm

#### Overall Percent Reduction

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

PCE: 96%

TCE: 95%

#### Residence Time

Lagoon volume = 556.3 cyds

Convert to gallons = 112,350 gallons

Calculate residence time:

$$\frac{112,350 \text{ gal}}{347 \text{ gal/min}}$$

Residence time = 324 minutes or 5.4 hours

## Percent Contaminant Reduction by Lagoon for June 6, 2006

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### Measured Parameters

Lagoon influent		
PCE	10	ug/L
TCE	24	ug/L
Flow	107	gpm
Lagoon effluent		
PCE	0.39	ug/L
TCE	1.5	ug/L
Flow	234	gpm

\* Flow rate is too low

### Overall Percent Reduction

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

PCE: 96%

TCE: 94%

### Residence Time

Lagoon volume = 556.3 cyds

Convert to gallons = 112,350 gallons

Calculate residence time:

$$\frac{112,350 \text{ gal}}{234 \text{ gal/min}}$$

Residence time = 480 minutes or 8 hours