Klosterman Bayou and Joe's Creek Nutrient Source Evaluation

Final Report

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Prepared for:

Pinellas County, Florida

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SECTION 1

INTRODUCTION

1.1 Project Background

This report provides a summary of field and laboratory efforts conducted by Environmental Research & Design, Inc. (ERD) for Pinellas County (County) as part of the Klosterman Bayou and Joe's Creek Nutrient Source Evaluation Project. These work efforts were authorized by Pinellas County under P.O. No. 227551, issued May 28, 2008. The purpose of this project is to identify the sources of elevated nutrient levels observed in the Klosterman Bayou and Joe's Creek watersheds in Pinellas County. General locations of the Klosterman Bayou and Joe's Creek watersheds are given on Figure 1-1.

The Klosterman Bayou drainage basin is located in northeast Pinellas County, west of Lake Tarpon. The total basin area includes approximately 2068 acres (Pinellas County GIS) comprised of low-density residential, medium-density residential, recreation/open space, industrial, and commercial land uses. The central portion of the basin contains a 900 acre residential golf course complex, known as the Innisbrook Golf Course (IGC). The golf course complex is located adjacent to the William E. Dunn Wastewater Treatment Plant which provides wastewater reuse to the golf course for irrigation purposes. Central portions of the Klosterman Bayou watershed in the vicinity of IGC have a history of extremely elevated nutrient concentrations since the early 1990s. The project area included in this analysis consists primarily of areas east of the former Seaboard Coast railroad which has been converted into a recreational trail, referred to as the Fred Marquis Pinellas Trail. Work efforts outlined under this project are designed to assess the sources of nutrients which are causing elevated concentrations within this portion of the Klosterman Bayou watershed.

The Joe's Creek watershed includes approximately 9256 acres of residential, commercial, industrial, recreation, open space, and preservation lands in south-central Pinellas County. The watershed includes parts of the cities of Pinellas Park, St. Petersburg, and Kenneth City. Joe's Creek is highly channelized and generally flows east-to-west with a total length of approximately 11.2 miles. The County has monitored water quality at multiple sites along Joe's Creek since 1991, and water quality has consistently been rated poor due to elevated nutrient concentrations. The primary objective of this evaluation is to identify the sources of elevated nutrients along the main channel of Joe's Creek. The project area included in this evaluation begins at the Southwest Florida Water Management District (District)-owned pond east of 28th Street North and continues westward along the main channel of Joe's Creek to approximately 49th Street North.

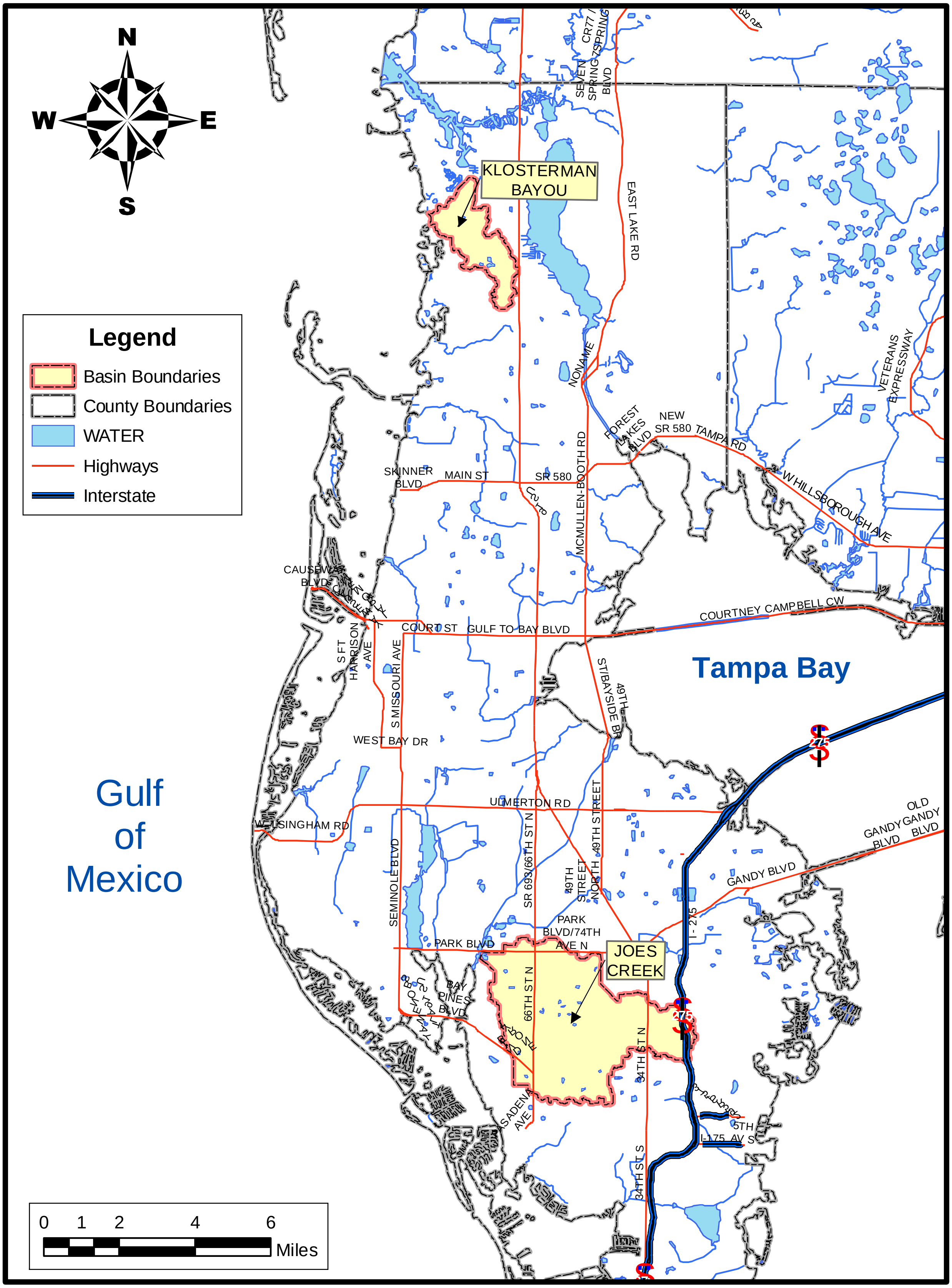


Figure 1-1. Location Map for Klosterman Bayou and Joe’s Creek Watersheds.

The specific objectives of this project, as defined by Pinellas County, are to:

1. Design a monitoring program to determine the source of nutrients within the Klosterman Bayou and Joe's Creek project areas

2. Interpret the collected data and other information to identify nutrient sources

3. Develop suggestions to alleviate the nutrient impairment

4. Prepare a Final Report which presents the results and recommendations

1.2 Work Efforts Conducted by ERD

Field monitoring was conducted by ERD from July-September 2008 within the Klosterman Bayou and Joe's Creek watersheds to characterize discharges through each area. Twelve surface water sites were monitored on a biweekly basis, which included measurement of field parameters, discharge rates, and sample collection for laboratory analyses. Five groundwater monitoring wells were installed to evaluate groundwater impacts from potential pollutant sources. Samples of shallow groundwater were also collected during each biweekly monitoring event. Each of the collected samples was analyzed in the ERD Laboratory for general parameters and nutrients. In addition, aliquots of each collected sample were shipped to the Colorado Plateau Stable Isotope Laboratory for isotope analyses of nitrogen and oxygen within the collected samples to assist in identifying potential pollutant sources.

1.3 Report Organization

This report has been divided into six separate sections for presentation and analysis of the field and laboratory activities. Section 1 contains an introduction to the report and provides a summary of the work efforts performed by ERD. Section 2 contains a discussion of the characteristics of the Klosterman Bayou and Joe's Creek watershed areas. A description of field monitoring and laboratory analyses conducted for this project is given in Section 3. A discussion of the results of the field and laboratory activities is given in Section 4. Nutrient management recommendations are discussed in Section 5, a summary is given in Section 6, and a list of references is given in Section 7. Appendices are also attached which contain technical data and analyses used to support the information, conclusions, and recommendations contained within this report.

SECTION 2

CHARACTERISTICS OF THE KLOSTERMAN BAYOU AND JOE'S CREEK WATERSHEDS

2.1 Klosterman Bayou Watershed

2.1.1 General Characteristics

The Klosterman Bayou watershed is a 2068-acre basin area located in northeast Pinellas County. The majority of the Klosterman Bayou watershed is located within unincorporated Pinellas County, with northern portions of the watershed located in the City of Tarpon Springs. The Klosterman Bayou watershed is located in the Springs Coast Basin, as defined by the Florida Department of Environmental Protection (FDEP), which is a Group 5 basin. The Klosterman Bayou watershed is bordered on the west by the Gulf of Mexico, on the north by the Spring Bayou watershed, and on the south by the Hope Spring drain.

An overview of the Klosterman Bayou watershed is given on Figure 2-1 based upon information obtained from the Pinellas county GIS database. The Klosterman Bayou watershed contains both marine and freshwater segments. According to URS (2007), the Klosterman Bayou watershed contains 122 identified surface waterbodies, covering an area of 321 acres, which include storage areas, stormwater facilities, ditches, ponds, and streams. The 696-acre marine segment (WBID 1508) is a tidally-influenced segment which begins at the Gulf of Mexico and extends inland to the vicinity of the Fred Marquis Pinellas Trail (hereinafter referred to as the Pinellas Trail), east of Alt. U.S. 19. The marine segments contain high-density residential areas, the Klosterman Bayou area, and a commercial corridor along Alt. U.S. 19. The 1372-acre freshwater segment of Klosterman Bayou (WBID 1508A) contains residential units in the northern and eastern areas and the Innisbrook Golf Course (IGC) which comprises the central portions of the watershed area. Work efforts conducted by ERD for this project were located in the freshwater segment of the watershed.

Although not included in the watershed boundaries provided by Pinellas County, the golf course areas located in the northeast portion of the IGC, bounded on the north by Klosterman Road and on the east by the utility easement, are also hydrologically connected to the Innisbrook area of the drainage basin. These areas are topographically downhill from other portions of the IGC, but excess water generated within this basin is pumped southwest to an irrigation supply pond located within the IGC. Therefore, this additional 119-acre area is also technically part of the IGC watershed which increases the total basin area associated with the freshwater segment to approximately 1491 acres.

Prior to the 1960s, development within the Klosterman Bayou watershed consisted primarily of agricultural activities in upland areas, with waterfront developments located immediately adjacent to the Gulf of Mexico. The dominant agricultural activity at the time was citrus, with most of the groves located in the north and southeast portions of the watershed. Extensive residential development of the watershed began in the 1960s with the construction of a network of finger canals which provided waterfront access to property owners in more upland areas of the watershed. Citrus production within the area was impacted by a major freeze in 1962 which opened up large agricultural areas for urbanization. Construction of the 72-hole IGC resort began in 1970 and was completed in the early 1980s.

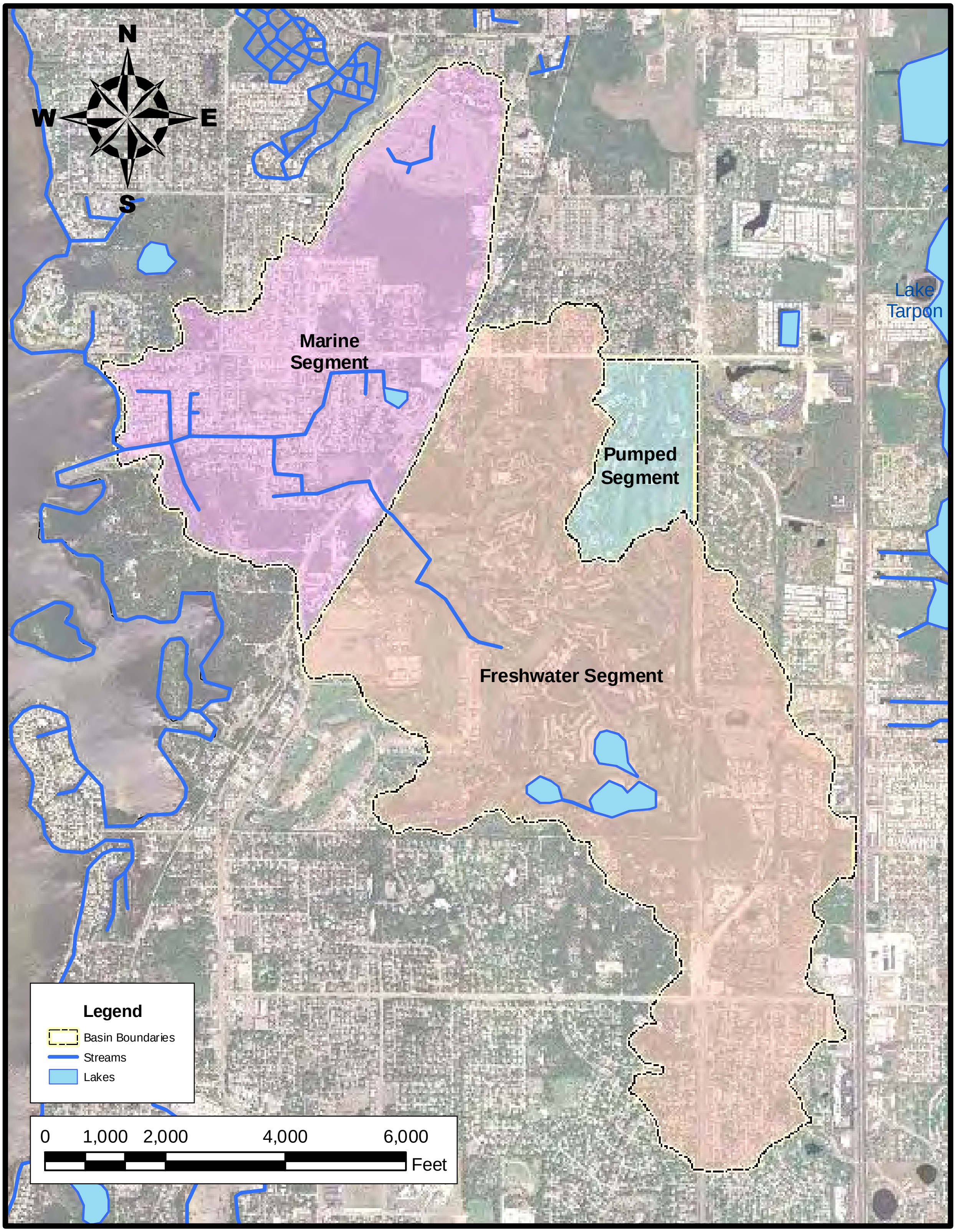


Figure 2-1. Overview of the Klosterman Bayou Watershed.

A domestic wastewater treatment facility, referred to as the William E. Dunn Water Reclamation Facility, is located in the freshwater segment of the Klosterman Bayou watershed, west of IGC. This facility was originally constructed in 1973 with a capacity of 3 mgd. The process was expanded as other facilities in the area were closed and now provides treatment for a permitted annual average daily sewage flow of 9 mgd, with the effluent permitted to irrigate golf courses, common areas, residential subdivisions, parks, schools, athletic facilities, and other public and private areas. The William E. Dunn facility provides 5-stage Bardenpho advanced secondary treatment for wastewater generated in northern portions of Pinellas County with the exception of Tarpon Springs.

By contract agreement, Pinellas County Utilities (PCU) provides a daily reclaimed water flow range of 2.5-5.0 mgd, on an as-needed basis, to the properties of IGC and the adjacent golf course property at the Highlands of Innisbrook development. The IGC receives approximately 1.77 mgd of reclaimed water from the facility to irrigate 506 acres (an average of 0.90 inches/week) and has been receiving reclaimed irrigation water from the Dunn facility since the early 1970s. An overview of the William E. Dunn Water Reclamation facility is given on Figure 2-2. During the periods from 2001-2002 and 2005-2006, the median total nitrogen and total phosphorus concentrations in the reclaimed water were 1.43 mg/l and 1.91 mg/l, respectively.

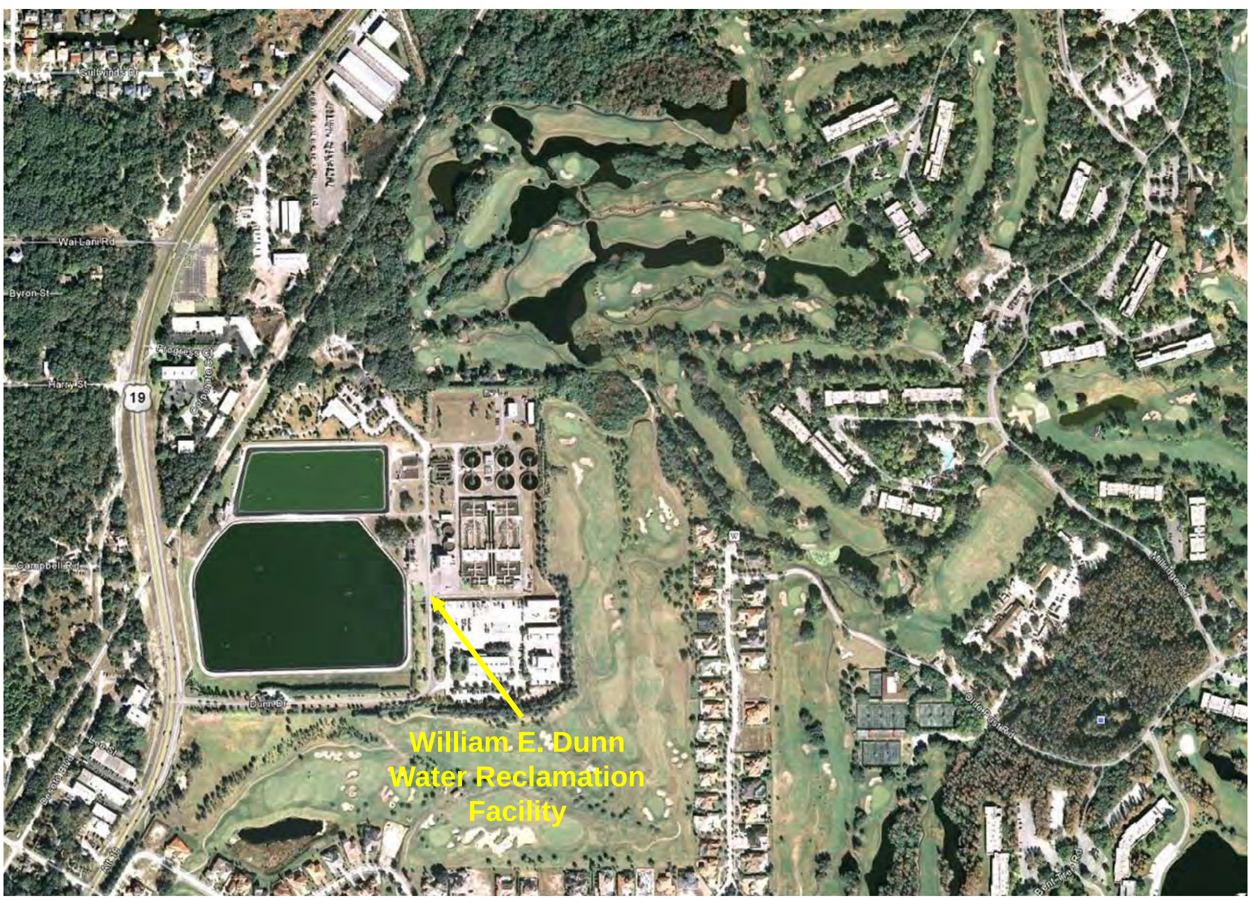


Figure 2-2. Overview of the William E. Dunn Water Reclamation Facility.

An evaluation of the Klosterman Bayou drainage basin was conducted by URS and Dynamic Solutions, LLP during 2007 as part of a TMDL evaluation for FDEP. The resulting document titled "Watershed Hydrologic Water Quality Model Calibration for Klosterman Bayou" provides a discussion of the drainage basin characteristics and estimates of nonpoint source loadings using HSPF modeling. According to URS, approximately 70% of the soils within the Klosterman Bayou drainage basin are classified in Hydrologic Soil Group (HSG) A which is characterized by a high infiltration rate and a low runoff potential. As a result, much of the water movement within the basin occurs in a subsurface manner. The modeling conducted by URS was based upon standard runoff characterization data collected within the State of Florida. However, the model appears to show a poor correlation between simulated and measured concentrations for both total phosphorus and total nitrogen, with consistently higher measured values for both parameters than predicted by the model. This pattern suggests that supplemental sources of nitrogen and phosphorus are present within the drainage basin which are not predicted by standard runoff characterization data.

2.1.2 Topography

A topographic map of the Klosterman Bayou watershed is given in Figure 2-3 based upon a LIDAR digital elevation model (2007) with 1-ft elevation contours provided by Pinellas County. Topography within the basin ranges from near sea level in western portions of the watershed to a maximum of approximately 25 ft (NGVD) in central portions of the watershed. Extreme southern portions of the Klosterman Bayou watershed are contained within a geographic area referred to as the Pinellas Ridge, where elevations increase to more than 80 ft (NGVD). In general, runoff generated within the freshwater segment of the watershed is ultimately directed to central portions of the watershed where it collects in a conveyance system referred to as the Innisbrook Canal. The Innisbrook Canal meanders through the IGC area and discharges from the golf course into the tidal portion of the watershed.

2.1.3 Soil Characteristics

Information on soil types within the Klosterman Bayou watershed were obtained from the Pinellas County GIS database. Soil information was extracted in the form of Hydrologic Soil Groups (HSG) which classify soil types with respect to infiltration rate and runoff potential. A summary of the characteristics of each of the hydrologic soil groups is given in Table 2-1.

A graphical summary of hydrologic soil groups in the Klosterman Bayou drainage basin is given in Figure 2-4, and a tabular summary of soil groups is given in Table 2-2. The vast majority of soils within the drainage basin appear to be classified in HSG A which includes deep sandy soils with high infiltration rate and low runoff potential. Central portions of the watershed, particularly areas associated with the Innisbrook Canal, are characterized by soils in HSG C and D which reflect soils with a low infiltration rate and medium to high runoff potential. However, overall, the runoff potential for the watershed appears to be relatively low, with the majority of rainfall infiltrating into the permeable watershed soils.

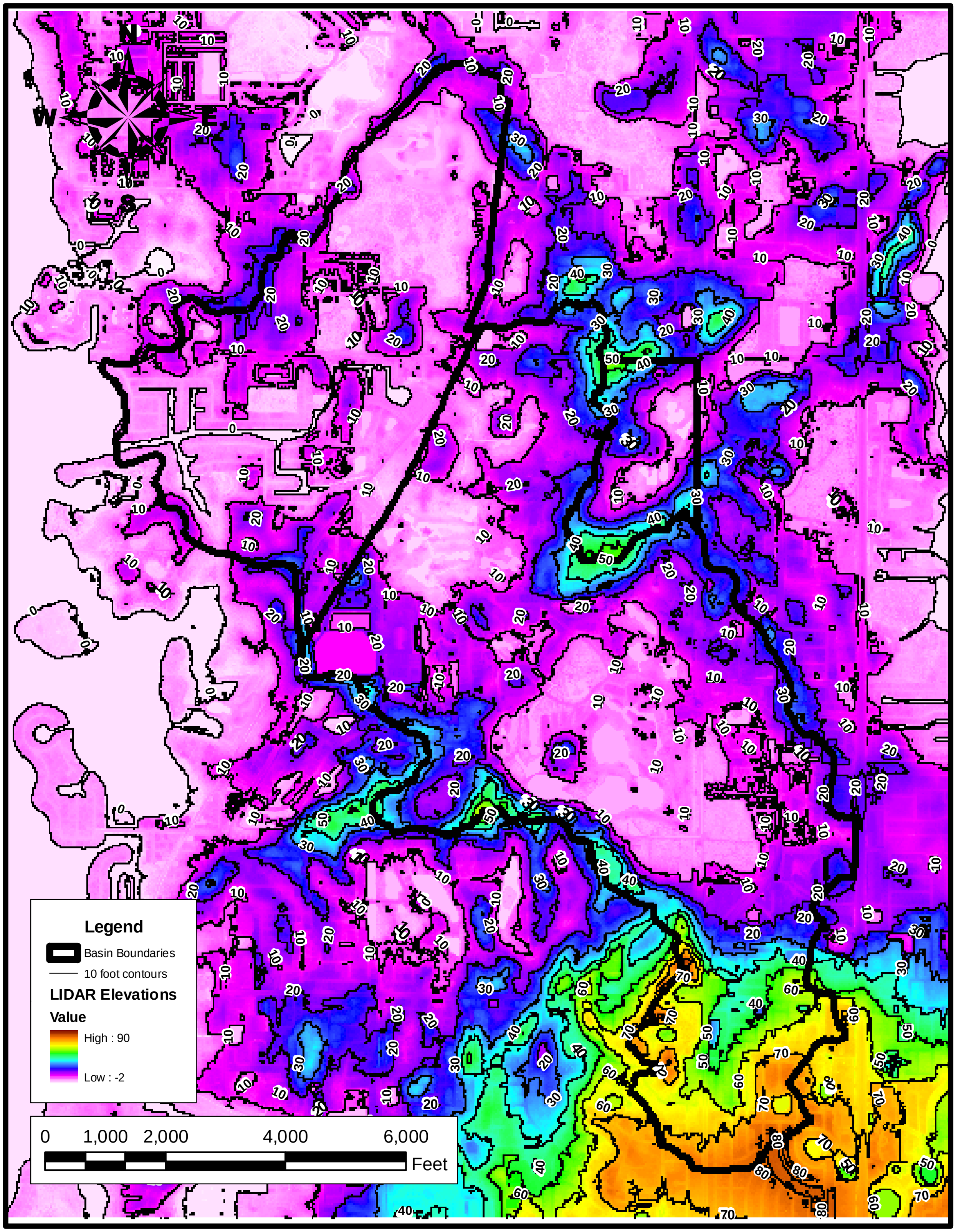


Figure 2-3. Topographic Contours in the Klosterman Bayou Watershed.

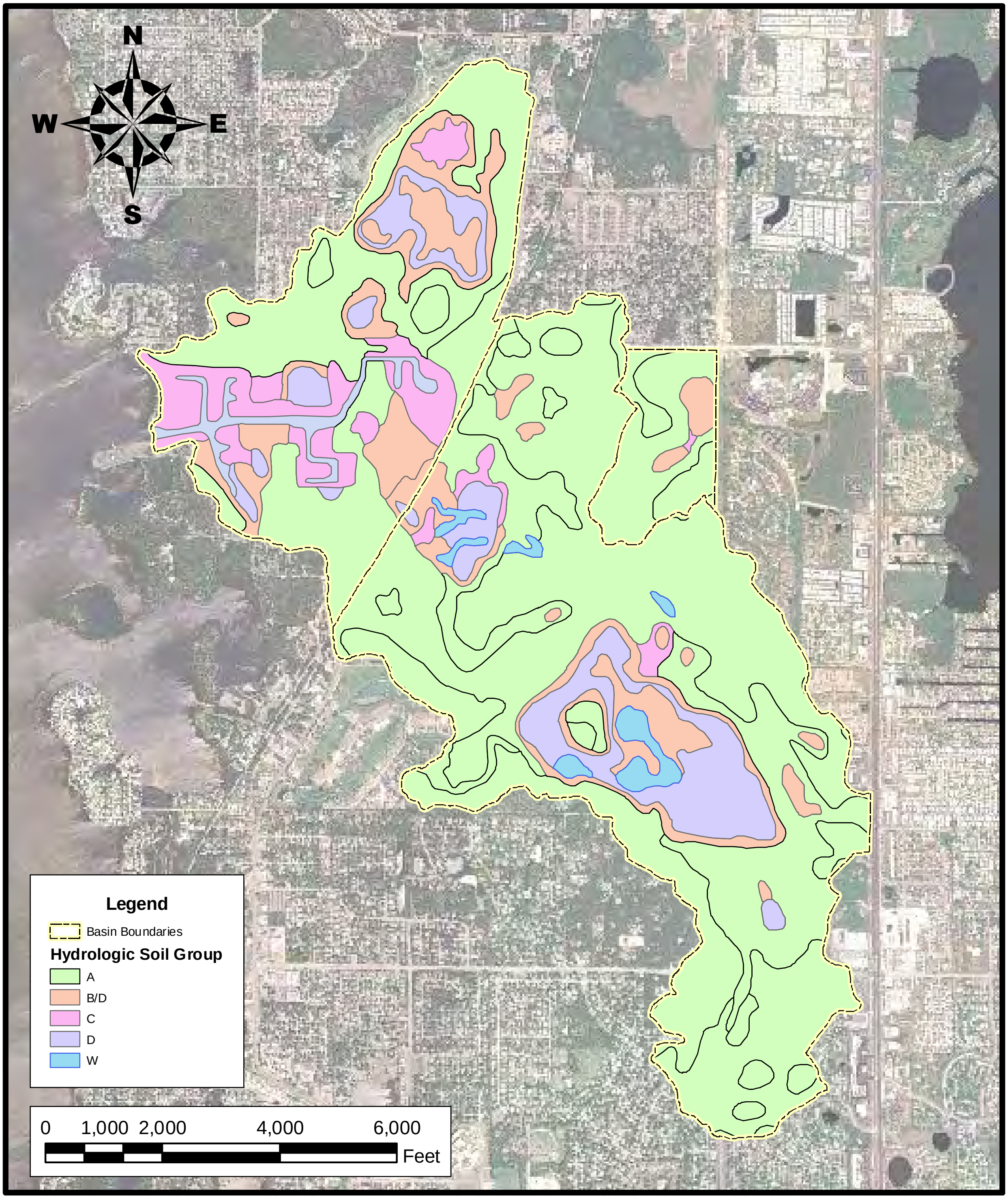


Figure 2-4. Hydrologic Soil Groups in the Klosterman Bayou Watershed.

TABLE 2-1

CHARACTERISTICS OF SCS HYDROLOGIC SOIL GROUP CLASSIFICATIONS

SOIL GROUP	DESCRIPTION	RUNOFF POTENTIAL	INFILTRATION RATE
A	Deep sandy soils	Very low	High
B	Shallow sandy soils over low permeability layer	Low	Moderate
C	Sandy soil with high clay or organic content	Medium to high	Low
D	Clayey soils	Very high	Low to none
B/D	Shallow sandy soils in high groundwater table area	High – undeveloped Low – developed	Moderate; restricted by groundwater table in undeveloped condition
W	Wetland or hydric soils	--	--

TABLE 2-2

SUMMARY OF HYDROLOGIC SOIL GROUPS IN THE KLOSTERMAN BAYOU WATERSHED

HSG	AREA (acres)			
	Freshwater Segment	Marine Segment	Pumped Segment	Total
A	1073.84	352.69	103.84	1530.37
B/D	114.11	136.56	14.53	265.20
C	17.85	120.52	0.82	139.19
D	132.53	54.85	0	187.38
W	34.04	31.49	0	65.53
Total:	**1372.37**	**696.11**	**119.19**	**2187.67**

2.1.4 <u>Land Use</u>

Land use data were obtained from the SWFWMD GIS database, which reflects 2007 land coverage in the form of Level 3 FLUCCS codes. A graphical overview of land use within the Klosterman Bayou watershed is given on Figure 2-5, and a tabular summary is provided in Table 2-3. For purposes of this evaluation, land use characteristics are provided separately for freshwater and marine portions of the watershed, with the Pinellas Trail used as the distinction between these areas. The northeast area of the IGC, referred to as the "Pumped Segment" is also included in the land use summary.

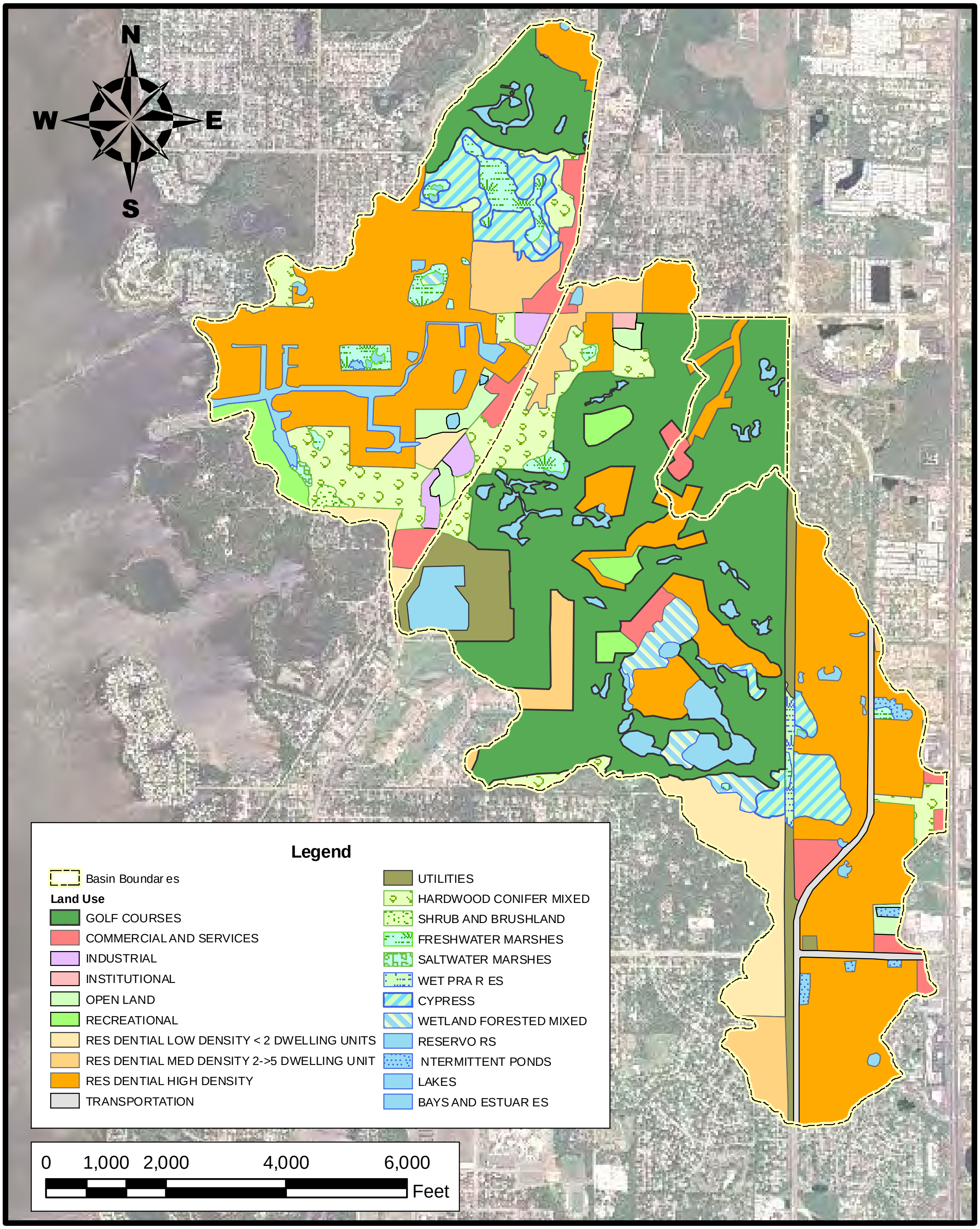


Figure 2-5. Land Use Characteristics in the Klosterman Bayou Watershed.
(Source: SWFWMD)

TABLE 2-3

SUMMARY OF CURRENT (2007) LAND USE IN THE KLOSTERMAN BAYOU WATERSHED

LAND USE CATEGORY	FRESHWATER SEGMENT		MARINE SEGMENT		PUMPED SEGMENT		TOTAL	
	Area (ac)	% of Total	Area (ac)	% of Total	Area (ac)	% of Total	Area (ac)	% of Total
Low-Density Residential (<2 du/ac)	72.29	5.3	17.52	2.5	0.00	0.00	89.81	4.1
Medium-Density Residential (2-5 du/ac)	79.09	5.8	32.10	4.6	0.00	0.00	111.19	5.1
High-Density Residential	388.46	28.2	278.48	40.0	14.95	12.5	681.89	31.2
Commercial and Services	34.86	2.5	34.38	4.9	4.44	3.7	73.68	3.4
Industrial	0.00	0.0	16.33	2.3	0.00	0.00	16.33	0.7
Institutional	2.32	0.2	0.00	0.0	0.00	0.00	2.32	0.1
Recreational	21.05	1.5	19.23	2.8	0.00	0.00	40.28	1.8
Golf Courses	446.73	32.5	71.67	10.3	95.75	80.3	614.15	28.1
Open Land	7.39	0.5	16.66	2.4	0.00	0.00	24.05	1.1
Shrub and Brushland	0.00	0.0	3.20	0.5	0.00	0.00	3.20	0.1
Hardwood Conifer Mixed	62.72	4.6	80.04	11.5	0.00	0.00	142.76	6.5
Lakes	44.96	3.3	1.36	0.2	0.00	0.00	46.32	2.1
Reservoirs	31.06	2.3	13.36	1.9	4.05	3.5	48.47	2.2
Bays and Estuaries	0.00	0.0	27.03	3.9	0.00	0.00	27.03	1.2
Gulf of Mexico	0.00	0.0	0.62	0.1	0.00	0.00	0.62	< 0.1
Cypress	33.95	2.5	45.09	6.5	0.00	0.00	79.04	3.6
Wetland Forested Mixed	29.59	2.2	3.70	0.5	0.00	0.00	33.29	1.5
Freshwater Marshes	8.52	0.6	33.45	4.8	0.00	0.00	41.97	1.9
Saltwater Marshes	0.00	0.0	1.87	0.3	0.00	0.00	1.87	0.1
Wet Prairies	5.97	0.4	0.00	0.0	0.00	0.00	5.97	0.3
Intermittent Ponds	7.82	0.6	0.00	0.0	0.00	0.00	7.82	0.4
Transportation	25.61	1.9	0.00	0.0	0.00	0.00	25.61	1.2
Utilities	69.98	5.1	0.02	0.0	0.00	0.00	70.00	3.2
Totals:	**1372.37**	**100.0**	**696.11**	**100.0**	**119.19**	**100.0**	**2187.67**	**100.0**

The dominant land use within both the freshwater and marine segments of the Klosterman Bayou watershed is residential which occupies 39.3% of the freshwater segment and 47.0% of the marine segment. The golf course covers approximately 32.5% of the freshwater segment, with relatively small contributions from the remaining listed land use categories. The second most dominant land use categories in the marine segment include golf courses and hardwood conifer forests, with relatively minimal contributions from the remaining listed land use types.

2.1.5 Hydrology

An overview of hydrologic drainage patterns in northernmost portions of the freshwater segment of the Klosterman Bayou watershed is given on Figure 2-6. Drainage patterns in this portion of the watershed are relatively complex and include a series of interconnected lakes, pumping stations to supply reuse water for irrigation purposes, and pumping stations used to control surface waterbody elevations.

As discussed in Section 2.1.2, the northeast portion of the IGC is topographically downhill from other portions of the Klosterman Bayou watershed, and from a surface runoff perspective, is considered to be outside of the watershed area. The northeast area contains a series of interconnected wet detention ponds which flow in a general north-to-south direction. The northernmost pond within the system also receives discharges from the wet detention pond associated with St. Petersburg College, located east of the area, which has a high level overflow that can discharge water into the golf course pond under extreme rain conditions. However, discharges through this overflow are considered to occur infrequently and are not considered to be significant for purposes of this evaluation. A reuse pump station is also located on the southern pond in the northeast area to provide reuse water for irrigation purposes. The southern pond also contains an additional pump station which pumps excess water, as necessary to avoid flooding, in a southwesterly direction to the series of interconnected ponds located in central portions of the IGC area.

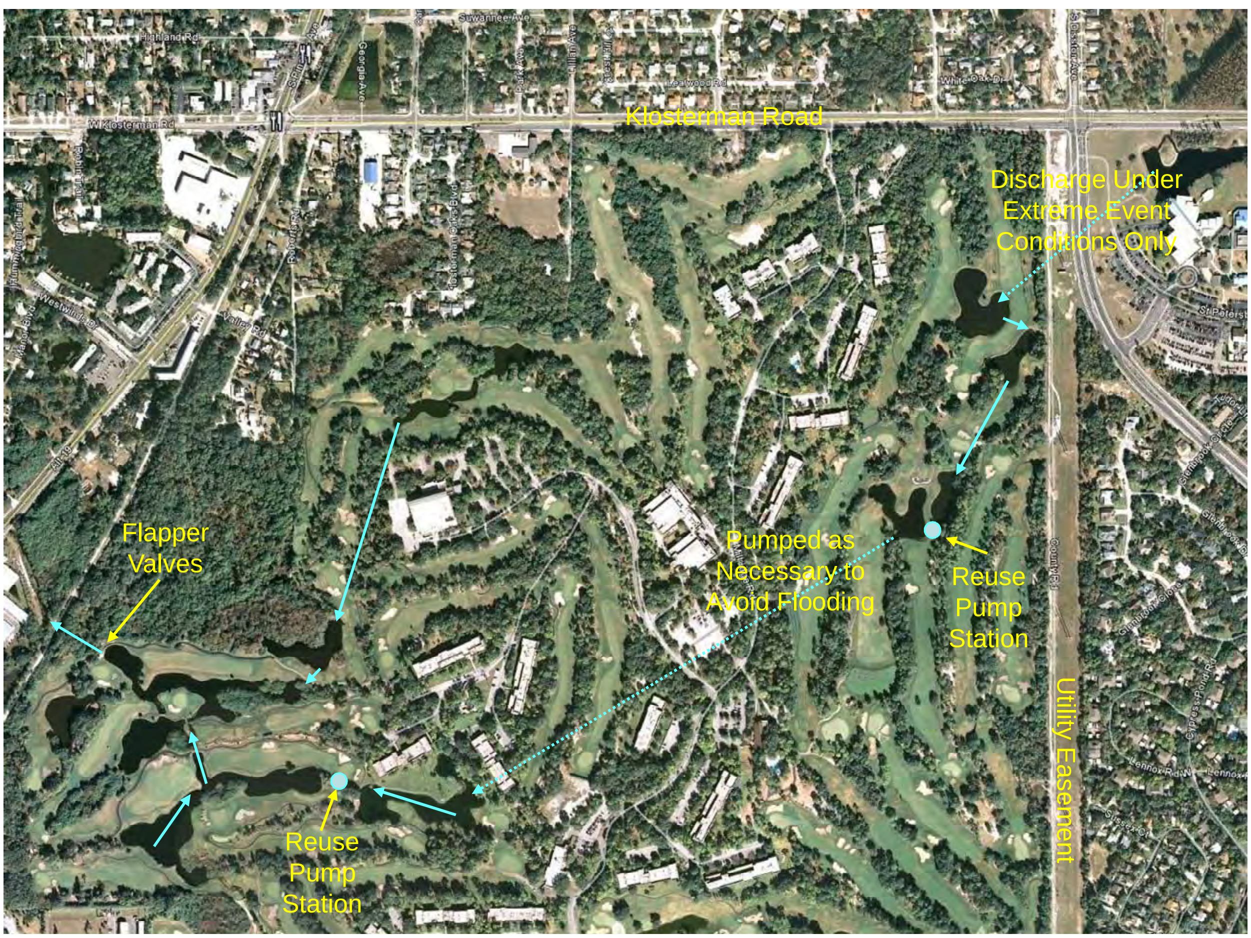


Figure 2-6. Drainage Patterns in Northern Portions of the Freshwater Segment of the Klosterman Bayou Watershed.

All surface water runoff generated in northern portions of the freshwater segment of the Klosterman Bayou watershed ultimately enters the series of interconnected lakes located in the western-central portion of the basin area. Discharges from these lakes occur through a series of flapper valves, which prevent backflow of brackish water into the lake system. A photograph of the discharge structure from the IGC is given on Figure 2-7. The flapper valves are located inside the two culverts which discharge from the final pond system into the marine portion of the watershed. An additional reuse pump station is also located adjacent to the interconnected lakes.

Drainage patterns in southern portions of the freshwater segment of the Klosterman Bayou watershed are illustrated on Figure 2-8. The IGC receives inflow from approximately 509 acres of residential areas located east and south of the IGC property. Flow from these areas is collected in a shallow waterbody, referred to as Bee Pond, which is located near the southeast corner of the IGC property. A photograph of the 24-inch CMP inflow from the Bee Pond discharge into the IGC pond system is given on Figure 2-9. However, as discussed in Section 2.1.3, soils in this area are highly permeable with a low runoff potential, and inflow onto the IGC property from the off-site areas is relatively limited. Inflows which occur are directed into the southernmost pond system which consists of a series of interconnected ponds which flow in the general direction illustrated on Figure 2-8.

Discharge from this pond system ultimately enters the Innisbrook Canal which flows into the central interconnected lake system discussed previously. Photographs of the Innisbrook Canal in central portions of the golf course area are given in Figure 2-10, including the horizontal weir structure and the Pinellas County stream gauging station maintained and operated by Hydrologic Data Collection, Inc. Three additional reuse pump stations are located in southern portions of the freshwater segment at the locations indicated on Figure 2-8. All surface water flow generated in southern portions of the freshwater segment, along with intercepted groundwater flow, ultimately pass through the drainage system and is discharged at the primary outfall for the property.

After leaving the IGC property, discharges enter the tidally influenced portion of the watershed. This area consists of a series of man-made channels and finger canals, most of which connect to the Gulf of Mexico. This area is tidally influenced up to the point of discharge from the IGC property.

2.1.6 Impaired Waters

Section 303(d) of the Clean Water Act (CWA) requires states to submit lists of surface waterbodies that do not meet applicable water quality standards. These waterbodies are defined as "impaired waters" and Total Maximum Daily Loads (TMDLs) must be established for these waters on a prioritized schedule. FDEP has established a series of guidelines to identify impaired waters which may require the establishment of TMDLs. Waterbodies within the State of Florida have been divided into five separate groups for planning purposes, with the Klosterman Bayou located in the Springs Coast Basin in Group 5.

a. IGC Outfall Structure

b. Channel Downstream from IGC Outfall

Figure 2-7. Outfall Structures for the Freshwater Segment of the Klosterman Bayou Watershed.

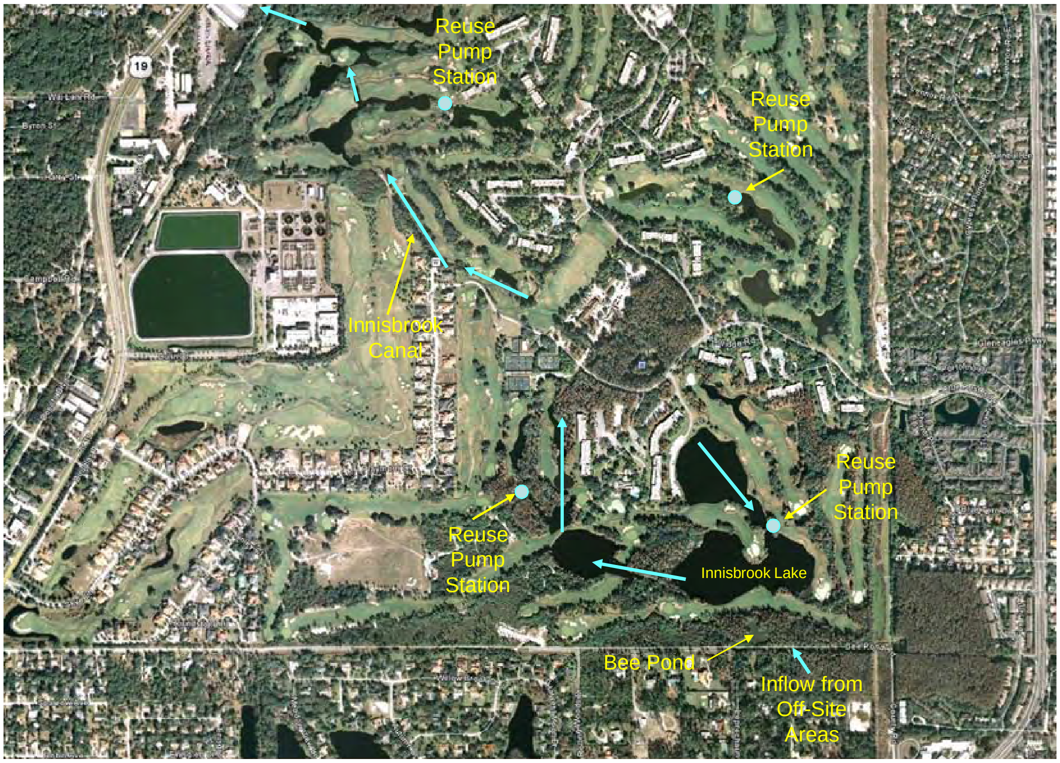


Figure 2-8. Drainage Patterns in Southern Portions of the Freshwater Segment of the Klosterman Bayou Watershed.

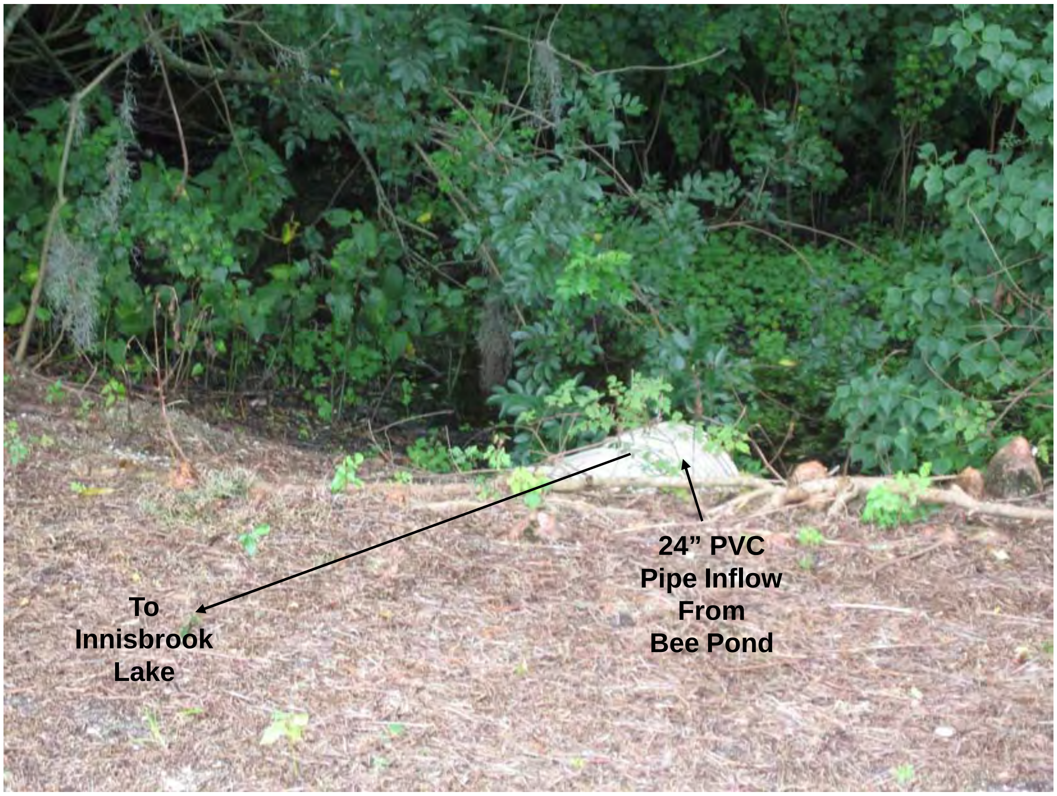


Figure 2-9. Inflow from Southern Off-site Areas.

a. Gauging Station Upstream from the Horizontal Weir

b. Horizontal Weir Structure

Figure 2-10. Photographs of the Innisbrook Canal.

The tidal segment of Klosterman Bayou (WBID 1508) in Pinellas County is on the FDEP-verified list for dissolved oxygen and nutrients. According to FDEP, nutrients and BOD were identified as the causative pollutants for the dissolved oxygen impairment within the Klosterman Bayou estuary. During the verification period, the medium total phosphorus concentration was 0.165 mg/l, with a median total nitrogen concentration of 0.98 mg/l and a medium BOD of 2.9 mg/l. The tidal portion of Klosterman Bayou is also impaired for nutrients based upon annual average chlorophyll-a values which exceeded 11 mg/m^3 in 1999-2002 and in 2004. Nitrogen is stated as the limiting nutrient based on a median TN/TP ratio of 6.0. The Klosterman tidal section is also impaired for fecal coliforms and mercury in fish tissue, as indicated on the 2009 FDEP-verified list and a federal TMDL approved in September 2007.

Although the upstream freshwater portion of Klosterman Bayou (identified as WBID 1508a) is not included in the impairment designation, the freshwater portions of the watershed appear to be the sources for many of the physical processes affecting dissolved oxygen, BOD, and chlorophyll in Klosterman Bayou. A TMDL for the Springs Coast Basin, which includes WBID 1508, was prepared by the U.S. EPA and released in September 2007. The TMDL indicates a target pollutant load reduction of 69% for total nitrogen and 92% for total phosphorus within the basin, although these values may be modified as TMDL updates occur.

2.1.7 Water Quality Data

A review of available historical water quality data collected in the Klosterman Bayou watershed was conducted using the U.S. EPA STORET database as well as the Pinellas County Water Atlas data. Much of the historical data is duplicated within the two databases, although unique data were obtained from both the STORET and Water Atlas sources which were not contained within the other system. Locations of the identified water quality monitoring sites in the Klosterman Bayou watershed are indicated on Figure 2-11 along with the sample site reference number for each location. All of the historical water quality monitoring sites are located along either freshwater or marine segments of the Innisbrook Canal. Six of the historical monitoring sites are located downstream from the IGC (IGC) point of discharge, with five monitoring sites located upstream within the IGC area. In addition, a flow monitoring station is also located within the IGC along the Innisbrook Canal. A complete listing of available water quality data for monitoring sites located within the Klosterman Bayou watershed is given in Appendix A.1.

A summary of available water quality data sources for the Klosterman Bayou watershed is given in Table 2-4. Water quality data have been collected at a total of 11 monitoring sites within the watershed area, beginning as early as 1971. Five of the surface water sites were monitored by the U.S. Geological Survey (USGS), with four sites located in the freshwater segment of the watershed and one site located in the marine segment. Monitoring by USGS was conducted during the 1970s at four of the five sites, and during 1989 at the remaining site. Surface water monitoring has also been conducted at six monitoring sites by Pinellas County, with one monitoring site located in the freshwater portion of the watershed and five monitoring sites in the marine segment. Surface water monitoring conducted by Pinellas County extends from the 1990s to the 2000s, depending upon the particular monitoring site.

Figure 2-11. Identified Water Quality Monitoring Sites in the Klosterman Bayou Watershed.

TABLE 2-4

SUMMARY OF AVAILABLE WATER QUALITY DATA SOURCES FOR THE KLOSTERMAN BAYOU WATERSHED

STATION I.D.	STATION NAME	DATA SOURCE	COLLECTION DATES	NUMBER OF SAMPLES
2309502	Innisbrook Canal near Crystal Beach, FL	USGS-NWIS	2/14/73 – 8/20/74	6
280634082453500	Innisbrook Ditch at bridge	USGS-NWIS	2/1/89 - 3/3/89	3
280635082453300	Surface water Site 3 at Innisbrook, FL	USGS-NWIS	10/19/71 – 9/30/77	8
280651082454400	Surface water Site 2 at Innisbrook, FL	USGS-NWIS	10/18/71 – 5/16/72	2
280702082460000	SW-4 Alt. 19 of Tarpon Springs near Innisbrook, FL	USGS-NWIS	5/22/74 – 3/22/76	2
02-01	Innisbrook Canal	Pinellas County	1/17/91 – 12/3/02	344
02-02	Innisbrook Canal	Pinellas County	3/26/91 – 11/24/03	114
02-05	Innisbrook Canal	Pinellas County	11/15/99 - 11/15/99	2
02-06	Innisbrook Canal	Pinellas County	11/15/99 – 11/15/99	2
02-07	Innisbrook Canal	Pinellas County	11/15/99 – 10/19/06	24
02-09	Innisbrook Canal	Pinellas County	12/12/06 – 2/17/09	18

A summary of mean water quality characteristics measured at monitoring sites in the Klosterman Bayou watershed is given in Table 2-5. In general, monitoring stations are listed in order along the canal, beginning at the most upstream monitoring site and extending to near the Gulf of Mexico. This ordering allows a limited evaluation of changes in water quality characteristics with distance downstream in spite of the highly variable time frames included in the monitoring program.

In general, freshwater characteristics, as indicated by measured values of specific conductivity and chloride, appear to be maintained at the first five monitoring sites, with brackish to marine characteristics exhibited by the remaining sites. Mean total nitrogen concentrations in the freshwater segment also appear to be higher in value than concentrations measured in the marine segment. A general trend of decreasing nitrogen concentration with increasing distance along the main channel is apparent. Measured concentrations of phosphorus species also appear to be higher in value in the freshwater segment compared with the marine segment.

The historical data suggest a decrease in concentrations of both soluble reactive phosphorus (SRP) and total phosphorus from Monitoring Site 02-09 (located near the middle of the freshwater segment) to Monitoring Site 02-07 (located immediately downstream of the outfall from the IGC). However, a significant increase in both SRP and total phosphorus occurs over the 525-ft distance between Monitoring Sites 02-07 and 02-02 located at the culvert crossing for Alt. U.S. 19, with an approximate doubling of concentrations for the measured phosphorus species. This is followed by a gradual decrease in phosphorus concentrations with increasing distance along the channel.

TABLE 2-5

SUMMARY OF MEAN WATER QUALITY CHARACTERISTICS MEASURED AT MONITORING SITES IN THE KLOSTERMAN BAYOU WATERSHED

	STATION I.D.	PARAMETER															
		pH (s.u.)	Cond. (µmho/cm)	SO_4 (mg/l)	Cl (mg/l)	Color (pcu)	BOD_5 (mg/l)	Fecal Col. (cfu/ 100 ml)	Total Col. (cfu/ 100 ml)	NH_3 (µg/l)	NO_x (µg/l)	TKN (µg/l)	Total N (µg/l)	SRP (µg/l)	Total P (µg/l)	TDS (mg/l)	TSS (mg/l)
Freshwater	2309502 (Innisbrook Canal near Crystal Beach, FL)	--	1064	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	280635082453300 (Surface water Site 2 at Innisbrook, FL)	7.93	981	40	236	85	7.4	--	410	2627	1185	2297	3482	1010	1568	733	--
	280634082453500 (Innisbrook ditch at bridge)	7.17	717	48	110	--	--	--	--	690	2200	2250	4450	--	3710	444	--
	02-09	7.46	1130	--	--	--	5.4	380	--	--	271	2241	2512	1030	1175	--	8.4
	280651082454400 (Surface water Site 2 at Innisbrook, FL)	--	1470	--	515	--	--	--	--	2900	--	2600	--	--	1325	--	--
Estuarine	02-07	7.75	7946	--	--	--	4.8	707	1420	--	348	1849	2197	560	701	--	11.6
	02-02	8.01	5221	--	--	--	4.3	387	791	--	220	2035	2255	1130	1303	--	14.4
	280702082460000 (SW-4 Alt. 19 south of Tarpon Springs near Innisbrook, FL)	6.30	22,550	1500	7800	40	22.2	--	2400	600	10	1650	1660	470	490	20,600	--
	02-06	8.02	32,000	--	--	--	3.0	--	--	--	240	970	1210	250	380	--	10.0
	02-05	8.19	37,050	--	--	--	3.0	--	--	--	20	760	780	20	140	--	8.0
	02-01 (Innisbrook Canal)	8.01	43,003	--	--	--	2.7	106	250	--	43	948	991	140	343	--	9.1

A statistical summary of selected historical water quality data for nitrogen species in the Innisbrook Canal is given in Figure 2-12 in the form of Tukey box plots, also often called "box and whisker plots". The bottom of the box portion of each plot represents the lower quartile, with 25% of the data points falling below this value. The upper line of the box represents the 75% upper quartile, with 25% of the data falling above this value. The horizontal line within the box represents the median value, with 50% of the data falling both above and below this value. The vertical lines, also known as "whiskers", represent the 5 and 95 percentiles for the data sets. Individual values which lie outside of the 5-95 percentile range are indicated as **red dots**.

The monitoring sites summarized in Figure 2-12 include Pinellas County monitoring Site 02-09 (located at the gauging station in the freshwater portion of the Innisbrook Canal), monitoring Site 02-07 (located at the IGC outfall structure and 2100 ft downstream from Site 02-09), and monitoring Site 02-02 (located approximately 525 ft downstream from monitoring Site 02-07). It should be emphasized that the historical data summarized in this plot reflect differing collection periods, with data at Site 02-02 collected from 1991-2003, Site 02-07 collected from 1999-2006, and Site 02-09 collected from 2006-2009 which complicates comparison of water quality characteristics between the three sites.

In general, a relatively low degree of variability was observed for measured concentrations of nitrogen species at Site 02-09, located in the freshwater portion of the Innisbrook Canal. A slight decrease in measured concentrations for TKN and total nitrogen appears to occur between Sites 02-09 and 02-07, with a corresponding increase in the variability of measured concentrations observed at Site 02-07. A substantially higher degree of variability is apparent for nitrogen species at monitoring Site 02-02, presumably due to the tidal impacts at this location. As seen in Table 2-5, measured total nitrogen concentrations decrease from a mean of 2512 μg/l at Site 02-09 to mean concentrations ranging from 2197-2255 μg/l in the downstream marine segment. A similar reduction in concentrations is also apparent on Table 2-5 for TKN between the freshwater and marine segments. However, it is not known whether the apparent decreases in concentration from Site 02-09 to the off-site monitoring areas is due to assimilation within the golf course ponds or dilution processes after leaving the IGC site.

A statistical summary of selected historical water quality data for phosphorus, BOD, and dissolved oxygen in the Innisbrook Canal is given on Figure 2-13. In general, historical measured concentrations of total phosphorus at the three monitoring sites are approximately 2-4 times higher than phosphorus concentrations commonly observed in urban runoff. The vast majority of phosphorus measured at the site is contributed by SRP which is consistent with a phosphorus source other than urban runoff where SRP would contribute approximately 30-50% of the total phosphorus. As observed for nitrogen species, a decrease in phosphorus concentrations is apparent between Site 02-09 and Site 02-07, located immediately downstream from the IGC outfall. A large increase in phosphorus concentrations appears to occur between monitoring Sites 02-07 and 02-02. Monitoring Site 02-02 is also characterized by a substantially higher degree of variability in measured values, presumably due to the tidal impacts at this site. However, it is not known whether the apparent decrease in phosphorus concentrations between Sites 02-09 and 02-07 is due to assimilation of phosphorus within the IGC area or dilution of discharges with off-site water.

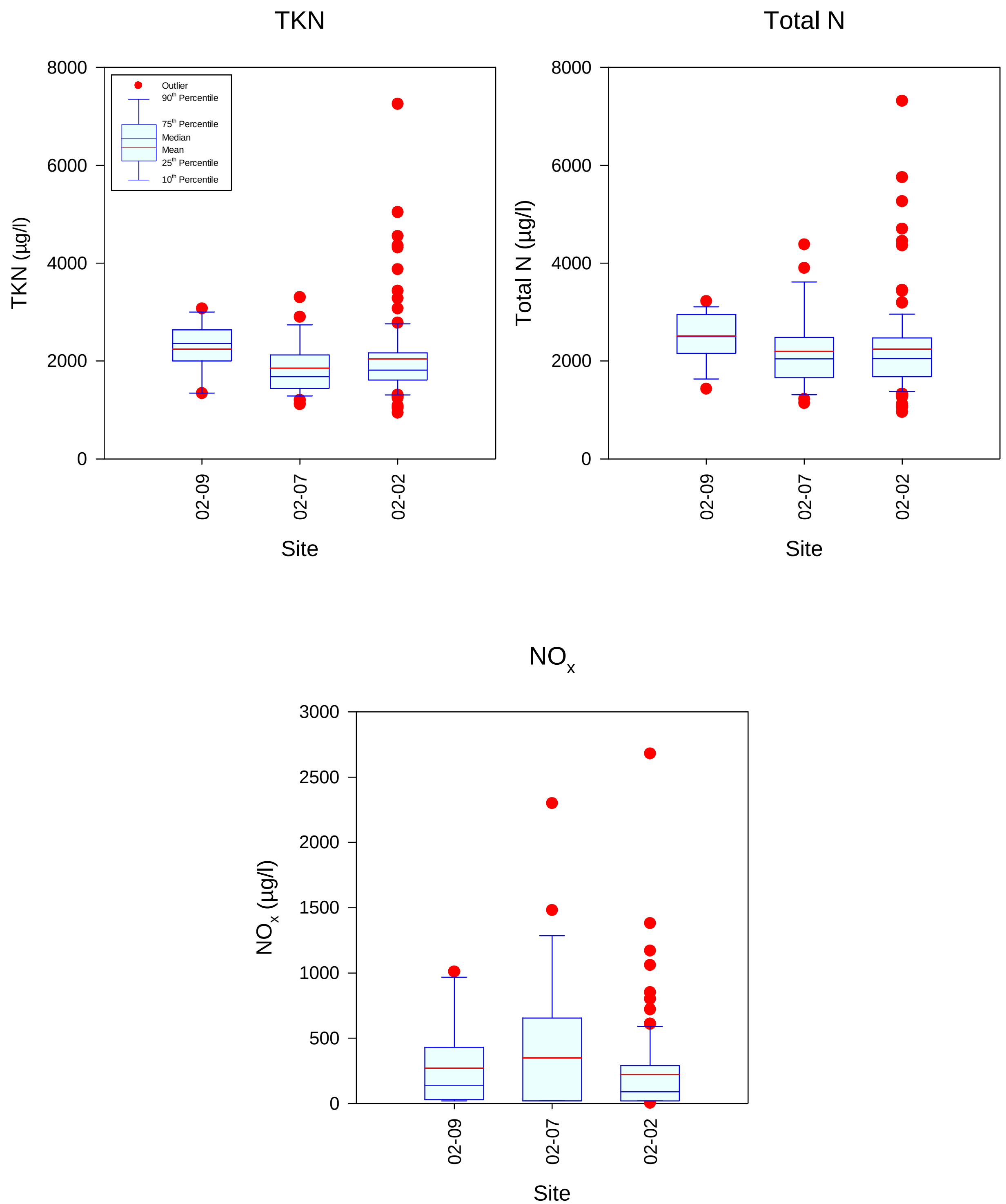


Figure 2-12. Statistical Summary of Selected Historical Water Quality for Nitrogen Species in the Innisbrook Canal.

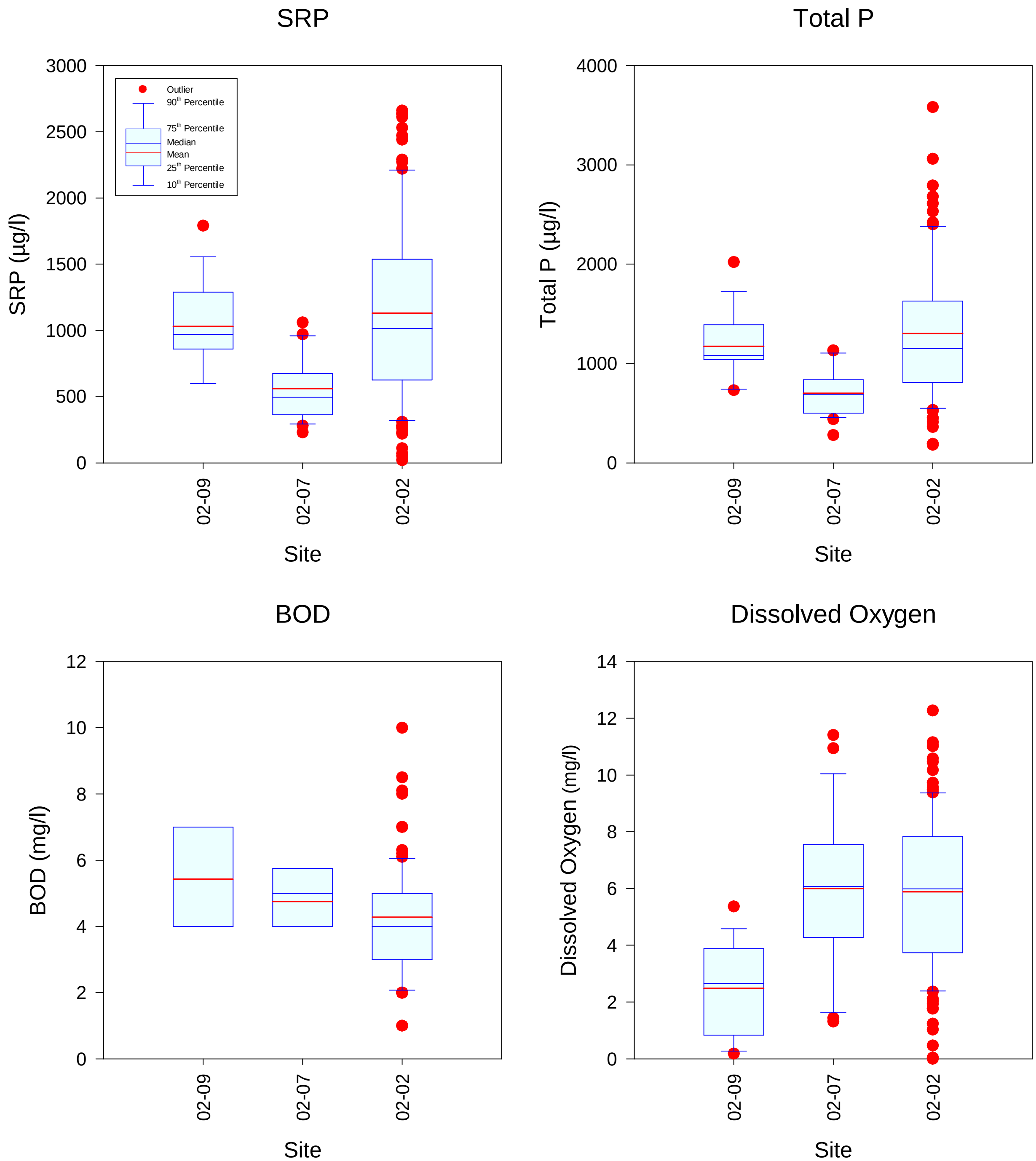


Figure 2-13. Statistical Summary of Selected Historical Water Quality for Phosphorus, BOD, and Dissolved Oxygen in the Innisbrook Canal.

In general, historical BOD values have been somewhat elevated at the three monitoring sites, with median values ranging from approximately 4-5 mg/l. A general trend of decreasing BOD is apparent from the freshwater segment to the marine segments of the canal. Similar to the patterns observed for other parameters, a higher degree of variability in BOD measurements is apparent at Site 02-02, presumably due to tidal influences at this site.

A high degree of variability is apparent in measured dissolved oxygen concentrations between the three monitoring sites. Low levels of dissolved oxygen, characterized by a median concentration of approximately 2.5 mg/l, have been observed at the freshwater monitoring site designated as 02-09. Virtually all dissolved oxygen measurements conducted at this site have been less than the Class III criterion of 5 mg/l for dissolved oxygen in freshwater systems. Higher levels of dissolved oxygen have been observed at the downstream marine monitoring sites, with median values at each of these sites in excess of 5 mg/l. A higher degree of variability in dissolved oxygen concentrations is apparent at the most downstream monitoring site (Site 02-02), presumably due to tidal influences.

2.1.8 <u>Discharge Data</u>

As indicated on Figure 2-11, a discharge gauging station (ID No. 2309502) is located in upper freshwater portions of the Innisbrook Canal which provides estimates of discharges originating in upstream portions of the Klosterman Bayou watershed. Data are available for this site over the period from December 2005 to the present. This site is currently operated and maintained by Hydrologic Data Collection, Inc. (HDI).

A graphical summary of historical discharge data for the Innisbrook Canal at monitoring Site 02-09 over the period from December 2005-September 2009 is given on Figure 2-14. Daily rainfall records are superimposed upon the historical discharge data based upon rainfall records collected by SWFWMD at the monitoring location identified as Tarpon Sink (I.D. No. 393) located approximately 1.7 miles from the center of the freshwater segment. Discharges over the horizontal weir structure have been highly variable, ranging from approximately 0-40 cfs over the period of record. However, the vast majority of measured values appear to be in the range of approximately 0-5 cfs, with peaks in discharge rates associated with significant large rain events or with significant cumulative rainfall occurring during prior days or weeks. The mean discharge rate at this site from December 2005-September 2009 is 0.95 cfs, with mean daily discharges ranging from 0-38.7. A virtually constant discharge has been observed at this site, even in the absence of rain events, with the exception of extreme dry periods during late spring conditions.

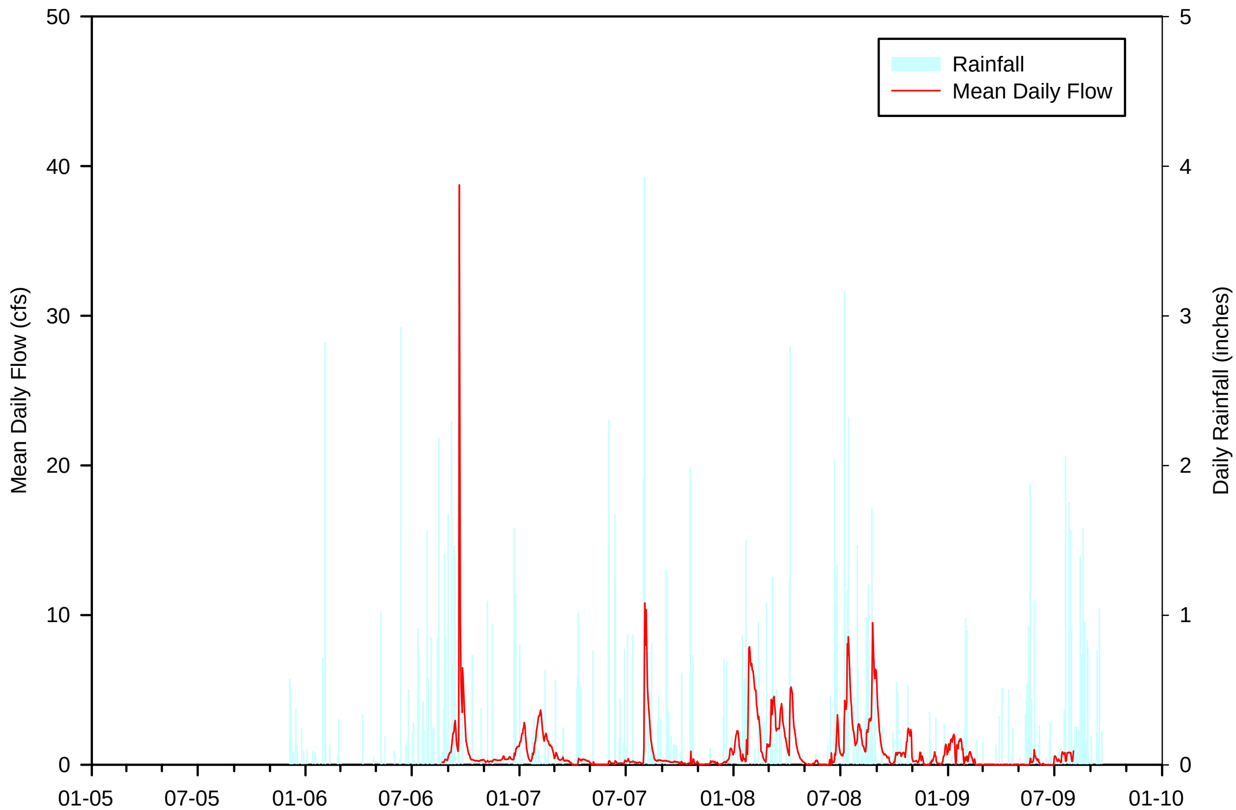


Figure 2-14. Historical Discharge Data for the Innisbrook Canal at Monitoring Site 02-09.

2.2 Joe's Creek Watershed

2.2.1 General Characteristics

The Joe's Creek Watershed is a 9256-acre drainage basin located in south-central Pinellas County. This large drainage basin includes parts of the cities of Pinellas Park, St. Petersburg, and Kenneth City. The Joe's Creek system includes a main branch and three tributaries identified as Miles Creek and Pinellas Park Ditch #4 and Ditch #5. Dominant land use categories in the Joe's Creek Watershed include residential, commercial, industrial, and recreational open space. The main channel of Joe's Creek flows from east to west, ultimately discharging into Cross Bayou. The primary tributary to Joe's Creek is Miles Creek which has existing poor water quality and is thought to contribute significant sediment loadings to Joe's Creek. An overview of the Joe's Creek drainage basin and significant tributaries is given on Figure 2-15.

The main channel of Joe's Creek is divided into a tidal segment (WBID 1668E) and a freshwater segment (WBID 1668A). The freshwater segment extends for approximately 2.3 miles along the creek until it reaches the uppermost portion of the tidal influence. In general, the tidal portion begins where the creek crosses under 46th Avenue in the City of St. Petersburg, with the freshwater segment located east of this crossing. The tidal segment of Joe's Creek illustrated on Figure 2-15 extends for an additional 4.6 miles. Work efforts conducted for this project are limited primarily to the freshwater segment of Joe's Creek (WBID 1668A).

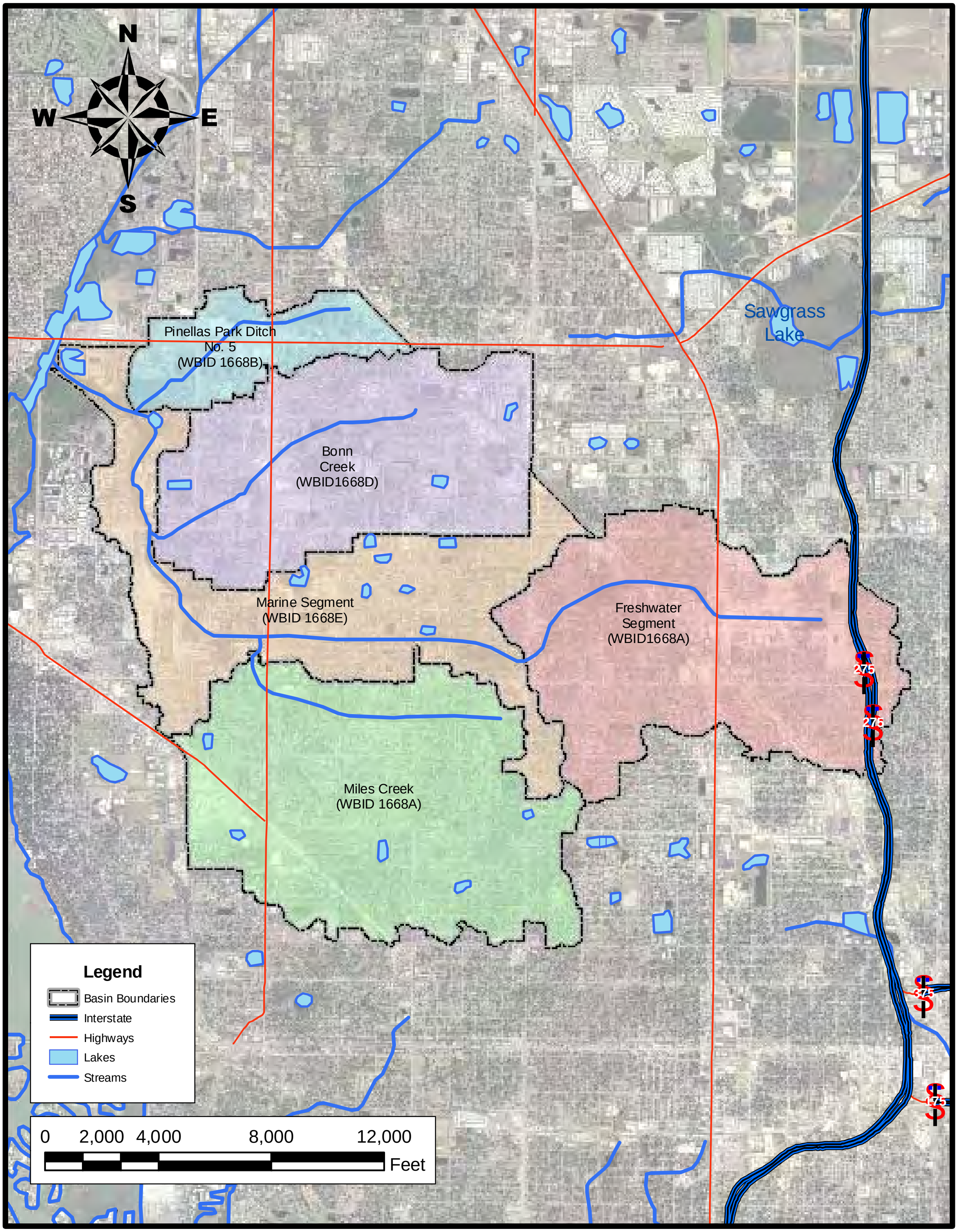


Figure 2-15. Hydrologic Segments in the Joe's Creek Watershed.

A summary of characteristics of sub-basin areas in the Joe's Creek watershed is given in Table 2-6. The largest sub-basin within the watershed is the Miles Creek basin which covers approximately 27.3% of the watershed. Approximately 24.3% of the watershed is covered by the freshwater segment, with 21.3% covered by the tidal segment, and 20.8% covered by the Bonn Creek basin. The Pinellas Park Ditch #5 basin area is relatively small, comprising only 6.3% of the total watershed area.

TABLE 2-6

CHARACTERISTICS OF SUB-BASIN AREAS IN THE JOE'S CREEK WATERSHED

SUB-BASIN	WBID NO.	AREA (acres)	PERCENT OF TOTAL
Freshwater Segment	1668A	2246.10	24.3
Tidal Segment	1668E	1971.30	21.3
Miles Creek	1668A	2524.80	27.3
Bonn Creek	1668D	1922.91	20.8
Pinellas Park Ditch #5	1668B	590.51	6.3
Totals:		**9255.62**	**100.0**

The basin area addressed as part of this project includes only the eastern freshwater portions of the Joe's Creek watershed, as indicated on Figure 2-15. The project area is bounded roughly by I-275 on the east, 49th Street North on the west, 54th Avenue North on the north, and 38th Avenue North on the south. This area is densely developed, consisting of a mixture of residential, commercial, and industrial land use activities. The estimated existing population in the freshwater portion of Joe's Creek is approximately 124,890 individuals (U.S. EPA, 2007). Much of the development within this portion of the basin was constructed prior to requirements for stormwater management system. The freshwater portion of the watershed has a total surface area of approximately 9 square miles and lies totally within Pinellas County. Major urban areas included in the freshwater segment are the City of St. Petersburg, Kenneth City, and West and East Lealman.

An evaluation of the Joe's Creek drainage basin was conducted by PBS&J during 2007 as part of a TMDL model development for FDEP. The resulting document titled "Technical Memorandum – Model Set-up, Refinement, Calibration, and Validation – Joe's Creek/Pinellas Park Ditch #5 Watershed TMDL Model Development" provides a discussion of the results of a HSPF and WSP modeling effort to estimate hydrologic and pollutant loadings to Joe's Creek. The modeling conducted by PBS&J was based upon standard runoff characterization data collected within the State of Florida. Similar to the Klosterman Bayou evaluation, the Joe's Creek Watershed model appears to show a poor correlation between simulated and measured concentrations of total nitrogen and total phosphorus. This pattern suggests that water quality processes in the Joe's Creek drainage basin are impacted by additional pollutant sources other than those predicted by standard runoff characterization data.

An additional evaluation of the Joe's Creek drainage basin was conducted by US EPA Region IV as part of a fecal coliform TMDL for Joe's Creek. The resulting document titled "Proposed TMDL Report – Fecal Coliform TMDL for St. Joes Creek WBID 1668A" provides a discussion of water quality impairment issues targeted at fecal coliform sources. This report also contains useful information on septic tanks, domestic wastewater, and reclaimed water usage within the basin. The US EPA report indicates that reuse water is used for irrigation within the Joe's Creek Watershed, although specific areas where reuse is used are not delineated.

2.2.2 Topography

A topographic map of the Joe's Creek watershed is given on Figure 2-16 based upon Lidar information obtained from the SWFWMD GIS system. Topography within the watershed ranges from near sea level in western portions of the basin to a maximum of approximately 80 ft (NGVD) in southeastern portions of the basin. A gradual decrease in land surface elevations is apparent in western portions of the freshwater segment, with a rapid decrease in elevation within the marine segment. Land surface elevations in the marine segment, Miles Creek, Bonn Creek, and Pinellas Park Ditch #5 basin areas range from approximately 0-20 ft (NGVD).

2.2.3 Soil Characteristics

Information on soil types within the Joe's Creek watershed were obtained from the Pinellas County GIS database. A graphical summary of hydrologic soil groups in the Joe's Creek watershed area is given on Figure 2-17, and a tabular summary of soil groups is given in Table 2-7. The vast majority of soils within the Joe's Creek watershed appear to be classified in HSG D which indicates sandy soils with a low infiltration rate and high runoff potential. This soil type covers more than 80% of the area within the freshwater segment. Areas of HSG C soils are also present in the basin, which include sandy soils with a moderate infiltration rate and moderate runoff potential. Areas of B/D soils are present in northwestern portions of the watershed, particularly in the Bonn Creek and Pinellas Park Ditch #5 sub-basins. Overall, the runoff potential for the freshwater segment appears to be relatively high due to the low permeability of the soils within this area.

TABLE 2-7

SUMMARY OF HYDROLOGIC SOIL GROUPS IN THE JOE'S CREEK WATERSHED

HSG	AREA (acres)					
	Freshwater Segment	**Marine Segment**	**Miles Creek**	**Bonn Creek**	**Pinellas Park Ditch #5**	**Total**
B/D	41.16	279.80	348.20	1120.07	448.15	2237.38
C	190.97	453.19	558.48	152.96	116.67	1472.27
D	2000.35	1212.76	1606.89	639.05	25.69	5484.74
W	13.62	25.55	11.23	10.83	0.00	61.23
Total:	**2246.10**	**1971.30**	**2524.80**	**1922.91**	**590.51**	**9255.62**

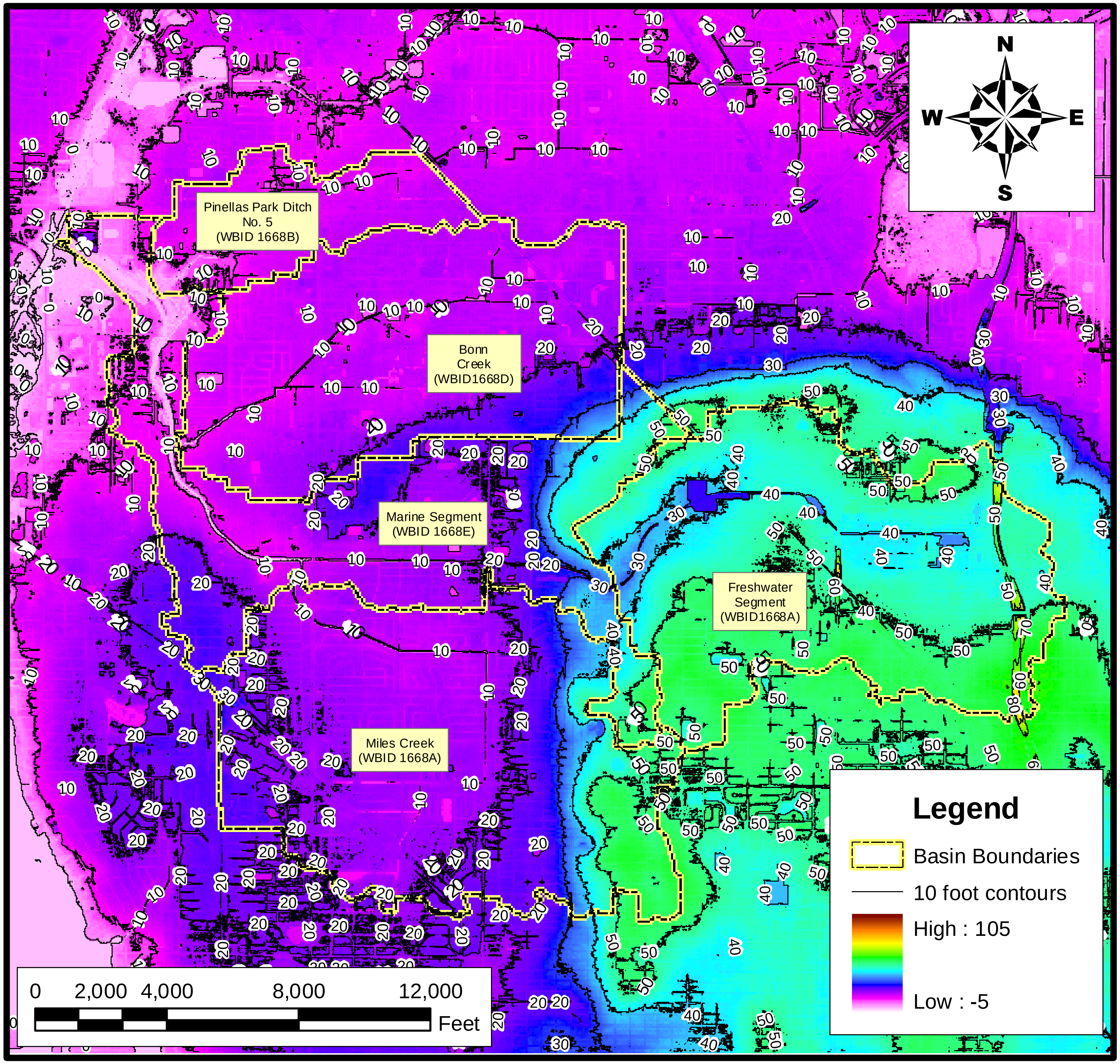


Figure 2-16.

Topographic Contours in the Joe's Creek Watershed.

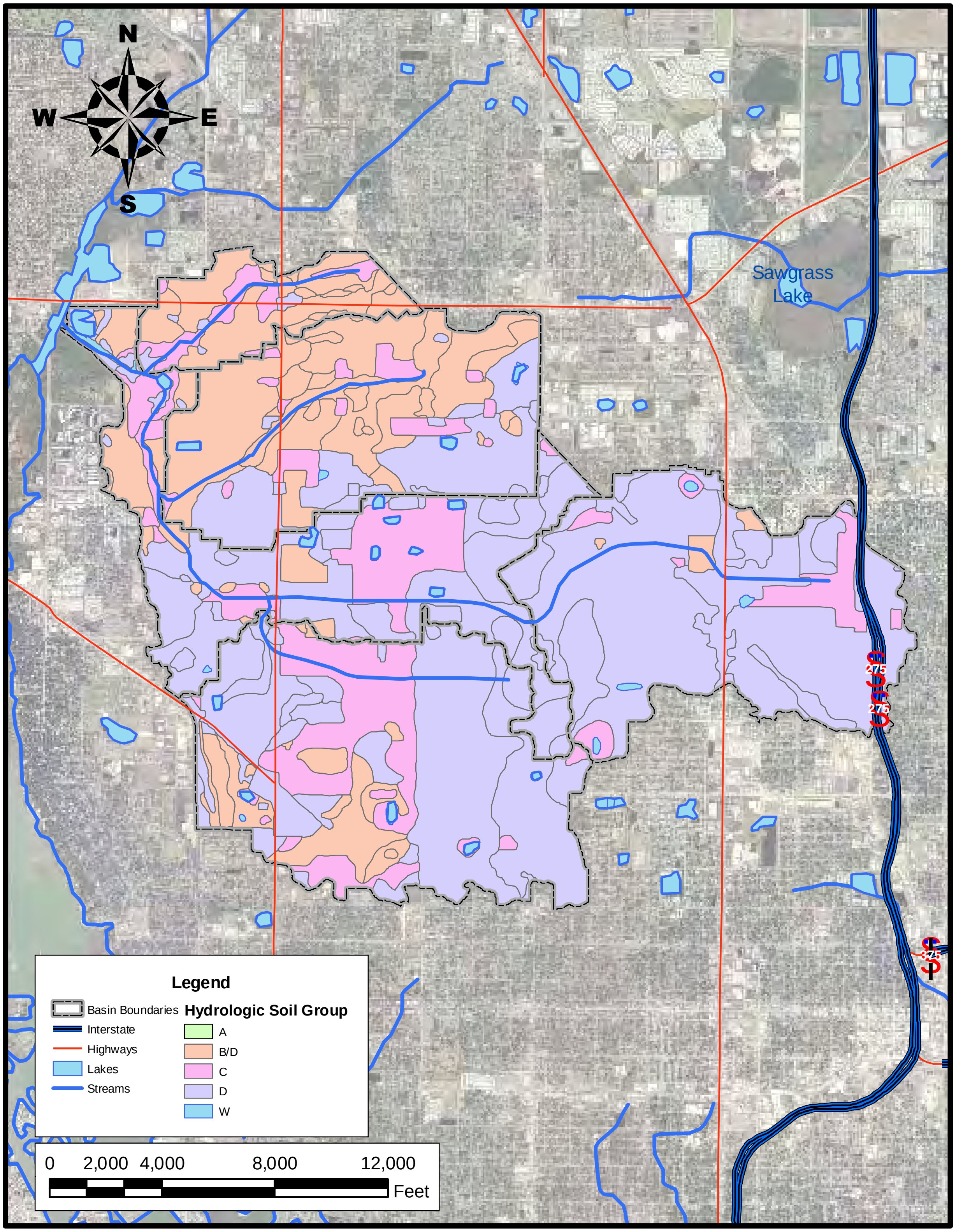


Figure 2-17. Hydrologic Soil Groups in the Joe's Creek Watershed.

2.2.4 Land Use

Land use data were obtained from the SWFWMD GIS database, which reflects 2007 land coverage in the form of Level 3 FLUCCS codes. A graphical overview of land use within the Joe's Creek watershed is given on Figure 2-18, and a tabular summary is given in Table 2-8. Residential land use is the largest land use component in the freshwater segment, comprising approximately 67.7% of the total area for this basin. An additional 12.4% of the basin area is covered by industrial land uses, with 8.6% covered by commercial activities. The remaining land use categories comprise approximately 3% or less of the total basin area.

2.2.5 Hydrology

Photographs of upstream portions of Joe's Creek are given on Figure 2-19. Joe's Creek originates as the discharge from the box culvert structure indicated on Figure 2-19. Discharges from the culvert enter a man-made waterbody referred to as Silver Lake which provides detention for inflows prior to discharging downstream. Photographs of Silver Lake are given on Figure 2-20. Water level in Silver Lake is regulated by a compound weir structure, consisting of a rectangular concrete weir with a 4-ft wide x 1 ft deep trapezoidal weir in the center of the rectangular weir. The photograph indicated on Figure 2-20b shows a rare submerged condition for the Silver Lake weir. During the majority of monitoring events conducted by ERD, water levels in Silver Lake were lower than the weir crest elevation, with a minimal flow discharging through the trapezoidal portion of the weir.

After leaving Silver Lake, discharges through Joe's Creek enter a channelized portion of the creek characterized by vertical sea walls and concrete-lined channels. These channelized areas extend approximately from the Silver Lake weir to the U.S. 19 bridge. Photographs of the channelized portions of Joe's Creek are given on Figure 2-21. A number of miscellaneous inflows discharge to Joe's Creek through this area which introduce additional volumetric and pollutant loadings to the creek. Photographs of miscellaneous inflows are given on Figure 2-22.

After crossing under 34th Street, Joe's Creek transforms into an earthen channel with steep side banks. Most of the side banks are in a vegetated state, with riprap placed in steeper areas in the vicinity of the railroad crossing. A photograph of the earthen channel portions of Joe's Creek is given on Figure 2-23. The earthen channel portions of the creek eventually discharge into the SWFWMD treatment pond. This pond was constructed by the District to provide additional treatment for discharges through Joe's Creek. Photographs of the SWFWMD pond are given on Figure 2-24. Water level within the pond is regulated by a weir structure located downstream from the pond. Discharges through the weir structure then continue downstream, ultimately reaching tidal portions of the Joe's Creek watershed.

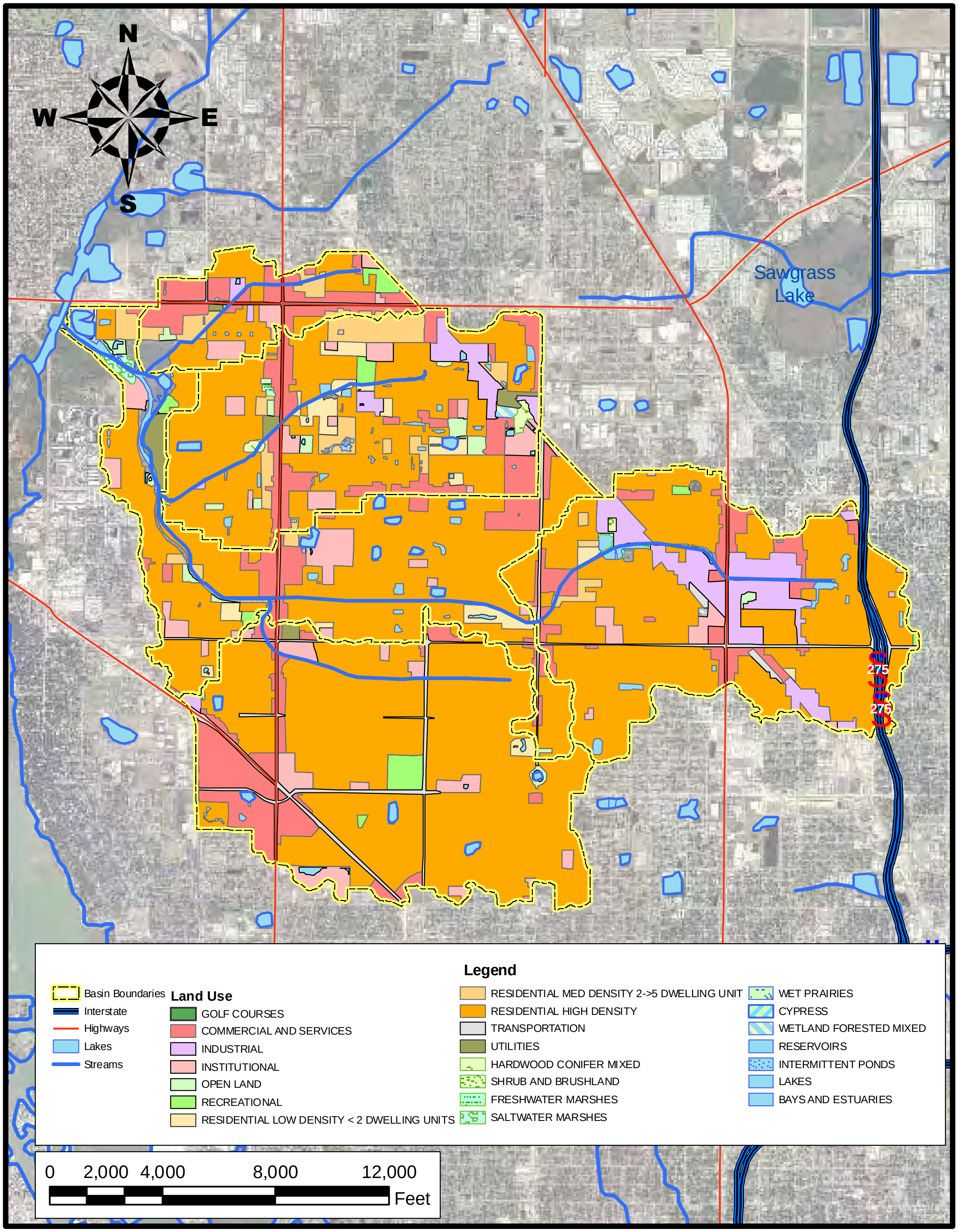


Figure 2-18. Land Use Characteristics in the Joe's Creek Watershed.
(Source: SWFWMD)

TABLE 2-8

SUMMARY OF CURRENT (2007) LAND USE IN THE JOE'S CREEK WATERSHED

LAND USE CATEGORY	FRESHWATER SEGMENT		MARINE SEGMENT		MILES CREEK		BONN CREEK		PINE. PARK DITCH #5		TOTAL	
	Acres	% of Total	Acres	% of Total	Acres	% of Total	Acres	% of Total	Acres	% of Total	Acres	% of Total
Low-Density Residential (<2 du/ac)	11.57	0.5	44.13	2.2	9.82	0.4	80.85	4.2	0.00	0.0	146.37	1.6
Medium-Density Residential (2-5 du/ac)	26.74	1.2	37.85	1.9	0.00	0.0	153.29	8.0	60.70	10.3	278.58	3.0
High-Density Residential	1484.09	66.1	1313.21	66.6	1883.51	74.6	1058.84	55.1	197.75	33.5	5937.40	64.1
Commercial and Services	192.64	8.6	183.35	9.3	303.93	12.0	265.28	13.8	190.46	32.2	1135.66	12.3
Industrial	279.58	12.4	22.36	1.1	12.98	0.5	94.11	4.9	11.52	2.0	420.55	4.5
Institutional	51.25	2.3	125.26	6.4	130.14	5.1	94.46	4.9	45.58	7.7	446.69	4.8
Recreational	9.15	0.4	12.52	0.6	40.93	1.6	13.47	0.7	16.69	2.8	92.76	1.0
Open Land	4.48	0.2	17.24	0.9	4.99	0.2	36.34	1.9	5.29	0.8	68.34	0.8
Nurseries and Vineyards	3.50	0.2	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	3.50	< 0.1
Pine Flatwoods	0.00	0.0	1.58	0.1	0.00	0.0	0.00	0.0	0.00	0.0	1.58	< 0.1
Hardwood Conifer Mixed	2.95	0.1	1.10	0.1	0.00	0.0	19.46	1.0	0.00	0.0	23.51	0.3
Streams and Waterways	3.91	0.2	14.73	0.7	0.10	< 0.1	0.83	< 0.1	0.00	0.0	19.57	0.2
Lakes	0.00	0.0	0.00	0.0	2.70	0.1	0.00	0.0	0.00	0.0	2.70	< 0.1
Reservoirs	40.63	1.8	40.54	2.1	18.80	0.7	47.83	2.5	2.70	0.5	150.50	1.6
Bays and Estuaries	0.00	0.0	28.46	1.4	0.00	0.0	0.00	0.0	0.11	< 0.1	28.57	0.3
Mangrove Swamp	0.00	0.0	3.10	0.2	0.00	0.0	0.00	0.0	0.00	0.0	3.10	< 0.1
Stream and Lake Swamps (bottomland)	1.65	0.1	31.90	1.6	0.00	0.0	2.81	0.1	31.01	5.3	67.37	0.7
Wetland Forested Mixed	0.00	0.0	3.64	0.2	0.00	0.0	6.62	0.3	0.00	0.0	10.26	0.1
Freshwater Marshes	5.10	0.2	0.48	< 0.1	0.00	0.0	4.40	0.2	0.00	0.0	9.98	0.1
Saltwater Marshes	0.00	0.0	20.52	1.0	0.00	0.0	0.00	0.0	0.00	0.0	20.52	0.2
Emergent Aquatic Vegetation	2.32	0.1	0.00	0.0	0.00	0.0	3.53	0.2	1.01	0.2	6.86	0.1
Transportation	124.18	5.5	31.33	1.6	107.68	4.3	14.43	0.8	24.83	4.2	302.45	3.3
Communications	2.36	0.1	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	2.36	< 0.1
Utilities	0.00	0.0	38.00	1.9	9.22	0.4	26.39	1.4	2.90	0.5	76.51	0.8
Totals:	**2246.10**	**100.0**	**1971.30**	**100.0**	**2524.80**	**100.0**	**1922.91**	**100.0**	**590.51**	**100.0**	**9255.62**	**100.0**

Figure 2-19. Photographs of Upstream Portions of Joe's Creek.

a. Silver Lake

b. Silver Lake Weir

Figure 2-20. Photographs of Silver Lake.

a. Joe's Creek Downstream from Silver Lake Weir

b. Joe's Creek at U.S. 19 Bridge Crossing

Figure 2-21. Channelized Portions of Joe's Creek.

Figure 2-22.   Miscellaneous Inputs to Joe's Creek.

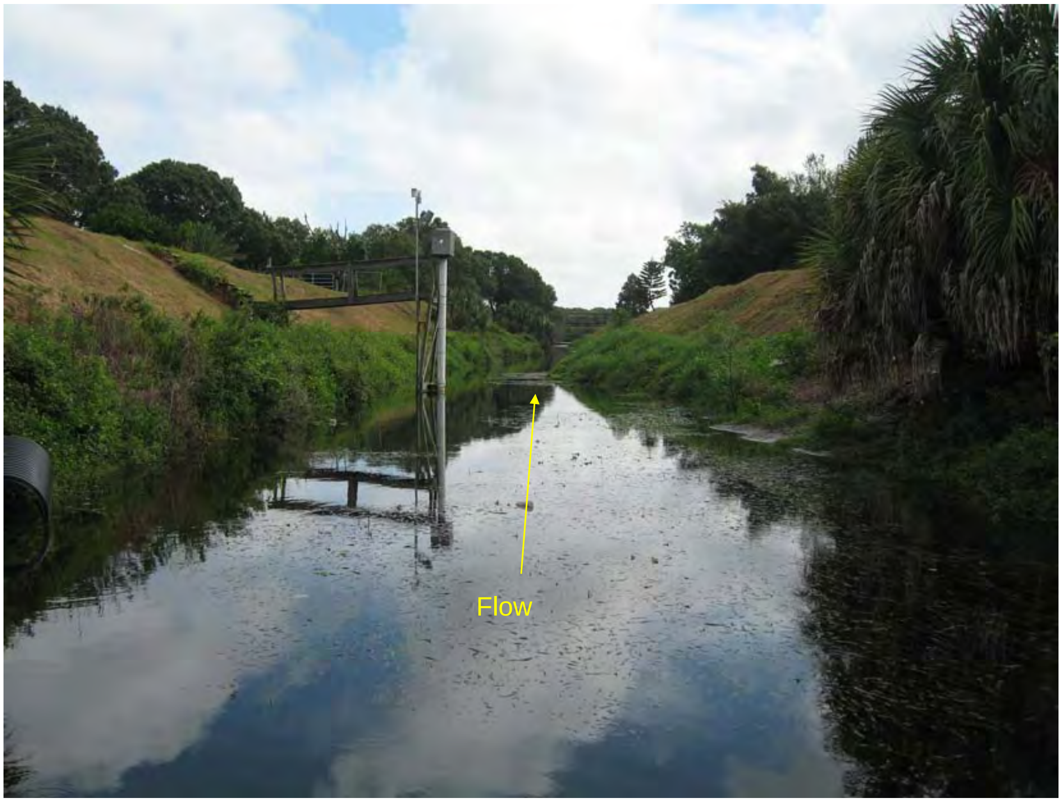


Figure 2-23. Earthen Channel Portions of Joe's Creek.

2.2.6 Impaired Waters

The freshwater portion of the Joe's Creek watershed is designated as a Class III recreational water, as outlined in Section 62-302.530 of the Florida Administrative Code (FAC). The freshwater segment of Joe's Creek (WBID 1668A) in Pinellas County is listed as an impaired water for dissolved oxygen, nutrients, and BOD. Nutrients are stated to be the causative pollutant for the dissolved oxygen impairment, with a median total phosphorus concentration of 0.07 mg/l during the verified period, a total nitrogen concentration of 0.93 mg/l, and a median BOD concentration of 2.0 mg/l. The nutrient impairment is based upon average chlorophyll-a values over the period from 1999-2005 which exceeded the historical annual average value of 4.75 mg/m^3 by more than 50% in 1999, 2000, 2001, 2003, 2004, and 2005. The waterbody is stated to be co-limited by nitrogen and phosphorus based on a median TN/TP ratio of 12.2.

A TMDL for the freshwater segment was prepared by the U.S. EPA and released in September 2007. The TMDL indicates a target pollutant load reduction of 49% for total phosphorus and 49% for total nitrogen. According to U.S. EPA, Joe's Creek had an exceedance rate of 62% for dissolved oxygen over the period from 1993-2006, with violations of the Class III criterion for dissolved oxygen in 203 out of 295 observations. Over this time, the average total nitrogen and total phosphorus concentrations were 0.91 mg/l and 0.08 mg/l, respectively.

Figure 2-24. Photographs of the SWFWMD Pond.

2.2.7 Water Quality Data

A review of available historical water quality data collected in the Joe's Creek watershed was conducted using the U.S. EPA STORET database as well as the Pinellas County Water Atlas data. Much of the historical data is duplicated within the two databases, although unique data were obtained from both the STORET and Water Atlas sources which were not contained within the other system. Locations of the identified water quality monitoring sites in the Joe's Creek watershed are indicated on Figure 2-25, along with the sample site reference number for each location. Surface water monitoring sites are scattered throughout the freshwater and marine segments of the Joe's Creek watershed. A complete listing of available water quality data for monitoring sites located within the Joe's Creek watershed is given in Appendix A.2.

A summary of available water quality data sources for the Joe's Creek watershed is given in Table 2-9. Water quality data have been collected at a total of 25 monitoring sites within the watershed area, beginning as early as 1973. Five of the surface water sites were monitored by USGS, although most of the sites contain very limited amounts of data, most of which was collected during the 1970s and 1980s. The most continuous data set collected by USGS was at Station ID No. 2308935, located at the same site as Pinellas County Site 35-11, which contains 276 measurements collected from 1984-2003. Surface water monitoring was also conducted at eight monitoring sites by the Southwest District of FDEP from 2004-2009, although the available data are relatively limited. These monitoring sites are designated on Table 2-9 as "STORET_21FLTPA".

The largest amount of available data appears to have been generated as part of the Pinellas County surface water monitoring program. Pinellas County has 10 surface water monitoring sites within the Joe's Creek watershed, with data available from 1991-2009 and sample sizes ranging from 24-266. Historical monitoring sites located within portions of Joe's Creek evaluated as part of this project are highlighted in yellow.

A summary of mean water quality characteristics measured at monitoring sites in the Joe's Creek watershed is given in Table 2-10. Water quality data are only provided for the monitoring sites conducted by Pinellas County since these sites reflect the most recent and complete data sources for the creek. The monitoring sites are divided into sites located along the Main Channel, along Miles Creek, along Bonn Creek, and Channel #5. Water samples collected at all of the monitoring sites appear to be characterized by elevated fecal coliform counts, with mean fecal coliform concentrations substantially in excess of the Class III criterion of 400 cfu/100 ml (monthly average). The historical data collected along the Main Channel indicate moderate levels of total nitrogen, with mean concentrations ranging from 677-1073 μg/l, and moderately elevated levels of total phosphorus, with mean concentrations ranging from 58-105 μg/l. Concentrations of both total phosphorus and total nitrogen in the Miles Creek tributary, Bonn Creek tributary, and Channel #5 monitoring sites are all higher in value than concentrations measured along the main channel of Joe's Creek upstream of the point of inflow for Miles Creek.

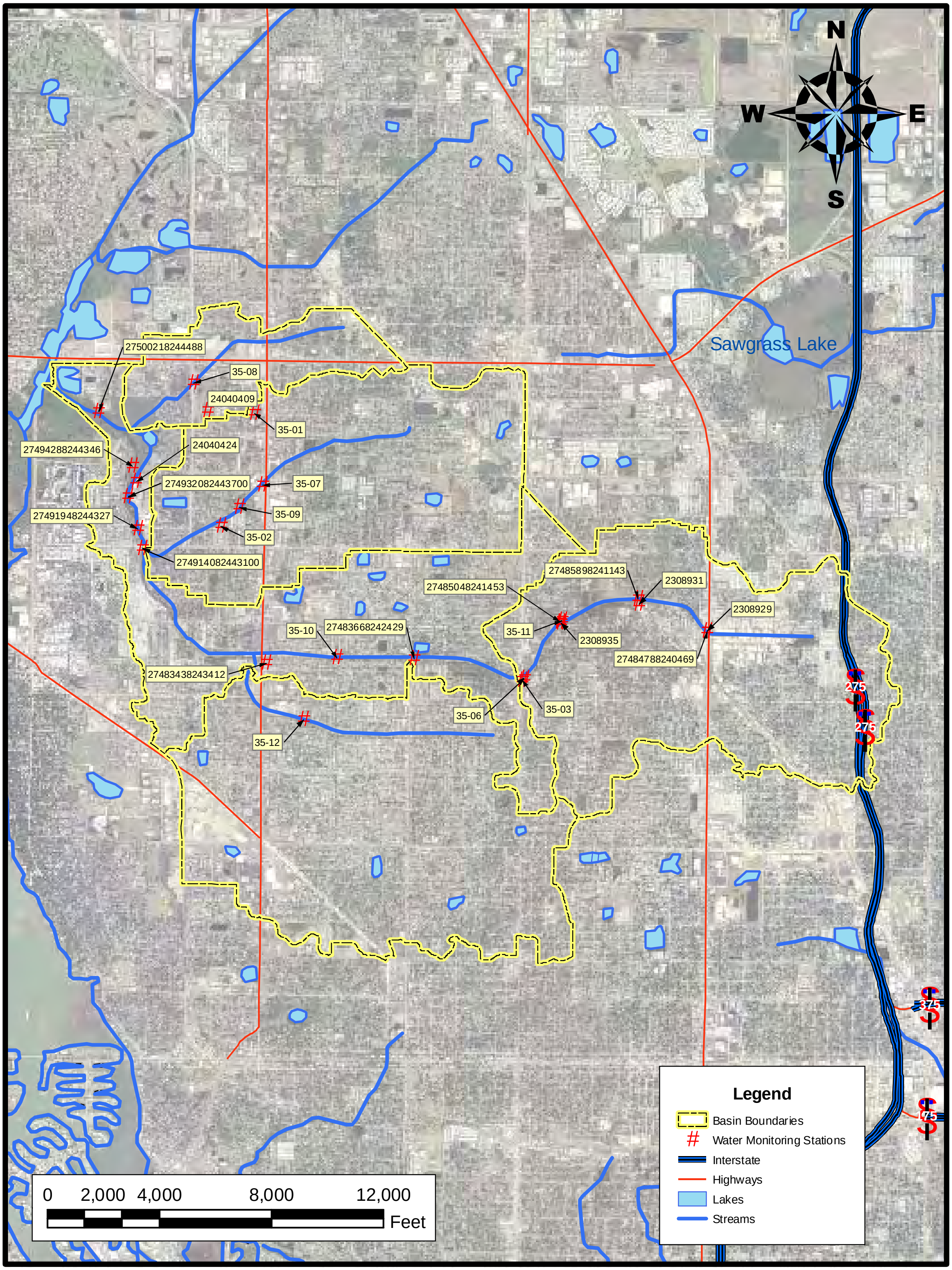


Figure 2-25. Locations of Historical Water Quality Monitoring Sites in the Joe's Creek Watershed.

TABLE 2-9

SUMMARY OF AVAILABLE WATER QUALITY DATA SOURCES FOR THE JOE'S CREEK WATERSHED

STATION I.D.	STATION NAME	DATA SOURCE	COLLECTION DATES	NUMBER OF SAMPLES
2308929	St. Joe's Creek at St. Petersburg, FL	USGS-NWIS	8/29/75 - 3/21/80	23
2308931	St. Joe's Creek at Lealman, FL	USGS-NWIS	8/18/86 – 8/22/91	82
2308935	St. Joe's Creek at Pinellas Park, FL	USGS-NWIS	11/19/84 – 4/29/03	276
24040409	5 km Joe's Creek off Cross Bayou	LEGACYSTORET_21FLA	4/30/75 – 8/27/75	4
24040424	Joe's Creek at 54th Avenue	LEGACYSTORET_21FLA	10/2/73 – 10/4/73	3
274914082443100	Joe's Creek at 54th Avenue N at St. Petersburg, FL	USGS-NWIS	10/19/73 – 10/19/73	2
274932082448700	10J Joe's Creek at SCB Pol Plant at St. Petersburg, FL	USGS-NWIS	10/19/73 – 11/8/74	5
27483438243412	TP343 – St. Joe's Creek	STORET_21FLTPA	3/29/04 – 1/21/09	7
27483668242429	TP342 – St. Joe's Creek	STORET_21FLTPA	3/29/04 – 1/21/09	6
27484788240469	TP339 – St. Joe's Creek	STORET_21FLTPA	3/29/04 - 12/13/04	6
27485048241453	TP341 – St. Joe's Creek	STORET_21FLTPA	3/29/04 – 1/21/09	7
27485898241143	TP340 – St. Joe's Creek	STORET_21FLTPA	3/29/04 – 1/21/09	5
27491948244327	TP336 – St. Joe's Creek	STORET_21FLTPA	3/29/04 – 1/18/05	10
27494288244346	TP337 – St. Joe's Creek	STORET_21FLTPA	3/29/04 – 1/18/05	10
27500218244488	TP338 – St. Joe's Creek	STORET_21FLTPA	3/29/04 – 1/18/05	10
35-01	Joe's Creek	Pinellas County	1/16/91 – 12/18/08	115
35-02	Joe's Creek	Pinellas County	1/16/91 – 11/20/02	226
35-03	Joe's Creek	Pinellas County	2/20/91 – 10/16/02	75
35-06	Joe's Creek	Pinellas County	1/11/95 – 11/20/02	66
35-07	Joe's Creek	Pinellas County	1/11/95 – 11/3/98	24
35-08	Joe's Creek	Pinellas County	1/13/99 – 11/20/02	61
35-09	Joe's Creek	Pinellas County	2/10/99 – 4/8/09	95
35-10	Joe's Creek	Pinellas County	1/7/03 – 4/8/09	59
35-11	Joe's Creek	Pinellas County	1/7/03 – 4/8/09	86
35-12	Joe's Creek	Pinellas County	1/7/03 – 4/8/09	63

(yellow box) Indicates monitoring sites located within the limits of this project

TABLE 2-10

SUMMARY OF MEAN WATER QUALITY CHARACTERISTICS MEASURED AT MONITORING SITES IN THE JOE'S CREEK WATERSHED

STATION I.D.		PARAMETER											
		pH (s.u.)	Cond. (μmho/cm)	D.O. (mg/l)	Turb. (NTU)	BOD_5 (mg/l)	Fecal Coliform (cfu/100 ml)	Total Coliform (cfu/100 ml)	NO_x (μg/l)	TKN (μg/l)	Total N (μg/l)	Total P (μg/l)	TSS (mg/l)
Main Channel	35-11 (Joe's Creek)	7.44	286	5.8	4	3.2	1178	767	59	812	870	71	5.9
	35-06 (Joe's Creek)	7.56	339	4.7	5	3.4	1892	2055	79	994	1073	105	8.3
	35-03 (Joe's Creek)	7.41	341	6.2	2	1.6	709	1329	95	583	677	75	3.2
	35-10 (Joe's Creek)	7.22	339	6.1	3	2.5	1720	1370	126	623	749	58	3.2
Miles Creek	35-12 (Joe's Creek)	7.35	592	6.3	3	3.2	2057	1681	217	812	1031	84	3.8
Bonn Creek	35-07 (Joe's Creek)	7.59	655	5.3	4	1.7	1439	1259	73	859	932	136	4.1
	35-09 (Joe's Creek)	7.57	734	5.9	7	1.8	1640	477	130	831	961	87	9.4
	35-02 (Joe's Creek)	7.48	11,785	5.0	6	2.9	1665	1577	112	921	1035	166	8.9
Channel #5	35-01 (Joe's Creek)	7.50	714	4.5	18	2.3	2010	1994	61	1073	1137	173	16.6
	35-08 (Joe's Creek)	7.49	4321	4.5	9	4.2	--	--	176	1147	1322	193	9.5

A statistical comparison of historical water quality data for nitrogen species in the freshwater segment of Joe’s Creek is given on Figure 2-26. As discussed previously for the historical data within the Klosterman Bayou watershed, the data summarized on Figure 2-26 reflect widely differing periods of time. In general, data collected at the Pinellas County monitoring sites indicate moderate to low concentrations of total nitrogen within the freshwater segment of Joe’s Creek. Somewhat higher levels of total nitrogen have been measured at the USGS monitoring sites indicated by Site Nos. 2308931 and 2308935. Measured historical concentrations of NO_x also appear to be relatively low in value within the freshwater segment, with median concentrations less than 100 μg/l at virtually all sites. However, substantial exceedances of this value have been observed on occasion at all monitoring sites.

A statistical comparison of historical water quality data for phosphorus, BOD, and dissolved oxygen in the freshwater segment of Joe’s Creek is given on Figure 2-27. In general, median concentrations of total phosphorus at the freshwater monitoring sites are near or below 100 μg/l at all sites, although substantial exceedances of this value have been observed on multiple occasions at each of the monitoring sites. Measured concentrations of BOD in Joe’s Creek appear to be relatively low in value, with median concentrations ranging from approximately 1.5-3 mg/l, although substantial exceedances of these values have also been observed. Dissolved oxygen concentrations in the freshwater segment of Joe’s Creek have been highly variable, with median values ranging from 4-6 mg/l. Measured values substantially less than and greater than this value have been observed on multiple occasions.

2.2.8 Discharge Data

Historical discharge data are available at two monitoring sites within the freshwater segment of Joe’s Creek. Both sites are operated by the USGS and are referred to as Site No. 2308931 (located upstream from the SWFWMD treatment pond) and Site No. 2308935 (located at the weir structure downstream from the SWFWMD treatment pond). Flow data at the upstream monitoring site (Site No. 2308931) are available over the period from 1989-1991. Flow data at the downstream site (Site No. 2308935) are available from 1985-1991 and from 2000 to the present.

A graphical summary of historical discharge data for the USGS monitoring Site No. 2308935 is given on Figure 2-28. Discharge rates within the creek have been highly variable over time, ranging from near zero to more than 250 cfs with periodic flow rates of 100 cfs or more. However, the vast majority of monitored flow rates are equal to 50 cfs or less. The USGS monitoring Site No. 2308935 also collects daily rainfall records which are superimposed on Figure 2-28 to illustrate the response of the Creek to various rain events.

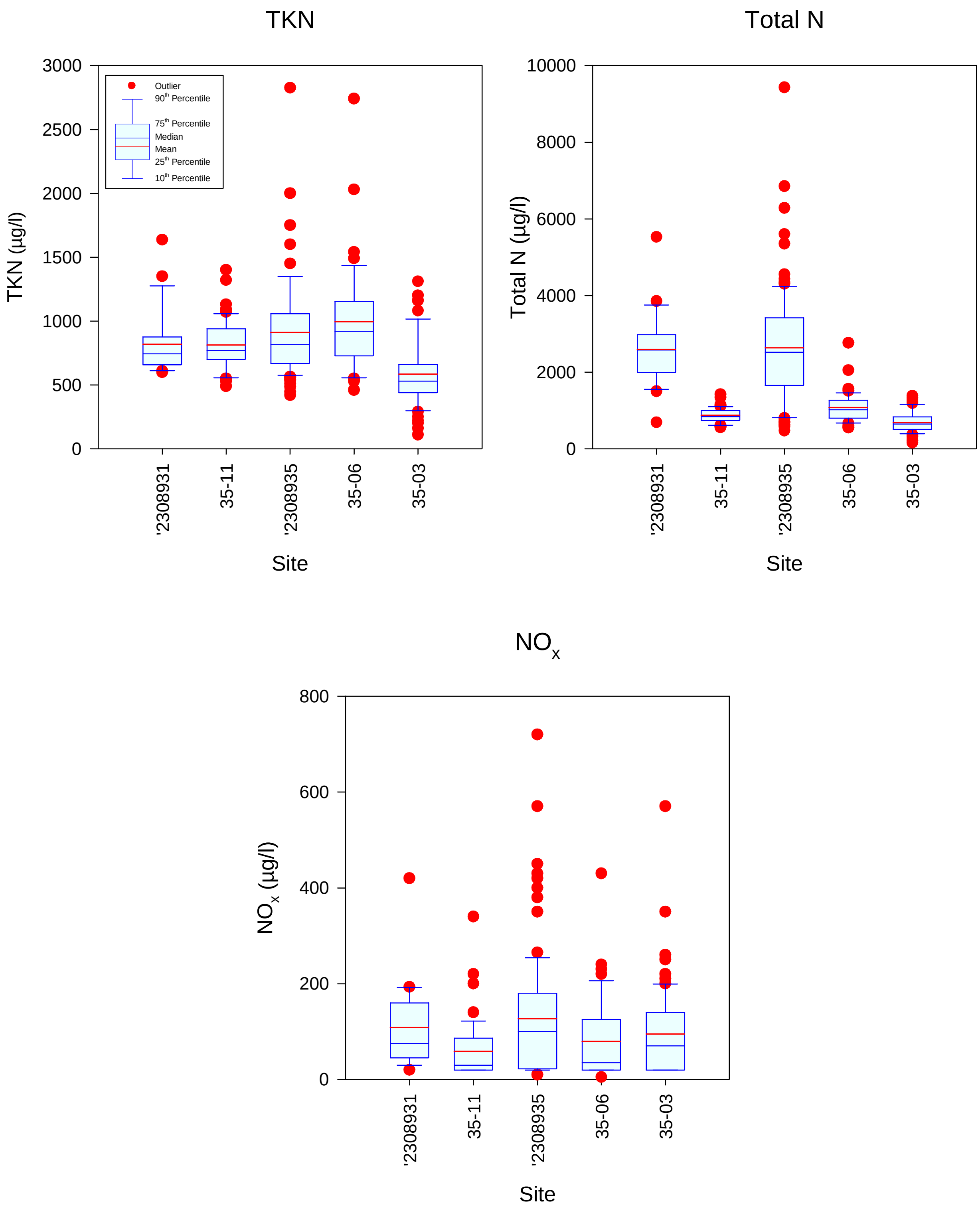


Figure 2-26. Statistical Comparison of Historical Water Quality Data for Nitrogen Species in the Freshwater Segment of Joe's Creek.

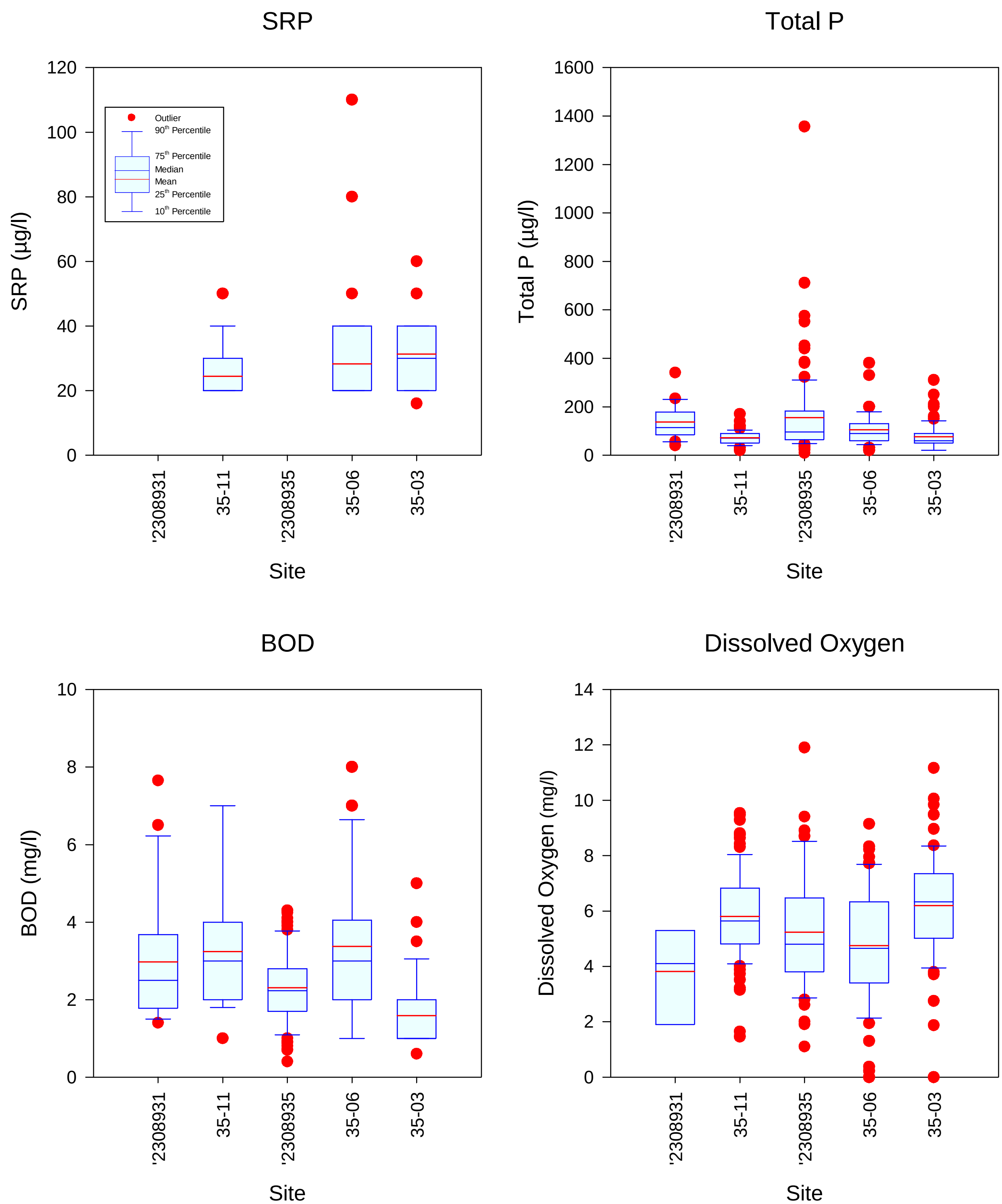


Figure 2-27. Statistical Comparison of Historical Water Quality Data for Phosphorus. BOD, and Dissolved Oxygen in the Freshwater Segment of Joe's Creek.

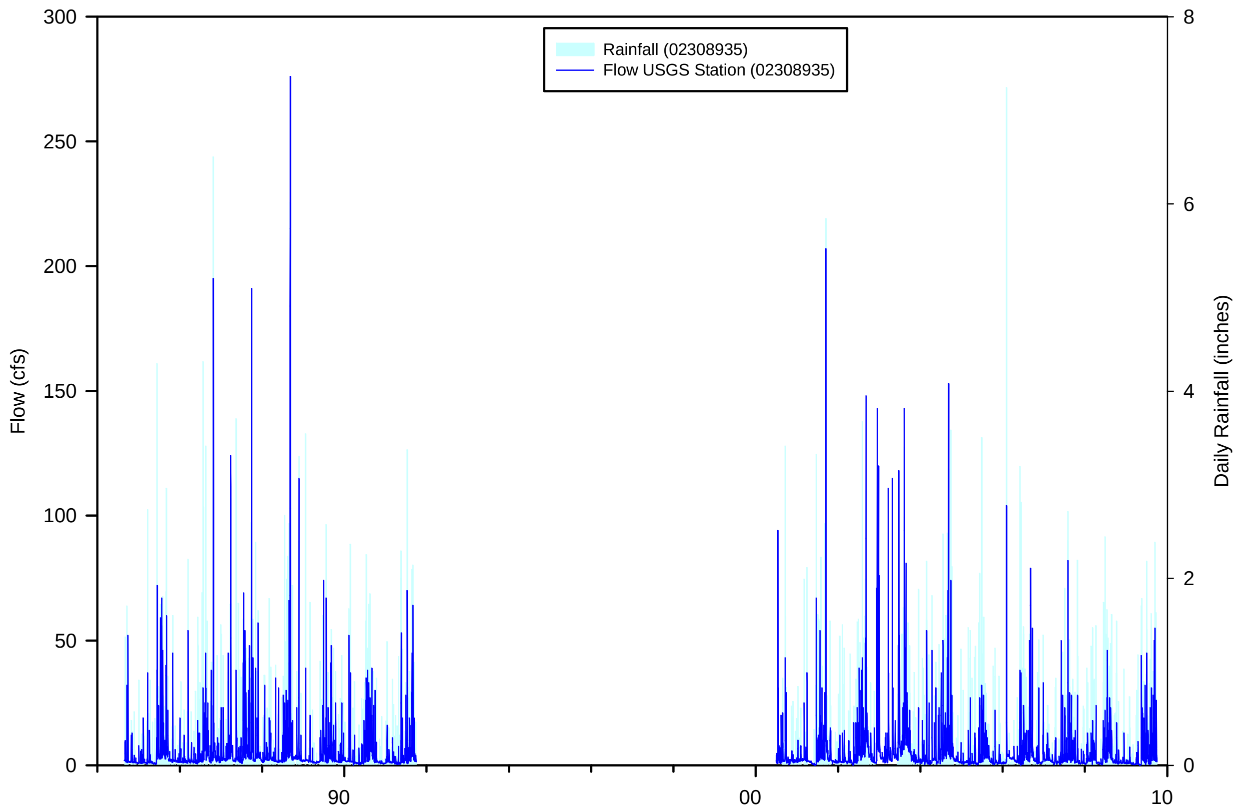
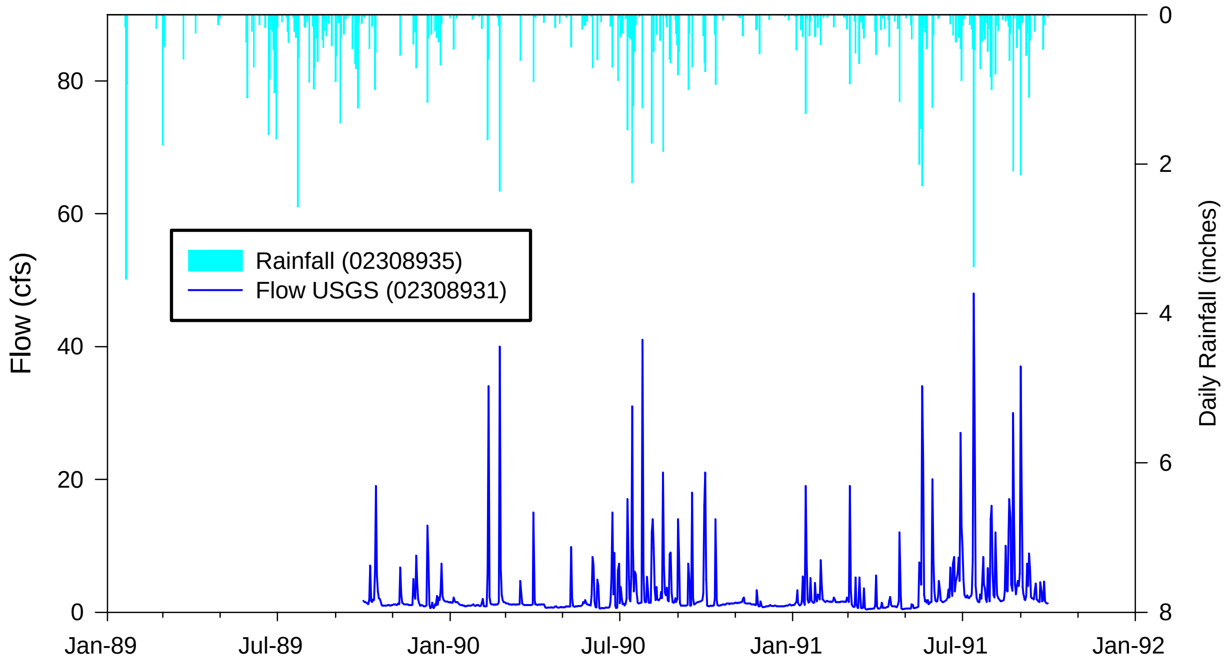
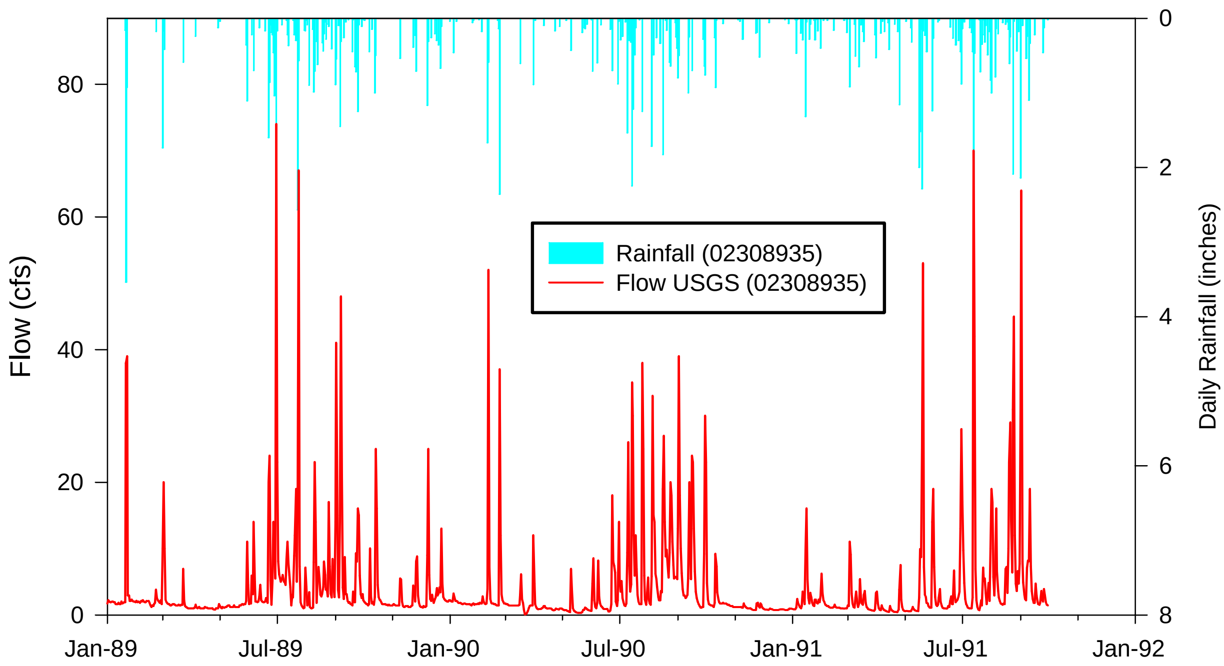


Figure 2-28. Historical Discharge Data for the Freshwater Segment of Joe's Creek (Site No. 2308935).

Historical discharge data for USGS gauging stations 2308935 and 2308931 are summarized in Figure 2-29 over the period from 1989-1991 which is the only period of time which has data for both sites. Over this period, discharge within the canal exceeded 70 cfs on two occasions and 60 cfs on two additional occasions. Peak flows during the remaining events are equal to approximately 50 cfs or less. Total daily rainfall for the period from 1989-1991 is superimposed on Figure 2-29 based upon rainfall measurements recorded at monitoring Site 2308935. The annual rainfall measured at the St. Petersburg airport during this period ranged from 46.81-62.29 inches, with an annual average of 56.54 inches, compared with a mean of 51.79 inches over the period from 1971-2009. The St. Petersburg meteorological site is used for the long-term comparison since data for Site 2308935 are only available from 1984-1991 and from 2000 to the present. Rainfall during the period indicated on Figure 2-29 appears to have been at or above normal annual rainfall. Measured flow rates during most events appear to be greater at Site 2308931 which is located downstream from Site 2308935.



a. Site No. 2308931



b. Site No. 2308935

Figure 2-29. Discharge Data for Site No. 2308931 and Site No. 2308935 from 1989-1991

SECTION 3

FIELD AND LABORATORY ACTIVITIES

Field monitoring and laboratory analyses were conducted by ERD from July-September 2008 within the Klosterman Bayou and Joe's Creek watersheds to characterize the quantity and quality of discharges through each area. Twelve surface water sites were monitored on a biweekly basis, which included measurement of field parameters, discharge rates (if applicable), and sample collection for laboratory analyses. Four groundwater monitoring wells were installed to evaluate groundwater impacts from potential pollutant sources, and samples of shallow groundwater were also collected during each biweekly monitoring event. Each of the collected samples was analyzed in the ERD Laboratory for general parameters and nutrients. In addition, aliquots of each collected sample were shipped to the Colorado Plateau Stable Isotope Laboratory for isotope analyses of nitrogen and oxygen within the collected samples to assist in identifying potential pollutant sources.

3.1 Field Activities

3.1.1 Monitoring Sites

A site visit and field reconnaissance meeting was conducted to the Klosterman Bayou and Joe's Creek project sites on May 27, 2008. This field meeting was attended by representatives of ERD, Pinellas County, and the Southwest Florida Water Management District (SWFWMD). The primary purpose of this meeting was to discuss drainage patterns within each of the two areas and select monitoring locations for both surface water and groundwater within each basin. A description of the selected monitoring locations in the Klosterman Bayou and Joe's Creek drainage basin areas is given in the following sections.

3.1.1.1 Klosterman Bayou Watershed

An overview of surface water monitoring sites selected within the Klosterman Bayou study area is given on Figure 3-1. Five monitoring locations were identified to document surface water flows into, within, and out of the Innisbrook Golf Course (IGC) complex. A tabular summary of monitoring sites for the Klosterman Bayou study is given on Table 3-1. The selected monitoring sites are intended to provide an analysis of water quality characteristics, including changes in nutrient loadings, during migration through the study area.

The location of surface water monitoring Site 1 for the Klosterman Bayou study is illustrated on Figure 3-2. This site is located at the point of inflow from Bee Pond into the southernmost golf course pond (referred to as Lake Innisbrook) system. Field monitoring was conducted at the inflow to the 24-inch PVC which discharges from the Bee Pond wetland into Lake Innisbrook. This site provides characteristics of inflow from the off-site residential areas east and south of the golf course and reflects the largest single off-site inflow onto the IGC site.

Figure 3-1. Overview of Surface Water Monitoring Sites for the Klosterman Bayou Watershed.

TABLE 3-1

SUMMARY OF MONITORING SITES FOR THE KLOSTERMAN BAYOU WATERSHED

SAMPLE WATER	SITE NO.	DESCRIPTION	PURPOSE
Surface Water	KB-1S	Discharge from Bee Pond	Primary off-site inflow
	KB-2S	a. Inflow from NE wetland area, or, if no inflow: b. NE pond	a. Secondary off-site inflow b. Most upstream pond in NE pond series
	KB-3S	Northern pond	Most upstream pond in northern central drainage flow
	KB-4S	Concrete weir in Innisbrook Canal	Controlled site located in middle of study area
	KB-5S	Site outfall	Primary outfall for IGC
Groundwater	KB-1G	Upstream monitoring well	Groundwater upstream from study area
	KB-2G	Golf course well	Groundwater in center of study area
	KB-3G	Wall spring	Spring used to represent groundwater downstream from study area

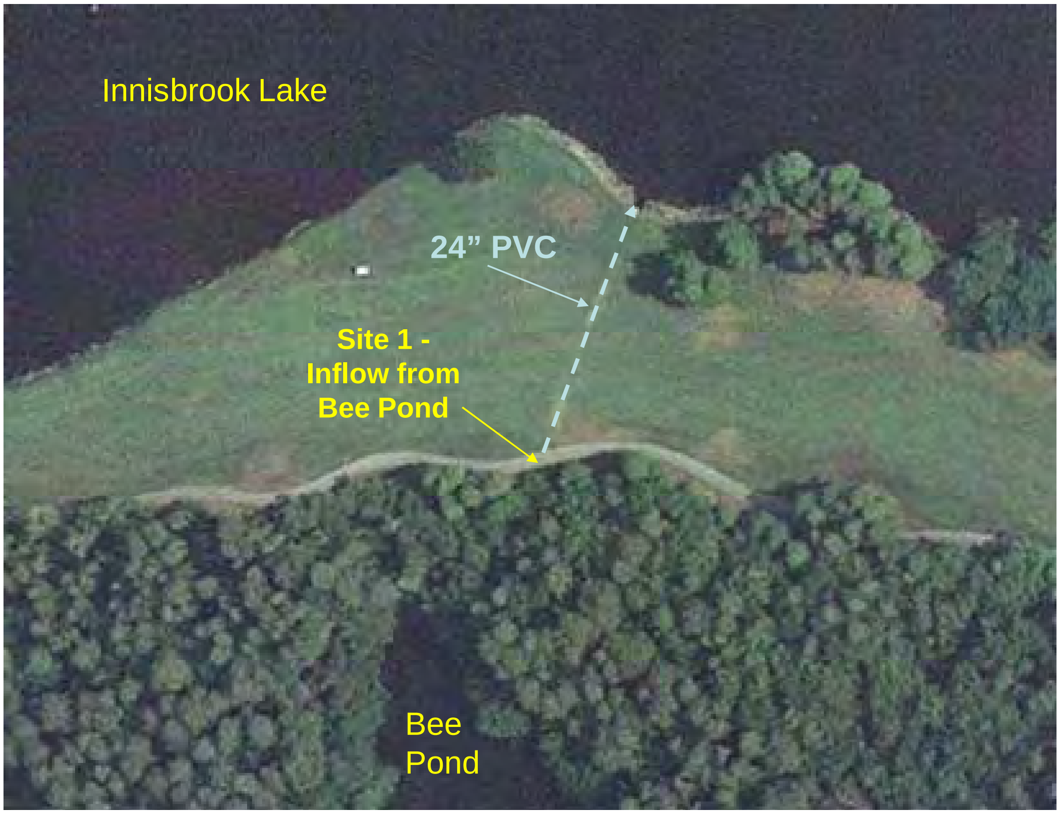


Figure 3-2. Location of Surface Water Monitoring Site 1 in the Klosterman Bayou Watershed.

The location of surface water monitoring Site 2 for the Klosterman Bayou study is illustrated on Figure 3-3. This site is intended to monitor the characteristics of off-site inflows from areas northeast of the golf course, particularly discharges from the drainage system for the newly-constructed Belcher Road. To reach the IGC site, runoff must travel across the 150-ft wide utility easement which consists of sparsely vegetated permeable sandy soils. Water which reaches the IGC site accumulates within the linear north-south wetland system located along the northeast corner of the golf course property, and excess water discharges through a 24-inch PVC pipe from the wetland area into the northeast pond system.

Based upon observations during the field reconnaissance, as well as discussions with County and District personnel, inflow into the golf course from these offsite areas may only occur during extreme storm events. Since flow may rarely occur at the proposed monitoring site, a second alternate monitoring location, designated as Site 2A, was also selected in the “Y”-shaped pond indicated on Figure 3-3. This pond constitutes the most upstream waterbody of the northeast pond system. If offsite inflow is not present during any given monitoring event, the monitoring site will be moved to Site 2A to characterize water quality in the upper northeast portions of the drainage basin. Measurable off-site inflow was not observed at Site 2 during this project, and all field monitoring was conducted at Site 2A.

Figure 3-3. Location of Surface Water Monitoring Site 2 in the Klosterman Bayou Watershed.

The selected monitoring location for Site 3 is indicated on Figure 3-4. This monitoring site is located in the northern-central drainage pathway and is designed to evaluate water quality characteristics in upstream portions of this sub-basin area. As discussed in Section 2.1.5, these ponds eventually discharge south, through a series of interconnected ponds, to the site outfall.

The location of monitoring Site 4 is illustrated on Figure 3-5. This monitoring site is on the upstream side of the concrete weir associated with the Pinellas County gauging station. This site is intended to characterize water quality in the creek prior to discharge into the downstream pond system. The location of monitoring Site 5 is given on Figure 3-6. This site is located at the outfall from the golf course complex into Klosterman Bayou.

An overview of the groundwater monitoring sites for the Klosterman Bayou watershed area is given on Figure 3-7. Groundwater monitoring sites were selected to provide information on groundwater quality upstream of the project site, within the project site, and downstream from the project site.

Figure 3-4. Location of Surface Water Monitoring Site 3 in the Klosterman Bayou Watershed.

Figure 3-5. Location of Surface Water Monitoring Site 4 in the Klosterman Bayou Watershed.

Figure 3-6. Location of Surface Water Monitoring Site 5 in the Klosterman Bayou Watershed.

Figure 3-7. Overview of Groundwater Monitoring Sites in the Klosterman Bayou Watershed.

The upgradient groundwater monitoring site for the Klosterman Bayou watershed area (Site 1) was located in the area northeast of the golf course site, as indicated on Figure 3-8. This groundwater monitoring site was located in the undeveloped utility corridor east of the golf course complex. The specific location for this site was selected in the field to avoid impacts from adjacent surface flows and provides characterization of shallow groundwater prior to entering the IGC site.

Figure 3-8. Location of Groundwater Monitoring Site 1 in the Klosterman Bayou Watershed.

The selected location for groundwater monitoring Site 2 in the Klosterman Bayou project area is illustrated on Figure 3-9. This site is located near the center of the golf course complex in a wooded median area. This monitoring well will provide information on the characteristics of shallow subsurface flow beneath the golf course complex.

The selected location for groundwater monitoring Site 3 in the Klosterman Bayou project area is illustrated on Figure 3-10. This site is located hydrologically downstream from the golf course complex and is intended to evaluate impacts on groundwater from the golf course operations. After reviewing potential monitoring sites, it was decided that discharges from Wall Spring be used to represent groundwater discharges downstream from the golf course complex. This spring is hydrologically connected to the shallow aquifer system underlying the Klosterman Bayou watershed.

Figure 3-9. Location of Groundwater Monitoring Site 2 in the Klosterman Bayou Watershed.

Figure 3-10. Location of Groundwater Monitoring Site 3 in the Klosterman Bayou Watershed.

3.1.1.2 Joe's Creek Watershed

An overview of monitored surface water sites for Joe's Creek is given on Figure 3-11. Surface water monitoring sites are located strategically along the flow path of Joe's Creek between the selected project boundaries and are intended to identify areas of significant nutrient loading into the creek. A tabular summary of surface water and groundwater monitoring sites for the Joe's Creek study area is given in Table 3-2.

Figure 3-11. Overview of Surface Water Monitoring Sites in the Joe's Creek Watershed.

TABLE 3-2

SUMMARY OF MONITORING SITES FOR THE JOE'S CREEK WATERSHED

SAMPLE WATER	SITE NO.	DESCRIPTION	PURPOSE
Surface Water	JC-OS	Discharge from box culvert	Most upstream portion of Joe's Creek
	JC-1S	At concrete weir discharging from upstream pond	Discharge from Silver Lake
	JC-2S	Upstream side of box culvert at 34th Street North and Joe's Creek	Evaluate changes in quantity and quality along Joe's Creek in industrial area
	JC-3S	Downstream side of box culvert at 37th Street North and Joe's Creek	Evaluate changes in quantity and quality along Joe's Creek; site reflects inflow characteristics to wetland and SWFWMD pond improvement project
	JC-4S	Concrete weir at downstream end of park area	Evaluate changes in quantity and quality along Joe's Creek; site reflects discharge from wetland and pond project
	JC-5S	Upstream side of box culvert at 49th Street North and Joe's Creek	Most downstream point in study area – limit of freshwater segment
Groundwater	JC-1G	In peninsula within Silver Lake	Monitor groundwater characteristics in upstream portion of Joe's Creek
	JC-2G	In park area along Joe's Creek upstream from Site JC-4S	Monitor groundwater characteristics near downstream portion of Joe's Creek

The monitoring site designated as Site "0", indicated on Figure 3-11, was added after the initial five monitoring sites had been selected and approved by Pinellas County and the District. This site represents inflow at the headwaters of Joe's Creek and allows an evaluation of changes in water quality characteristics during migration through Silver Lake. The location for Site 0 is indicated on Figure 3-12. This site is located at the discharge for the box culvert illustrated on Figure 2-19.

The selected location for surface water monitoring Site 1 is also shown on Figure 3-12a. This site is located on the downstream side of the weir structure at the discharge from Silver Lake into the headwaters of Joe's Creek. This monitoring site represents water quality in the upstream portions of Joe's Creek.

The location of surface water monitoring Site 2 is indicated on Figure 3-13. This site is located downstream from monitoring Site 1 at the upstream side of the box culvert which discharges Joe's Creek beneath 34th Street North (U.S. 19).

a. Site Locations

b. Box Culvert Discharge Monitoring Site

Figure 3-12. Locations of Surface Water Monitoring Sites 0 & 1 in the Joe's Creek Watershed.

Figure 3-13. Location of Surface Water Monitoring Site 2 in the Joe's Creek Watershed.

The location of surface water monitoring Site 3 is indicated on Figure 3-14. This monitoring site is located on the downstream side of the box culvert which conveys Joe's Creek beneath 37th Street North. This site is also used to represent inflow characteristics into the wetland and pond improvement project.

The location of surface water monitoring Site 4 is indicated on Figure 3-15. This monitoring site is located at the concrete weir which is located downstream from the wetland and pond improvement project constructed by Pinellas County in the late 1980s. In addition to providing information on nutrient changes during travel through Joe's Creek, this site will also be used in conjunction with Site 3 to evaluate the water quality performance efficiency of the constructed treatment system.

The location for monitoring Site 5 is indicated on Figure 3-16. This monitoring site represents the most downstream portion of the study area and is located at the upstream end of the box culvert which discharges under 49th Street North.

Monitoring of groundwater characteristics was conducted at two sites along Joe's Creek. The location of groundwater monitoring Site 1 is given on Figure 3-17. This monitoring well was located in the vicinity of Silver Lake which reflects the upstream portion of the watershed. The location for groundwater monitoring Site 2 is indicated on Figure 3-18. This monitoring well was located adjacent to the boat ramp within the park facility associated with the wetland and water quality improvement pond area near the center of the Joe's Creek basin.

a. Site Location

b. Monitoring Site

Figure 3-14. Location of Surface Water Monitoring Site 3 in the Joe's Creek Watershed.

Figure 3-15. Location of Surface Water Monitoring Site 4 in the Joe's Creek Watershed.

Figure 3-16. Location of Surface Water Monitoring Site 5 in the Joe's Creek Watershed.

Figure 3-17. Location of Groundwater Monitoring Site 1 in the Joe's Creek Watershed.

Figure 3-18. Location of Groundwater Monitoring Site 2 in the Joe's Creek Watershed.

3.1.2 Field Monitoring

ERD field personnel conducted biweekly monitoring at each of the monitoring sites discussed in Section 3.1 for a period of approximately three months from July-September 2008, with a total of six events conducted at each of the surface water and groundwater monitoring sites. Typical field activities for surface water and groundwater monitoring are discussed in the following sections.

3.1.2.1 Surface Water Samples

ERD field personnel visited each of the monitoring sites on a biweekly basis and performed field measurements of discharge at each site, if applicable. The measurements reflect discharge conditions at the time of the monitoring event. Flow monitoring was conducted using the USGS velocity/cross-sectional area method with a Sontek acoustic Doppler flow meter. The spacing between individual velocity measurements was determined in the field such that not more than 10% of the total flow is represented by any one vertical cross-section. The depth at each cross-section was simultaneously measured using a graduated rod. A graduated tape was stretched across each channel so that reference locations can be determined for each simultaneous measurement of velocity and water depth.

If the water depth was less than 2.5 ft at a measurement point, the velocity was measured at 60% of the total water depth. If the water column depth exceeded 2.5 ft at a monitoring site, velocity measurements were performed at 20% and 80% of the total water depth, with the mean section velocity determined by taking the average of the two measurements. The velocity was then integrated over each of the cross-sectional areas to determine the total discharge through the section on each monitoring date.

During each biweekly monitoring visit, ERD field personnel performed field measurements of pH, temperature, dissolved oxygen, specific conductivity, turbidity, and ORP at each monitoring site. If the water depth at a given site was approximately 1 m or less, a single field measurement will be conducted at approximately mid-depth. If the water depth exceeded 1 m, field measurements were conducted at the surface (0.25 m), at 0.5 m, and at 0.5 m intervals to the bottom at each site.

A water sample was also collected at each site. All samples were collected as a grab sample at mid-depth in the water column at each site. All field monitoring was conducted in accordance with DEP-SOP-001/01- Department of Environmental Protection Standard Operating Procedures for Field Activities.

All collected water samples were returned to the ERD Laboratory and analyzed for the following nutrients and selected general parameters:

- Alkalinity
- Ammonia
- NO_x
- Total Nitrogen
- SRP
- Particulate Phosphorus
- Total Phosphorus
- Total Suspended Solids
- Color

This monitoring program generated a total of 66 samples (11 sites x 6 events). In addition, supplemental samples of potential nutrient sources such as reuse irrigation water were collected periodically to establish raw characteristics for potential inputs. Each of the supplemental samples was analyzed for the parameters listed previously. A total of 7 additional samples were collected as part of this effort, resulting in an overall total of 73 samples. Additional samples were also collected and analyzed, as appropriate, to meet applicable QA criteria.

In addition to the parameters listed above, aliquots of the collected samples were shipped to the Colorado Plateau Stable Isotope Laboratory at Northern Arizona University for ^{15}N and ^{18}O isotope analysis. A total of 73 samples were provided to the Stable Isotope Lab for analysis. Details of the stable isotope methodology are given in Section 2.2

3.1.2.2 Groundwater Samples

Four shallow groundwater monitoring wells were installed at the previously discussed locations within the two study areas, with two monitoring wells installed in the Klosterman Bayou watershed and two monitoring wells installed in the Joe's Creek watershed. As discussed previously, the final groundwater monitoring site was located at Wall Spring and did require installation of a monitoring well. Locations for the groundwater monitoring sites were discussed in Section 3.1.

Each of the groundwater monitoring wells consisted of a 1.25-inch slotted casing which was hand-augered to a depth of approximately 3-4 ft below the surficial groundwater table at the time of installation. A diagram of monitoring well installation details is given in Figure 3-19. Construction logs for the monitoring wells are given on Figure 3-20. Each of the wells contained a bottom slotted PVC screen, approximately 4 ft in length, with slot widths of 0.01 inches. The void space around the well was filled with 20-30 silica sand to a level above the slotted PVC screen. Soil backfill from the excavated hole was then placed around the well to a level approximately 6 inches below the ground surface. A 6-inch thick bentonite pellet seal was then added to prevent short-circuiting of water through the well bore hole. The 1.25-inch PVC riser extended 24 inches above the ground, with a vented PVC cap placed on the top to prevent contamination of the well between monitoring events. Photographs of typical monitoring well construction are given on Figure 3-21.

Monitoring for groundwater characteristics was conducted on a biweekly basis. During each monitoring event, the depth to the surficial groundwater table was measured using a Global Water Model WL500 water level sounder, consisting of a submersible pressure transducer with an accuracy of 0.008%. The approximate water volume within the well was calculated, and the well was purged by removing a water volume equivalent to three times the initial well volume.

After the purging was completed, the well was allowed to equilibrate, and the groundwater was pumped through a flow-through cell attached to a Hydrolab H2O water quality monitor for measurement of pH, temperature, conductivity, dissolved oxygen, ORP, and turbidity. The flow-through cell was then removed, and a groundwater sample was collected using a submersible battery-powered centrifugal pump. The groundwater sample was field-filtered using a disposable 0.45-micron groundwater filter. The filtered samples were placed in ice and returned to the ERD Laboratory for analysis of the parameters listed previously for surface water, with the exceptions of particulate phosphorus and TSS, since the groundwater samples were field filtered. This monitoring regime generated a total of 30 samples (5 sites x 6 events) during this program. Additional samples were also collected to meet applicable QA criteria.

In addition to the parameters listed above, aliquots of the collected groundwater samples were shipped to the Colorado Plateau Stable Isotope Laboratory at Northern Arizona University for ^{15}N and ^{18}O isotope analysis. A total of 30 groundwater samples were provided for isotope analysis.

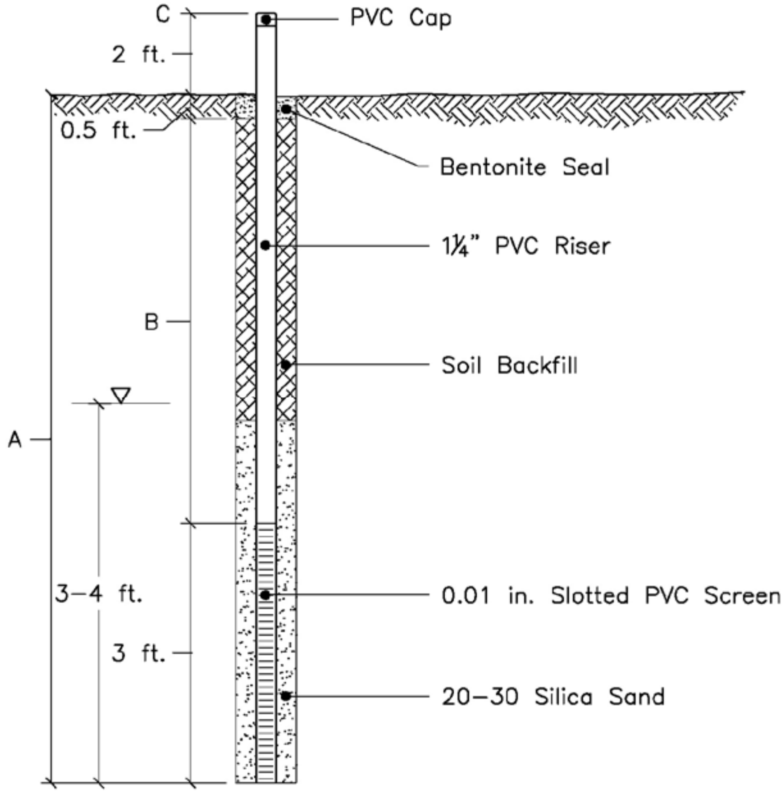


Figure 3-19. Construction Details for Groundwater Monitoring Wells.

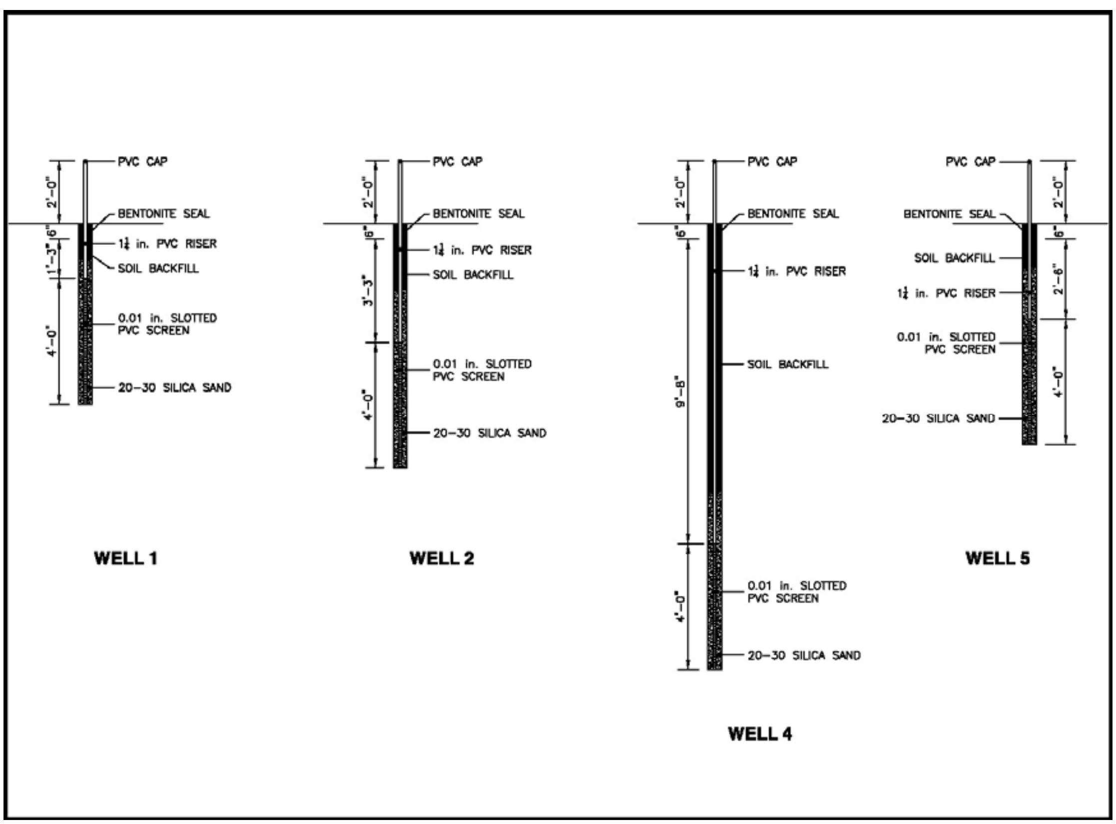


Figure 3-20. Construction Log for the Shallow Monitoring Wells.

a. Slotted Groundwater Well

b. Well Installation

c. Klosterman Groundwater Monitoring Site 2

d. Klosterman Groundwater Monitoring Site 1

Figure 3-21. Monitoring Well Construction Details.

3.1.2.3 Sampling Equipment

All field sampling procedures and documentation followed procedures outlined in the document titled "Department of Environmental Protection Standard Operating Procedures for Field Activities," DEP-SOP-001/01, dated February 1, 2004. A listing of sampling equipment used for this project is given in Table 3-3.

TABLE 3-3

SAMPLING EQUIPMENT

EQUIPMENT DESCRIPTION	CONSTRUCTION MATERIALS	USE
Sampling Equipment		
Geotech Submersible Geosquirt Purging/ Sampling Pump	Plastic case, S.S. impeller, vinyl tubing	Purging for monitoring wells; Sample collection for general parameters and nutrients
Nalgene Syringe Filter System - Surface Water	Acrylic/polyethylene	Filtration for Orthophosphorus
Filtration Equipment		
Geotech 0.45 μ high-capacity disposable filter	Plastic casing glass fiber filter	Filtration for isotope samples
Masterflex E/S Portable Sampler	Silicon tubing	Filtration for isotope samples
Field Measurement Equipment		
Hydrolab H2O Water Quality Monitor	Teflon	Field parameters
SonTek FlowTracker Hand-held ADV	Polyethylene, S.S.	Measure discharge at inflow and outflow to calibrate autosampler flow meters

3.1.2.4 Sample Preservation and Holding Times

A listing of sample containers, sample preservation techniques and maximum holding times for water and groundwater sample parameters during this project are listed in Table 3-4. Sample preservation techniques involve either cooling to 4^oC in ice, addition of acid to reduce the pH to a specified level, or both.

TABLE 3-4

REQUIRED CONTAINERS, SAMPLE PRESERVATION TECHNIQUES, AND MAXIMUM HOLDING TIMES FOR MEASURED PARAMETERS

PARAMETER	CONTAINER	PRESERVATIVES	MAXIMUM HOLDING TIME
Alkalinity	Plastic	Cool 4^oC	14 days
Color	Plastic	Cool 4^oC	48 hours
Nitrogen, Ammonia	Plastic	Cool 4^oC; H_2SO_4 to pH < 2	28 days
Nitrogen, Nitrate + Nitrite, Total	Plastic	Cool 4^oC; H_2SO_4 to pH < 2	28 days
Total Nitrogen	Plastic	Cool 4^oC; H_2SO_4 to pH < 2	28 days
Phosphorus, Orthophosphate	Plastic	Cool 4^oC; filter on-site	48 hours
Phosphorus, Total	Plastic	Cool 4^oC; H_2SO_4 to pH < 2	28 days
Residue, Non-Filterable (Total Suspended Solids)	Plastic	Cool 4^oC	7 days

3.2 Laboratory Analyses

3.2.1 Analytical Methods

Each of the collected runoff samples was returned to the ERD Laboratory and evaluated for general parameters, nutrients, BOD, fecal coliform, and selected heavy metals. A summary of laboratory methods and MDLs for analyses conducted on water samples collected during this project is given in Table 3-5. All laboratory analyses were conducted in the ERD Laboratory which is NELAC-certified (No. 1031026). Details on field operations, laboratory procedures, and quality assurance methodologies are provided in the FDEP-approved Comprehensive Quality Assurance Plan No. 870322G for Environmental Research & Design, Inc.

TABLE 3-5

ANALYTICAL METHODS AND DETECTION LIMITS FOR LABORATORY ANALYSES

PARAMETER	METHOD OF ANALYSIS	METHOD DETECTION LIMITS (MDLs)[1]
pH	EPA-83, Sec. 150.1[2]	N/A
Dissolved Oxygen	SM-19, Sec. 4500-O G[3]	0.1 mg/l
Conductivity	EPA-83, Sec. 120.1[2]	0.3 µmho/cm
Alkalinity	EPA-83, Sec. 310.1[2]	0.5 mg/l
Ammonia	EPA-83, Sec. 350.1[2]	0.005 mg/l
NO_x	EPA-83, Sec. 353.2[2]	0.005 mg/l
TKN	Alkaline Persulfate Digestion[4]	0.01 mg/l
Ortho-P	EPA-83, Sec. 365.1[2]	0.001 mg/l
Total Phosphorus	Alkaline Persulfate Digestion[4]	0.001 mg/l
Turbidity	EPA-83, Sec. 180.1[2]	0.1 NTU
Color	EPA-83, Sec. 110.3[2]	1 Pt-Co Unit
TSS	EPA-83, Sec. 160.2[2]	0.7 mg/l

1. MDLs are calculated based on the EPA method of determining detection limits
2. Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, Revised March 1983.
3. Standard Methods for the Examination of Water and Wastewater, 19th Ed., 1995.
4. FDEP-approved alternate method

3.2.2 Quality Control

Multiple QA/QC procedures were used by ERD during this project. A summary of QA/QC procedures is given in Table 3-6. The listed QA/QC procedures are designed to evaluate both the field and laboratory systems. Approximately 90 additional laboratory QA/QC samples were evaluated by ERD in addition to the 70 collected surface water samples and 30 collected groundwater samples. In addition, more than 30 field QA/QC samples were collected and analyzed to address potential field contamination. A complete listing of QA/QC samples evaluated as part of this project is given in Appendix B.

TABLE 3-6

QA/QC PROCEDURES USED BY ERD

QC ITEM	FREQUENCY
Continuous Calibration Verification Standards	Every 10 samples
Continuing Calibration Blanks	Every 10 samples
Lab Control Samples (Check Standards)	Every 20 samples and beginning/end of each run
Method Blank	Every 20 samples and beginning/end of each run
Duplicate Samples (Precision)	Every 10 samples
Spiked Samples (Accuracy)	Every 20 samples
Initial Calibration Verification (pH)	Every run
Field Equipment Blanks	Every 10 samples
Pre-Cleaned Equipment Blank	Every 10 samples

3.2.3 Isotope Analyses

3.2.3.1 Introduction

Isotopes are atoms of an element that differ in mass, due to differing numbers of neutrons in the atoms' nucleus. Some isotopes are unstable and are referred to as radioisotopes. Other isotopes have no known decay constants and are referred to as stable isotopes. Isotopes of the same element have the same numbers of protons and electrons, and so have similar chemical properties and similar chemical reactions. But, because of the difference in bond strength due to differing numbers of neutrons, different stable isotopes react at slightly different rates. In general, molecules containing heavier isotopes react more slowly. Differences in reaction rates give rise to "fractionation", such that isotopes are distributed unevenly in natural systems. Biological systems often exhibit strong fractionation effects, such that molecules containing the light isotope of an element react more quickly with a biological enzyme than do molecules containing the heavier isotope. Thus, molecules from different sources in the environment often exhibit isotopic "fingerprints" which can be useful in source partitioning studies.

There are two stable isotopes of nitrogen, ^{14}N and ^{15}N, where the superscripts describe the atomic mass of the isotope. ^{14}N contains seven protons and neutrons, whereas ^{15}N contains seven protons but eight neutrons. ^{14}N is the more abundant isotope of nitrogen since most nitrogen reservoirs in nature (e.g., the atmosphere) contain approximately 99.6% ^{14}N and only 0.4% ^{15}N. Fractionation processes cause very slight variations in this composition, differences that can be detected using isotope-ratio mass spectroscopy, routinely distinguishing samples that differ by as little as 0.0001 atom percent ^{15}N.

3.2.3.2 <u>Theory of Measurement</u>

Stable isotopes of carbon, nitrogen, sulfur, oxygen, and hydrogen, which are the most commonly used isotopes in ecological and environmental research, are measured by gas isotope-ratio mass spectroscopy. The sample is converted into a gas, such as N_2O, CO_2, N_2, SO_2, or H_2, and the gas molecules are ionized in the Ion Source (Figure 3-22) which strips an electron from each of them, causing each molecule to be positively charged. The charged molecules then enter a flight tube. The flight tube is bent, and a magnet is positioned over it such that the charged molecules separate according to their mass, with molecules containing the heavier isotope bending less than those containing the lighter isotope.

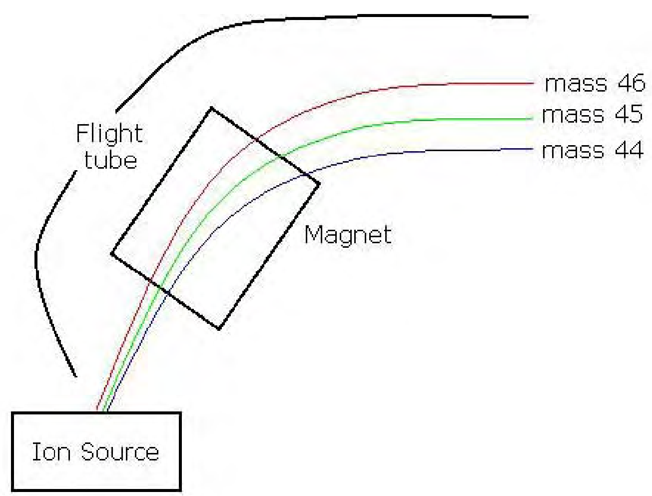


Figure 3-22. Separation of Isotopes by Gas Isotope-Ratio Mass Spectrometry.

Faraday collectors are present at the end of the flight tube to measure the intensity of each beam of ions of a given mass after they have been separated by the magnet. For N_2O, three faraday collectors are set to collect ion beams of masses 44, 45, and 46. Several masses are collected simultaneously, so that the ratios of these masses can be determined very precisely.

In the flight tube, the magnet causes the ions to be deflected, with a radius of deflection that is proportional to the mass-to-charge ratio of the ion. Heavier ions are deflected less than lighter ions. For example, N_2O, mass 46 has the largest radius of deflection, mass 44 has the smallest, and mass 45 is intermediate. Charge also affects the radius of deflection but, for the most part, this is held constant because the ion source strips only one electron from most molecules.

Stable isotope abundances are expressed as the ratio of the two most abundant isotopes in the sample compared to the same ratio in an international standard, using the "delta" (δ) notation. Because the differences in ratios between the sample and standard are very small, they are expressed as parts per thousand or "per mil" (‰) deviation from the standard:

$$\delta X\ sample = \{(^{H}X / ^{L}X\ sample) / (^{H}X / ^{L}X\ standard) - 1\} \times 100$$

Where "^{H}X and ^{L}X" are the heavy and light stable isotopes of element X, "sample" refers to the environmental sample being analyzed, and "standard" refers to the international standard for element X. This equation defines the delta value of the standard as 0‰. For carbon, the international standard is Pee Dee Belemnite, a carbonate formation, with a generally accepted absolute ratio of $^{13}C/^{12}C$ equal to 0.0112372. Materials with ratios of $^{13}C/^{12}C$ greater than 0.0112372 have positive delta values, and those with ratios less than 0.0112372 have negative delta values.

Stable isotope techniques rely on natural differences in the ways that "heavy" and "light" isotopes are processed in the environment through chemical, biological, and physical transformations. These are referred to as "natural abundance isotope techniques". Stable nitrogen isotopes of dissolved nutrients also provide specific information about the origin of nutrients. Pastureland, residential communities, and golf courses all produce nitrogen with unique isotopic signatures (Kendal, 1998). Land that is covered with a significant amount of cattle often produce nitrate with very heavy $\delta^{15}N$ values. This isotopic signature is due to the large amount of $^{14}NH_3$ released during ammonia volatilization of animal wastes which leaves the remaining material enriched in the heavier nitrogen isotope, ^{15}N.

Nitrogen derived from treated sewage undergoes similar biogeochemical processing through denitrification, which is the heterotrophic breakdown of organic matter. Denitrification produces N_2 with a high concentration of ^{14}N, leaving the remaining bulk waste material concentrated in ^{15}N. Consequently, nitrate that originates from pastureland and sewage have similar $\delta^{15}N$ values (12- 20‰). Contrastingly, nitrate derived from residential soils often has an intermediate nitrogen isotopic range (3-8‰). Possible contributions to the residential signal may include nitrogen derived from septic tanks, fertilizer application, or soil redistribution and relocation. Residential land development may also transport the ^{15}N-enriched organic matter that normally occurs in deeper soil layers to the surface.

The isotopic signature of nitrogen derived from golf courses is also unique. The fertilizer applied to golf courses is often derived from atmospheric nitrogen. This causes golf course runoff to contain nitrate with ^{15}N values similar to those of atmospheric N_2 (0-3‰). Golf course areas which irrigate with reclaimed water derived from sewage often exhibit a sewage signal (i.e., 12-20‰, as above). However, $\delta^{15}N$ can be used as a tracer only if large verifiable differences in $\delta^{15}N$ exist between the potential nitrogen sources.

3.2.3.3 <u>Analyses</u>

All stable isotope analyses were conducted by the Colorado Plateau Stable Isotope Laboratory (CPSIL), based at Northern Arizona University (NAU). This laboratory was designed to serve students, researchers, and faculty at NAU who require stable isotope analyses for their research, although analyses are also conducted for researchers outside the university. All isotope analyses were overseen by Dr. Bruce Hungate, Professor and Director of CPSIL. Details concerning sample collection, preservation, and shipping were provided to ERD by CPSIL.

Surface and groundwaters collected in the Klosterman Bayou and Joe's Creek watersheds were analyzed for $\delta^{15}N\text{-}NO_3^-$ and $\delta^{18}O\text{-}NO_3^-$, along with putative sources. Two general questions were addressed: (1) are there changes in NO_3^-, $\delta^{15}N$, and $\delta^{18}O$ signatures within these systems that are consistent with internal microbial processing, and if so, is it possible to constrain the $\delta^{15}N$ and $\delta^{18}O$ signature of NO_3^- entering these systems; and (2) do the estimates of the $\delta^{15}N$ and $\delta^{18}O$ signature of source NO_3^- match any of the putative sources identified?

Samples were collected in the field and shipped to the Colorado Plateau Stable Isotope Laboratory at Northern Arizona University for preparation and analysis. Samples were measured for NO_3^- concentrations using automated colorimetry on a Lachat QuikChem 8000 to determine appropriate volumes for isotope analyses. The denitrifier method was used to measure the $\delta^{15}N$ and $\delta^{18}O$ composition of nitrate in each water sample (Sigman, et al., 2001; Casciotti et al., 2002; Révész and Casciotti, 2007). In this method, isotopes of both elements are measured simultaneously after the nitrate is converted to nitrous oxide (N_2O). Mass ratios of 45:44 and 46:44 distinguish $\delta^{15}N$ and $\delta^{18}O$ signatures, respectively. *Pseudomonas aurefaciens* lacks N_2O reductase, the enzyme that converts N_2O to N_2 during denitrification, so the reaction stops at N_2O, unlike normal denitrification which converts most of the NO_3^- to N_2.

Pseudomonas aurefaciens cultures were grown in tryptic soy broth, centrifuged to concentrate bacterial cells, and then concentrated suspensions of cells are added to sealed vials with headspace. The headspace vials were purged with helium gas to promote the anaerobic conditions suitable for denitrification, and the environmental samples containing NO_3^- were added to the vials and the volume of sample adjusted to obtain sufficient N_2O for analysis. Several drops of anti-foaming agent were added to each vial to reduce bubble formation during the reaction. The vials were allowed to incubate for 8 hours, during which time NO_3^- is converted completely to N_2O. After the 8-hour period, 0.1 ml of 10N NaOH was added to each vial to stop the reaction and to absorb CO_2 which can interfere with N_2O analysis. The samples were then placed on an autosampler tray interfaced with the mass spectrometer, and interspersed with standards with known $\delta^{15}N$ and $\delta^{18}O$ composition.

SECTION 4

RESULTS

Field monitoring, sample collection, and laboratory analyses were conducted by ERD from July-September 2008 to evaluate the characteristics of discharges through the freshwater segments of the Klosterman Bayou and Joe's Creek watersheds. A discussion of the results of these efforts is given in the following sections.

4.1 Klosterman Bayou Watershed

4.1.1 Rainfall Characteristics

A survey was conducted of available rainfall records in the vicinity of the Klosterman Bayou watershed during the field monitoring program as well as antecedent rainfall leading up to the monitoring events. The closest government-operated rainfall recording station to the Klosterman Bayou watershed appears to be the SWFWMD rainfall recording site referred to as Tarpon Sink (Site No. 22889) which is located approximately 1.4 miles northeast of the freshwater portion of Klosterman Bayou. This site has available daily rainfall records over the period from 1991 to the present. A location map for the Tarpon Sink rainfall recording site is given on Figure 4-1. This site was used to provide information on rainfall characteristics during and prior to the 2008 monitoring events.

Information on long-term historical rainfall within the vicinity of Klosterman Bayou was obtained from Tarpon Springs Co-op monitoring site (Site No. 088824), located approximately 2.8 miles north of the freshwater segment of Klosterman Bayou. This site has historic data dating back to 1971 which provides a better indication of long-term rainfall trends within this area. The location of this site is also indicated on Figure 4-1. This site is used to generate estimates of historical monthly rainfall for comparison with rainfall observed during and prior to the monitoring program.

A comparison of measured and historical rainfall in the vicinity of the Klosterman Bayou watershed is given on Table 4-1. Monthly rainfall recorded at the Tarpon Sink site is provided for the period from January-September 2008. These values are compared with the long-term monthly average rainfall recorded at the Tarpon Springs monitoring site from 1971-2000. A graphical comparison of measured and historical monthly rainfall is given on Figure 4-2.

During the period from January-March 2008, rainfall measured at the Tarpon Sink site was approximately normal. A substantial excess of rain occurred during April, with virtually no rainfall occurring during May. Approximately normal rainfall was observed during June. During the monitoring period from July-September, substantially higher than normal rainfall was observed during July, with near-normal rainfall during August, and substantially lower than normal rainfall during September. Rainfall in the vicinity of the Tarpon Sink from July-September 2008 was approximately 19.37 inches compared with a "normal" rainfall of 22.79 inches. Rainfall in the vicinity of the Klosterman Bayou watershed over the period from January-September 2008 was approximately 38.68 inches compared with a "normal" rainfall for this period of approximately 43.71 inches, approximately 12% less than normal.

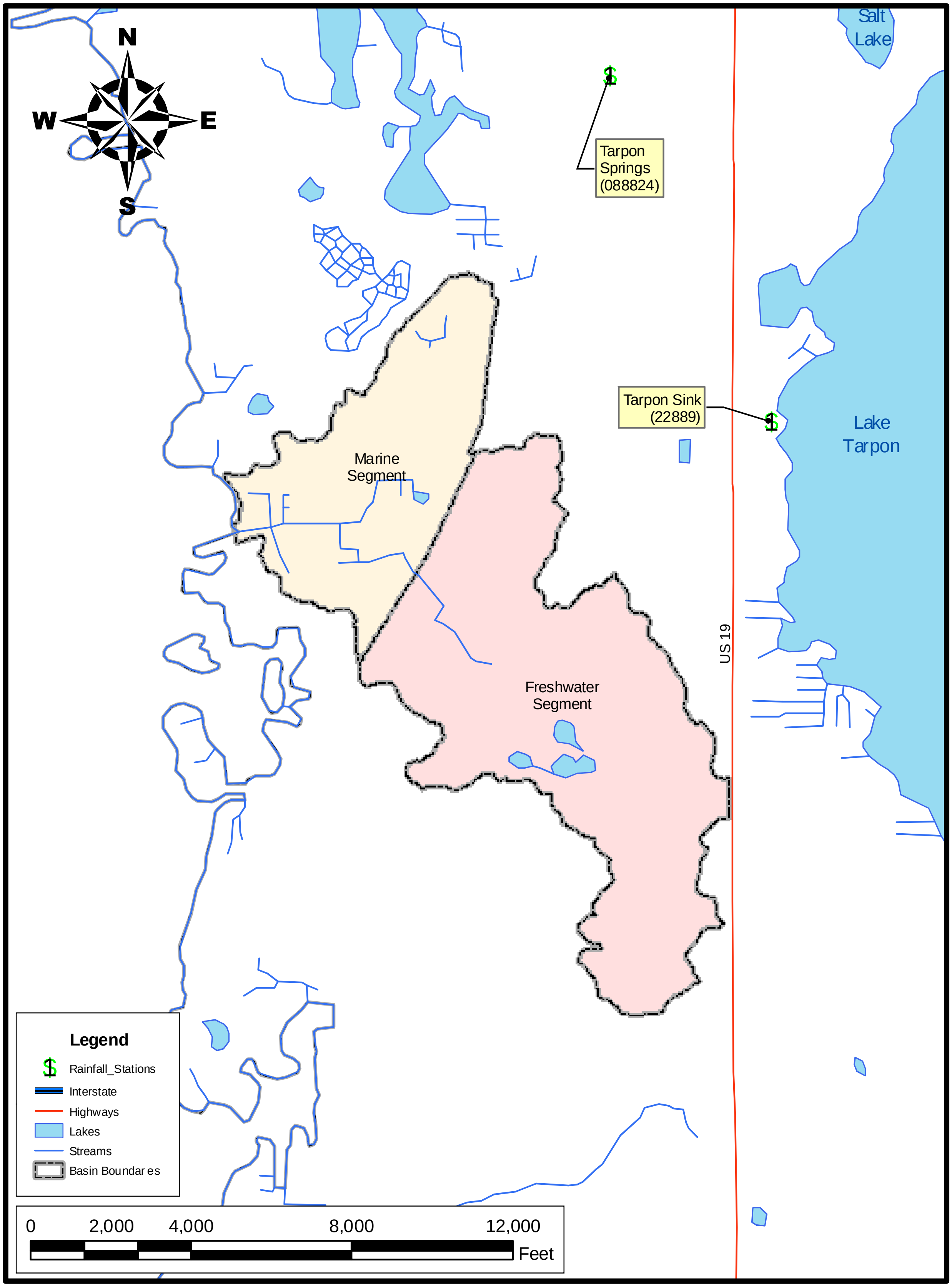


Figure 4-1. Recording Rainfall Sites in the Vicinity of the Klosterman Bayou.

TABLE 4-1

COMPARISON OF MEASURED AND HISTORICAL RAINFALL IN THE VICINITY OF THE KLOSTERMAN BAYOU WATERSHED

MONTH	MONTHLY RAINFALL (inches)	
	Tarpon Sink (2008)	Tarpon Springs (Mean 1971-2000)
January	3.26	3.17
February	2.77	3.14
March	3.47	3.85
April	4.09	1.96
May	0.08	3.02
June	5.64	5.78
July	10.86	7.07
August	7.73	8.47
September	0.78	7.25

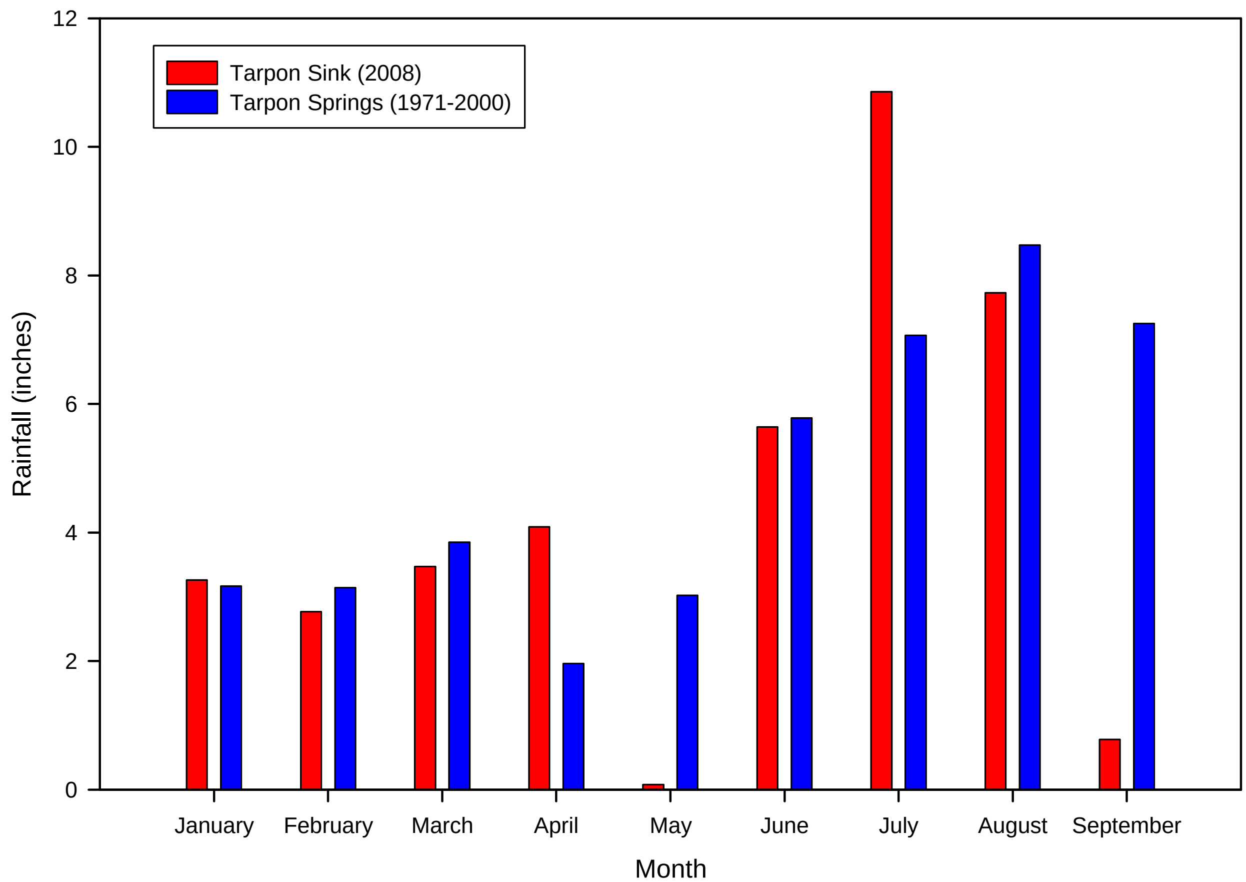


Figure 4-2. Graphical Comparison of Measured and Historical Mean Monthly Rainfall in the Vicinity of the Klosterman Bayou Watershed.

4.1.2 Discharge Measurements

A summary of measured discharge rates at the Klosterman Bayou surface water monitoring sites is given in Table 4-2. Discharge rates are not provided for monitoring Site 3S since this site reflects a surface waterbody rather than a channel. The measured discharge rates reflect conditions at the time of the monitoring event and are used to evaluate changes in water movement throughout the basin.

TABLE 4-2

MEASURED DISCHARGE RATES AT THE KLOSTERMAN BAYOU SURFACE WATER MONITORING SITES

DATE	MEASURED DISCHARGE (cfs)			
	1S	**2S**	**4S**	**5S**
7/17/08	1.40	0.00	7.56	12.67
7/30/08	0.00	0.00	2.62	0.00
8/13/08	0.00	0.00	0.69	2.99
8/27/08	2.15	0.00	7.76	10.65
9/9/08	0.98	0.00	0.76	3.83
9/23/08	0.00	0.00	0.00	0.54
MEAN	**0.76**	0.00	**3.23**	**5.11**

Flow measurements conducted at monitoring Site 1S represent inflow from the southeastern off-site basin through Bee Pond. Measurable flow at this site was recorded during three of the six monitoring events, with either no flow or dry conditions present during the remaining three events. Measured flow rates at this site ranged from 0-2.15 cfs, with an overall average of 0.76 cfs. Since these measurements were collected during rainy season conditions, it appears that inputs onto the IGC site from Bee Pond occur infrequently, and when flow does occur, is characterized by relatively low inflow rates. The lack of significant continuous inflow from this site is a function of the highly permeable sandy soils within this off-site basin.

Flow measurements conducted at monitoring Site 2S represent inflow from the northeastern off-site basin onto the IGC property. No flow was observed at this site during any of the six monitoring events. It appears that inputs onto the IGC site from the northeast off-site basin occur very infrequently and do not reflect a significant input on an annual basis. Since no flow is present at Site 2, sample collection was relocated to the adjacent pond which is referred to as Site 2A. No flow data were collected at Site 2A since it reflects a pond site.

Monitoring Site 4S is located at the concrete weir in the central portion of the IGC site. Measurable discharge occurred at this site during five of the six monitoring events, with no discharge during the final event on 9/23/08. However, as seen in Table 4-1, the total rainfall measured in the vicinity of the Klosterman Bayou watershed during September 2008 was only 0.78 inches, reflecting near-record low rainfall for the month of September. This lack of rainfall appears to have had an impact on flow measurements at each of the Klosterman Bayou monitoring sites. Monitored flow rates at Site 4 ranged from 0-7.76 cfs, with an overall average of 3.23 cfs.

Monitoring Site 5S is located downstream from the outfall structure for IGC. This site experiences limited tidal influence which is reflected in field measurements for conductivity and pH. Measured discharge rates at this site ranged from 0-12.67 cfs, with an overall mean of 5.11 cfs at this site.

Overall, discharge rates appear to increase during migration through the IGC site as a result of additional runoff and applied irrigation. The only significant off-site inflow appears to be from Bee Pond which was characterized by a mean inflow of 0.76 cfs. Discharge rates in middle portions of the IGC site have increased to a mean of 3.23 cfs, with an additional increase to 5.11 cfs from the concrete weir to the outfall structure.

4.1.3 Surface Water Characteristics

Field monitoring was conducted at five surface water sites in the Klosterman Bayou watershed over the period from July-September 2008, with a total of six events conducted at each of the five monitoring sites. A discussion of the characteristics of surface water collected in the Klosterman Bayou watershed is given in the following sections.

4.1.3.1 Field Measurements

A complete listing of field measurements collected at the Klosterman Bayou watershed monitoring sites is given on Table 4-3. Field measurements of temperature, pH, conductivity, TDS, dissolved oxygen, and oxidation-reduction potential (redox) were collected at approximately mid-depth in the water column at each monitoring site. In general, measured pH values at the monitoring site were found to be approximately neutral, with a slightly higher pH value measured at the Innisbrook Golf Course (IGC) outfall, presumably due to tidal influence.

In general, moderate levels of conductivity were observed at monitoring Site 1S (which reflects inflow onto the IGC property from Bee Pond) and Site 2S-A (which reflects water quality characteristics in the extreme northeast portion of the IGC property. Discharges from each of these sites enter the central drainage system for IGC and ultimately end up discharging through the Innisbrook Canal and monitoring Site 4S. The mean conductivity value measured at Site 4S of 957 μmho/cm is approximately 60-70% higher than conductivity values measured in the extreme northeastern and southern portions of the site, suggesting an increase in dissolved ions during migration through the IGC area. An even more elevated conductivity value was observed at monitoring Site 3S which is located in the northern portions of the IGC area. Since this site is not impacted by tidal inputs, the elevated conductivity measurements observed at this site must be related to activities which occur within the golf course area. The most elevated conductivity value was observed at the IGC outfall (Site 5S) which ranged from freshwater to highly brackish throughout the monitoring program.

In general, measured dissolved oxygen concentrations within the IGC area were highly variable and moderate to low in value on most occasions. Relatively low dissolved oxygen levels were observed in inflow from Bee Pond, with four of the six measurements characterized by dissolved oxygen levels of 5 mg/l or less. Highly variable dissolved oxygen concentrations were observed at Sites 2S-A and 3S which reflect pond systems in the northeast and northern portions of the IGC property, respectively. However, the overall mean dissolved oxygen value for these sites is greater than the Class III freshwater criterion of 5 mg/l. The lowest levels of dissolved oxygen were observed at the concrete weir structure at Site 4S, with a mean dissolved oxygen concentration of 3.4 mg/l, and all six of the field measurements less than the minimum Class III criterion of 5 mg/l. The mean dissolved oxygen concentration measured at the IGC outfall was 3.2 mg/l, with all six measurements less than the 5.0 mg/l Class III criterion. However, in spite of the low dissolved oxygen measured on certain monitoring dates, oxidized conditions (indicated by redox potential values in excess of 200 mv) were present during each monitoring event at each site.

TABLE 4-3

FIELD MEASUREMENTS COLLECTED AT THE KLOSTERMAN BAYOU WATERSHED MONITORING SITES

SITE	DATE	TIME	TEMP. (°C)	pH (s.u.)	COND. (μmho/cm)	TDS (mg/l)	D.O. (mg/l)	D.O. (% Sat.)	REDOX (mv)
1S	7/17/08	10:58:19	25.49	6.80	366	234	0.8	10	421
	7/30/08	12:30:35	30.83	7.26	752	481	5.0	68	455
	8/13/08	13:29:50	30.58	7.37	767	491	6.1	82	470
	8/27/08	13:10:11	26.64	6.70	301	192	0.9	12	441
	9/9/08	13:09:22	30.17	7.11	605	387	4.9	65	451
	9/23/08	14:11:16	29.81	7.40	690	442	7.1	94	313
	Mean		**28.92**	**7.11**	**580**	**371**	**4.1**	**55**	**425**
2S-A	7/17/08	10:26:53	29.17	6.91	458	293	4.2	55	394
	7/30/08	12:11:06	31.20	6.58	607	388	9.1	123	438
	8/13/08	13:11:10	30.70	7.03	593	380	9.4	126	473
	8/27/08	12:50:28	33.10	7.54	503	322	> 20	> 200	505
	9/9/08	12:45:21	31.58	6.32	591	378	6.7	91	377
	9/23/08	13:44:12	30.38	6.59	663	424	9.4	125	399
	Mean		**31.02**	**6.83**	**569**	**364**	**7.7**	**104**	**398**
3S	7/17/08	9:07:45	27.05	6.93	613	392	1.2	16	411
	7/30/08	11:39:41	30.10	7.32	917	587	6.3	84	448
	8/13/08	12:30:28	29.23	7.59	931	596	6.5	85	510
	8/27/08	12:13:18	30.92	7.20	700	448	6.6	89	433
	9/9/08	12:04:47	29.74	7.01	1082	693	3.8	50	379
	9/23/08	13:00:31	28.85	7.35	2787	1780	6.4	83	280
	Mean		**29.32**	**7.23**	**1172**	**749**	**5.1**	**68**	**410**
4S	7/17/08	8:23:16	26.16	7.25	874	559	2.6	32	481
	7/30/08	11:19:40	29.42	7.34	1083	693	3.0	40	537
	8/13/08	11:58:23	25.63	7.25	1148	735	3.0	36	491
	8/27/08	11:33:32	29.73	7.07	739	473	4.6	61	455
	9/9/08	11:34:38	27.98	6.95	806	516	2.3	30	416
	9/23/08	12:27:58	27.51	7.33	1090	697	4.8	60	272
	Mean		**27.74**	**7.20**	**957**	**612**	**3.4**	**43**	**442**
5S	7/17/08	8:47:59	27.63	7.35	827	529	1.3	17	446
	7/30/08	11:29:05	31.44	7.79	37102	23745	2.3	36	523
	8/13/08	12:17:25	30.33	7.33	9719	6220	1.9	26	467
	8/27/08	11:50:57	30.25	7.26	814	521	4.7	62	405
	9/9/08	11:51:17	29.87	7.48	1568	1000	4.7	62	422
	9/23/08	12:47:09	30.34	7.43	6983	4470	4.5	62	244
	Mean		**29.98**	**7.44**	**9502**	**6081**	**3.2**	**44**	**418**

A statistical comparison of field parameters measured at the Klosterman Bayou surface water monitoring sites is given on Figure 4-3. Dissolved oxygen concentrations were highly variable at each of the monitoring sites, with the highest dissolved oxygen levels measured in the northeast pond at Site 2S-A. During the August 27, 2008 monitoring event at this site, a dissolved oxygen concentration in excess of 20 mg/l was measured. The exact concentration is not known since the dissolved oxygen sensor used at this site has a maximum readable concentration of 20 mg/l. A lower degree of variability is apparent in measured pH values, with the highest pH levels observed near the IGC outfall. A high degree of variability was observed in conductivity values at the downstream monitoring site, with a relatively low degree of variability at the remaining sites. Oxidized conditions, indicated by redox values in excess of 200 mv, were maintained within the creek during all monitoring events.

4.1.3.2 Chemical Characteristics

A summary of the results of laboratory analyses conducted on surface water samples collected from the Klosterman Bayou watershed is given on Table 4-4. Water quality data are provided for each of the five monitoring sites and each of the six monitoring dates. Mean values are also provided for each evaluated parameter at each site.

4.1.3.2.1 Site 1S

The characteristics of off-site inflow from the southeast basin area through Bee Pond are represented by the samples collected at Site 1S. Samples at this site were moderately buffered, with a mean alkalinity of 78.7 mg/l. Measured total nitrogen concentrations ranged from 860-1828 μg/l, with an overall mean of 1475 μg/l. This value is somewhat lower than nitrogen concentrations commonly observed in urban runoff and reflects attenuation of nitrogen loadings during migration through the southeast basin area. The majority of the total nitrogen measured at this site was present as dissolved organic nitrogen which comprised 63% of the total nitrogen on an average basis. Approximately 24% of the total nitrogen was contributed by particulate nitrogen, with only 14% contributed by ammonia and NO_x. Measured NO_x concentrations at this site were relatively low in value, with an overall mean of only 35 μg/l. Somewhat higher concentrations were observed for ammonia, with an overall mean of 168 μg/l.

Substantially elevated total phosphorus concentrations were measured at this site, with an overall mean of 674 μg/l, approximately 2-3 times greater than phosphorus concentrations commonly observed in urban runoff. Soluble reactive phosphorus (SRP) is the dominant phosphorus species at this site, comprising 73% of the total phosphorus measured. The observed SRP values ranged from 178-752 μg/l, reflecting substantially elevated levels for runoff inputs. These elevated SRP concentrations may be related to phosphorus release from the wetland area which surrounds Bee Pond or may be impacted by activities from the adjacent IGC area. However, regardless of the source, elevated levels of SRP appear to be discharging onto the IGC site from this inflow. The second most significant phosphorus species is particulate phosphorus, which comprises 18% of the total phosphorus measured, followed by dissolved organic phosphorus which contributed 9% of the total.

Measured TSS concentrations at Site 1S were highly variable, ranging from 1.0-12.6 mg/l. These concentrations are low in value for urban runoff and reflect attenuation of TSS within the watershed. Inputs at this site are characterized by a moderately elevated color concentration which ranged from 98-170 Pt-Co units, with a mean of 123 Pt-Co units. The observed color is probably generated within the wetland areas adjacent to the pond.

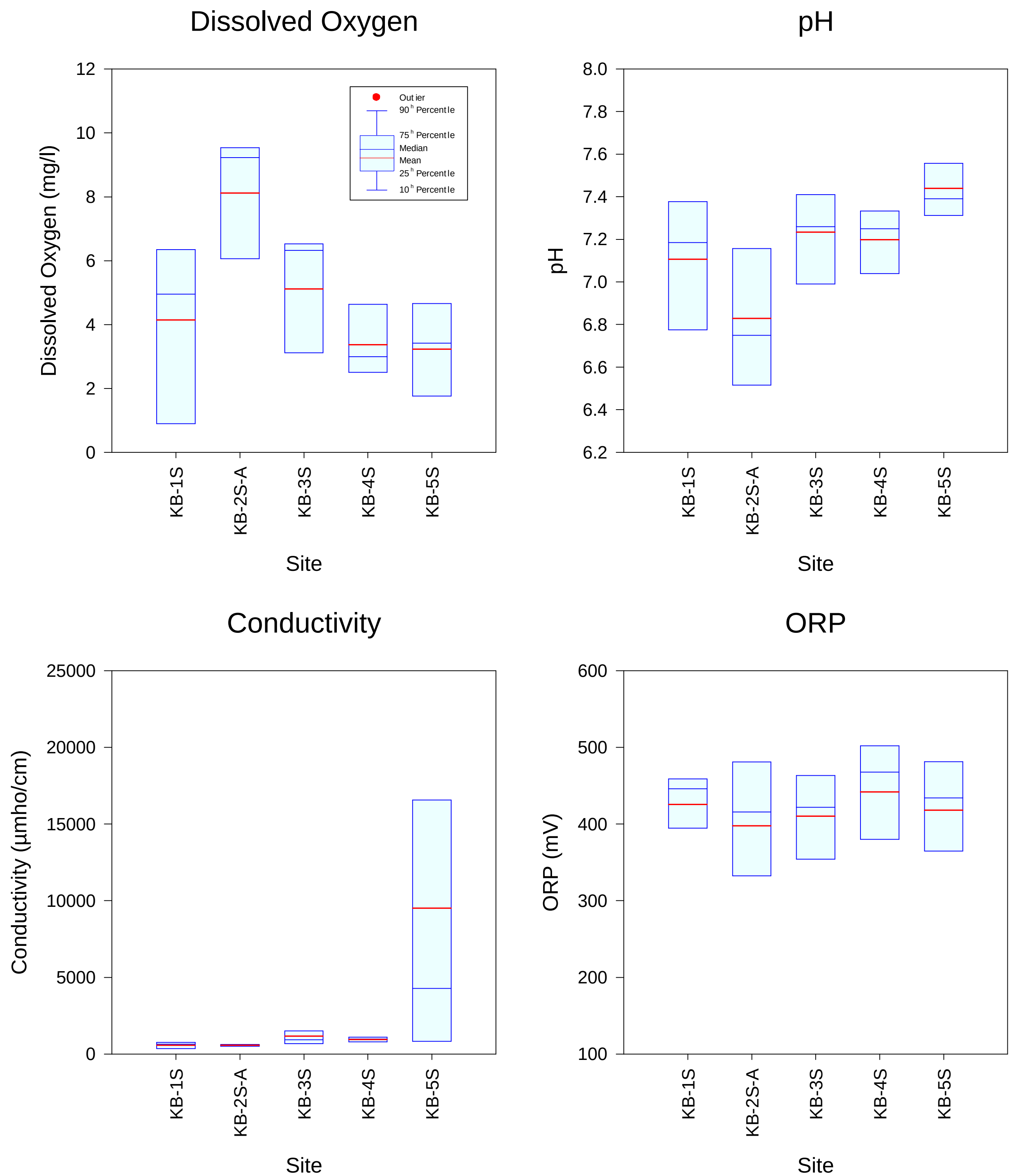


Figure 4-3. Statistical Comparison of Field Parameters Measured at the Klosterman Bayou Surface Water Monitoring Sites.

TABLE 4-4

RESULTS OF LABORATORY ANALYSES CONDUCTED ON SURFACE WATER SAMPLES COLLECTED FROM THE KLOSTERMAN BAYOU WATERSHED

SITE	DATE	ALK. (mg/l)	NH_3 (µg/l)	NO_X (µg/l)	DISS. ORG. N (µg/l)	PART. N (µg/l)	TOTAL N (µg/l)	SRP (µg/l)	DISS. ORG. P (µg/l)	PART. P (µg/l)	TOTAL P (µg/l)	TSS (mg/l)	COLOR (Pt-Co)
1S	7/17/08	51.2	125	8	653	74	860	298	47	32	377	1.9	170
	7/30/08	94.4	131	13	1457	152	1753	752	83	79	914	8.0	111
	8/13/08	94.8	179	<5	1186	365	1733	727	60	63	850	12.6	115
	8/27/08	45.8	139	13	526	185	863	178	7	56	241	1.0	123
	9/9/08	87.4	210	68	737	813	1828	423	90	230	743	6.6	118
	9/23/08	98.4	226	103	988	493	1810	561	85	273	919	6.4	98
	Mean	**78.7**	**168**	**35**	**925**	**347**	**1475**	**490**	**62**	**122**	**674**	**6.1**	**123**
2S-A	7/17/08	43.2	405	62	568	628	1663	<1	64	127	192	7.5	58
	7/30/08	45.0	359	438	1493	293	2583	<1	21	163	185	18.3	53
	8/13/08	48.4	302	185	1083	836	2406	<1	24	132	157	14.7	78
	8/27/08	43.0	49	498	748	996	2291	<1	11	158	170	16.2	72
	9/9/08	33.8	493	858	610	992	2953	<1	11	133	145	10.2	79
	9/23/08	36.4	391	957	433	1117	2898	<1	14	92	107	9.2	78
	Mean	**41.6**	**333**	**500**	**823**	**810**	**2466**	**<1**	**24**	**134**	**159**	**12.7**	**70**
3S	7/17/08	63.2	156	14	912	374	1456	349	61	57	467	2.4	184
	7/30/08	85.6	112	177	1439	31	1759	210	50	73	333	8.5	111
	8/13/08	92.2	162	142	1087	478	1869	210	26	71	307	8.8	102
	8/27/08	83.4	52	13	1066	177	1308	347	6	59	412	6.0	182
	9/9/08	94.0	219	155	855	373	1602	293	17	67	377	4.9	144
	9/23/08	101	128	68	990	280	1466	291	15	12	318	4.8	93
	Mean	**86.6**	**138**	**95**	**1058**	**286**	**1577**	**283**	**29**	**57**	**369**	**5.9**	**136**
4S	7/17/08	114	308	62	880	389	1639	448	762	61	1271	9.2	115
	7/30/08	175	496	323	1135	386	2340	1148	261	42	1451	5.5	72
	8/13/08	170	625	42	1582	217	2466	1101	210	66	1377	4.2	72
	8/27/08	92.6	277	340	925	411	1953	798	19	81	898	6.9	113
	9/9/08	115	446	590	870	589	2495	764	6	101	871	4.7	109
	9/23/08	161	556	708	1225	349	2838	704	240	75	1019	6.9	68
	Mean	**138**	**451**	**344**	**1103**	**390**	**2289**	**827**	**250**	**71**	**1148**	**6.2**	**92**
5S	7/17/08	115	344	129	729	376	1578	1144	33	94	1271	3.3	99
	7/30/08	121	191	38	810	248	1287	197	50	39	286	6.5	41
	8/13/08	175	419	8	1208	272	1907	1376	9	35	1420	2.4	88
	8/27/08	112	276	363	832	318	1789	855	35	41	931	3.8	97
	9/9/08	163	20	204	977	180	1381	1244	17	13	1274	4.9	87
	9/23/08	158	513	124	1037	149	1823	745	338	38	1121	2.8	75
	Mean	**141**	**294**	**144**	**932**	**257**	**1628**	**927**	**80**	**43**	**1051**	**4.0**	**81**

4.1.3.2.2 Site 2S-A

Monitoring Site 2S was intended to reflect characteristics of off-site inflow along the northeast portion of the IGC property. However, during the monitoring program, no runoff inflow was observed in this area, and it is extremely unlikely that significant inflow would occur from these areas except under extreme rain events. As a result, surface water monitoring was collected from the most upstream pond in this portion of the IGC property which is referred to as Site 2S-A. Site 2S-A is characterized by moderate to low levels of alkalinity, with a mean alkalinity of only 41 mg/l. Water within this pond is characterized by elevated levels of total nitrogen which ranged from 1663-2953 µg/l, with an overall mean of 2466 µg/l. The dominant nitrogen species within the pond was dissolved organic nitrogen which comprised 33% of the total nitrogen measured at the site. An additional 33% was contributed by particulate nitrogen. Relatively elevated levels of both ammonia and NO_x were observed within the pond, with a mean ammonia concentration of 333 µg/l and a mean NO_x concentration of 500 µg/l, with individual NO_x measurements as high as 957 µg/l. As will be discussed in a subsequent section, reuse water applied to the golf course for irrigation purposes contains relatively low concentrations of both ammonia and NO_x, suggesting that the elevated levels observed within the northeast pond system are enhanced as a result of fertilizer activities.

Surface water within the pond was also characterized by extremely elevated levels of total phosphorus, with an overall mean of 159 µg/l. Virtually all of the phosphorus is present as particulate phosphorus which comprised 84% of the total phosphorus measured. An additional 15% is contributed by dissolved organic phosphorus, with virtually no measurable dissolved inorganic phosphorus at this site. The calculated TN/TP ratio of 15.5 for this site suggests balanced nutrient conditions, although this pond is clearly phosphorus-limited due to the severe lack of SRP within the water column. Most of the available phosphorus is currently tied up with algae within the pond which is reflected in the high percentage of particulate phosphorus measured at this site.

Surface water within the pond was characterized by elevated levels of TSS ranging from 7.5-18.3 mg/l, with an overall mean of 12.7 mg/l. These elevated values are an additional reflection of the algal biomass present within this pond. The pond water is also characterized by moderate color concentrations, with an overall mean of 70 Pt-Co units.

4.1.3.2.3 Site 3S

Monitoring Site 3S is located in the upstream portions of the pond system located in the northern portion of the IGC area. Water within this pond appears to be moderately well buffered with an overall mean alkalinity of 86.6 mg/l. Total nitrogen concentrations within this pond are substantially lower in value than concentrations measured at Site 2S-A, with an overall mean total nitrogen concentration at Site 3S of 1577 µg/l. The dominant nitrogen species at this site is dissolved organic nitrogen which contributed 67% of the total nitrogen, with an additional 18% contributed by particulate nitrogen. Low to moderate levels of ammonia and NO_x were observed at this site, with an overall mean ammonia concentration of 138 µg/l and a mean NO_x concentration of 95 µg/l.

Samples collected at Site 3S were characterized by extremely elevated levels of total phosphorus for a pond system. The mean total phosphorus concentration of 369 µg/l is 10-20 times higher than phosphorus concentrations normally observed in lake systems. Approximately 77% of the total phosphorus is contributed by SRP, with relatively small contributions from dissolved organic phosphorus and particulate phosphorus. The extremely elevated mean SRP concentration of 283 µg/l represents a substantial significant source of available inorganic nutrients.

Measured TSS concentrations at this site were moderate in value, with an overall mean of 5.9 mg/l. Water within the pond contained moderate to elevated levels of color, with an overall mean of 136 Pt-Co units.

4.1.3.2.4 Site 4S

Surface water monitored at Site 4S reflects discharges to the Innisbrook Canal near the center of the IGC area. Water samples collected at this site were found to be well buffered, with a mean alkalinity of 138 mg/l. The discharges at this site are characterized by elevated levels of total nitrogen which ranged from 1953-2838 μg/l, with an overall mean of 2289 μg/l. The dominant nitrogen species at this site is dissolved organic nitrogen which comprised 48% of the total nitrogen, with 17% contributed by particulate nitrogen. Highly variable and elevated values of ammonia and NO_x were observed at this site, with a mean ammonia concentration of 451μg/l and a mean NO_x of 344μg/l. Nitrogen concentrations measured at Site 4S are similar to concentrations measured in the northeast pond at Site 2S-A, although substantially higher in value than observed at either Site 1S (Bee Pond inflow) or Site 3S (northern pond).

Discharges at Site 4S are characterized by extremely elevated levels of total phosphorus, with a mean total phosphorus concentration of 1148 μg/l. Approximately 72% of the total phosphorus is contributed by SRP, with an extremely elevated mean concentration of 827 μg/l. The total phosphorus and SRP values measured at this site are substantially higher in value than concentrations measured at the previous sites which are hydrologically uphill from Site 4S. This suggests a substantial increase or input of phosphorus within the golf course area during migration to Site 4S. The mean SRP concentration of 827 μg/l is 10-40 times greater than SRP concentrations commonly observed in urban drainage systems.

Measured TSS concentrations at this site were relatively uniform and low in value, with a mean of only 6.2 mg/l. Samples collected at this site were also moderately colored, with a mean of 92 Pt-Co units.

4.1.3.2.5 Site 5S

Monitoring Site 5S represents the discharge for water generated within the freshwater segment of the Klosterman Bayou. Samples collected at the discharge site were found to be well buffered, with a mean alkalinity of 141 mg/l. The mean total nitrogen concentration of 1628 μg/l measured at this site is moderate in value and substantially lower in value than the total nitrogen concentration measured upstream within the Innisbrook Canal at Site 4S. The dominant nitrogen species in discharges through the outfall is dissolved organic nitrogen which contributed 57% of the total nitrogen. An additional 16% was contributed by particulate nitrogen. Highly variable and at times highly elevated concentrations of ammonia and NO_x were observed at the outfall monitoring site. However, mean values for both of these species are lower than observed at Site 4S. In fact, mean concentrations for all nitrogen species at Site 5S were lower in value than measured at Site 4S.

Samples collected at Site 5S are characterized by extremely elevated levels of both total phosphorus and SRP, with a mean total phosphorus concentration of 1051 μg/l and a mean SRP of 927 μg/l. The SRP values measured at this site reflect a significant potential phosphorus loading to downstream receiving waters. Relatively low levels of dissolved organic phosphorus and particulate phosphorus were observed at this site. The SRP in discharges from the property indicate available phosphorus which is substantially in excess of the landscaping needs or uptake potential of the on-site vegetation and waterbodies. Relatively low levels of TSS were observed at the site outfall, with a mean of only 4 mg/l. Discharges at the outfall were also moderately colored, with a mean of 81 Pt-Co units.

4.1.4 **Reuse Characteristics**

As discussed in Section 3, samples of reuse irrigation water were also collected during the monitoring program to assist in identifying potential nutrient sources. Locations selected for collection of reuse irrigation water are indicated on Figure 4-4. Reuse water was collected from three separate locations. The first location is the reuse irrigation pond located east of groundwater monitoring Site 2 in the Klosterman Bayou watershed. According to IGC personnel, this pond is used exclusively for irrigation and is refilled regularly with reuse water. The second collection site is the sprinkler system located in southern portions of the IGC property near Bee Pond. This irrigation system was running during both monitoring events in September 2008, and samples were collected directly from the irrigation discharge. In addition, samples of reuse water were collected on two occasions during September directly from the William E. Dunn Reclamation Facility. Characteristics of reuse irrigation water collected within the Klosterman Bayou watershed are given in Table 4-5.

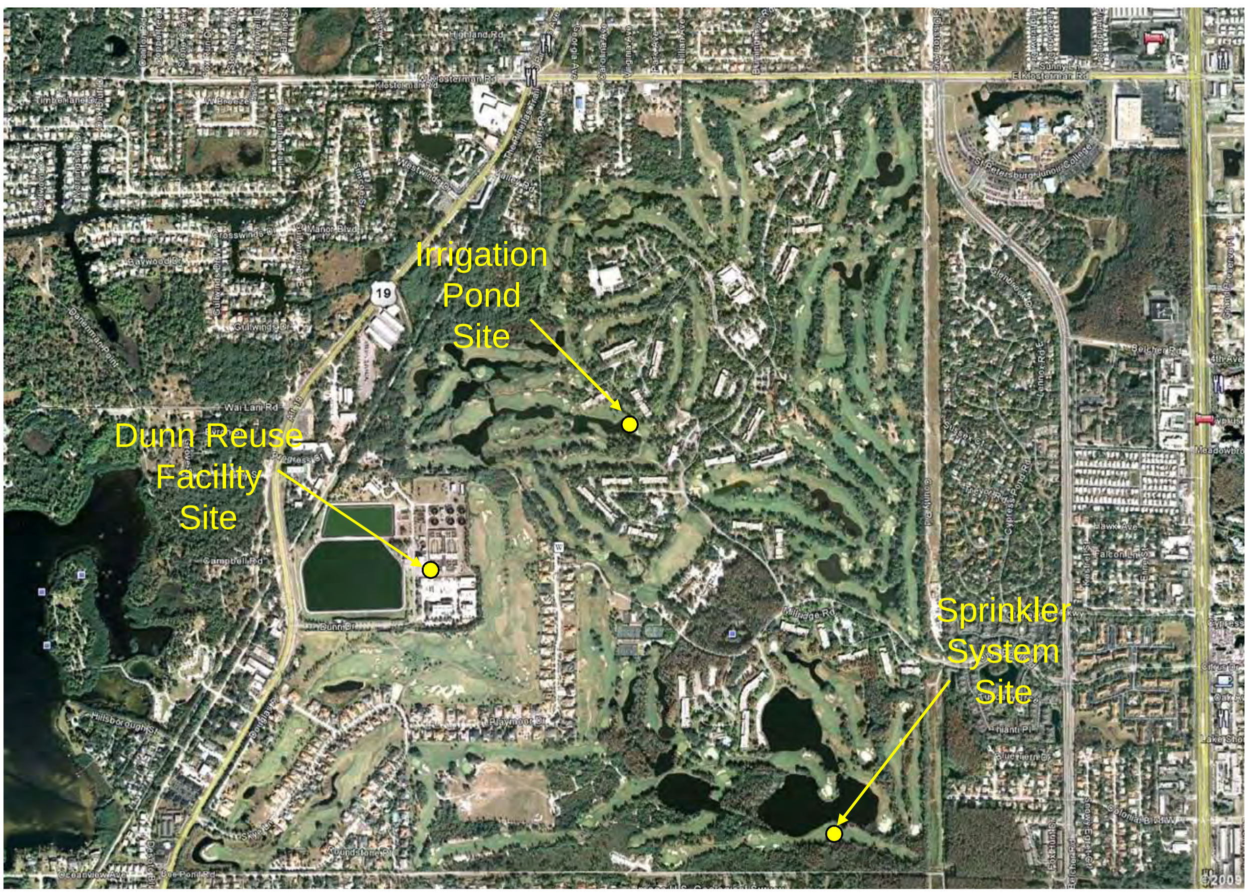


Figure 4-4. Locations for Collection of Reuse Water.

TABLE 4-5

CHARACTERISTICS OF REUSE IRRIGATION WATER COLLECTED WITHIN THE KLOSTERMAN BAYOU WATERSHED

SITE	DATE	ALK. (mg/l)	NH_3 (µg/l)	NO_X (µg/l)	DISS. ORG. N (µg/l)	PART. N (µg/l)	TOTAL N (µg/l)	SRP (µg/l)	DISS. ORG. P (µg/l)	PART. P (µg/l)	TOTAL P (µg/l)	TSS (mg/l)	COLOR (Pt-Co)
Irrigation Pond	8/13/08	261	45	22	955	552	1574	1595	137	141	1873	14.8	19
	8/27/08	223	31	<5	502	561	1097	871	440	172	1483	12.7	26
	9/9/08	243	27	13	452	728	1220	1483	34	313	1830	18.0	21
	9/23/08	213	145	58	678	850	1731	681	237	227	1145	19.7	16
Sprinkler Near Bee Pond	9/9/08	245	30	5	419	595	1049	1743	15	87	1845	16.4	20
	9/23/08	91.4	261	255	1117	515	2148	369	233	292	894	4.1	101
Reuse at Dunn Plant	9/9/08	255	37	2.5	365	298	703	1618	173	109	1900	7.6	9
	9/23/08	258	39	7	468	715	1229	897	313	233	1443	13.2	5
Mean		**224**	**77**	**46**	**620**	**602**	**1344**	**1157**	**198**	**197**	**1552**	**13.3**	**29**

In general, reuse irrigation water was extremely well buffered, with a mean alkalinity of 224 mg/l. The reuse irrigation water was relatively low in total nitrogen, with a mean of only 1344 µg/l, which is extremely low compared with values commonly observed in reuse water. The applied reuse water had extremely low levels of both ammonia and NO_x and was comprised primarily of dissolved organic nitrogen and particulate nitrogen. Since the reuse water was extremely low in inorganic nitrogen species, the elevated values for ammonia and NO_x observed at some of the surface water monitoring sites must have originated from other sources, such as fertilizer or stormwater runoff.

However, the reuse water was characterized by extremely elevated levels of total phosphorus, with a mean total phosphorus concentration of 1552 µg/l. This mean value is approximately 4-6 times greater than commonly observed in untreated urban runoff. Approximately 75% of the total phosphorus within the reuse irrigation water is comprised of SRP which represents a substantial source of available phosphorus to downstream receiving waters. The reuse water contained relatively low levels of both dissolved organic phosphorus and particulate phosphorus, although the mean values for each of these parameters are similar to phosphorus concentrations observed in low-density residential developments. The mean total phosphorus and SRP concentrations measured in the reuse water are substantially higher than SRP and total phosphorus concentrations measured at any of the surface water monitoring sites.

The reuse irrigation water contained moderate concentrations of TSS, with a mean of 13.3 mg/l. This value is also higher than TSS concentrations measured at the surface water monitoring sites. The reuse water was characterized by relatively low levels of color, with a mean color concentration of 29 Pt-Co units.

A statistical comparison of nitrogen species measured at the Klosterman Bayou surface water monitoring sites is given on Figure 4-5. Relatively low levels of ammonia were observed at the Bee Pond inflow and in the northern pond at Site 3S. More elevated concentrations and higher variability were observed in ammonia concentrations measured at the remaining sites. A similar pattern is apparent for measured concentrations of NO_x, with low concentrations and low variability observed at the Bee Pond inflow and northern pond monitoring sites, and higher concentrations and higher variability at the remaining sites. This pattern is also apparent for measured total nitrogen concentrations, with the highest levels of total nitrogen observed in the northeast pond and at the concrete weir structure.

A statistical comparison of phosphorus species and TSS measured at the Klosterman Bayou surface water monitoring sites is given on Figure 4-6. Elevated levels of SRP were observed at the Bee Pond inflow, concrete weir, and IGC outfall. These same sites also exhibited substantially elevated levels of total phosphorus, with much lower levels observed in the northeastern and northern pond systems. These data suggest that phosphorus inputs other than upstream waterbodies are impacting discharges measured at the concrete weir and at the IGC outfall. Elevated levels of TSS were measured in the northeastern pond system, presumably due to elevated algal productivity in this area.

4.1.5 Groundwater Characteristics

A summary of the chemical characteristics of shallow groundwater samples collected in the Klosterman Bayou watershed is given on Table 4-6. Measurements for temperature, pH, conductivity, and TDS were conducted in the field, with the remaining measurements conducted on collected samples in the laboratory. Groundwater monitoring Site GW-1 is located northeast of the IGC property in a utility easement, with Site GW-2 located near the middle of the IGC area, and Site GW-3 located in the Wall Sink.

In general, groundwater samples collected at Sites GW-1 and GW-2 are approximately neutral in pH, with moderate values for conductivity and TDS. Groundwater at these sites was also found to be very poorly buffered, with mean alkalinity values of 22.5 mg/l for Site GW-1 and 13.7 for Site GW-2. Groundwater collected from each of the two sites was also found to be relatively low in total nitrogen, with a mean of 349 μg/l at Site GW-1 and 682 μg/l at Site GW-2. However, a significant increase in NO_x concentrations is apparent in shallow groundwater collected beneath the IGC area compared with groundwater at the off-site monitoring well. This significant increase in NO_x is primarily responsible for the increase in total nitrogen observed beneath the IGC area.

Phosphorus concentrations at Sites GW-1 and GW-2 appear to be low to moderate in value, with mean total phosphorus concentrations ranging from 44-68 μg/l. The primary difference between phosphorus concentrations at the two sites is the substantial increase in SRP observed at GW-2 (located within the golf course area) which contributes the majority of the difference in total phosphorus concentrations. Measured color concentrations between the two groundwater sites appear to be relatively similar.

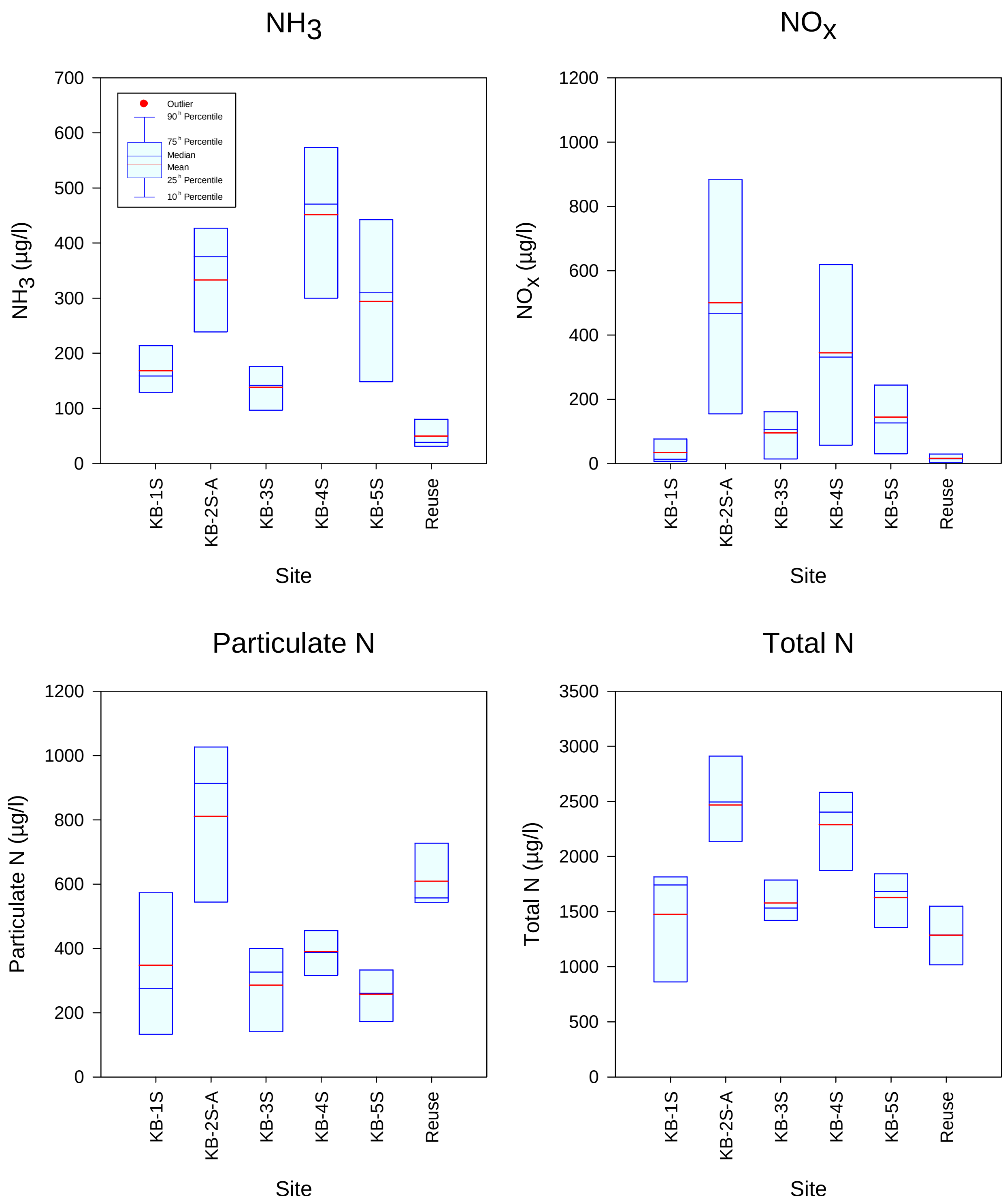


Figure 4-5. Statistical Comparison of Nitrogen Species in Surface Water and Reuse in the Klosterman Bayou Watershed.

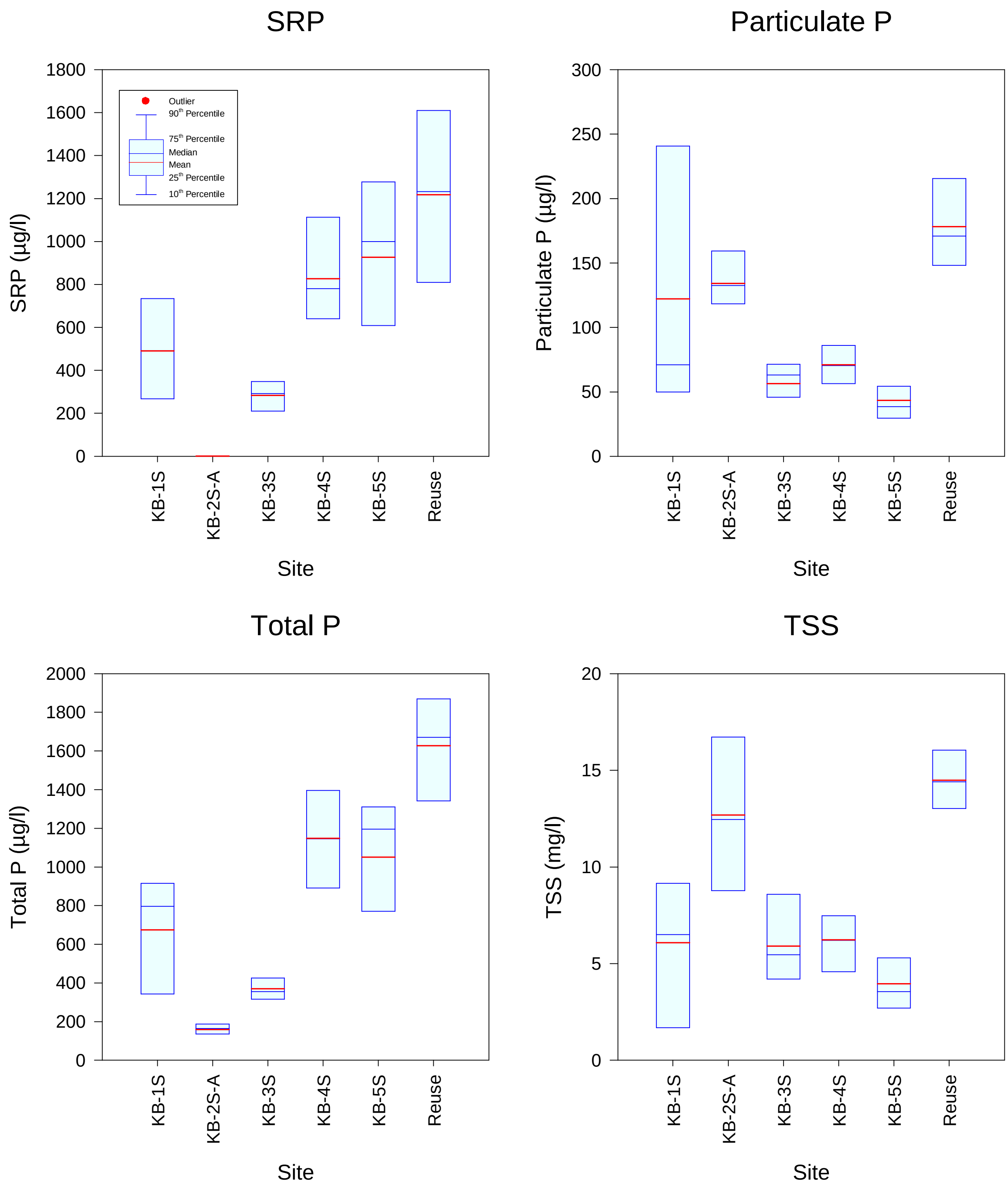


Figure 4-6. Statistical Comparison of Phosphorus Species in Surface Water and Reuse in the Klosterman Bayou Watershed.

TABLE 4-6

CHEMICAL CHARACTERISTICS OF SHALLOW GROUNDWATER SAMPLES COLLECTED IN THE KLOSTERMAN BAYOU WATERSHED

SITE	DATE	TEMP. (°C)	pH (s.u.)	COND. (µmho/cm)	TDS (mg/l)	ALK. (mg/l)	NH_3 (µg/l)	NO_X (µg/l)	DISS. ORG. N (µg/l)	TOTAL N (µg/l)	SRP (µg/l)	DISS. ORG. P (µg/l)	TOTAL P (µg/l)	COLOR (Pt-Co)
GW-1	7/17/08	26.50	6.61	198	127	22.0	45	16	256	317	21	44	65	132
	7/30/08	26.85	6.39	314	201	25.6	116	25	269	410	12	38	50	48
	8/13/08	27.50	6.59	304	195	21.6	89	44	160	293	17	13	30	35
	8/27/08	27.58	6.24	241	154	14.6	40	2.5	357	399	10	14	24	63
	9/9/08	28.75	6.37	291	186	26.2	74	12	262	348	9	46	55	59
	9/23/08	29.44	6.07	265	170	25.0	90	45	194	329	13	28	41	46
	Mean	**27.77**	**6.38**	**269**	**172**	**22.5**	**76**	**24**	**250**	**349**	**14**	**31**	**44**	**64**
GW-2	7/17/08	25.12	6.65	183	117	8.6	<5	665	106	773	22	30	52	13
	7/30/08	26.56	6.69	173	111	13.6	40	574	429	1043	71	22	93	28
	8/13/08	28.99	6.70	148	95	13.2	29	571	173	773	21	36	57	23
	8/27/08	26.58	6.39	160	102	12.4	21	106	409	536	6	53	59	36
	9/9/08	27.08	6.60	129	83	13.8	17	107	168	292	54	18	72	195
	9/23/08	26.98	6.38	117	75	20.8	84	149	444	677	56	19	75	85
	Mean	**26.89**	**6.57**	**152**	**97**	**13.7**	**32**	**362**	**288**	**682**	**38**	**30**	**68**	**63**
GW-3	7/17/08	24.81	7.16	8869	5676	178	35	2892	979	3906	55	11	66	7
	7/30/08	24.46	7.11	6347	4062	172	50	3663	1742	5455	66	14	80	7
	8/13/08	24.51	7.22	6356	4068	173	46	3189	222	3457	44	12	56	10
	8/27/08	24.58	7.16	3814	2440	183	31	3012	237	3280	39	18	57	5
	9/9/08	24.66	7.01	3711	2380	178	26	3313	125	3464	42	15	57	9
	9/23/08	24.48	7.10	4252	2720	174	24	4004	214	4242	50	15	65	4
	Mean	**24.58**	**7.13**	**5558**	**3558**	**176**	**35**	**3346**	**587**	**3967**	**49**	**14**	**64**	**7**

The downstream groundwater monitoring site (GW-3) was located in Wall Sink to provide an estimate of groundwater characteristics downstream from the Klosterman Bayou watershed. Groundwater collected at this site was approximately neutral in pH, with substantially elevated values of conductivity and TDS. Groundwater at this site was also characterized by elevated levels of total nitrogen, with a mean of 3967 μg/l. Approximately 84% of the total nitrogen is contributed by NO_x, with a mean of 3346 μg/l. This value is approximately 10 times greater than the mean of 362 μg/l for NO_x measured beneath the IGC area at Site GW-2. Phosphorus concentrations at the Wall Sink discharge are virtually identical to phosphorus concentrations measured beneath the IGC area.

4.1.6 <u>Isotope Analyses</u>

A report describing the results of the stable isotope analyses on surface and groundwater samples collected from Klosterman Bayou and Joe's Creek was prepared by Dr. Bruce Hungate. A complete version of this report is given in Appendix D, and a summary of the results is given in this section.

Isotopic analyses involving nitrogen and oxygen compounds require minimum levels of nitrate for analysis. Sufficient levels of nitrate were available in all five of the surface water monitoring sites within the Klosterman Bayou watershed as well the reuse irrigation samples. However, sufficient nitrate concentrations were available for only two of the three groundwater sources, with insufficient levels of nitrate present at the upstream groundwater well (Site GW-1) located northeast of the IGC site.

Water samples with sufficient nitrate for isotope analysis exhibited a high degree of variability in $\delta^{15}N$ measurements in the Klosterman Bayou watershed, with means ranging from -0.95 to 13.21‰. Two lines of evidence could support *in situ* denitrification as a major pathway of NO_3^- removal, and thus as a confounding signal for interpreting isotopes in source partitioning. One sign of denitrification is a negative slope for the relationship between $[NO_3^-]$ and $\delta^{15}N\text{-}NO_3^-$, reflecting preferential removal of $^{14}N\text{-}NO_3^-$ through denitrification. Within the Klosterman Bayou system, only site GW-3 showed the expected relationship consistent with denitrification.

A second sign of *in situ* denitrification is co-varying enrichment of $\delta^{15}N$ and $\delta^{18}O$ in nitrate, if the ratio of enrichments are between 1.3 and 2.1 to 1 (Aravena and Robertson, 1998; Fukada et al., 2003). For the surface water Klosterman Bayou samples considered together, the slope of the relationship between $\delta^{15}N$ and $\delta^{18}O$ in nitrate was 1.6, consistent with enrichment caused by denitrification. A number of sites considered separately also exhibited the expected positive relationship, including Site GW-3. For Site GW-3, these two lines of evidence indicate that denitrification enriches the NO_3^- in $\delta^{15}N$ and $\delta^{18}O$ at Site GW-3. For the other sites, evidence for *in situ* denitrification as a major NO_3^- removal pathway is equivocal.

Nitrate from Sites 2S-A, 3S, and 4S and, for the most part, Site 5S had similar $\delta^{15}N$ and $\delta^{18}O$ signatures, ranging from 9.34 to 15.25 for $\delta^{15}N$ and from 9.25 to 26.09 for $\delta^{18}O$, in general consistent with expected isotope signatures from animal waste, sewage, and wastewater sources. Two samples from Site 5S occurred outside of this range, with considerably lower $\delta^{15}N$ and $\delta^{18}O$ values more likely to reflect in situ NO_3^- production from nitrification. Nitrate from Site 1S also had low $\delta^{15}N$ and $\delta^{18}O$ signatures, consistent with microbial production via nitrification from native soil organic matter.

The two groundwater sites with sufficient NO_3^- for isotopic characterization had similar $\delta^{18}O$ values, ranging from -3.65 to 18.17, but differed in $\delta^{15}N$. Site GW-2 had consistently lower $\delta^{15}N$ than Site GW-3. The positive relationship between $\delta^{15}N$ and $\delta^{18}O$ for Site GW-3 was indistinguishable from that found for the other surface water samples within the Klosterman Bayou system (except Site 1S), suggesting that these samples share a common NO_3^- source. Denitrification of NO_3^- found in site GW-3 would be expected to produce NO_3^- enriched in $\delta^{15}N$ and $\delta^{18}O$, such as that found in the majority of surface water sites, specifically Sites 2S-A, 3S, and 4S, as well as several samples from Sites 5S and the reuse water. These findings indicate that the surface water monitoring sites (with the exception of Site 1S), reuse water, and GW-3 (Wall Spring) have a common nitrogen signature and share a common nitrogen source.

Finally, the irrigation water used for the golf course has $\delta^{15}N$ values (8.73 to 13.39) similar to Sites 2S-A, 3S, and 4S, but $\delta^{18}O$ values are equivocal, with two samples considerably lower (1.76 and 2.56 ‰) and one well within the range (20.87 ‰) of the other surface water samples). These samples also fall on the same $\delta^{15}N$ and $\delta^{18}O$ relationship typical for other surface water samples and by Site GW-3.

Based on isotope values, surface water samples within the Klosterman Bayou map together, with the exception of Site 1S. Therefore, nitrate found within the system is unlikely to originate from inputs occurring through Site 1S. The consistency of isotopic signatures of Sites 2S-A, 3S, and 4S suggest that they share a common NO_3^- source. Several samples from Site 5S and the reuse water were also consistent with the signatures of Sites 2S-A, 3S, and 4S, indicating that, at times, nitrogen in these samples originate from a common source. This suggests that nitrogen loadings at these sites are impacted by both reuse water and other nitrogen sources, presumably fertilizer. A common NO_3^- source is also shared by Sites S5, GW-3, and the reuse water, suggesting that reuse has a significant impact on nitrogen loadings at the IGC outfall as well as in groundwater discharging from Wall Spring located approximately 1 mile west of the IGC site.

4.1.7 Summary

Based upon the results of the field monitoring and laboratory analyses conducted from July-September 2008 within the Klosterman Bayou watershed, reuse irrigation water appears to have a significant impact on nutrient concentrations in surface water within the IGC area. An enhancement in concentrations of both nitrogen and phosphorus occurs during movement through the IGC area. Reuse water used within the basin is characterized by total phosphorus concentrations approximately 3-5 times higher than commonly observed in untreated stormwater runoff. A large percentage of the total phosphorus is present as SRP which represents a readily available phosphorus source to downstream waterbodies. However, relatively low concentrations of total phosphorus were measured in groundwater beneath the IGC area, suggesting that the phosphorus enhancement caused by reuse water is limited, at least at this time, to surface water impacts only.

Concentrations of total nitrogen in reuse water appear to be moderate in value, with a mean concentration of 1344 μg/l. Nitrogen concentrations measured throughout the IGC area are slightly higher than this value, suggesting additional nitrogen inputs, presumably from fertilizer applications within the basin. Groundwater concentrations of NO_x were higher in value than concentrations measured in reuse water, providing further evidence of additional nitrogen enhancement from other sources. Isotope analyses of nitrogen species in samples collected within the IGC area verify that reuse water is a significant source for nitrogen in off-site discharges and groundwater.

Off-site inputs into the IGC area appear to be extremely limited and occur only under extreme rain event conditions. As a result, virtually all nitrogen and phosphorus loadings discharging from the freshwater segment of the Klosterman Bayou originate within the IGC area itself.

4.2 Joe's Creek Watershed

4.2.1 Rainfall Characteristics

A survey was conducted of available rainfall records in the vicinity of the Joe's Creek watershed during the field monitoring program as well as antecedent rainfall leading up to the monitoring events. The USGS maintains a recording rainfall site within the freshwater segment of the Joe's Creek watershed. This site (Site 02308935) has available daily rainfall records over the period from 1984 to the present. A location map for the USGS rainfall recording site is given on Figure 4-7. This site was used to provide information on rainfall characteristics during and prior to the 2008 monitoring events.

Information on long-term historical rainfall within the vicinity of the Joe's Creek watershed was obtained from the St. Petersburg meteorological monitoring site (Site No. 087886), located approximately 2.7 miles southeast of the Joe's Creek freshwater segment. This site has an extensive historic database, but the period from 1971-2000 was selected to represent long-term rainfall trends to match the historic rainfall period used for evaluation of the Klosterman Bayou watershed. The location of this site is also indicated on Figure 4-7. Data from this site are used to generate estimates of historical monthly rainfall for comparison with rainfall observed during and prior to the monitoring program.

A comparison of measured and historical rainfall in the vicinity of the Joe's Creek watershed is given in Table 4-7. Monthly rainfall recorded at the USGS site is provided for the period from January-September 2008. These values are compared with the long-term monthly average rainfall recorded at the St. Petersburg meteorological monitoring site from 1971-2000. A graphical comparison of measured and historical monthly rainfall is given on Figure 4-8.

During the period from January-April 2008, rainfall measured at the USGS site appears to have been approximately normal. A substantial rainfall deficit occurred during May. However, substantially higher than normal rainfall was observed during June and July, with lower than normal rainfall observed during August and September. Rainfall in the vicinity of the Joe's Creek watershed from July-September 2008 was approximately 18.51 inches compared with a "normal" rainfall of 22.59 inches for this period. Rainfall in the vicinity of the Joe's Creek watershed over the period from January-September 2008 was approximately 40.44 inches compared with a "normal" rainfall for this period of approximately 42.30 inches, approximately 4.4% less than normal.

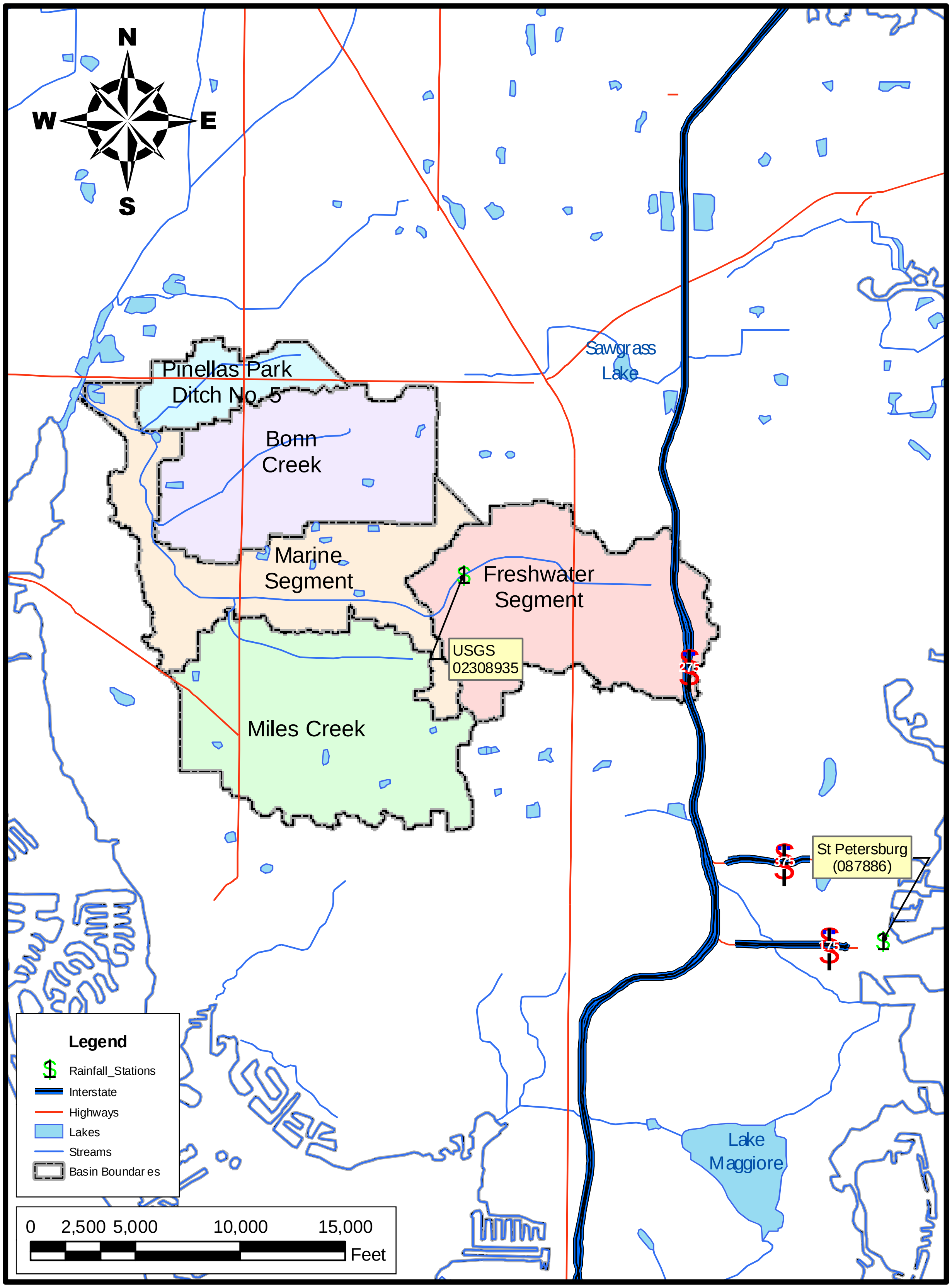


Figure 4-7. Recording Rainfall Sites in the Vicinity of the Joe's Creek Watershed.

TABLE 4-7

COMPARISON OF MEASURED AND HISTORICAL RAINFALL IN THE VICINITY OF THE JOE'S CREEK WATERSHED

MONTH	MONTHLY RAINFALL (inches)	
	USGS SITE No. 02308935 (2008)	ST. PETERSBURG (Mean 1971-2000)
January	3.33	2.76
February	2.48	2.87
March	4.52	3.29
April	2.03	1.92
May	0.53	2.80
June	9.04	6.09
July	10.31	6.72
August	6.1	8.26
September	2.1	7.59

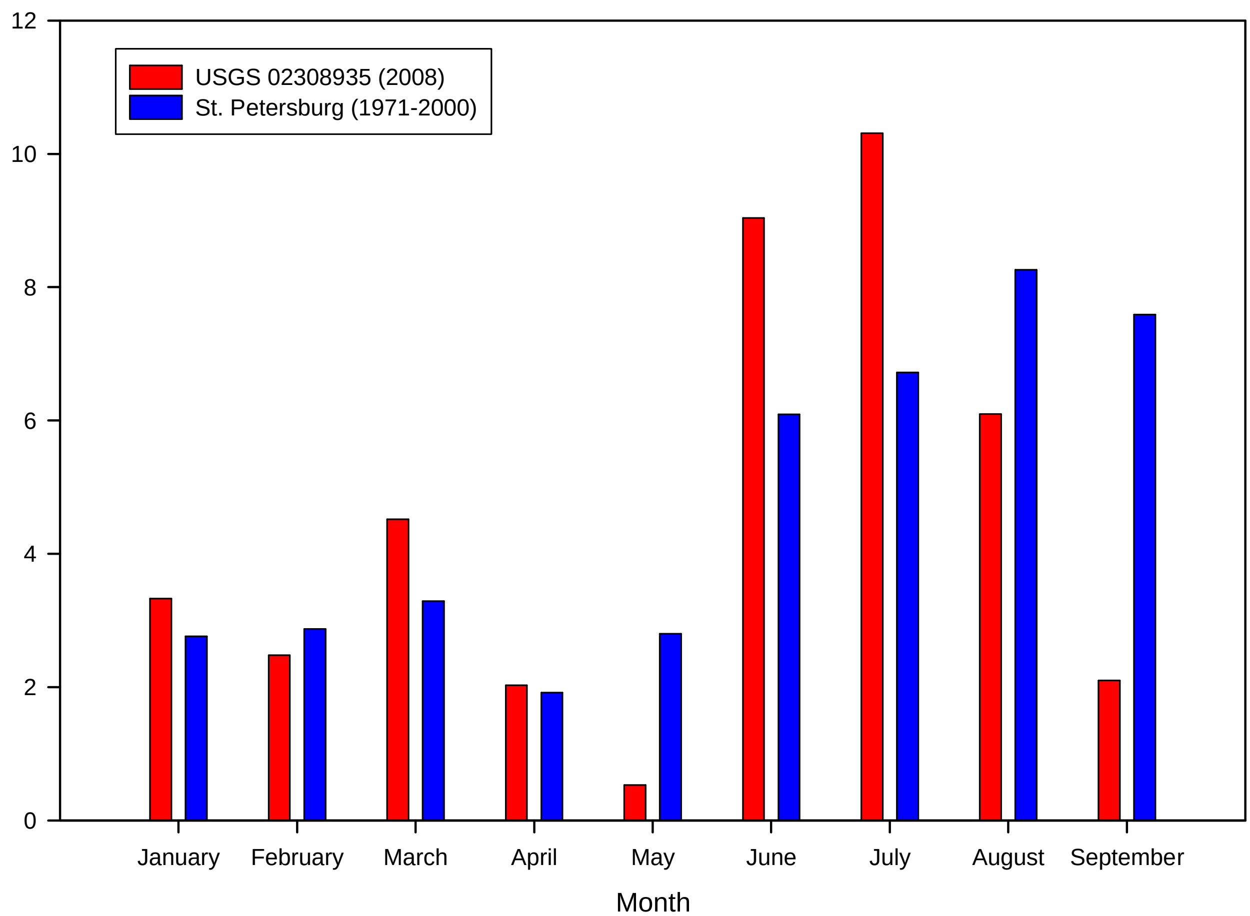


Figure 4-8. Graphical Comparison of Measured and Historical Mean Monthly Rainfall in the Vicinity of the Joe's Creek Watershed.

4.2.2 Discharge Measurements

A summary of measured discharge rates at the Joe's Creek surface water monitoring sites is given in Table 4-8. The discharge rates reflect conditions at the time of the monitoring event and are used to evaluate changes in flow and mass loadings along Joe's Creek and to assist in identifying potential nutrient inputs. The discharge measurements are not intended to reflect "average" or storm event conditions.

In general, measured flow rates appear to increase with increasing distance downstream along the creek. Discharge rates in upstream portions of the creek, as indicated by Site 0S, are relatively low in value, with no flow observed during three of the six monitoring events. However, as the monitoring stations move farther downstream, discharges become more consistent and appear to increase steadily in volume.

TABLE 4-8

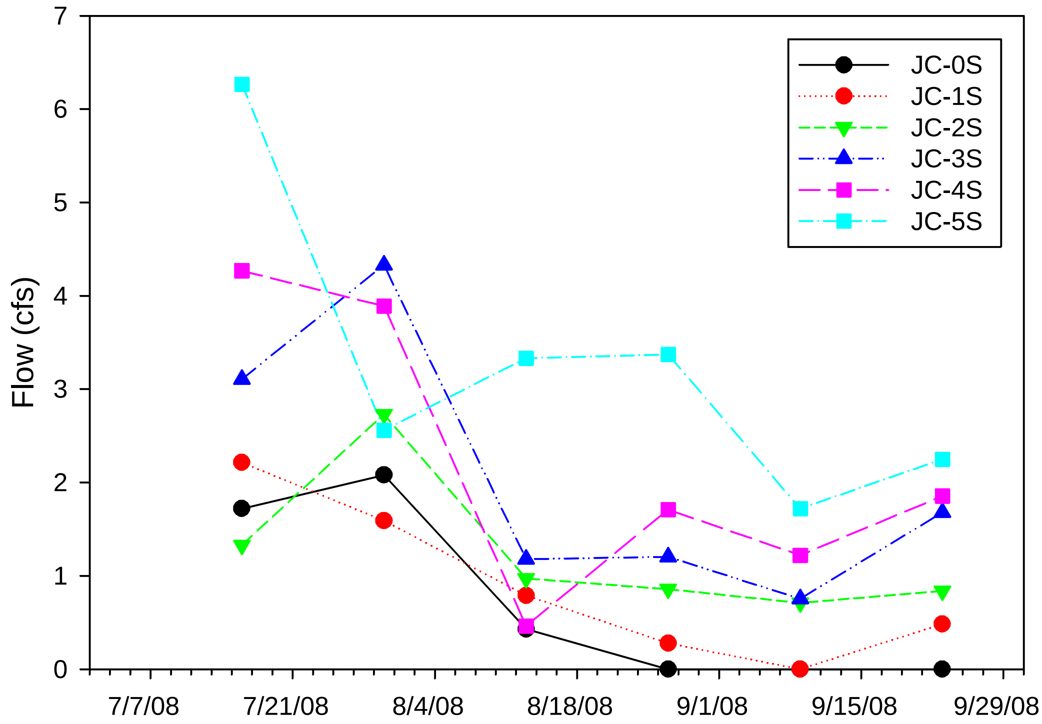
MEASURED DISCHARGE RATES AT THE JOE'S CREEK SURFACE WATER MONITORING SITES

DATE	MEASURED DISCHARGE (cfs)					
	0S	1S	2S	3S	4S	5S
7/16/08	1.72	2.21	1.33	3.11	4.27	6.27
7/30/08	2.08	1.59	2.73	4.33	3.89	2.56
8/13/08	0.43	0.79	0.97	1.18	0.46	3.33
8/27/08	0.00	0.28	0.86	1.20	1.71	3.37
9/9/08	0.00	0.00	0.71	0.75	1.22	1.72
9/23/08	0.00	0.48	0.84	1.68	1.86	2.25
Mean	**0.71**	**0.89**	**1.24**	**2.04**	**2.24**	**3.25**

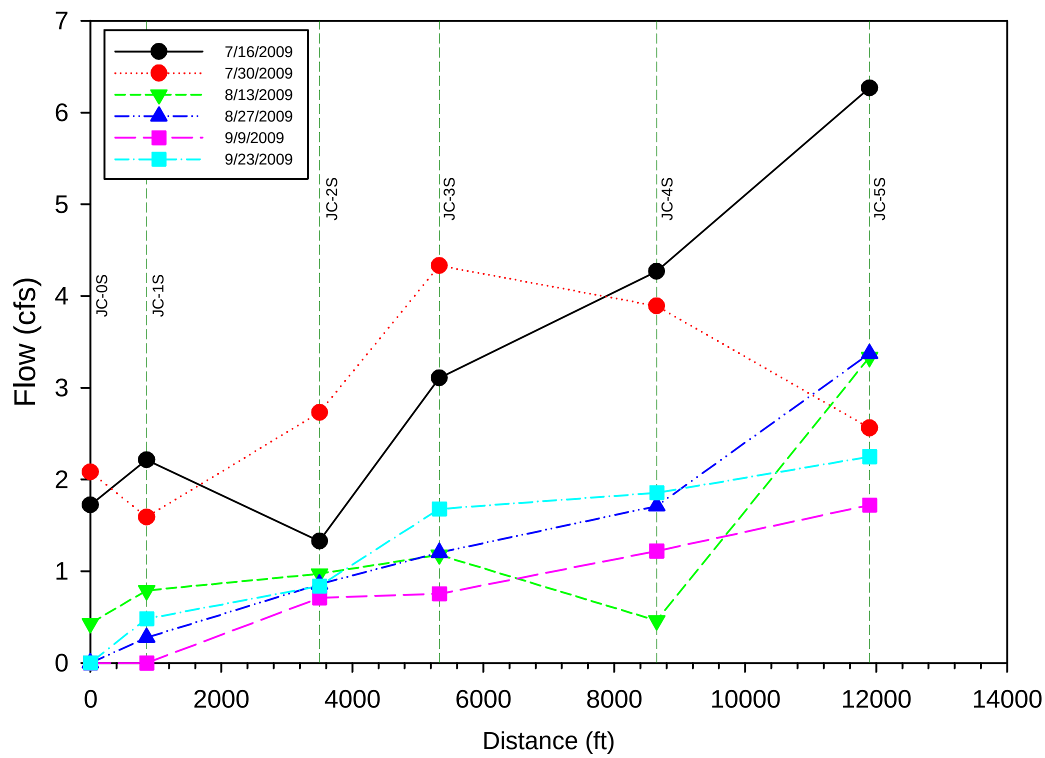
Graphical summaries of measured discharge rates within the Joe's Creek watershed are given on Figure 4-9. A summary of flow vs. monitoring date for each site is given in Figure 4-9a. In general, the highest flow rates were observed near the beginning of the monitoring program, with a gradual decrease in discharge rates over time. A summary of flow vs. distance along the creek path for each of the six monitoring dates is given on Figure 4-9b. In general, discharge rates appear to increase slightly with increasing distance along the creek path. For this figure, the discharge from the box culvert at Site 0S is assumed to represent the starting point of Joe's Creek, with the remaining sites referenced in terms of the flow path distance along the creek.

4.2.3 Surface Water Characteristics

Field monitoring was conducted at six surface water sites in the Joe's Creek watershed over the period from July-September 2008, with a total of six events conducted at each of the six monitoring sites. A discussion of the characteristics of surface water collected within the Joe's Creek watershed is given in the following sections.



a. Flow vs. Date by Site



b. Flow vs. Distance Along Creek by Date

Figure 4-9. Summaries of Measured Discharge Rates within the Joe's Creek Watershed.

4.2.3.1 Field Measurements

A complete listing of field measurements collected at the Joe's Creek watershed monitoring sites is given on Table 4-9. Field measurements of temperature, pH, conductivity, TDS, dissolved oxygen, and ORP were conducted at approximately mid-depth in the water column at each monitoring site. In general, measured pH values at the monitoring sites were found to be approximately neutral, with mean pH values ranging from approximately 7.16-7.51.

In general, moderate levels of conductivity were observed at each of the surface water monitoring sites, with mean values ranging from 295-399 μmho/cm. No tidal influence is apparent in the measured conductivity values even though the final monitoring site (Site 5S) is theoretically located downstream from the defined portion of the freshwater segment. The observed conductivity values are typical of conductivity measurements commonly observed in urban drainage systems.

In general, dissolved oxygen concentrations within Joe's Creek were highly variable and moderate to low in value on most occasions. Dissolved oxygen concentrations less than 5 mg/l were observed at each of the six monitoring sites on at least one occasion. The lowest levels of dissolved oxygen were observed at monitoring Site 2S, located near the intersection of Joe's Creek and U.S. 19. Mean dissolved oxygen concentrations at Sites 1S and 2S were less than the Class III criterion of 5 mg/l. However, in spite of the low dissolved oxygen measured within the creek on certain monitoring dates, oxidized conditions (indicated by redox potential values in excess of 200 mv) were present at each site during each monitoring event.

A statistical comparison of field parameters measured at the Joe's Creek surface water monitoring sites is given in Figure 4-10. In general, a moderate degree of variability was observed in dissolved oxygen concentrations measured at Sites 0S, 1S, 2S, 4S, and 5S, with a substantially higher degree of variability in dissolved oxygen concentrations measured at Site 3S. Relatively low degrees of variability were observed in pH values measured at Sites 0S, 1S, 2S, and 4S, with much higher variability observed at Sites 3S and 5S. The most elevated conductivity values were observed at Site 0S, with relatively similar conductivity values measured at the remaining sites.

A comparison of changes in temperature with distance along the Joe's Creek channel is given on Figure 4-11. In general, temperatures within Joe's Creek appear to be greatest at monitoring Site 4S which reflects the discharge from the SWFWMD retrofit pond, with slight decreases in temperature both before and after this site. Changes in pH with increasing distance along the Joe's Creek channel are illustrated on Figure 4-12. Measured pH values also appear to peak during most monitoring events at Site 4S which reflects the discharge from the District retrofit pond. Apparent decreases in pH occur before and after this monitoring site.

Changes in conductivity with distance along the Joe's Creek channel are illustrated on Figure 4-13. Significant decreases in conductivity were observed during migration through Silver Lake during the first two monitoring events. However, after this site, conductivity values appear to be relatively uniform throughout the remainder of Joe's Creek. Changes in dissolved oxygen concentrations with distance along the Joe's Creek channel are illustrated on Figure 4-14. Many areas within the Joe's Creek channel exhibit dissolved oxygen levels less than the Class III criterion of 5 mg/l. Dissolved oxygen concentrations appear to be greatest in the middle portions of the creek, with slightly lower values in the upstream and downstream portions of the creek.

TABLE 4-9

FIELD MEASUREMENTS COLLECTED AT THE JOE'S CREEK WATERSHED MONITORING SITES

SITE	DATE	TIME	TEMP. (^{o}C)	pH (s.u.)	COND. (μmho/cm)	TDS (mg/l)	D.O. (mg/l)	D.O. (% Sat.)	REDOX (mv)
0S	7/16/08	8:14:15	24.46	7.46	488	312	7.4	89	438
	7/30/08	7:16:39	28.40	7.55	478	306	6.5	84	462
	8/13/08	7:41:14	28.07	7.30	356	228	6.0	77	433
	8/27/08	7:37:41	28.23	7.39	368	236	5.4	69	491
	9/9/08	7:25:03	28.12	7.29	351	225	4.8	61	362
	9/23/08	7:47:02	26.93	7.16	353	226	3.1	39	222
	Mean		**27.37**	**7.36**	**399**	**255**	**5.5**	**70**	**401**
1S	7/16/08	7:36:40	27.95	7.37	205	131	5.7	72	447
	7/30/08	6:55:34	29.03	7.35	288	184	7.1	92	437
	8/13/08	7:13:48	26.70	7.16	332	212	4.9	61	424
	8/27/08	7:15:54	29.65	7.30	316	203	5.5	73	458
	9/9/08	7:07:30	28.29	7.27	343	219	3.2	41	367
	9/23/08	7:17:54	27.47	7.27	358	229	2.8	35	320
	Mean		**28.18**	**7.29**	**307**	**197**	**4.8**	**62**	**409**
2S	7/16/08	7:21:42	27.80	7.39	236	151	4.2	54	472
	7/30/08	6:46:56	28.37	7.22	331	212	5.0	64	446
	8/13/08	6:44:01	27.01	7.13	373	239	3.7	47	442
	8/27/08	6:48:51	29.85	7.00	379	242	3.3	44	423
	9/9/08	6:48:58	26.77	7.16	393	251	5.2	65	343
	9/23/08	6:53:54	26.48	7.04	362	231	2.2	28	235
	Mean		**27.71**	**7.16**	**346**	**221**	**3.9**	**50**	**393**
3S	7/16/08	9:49:39	27.82	7.55	204	131	6.0	76	459
	7/30/08	8:07:15	28.95	6.71	285	182	7.2	93	467
	8/13/08	8:12:14	28.78	7.18	338	216	3.5	45	471
	8/27/08	8:12:43	29.70	7.15	331	212	9.7	128	433
	9/9/08	8:05:06	28.85	7.42	369	236	7.2	94	406
	9/23/08	8:25:57	27.78	7.04	387	248	3.7	48	225
	Mean		**28.65**	**7.18**	**319**	**204**	**6.2**	**81**	**410**
4S	7/16/08	10:25:48	28.75	7.60	231	148	5.6	73	454
	7/30/08	8:41:19	29.58	7.52	281	180	6.3	83	514
	8/13/08	8:44:59	29.28	7.38	296	189	4.1	54	463
	8/27/08	8:38:13	30.36	7.37	304	195	6.8	90	397
	9/9/08	8:30:31	28.60	7.73	315	201	6.6	85	431
	9/23/08	9:21:24	27.72	7.47	344	220	5.5	70	281
	Mean		**29.05**	**7.51**	**295**	**189**	**5.8**	**76**	**424**
5S	7/16/08	11:20:27	28.19	7.55	216	138	6.2	80	468
	7/30/08	9:15:16	28.85	7.64	303	194	6.3	81	557
	8/13/08	9:40:44	27.89	7.61	339	217	5.4	69	570
	8/27/08	9:12:33	28.93	7.10	325	208	3.9	50	468
	9/9/08	9:13:12	25.45	6.99	374	239	3.3	40	416
	9/23/08	10:19:45	26.49	7.39	365	234	5.0	62	423
	Mean		**27.63**	**7.38**	**320**	**205**	**5.0**	**64**	**484**

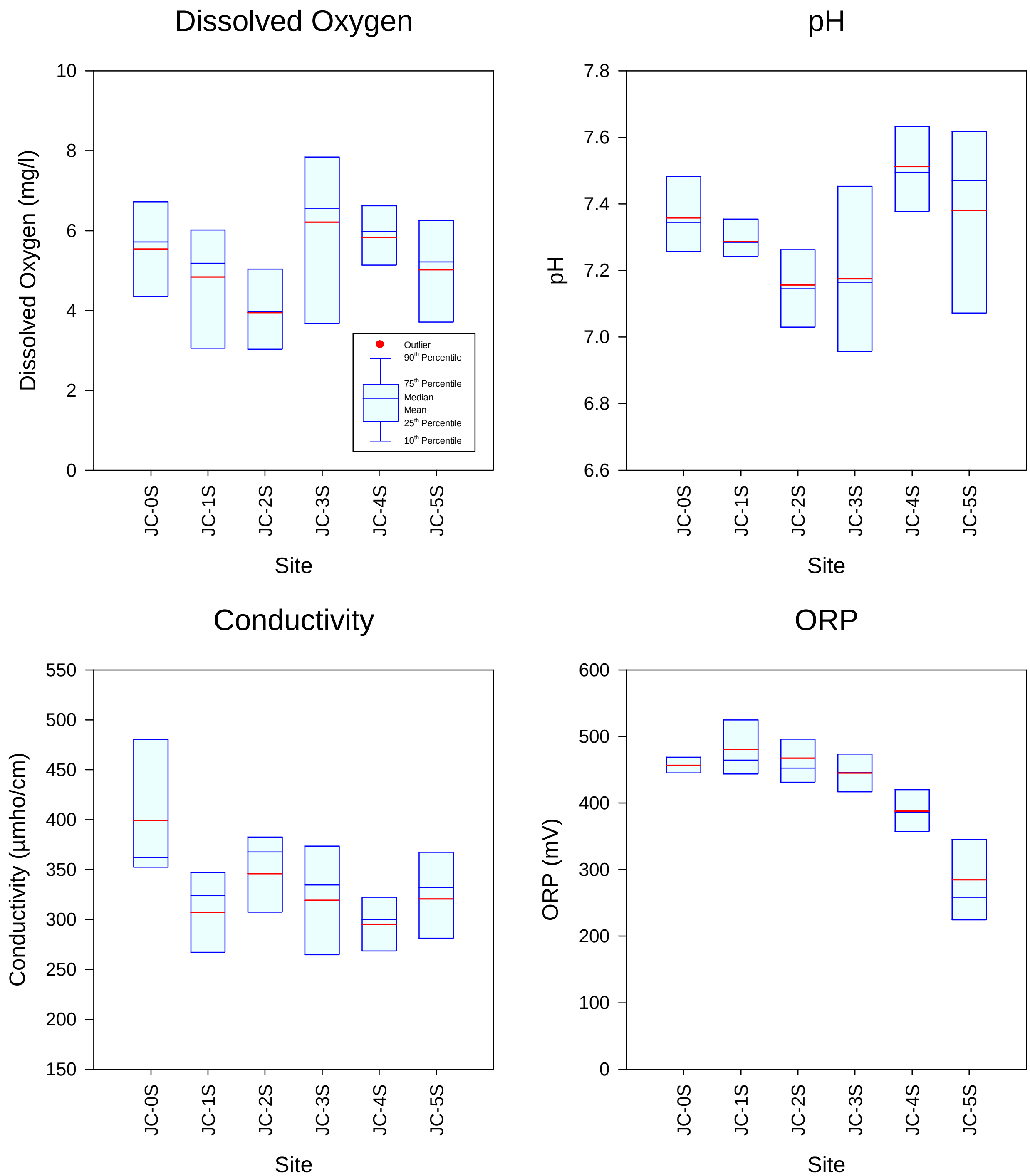


Figure 4-10. Statistical Comparison of Field Parameters Measured at the Joe's Creek Surface Water Monitoring Sites.

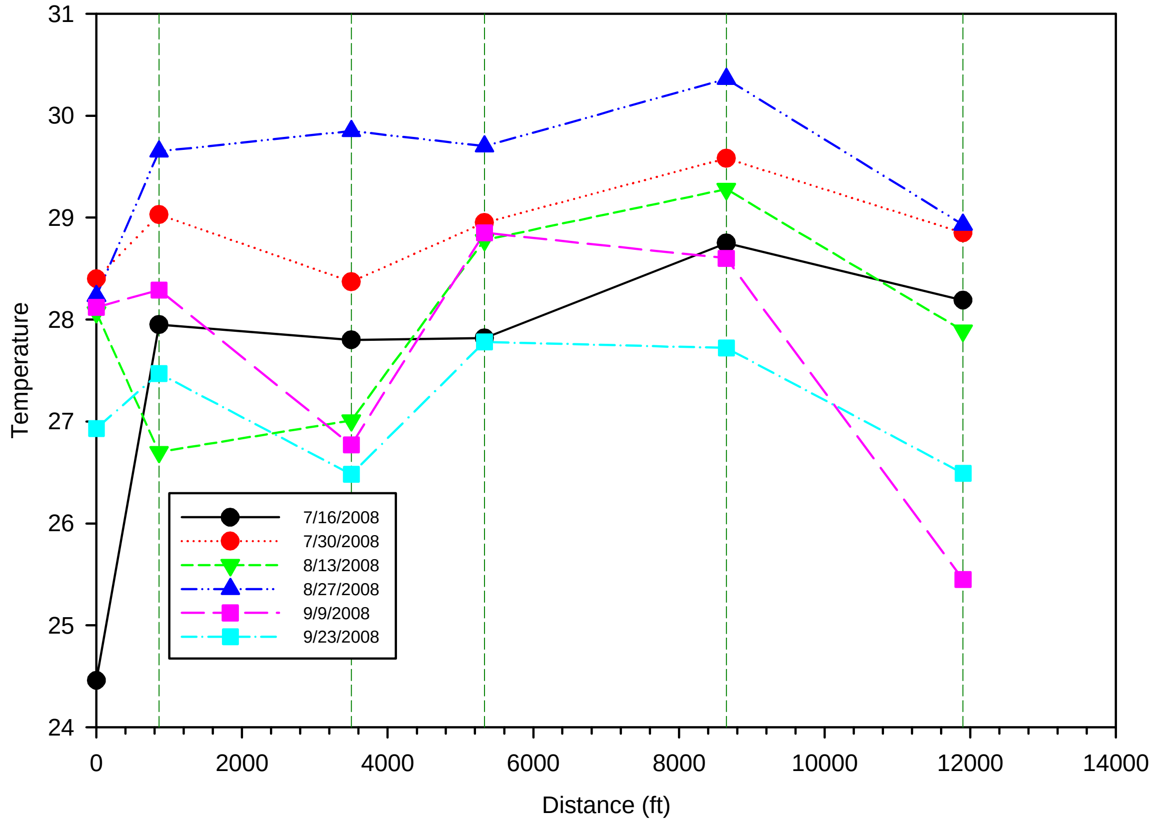


Figure 4-11. Changes in Temperature with Distance Along the Joe's Creek Channel.

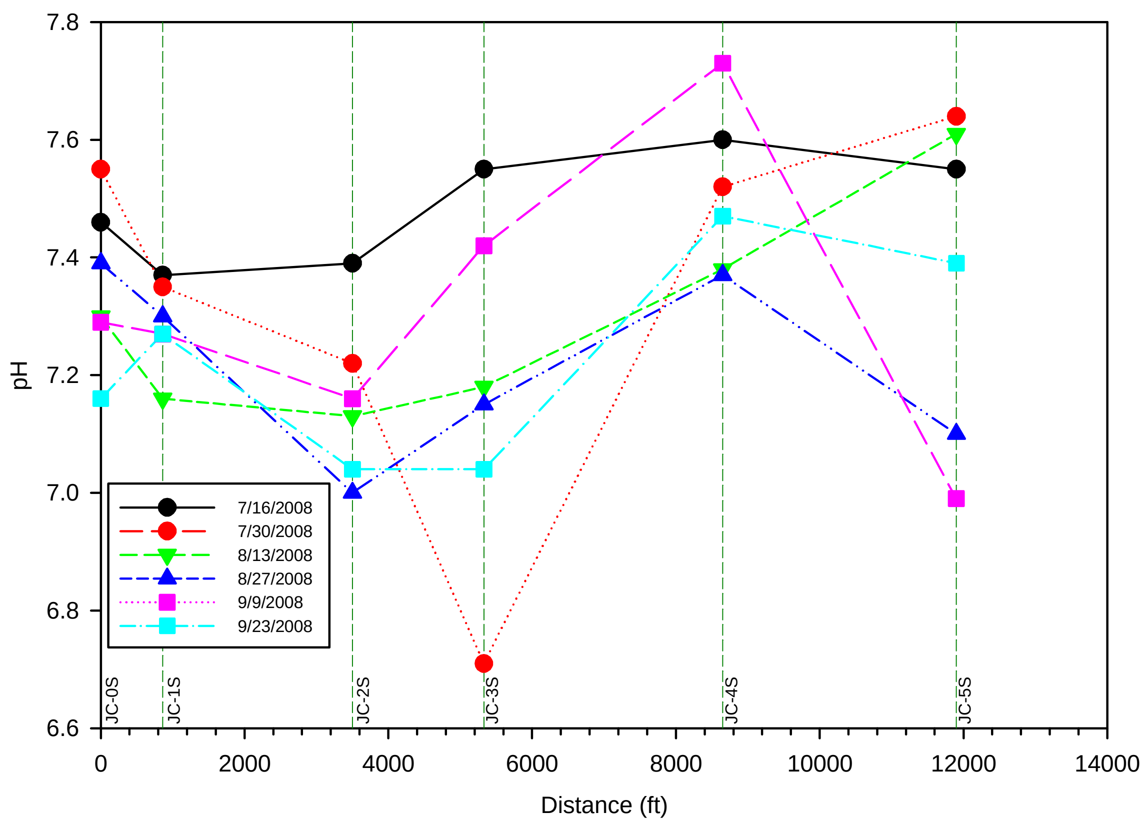


Figure 4-12. Changes in pH with Distance Along the Joe's Creek Channel.

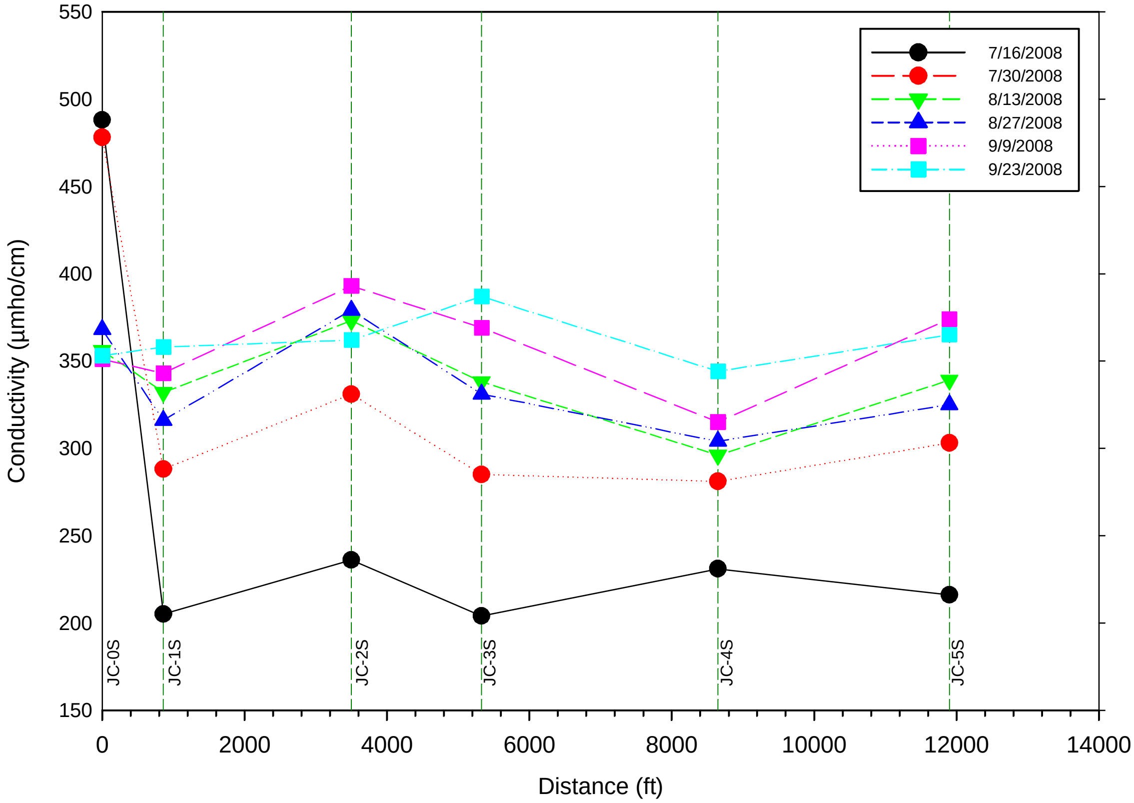


Figure 4-13. Changes in Conductivity with Distance Along the Joe's Creek Channel.

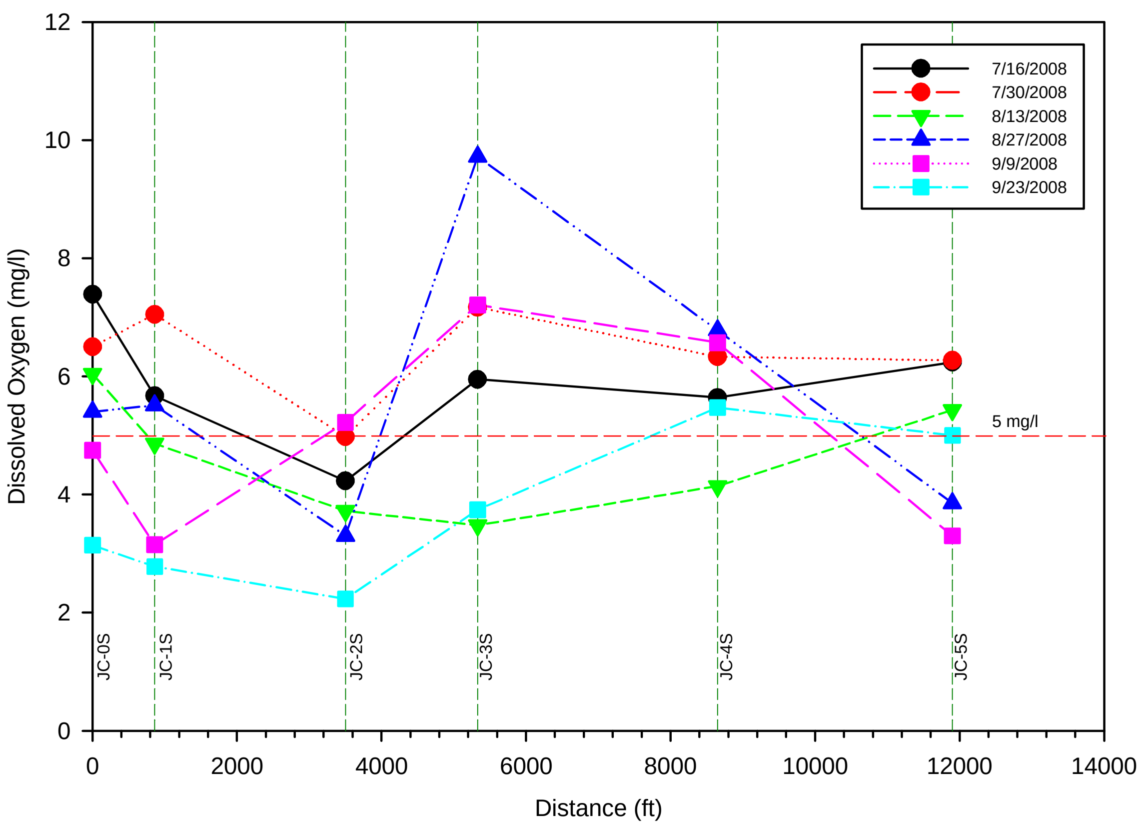


Figure 4-14. Changes in Dissolved Oxygen with Distance Along the Joe's Creek Channel.

4.2.3.2 Chemical Characteristics

A complete listing of the characteristics of surface water samples collected in the Joe's Creek watershed collected from July-September 2008 is given on Table 4-10. Water quality data are provided for each of the six monitoring sites and each of the six monitoring dates. Mean values are also provided for each evaluated parameter at each site.

4.2.3.2.1 Site 0S

Site 0S is located in the upstream headwaters of Joe's Creek at the discharge from the box culvert into Silver Lake. Samples collected at this site were found to be well buffered, with a mean alkalinity of 106 mg/l. Measured total nitrogen concentrations at this site ranged from 815-1374 μg/l, with an overall mean of 1083 μg/l. This value is substantially lower than nitrogen concentrations commonly observed in urban runoff and reflects attenuation of nitrogen loadings from the basin prior to discharge into Silver Lake. The dominant nitrogen species at this site is particulate nitrogen which comprised 36% of the total nitrogen measured at this site. An additional 34% of the total nitrogen is contributed by dissolved organic nitrogen, with 24% by NO_x and 7% by ammonia. The measured NO_x concentration of 255 μg/l at this site is moderate in value and typical of NO_x concentrations commonly observed in urban runoff. The mean ammonia concentration of 78 μg/l is relatively low in value for urban systems.

Relatively low levels of total phosphorus concentrations were measured at this site, with an overall mean of 66 μg/l. This value is substantially lower than total phosphorus concentrations commonly observed in urban runoff. The dominant phosphorus species at this site is particulate phosphorus which comprised 83% of the total phosphorus. Extremely low SRP concentrations were measured at this site, with an overall mean of only 7 μg/l. Values in this range are substantially lower than SRP concentrations commonly observed in urban runoff. The low measured concentrations for total phosphorus at this site suggest significant attenuation of phosphorus inputs prior to reaching the monitoring site.

In general, measured TSS concentrations at Site 0S were low to moderate in value, ranging from 4.0-15.7 mg/l. These concentrations are low in value for urban runoff and reflect attenuation of TSS within the watershed. Inputs at this site are characterized by relatively low color concentrations, with an overall mean of 36 Pt-Co units.

4.2.3.2.2 Site 1S

Site 1S reflects the discharge from Silver Lake at the beginning of the channelized portion of Joe's Creek. Samples collected at this site were found to be moderately to well buffered, with a mean alkalinity of 87 mg/l. Measured total nitrogen concentrations at this site ranged from 675-1321 μg/l, with an overall mean of 914 μg/l. This value reflects a decrease in total nitrogen of approximately 16% during migration through Silver Lake. Particulate nitrogen is the dominant nitrogen species measured at this site, comprising 51% of the total nitrogen measured. An additional 40% of the total nitrogen is contributed by dissolved organic nitrogen. Much of the observed reduction in total nitrogen appears to be a result of removal of NO_x which decreased from 255 μg/l at the inflow to Silver Lake to 9 μg/l at the outflow. The mean ammonia concentration of 76 μg/l measured at this site is similar to the value measured at the inflow to Silver Lake. Silver Lake appears to be removing NO_x with a corresponding increase in particulate nitrogen, likely due to an increase in algal production within the lake.

TABLE 4-10

CHARACTERISTICS OF SURFACE WATER SAMPLES COLLECTED IN THE JOE'S CREEK WATERSHED FROM JULY-SEPTEMBER 2008

SITE	DATE	ALK. (mg/l)	NH_3 (µg/l)	NO_X (µg/l)	DISS. ORG. N (µg/l)	PART. N (µg/l)	TOTAL N (µg/l)	SRP (µg/l)	DISS. ORG. P (µg/l)	PART. P (µg/l)	TOTAL P (µg/l)	TSS (mg/l)	COLOR (Pt-Co)
0S	7/16/08	121	89	595	285	111	1080	14	12	26	52	5.8	36
	7/30/08	121	149	433	583	209	1374	8	6	29	43	4.0	35
	8/13/08	104	59	305	321	130	815	5	7	42	54	6.6	50
	8/27/08	93.8	51	97	301	379	828	5	2	48	55	8.2	31
	9/9/08	97.8	62	39	279	715	1095	3	1	85	89	12.8	32
	9/23/08	101	59	60	418	767	1304	4	3	98	105	15.7	33
	Mean	**106**	**78**	**255**	**365**	**385**	**1083**	**7**	**5**	**55**	**66**	**8.9**	**36**
1S	7/16/08	54.8	9	9	209	448	675	3	23	71	97	13.6	26
	7/30/08	79.6	61	14	450	179	704	4	14	57	75	11.0	32
	8/13/08	91.4	132	12	377	402	923	5	6	69	80	10.6	36
	8/27/08	89.8	82	11	427	357	877	5	6	65	76	10.5	33
	9/9/08	104	59	8	286	632	985	3	0	90	93	13.1	33
	9/23/08	103	110	<5	433	775	1321	4	8	96	108	15.8	30
	Mean	**87**	**76**	**9**	**364**	**466**	**914**	**4**	**10**	**75**	**88**	**12.4**	**32**
2S	7/16/08	64.6	67	39	223	318	647	5	16	71	92	14.1	30
	7/30/08	86.4	136	42	754	61	993	5	42	16	63	10.0	36
	8/13/08	98.2	165	64	451	243	923	3	9	48	60	12.1	36
	8/27/08	98.0	208	59	389	199	855	6	1	48	55	9.5	37
	9/9/08	105	43	7	369	458	877	3	2	86	91	13.8	32
	9/23/08	102	51	109	609	413	1182	8	7	81	96	14.1	41
	Mean	**92**	**112**	**53**	**466**	**282**	**913**	**5**	**13**	**58**	**76**	**12.3**	**35**
3S	7/16/08	55.6	<5	10	276	163	452	2	17	46	65	10.2	26
	7/30/08	75.8	44	11	391	300	746	3	9	38	50	7.9	30
	8/13/08	93.6	104	6	291	495	896	2	3	62	67	11.2	29
	8/27/08	92.4	24	<5	241	384	652	4	1	44	49	7.6	30
	9/9/08	102	32	<5	327	266	628	3	1	37	41	4.4	29
	9/23/08	105	49	5	297	583	934	3	1	61	65	11.0	33
	Mean	**87**	**51**	**6**	**304**	**365**	**718**	**3**	**5**	**48**	**56**	**8.7**	**30**
4S	7/16/08	65.8	<5	<5	233	153	391	3	15	25	43	5.6	23
	7/30/08	76.8	37	8	435	47	527	3	9	18	30	3.7	28
	8/13/08	86.0	36	8	308	190	542	4	3	23	30	5.4	27
	8/27/08	84.4	32	<5	252	429	716	4	1	56	61	10.0	26
	9/9/08	90.0	23	<5	238	261	525	2	2	32	36	9.2	27
	9/23/08	96.6	36	<5	385	391	815	1	6	47	54	6.7	26
	Mean	**83**	**33**	**4**	**309**	**245**	**586**	**3**	**6**	**34**	**42**	**6.8**	**26**
5S	7/16/08	60.0	8	11	200	239	458	4	17	36	57	8.0	22
	7/30/08	82.8	56	34	428	265	783	7	10	28	45	5.4	29
	8/13/08	95.0	189	102	264	93	648	14	6	24	44	2.7	30
	8/27/08	88.4	93	186	218	136	633	3	5	32	40	2.4	26
	9/9/08	96.0	32	167	266	132	597	11	6	16	33	2.5	29
	9/23/08	97.0	29	172	374	93	668	22	3	23	48	2.8	24
	Mean	**87**	**68**	**112**	**292**	**160**	**631**	**10**	**8**	**27**	**45**	**4.0**	**27**

A slight increase in total phosphorus concentrations was observed during migration through Silver Lake, with a mean total phosphorus concentration of 88 μg/l. This value represents an increase of approximately 33% over the inflow total phosphorus concentration of 66 μg/l measured at Site 0S. The increase in total phosphorus is due almost entirely to increases in particulate phosphorus which comprise 85% of the total phosphorus measured at Site 1S. A slight increase is also apparent in measured concentrations of dissolved organic phosphorus which increased from 5 μg/l at Site 0S to 10 μg/l at Site 1S. A slight reduction in SRP occurs during migration through the pond. However, the increase in total phosphorus during migration through Silver Lake may be related to sediment phosphorus release within the lake under anoxic conditions. This assumption is supported by the substantial decrease in NO_x concentrations within the pond which could have occurred as a result of denitrification processes also under anoxic conditions. The increase in total phosphorus and decrease in NO_x concentrations both indicate anoxic processes within Silver Lake.

Measured TSS concentrations at Site 1S are moderate in value and slightly higher than observed at Site 0S. This increase in TSS corresponds with the increase in particulate phosphorus and particulate nitrogen observed at this site and is likely related to algal productivity. The mean color concentration of 32 Pt-Co units at this site is similar to the mean of 36 Pt-Co units measured at the inflow to Silver Lake.

4.2.3.2.3 <u>Site 2S</u>

Surface water samples collected at Site 2S were found to be moderately well buffered, with a mean alkalinity of 92 mg/l. The mean total nitrogen concentration of 913 μg/l measured at this site is similar to the total nitrogen measured at Site 1S. However, a change in nitrogen species appears to have occurred between Site 1S and Site 2S, a distance of approximately 1100 ft. Over this distance, concentrations of particulate nitrogen decreased by approximately 39%, with corresponding increases in both ammonia and NO_x, although the measured values for these parameters are relatively low in value.

Moderate levels of total phosphorus were measured at this site, with an overall mean of 76 μg/l. This value reflects a decrease of approximately 14% in total phosphorus compared with concentrations measured at Site 1S. A 23% decrease is also apparent for particulate phosphorus, with slight increases observed for SRP and dissolved organic phosphorus. However, measured concentrations for all phosphorus species at this site appear to be moderate to low in value for urban drainage systems.

Measured TSS concentrations at Site 2S are similar to those measured at Site 1S, with an overall mean of 12.3 mg/l. Measured color concentrations at this site are also similar to concentrations measured at Site 1S, with an overall mean of 35 Pt-Co units.

4.2.3.2.3 Site 3S

In general, surface water samples collected at Site 3S were found to be moderately to well buffered, with an overall mean alkalinity of 87 mg/l. Relatively low total nitrogen concentrations were observed at this site compared with concentrations commonly observed in urban runoff and urban drainage systems. The mean total nitrogen concentration of 718 μg/l reflects a decrease of approximately 21% between monitoring Sites 2S and 3S. A slight increase in particulate nitrogen appears to occur between these monitoring sites, with a significant decrease in dissolved organic nitrogen. Significant decreases in ammonia and NO_x are also apparent at this site compared with the upstream monitoring site. The mean ammonia concentration of 51 μg/l and mean NO_x concentration of 6 μg/l reflect extremely low levels for urban drainage systems.

Relatively low levels of total phosphorus species were measured at this site, with an overall total phosphorus concentration of 56 μg/l. This value reflects a decrease of 26% from samples collected at the upstream monitoring site. Decreases in concentrations were also observed for the remaining phosphorus species, with a 40% reduction in SRP between Sites 2S and 3S, a 17% reduction in particulate phosphorus, and a 26% reduction in total phosphorus.

Measured TSS concentrations at Site 3S were relatively low in value, ranging from 4.4-11.2 mg/l, with an overall mean of 8.7 mg/l. This value reflects a decrease of approximately 29% from concentrations measured at the upstream monitoring site. Measured color concentrations at Site 3S are also relatively low in value and slightly lower than concentrations measured at Site 2S.

4.2.3.2.5 Site 4S

In general, samples collected at Site 4S were found to be moderately well buffered, with a mean alkalinity of 83 mg/l. The measured total nitrogen concentration of 586 μg/l at Site 4S reflects a low value for an urban drainage system, and represents an 18% reduction in total nitrogen concentrations from the upstream monitoring site at Site 3S. The dominant nitrogen species at this site is dissolved organic nitrogen which comprises approximately 53% of the total nitrogen measured. An additional 42% of the total nitrogen is contributed by particulate nitrogen. A reduction in particulate nitrogen of approximately 33% occurs between Sites 3S and 4S. In general, measured concentrations of ammonia and NO_x at Site 4S are extremely low in value and lower in concentration than samples measured at the upstream monitoring site.

In general, relatively low levels of total phosphorus were measured at Site 4S, with an overall mean of 42 μg/l for total phosphorus. The dominant phosphorus species at this site is particulate phosphorus which comprises 81% of the total phosphorus. The mean particulate phosphorus concentration of 34 μg/l is approximately 29% lower than the values measured at the upstream monitoring location. Measured concentrations of SRP and dissolved organic phosphorus at Site 4S are similar in value to those measured at Site 3S and are approaching irreducible concentration levels for urban drainage systems.

Measured TSS concentrations at Site 4S were found to be low in value, with a mean of only 6.8 mg/l. This value is approximately 22% lower than TSS concentrations measured at the upstream monitoring site. In addition, color concentrations at this site are also low in value, with a mean of 26 Pt-Co units.

4.2.3.2.6 Site 5S

Surface water samples collected at Site 5S were found to be moderately well buffered, with a mean alkalinity of 87 mg/l. Measured total nitrogen concentrations at this site ranged from 458-783 μg/l, with an overall mean of 631 μg/l. This value reflects an increase of approximately 8% from the total nitrogen concentration measured at the upstream site (Site 4S). However, reductions in concentrations were observed for dissolved organic nitrogen and particulate nitrogen between Sites 4S and 5S, with a 6% decrease in dissolved organic nitrogen and a 35% decrease in particulate nitrogen. However, increases were observed for measured concentrations of both ammonia and NO_x at Site 5S compared with Site 4S.

Measured total phosphorus concentrations at Site 5S were found to be low in value and similar to concentrations measured at Site 4S. The mean total phosphorus concentration of 45 μg/l at Site 5S reflects an increase of approximately 7% over concentrations measured at Site 4S. However, particulate phosphorus appears to decrease by approximately 21% between the two monitoring sites, with slight increases observed for SRP and dissolved organic phosphorus. In general, the phosphorus concentrations measured at Site 5S reflect relatively low values for urban drainage systems.

Measured TSS concentrations at Site 5S were found to be low in value, with a mean concentration of 4.0 mg/l. This concentration is low in value for urban runoff. Measured color concentrations at the site were also low in value, with a mean of only 27 Pt-Co units.

4.2.3.2.7 Site Comparisons

A statistical comparison of nitrogen species in surface water samples collected in the Joe's Creek watershed is given on Figure 4-15. In general, ammonia concentrations are relatively low in value within Joe's Creek, with a relatively narrow range of variability in measured concentrations. Elevated levels of NO_x were observed at Site 0S, with substantially lower concentrations at the downstream monitoring sites. However, an increase in NO_x appears to occur between Sites 4S and 5S. A steady decline in particulate nitrogen was observed within Joe's Creek, with a reduction in both measured concentrations and variability in concentrations with increasing distance downstream. A similar pattern is apparent for total nitrogen, with a slight increase in total nitrogen observed at the final monitoring site.

A statistical comparison of phosphorus species and TSS in surface water samples collected in the Joe's Creek watershed is given on Figure 4-16. In general, measured concentrations for virtually all phosphorus species appear to be low in value for urban drainage systems. A gradual decline in SRP concentrations is apparent along Joe's Creek, although an increase was observed at the final monitoring site. After initial increases in Silver Lake, concentrations of both particulate phosphorus and total phosphorus also decreased with increasing distance downstream. A similar pattern is also present for TSS which exhibits an apparent increase during migration through Silver Lake, followed by a slow but steady decrease in concentration within Joe's Creek.

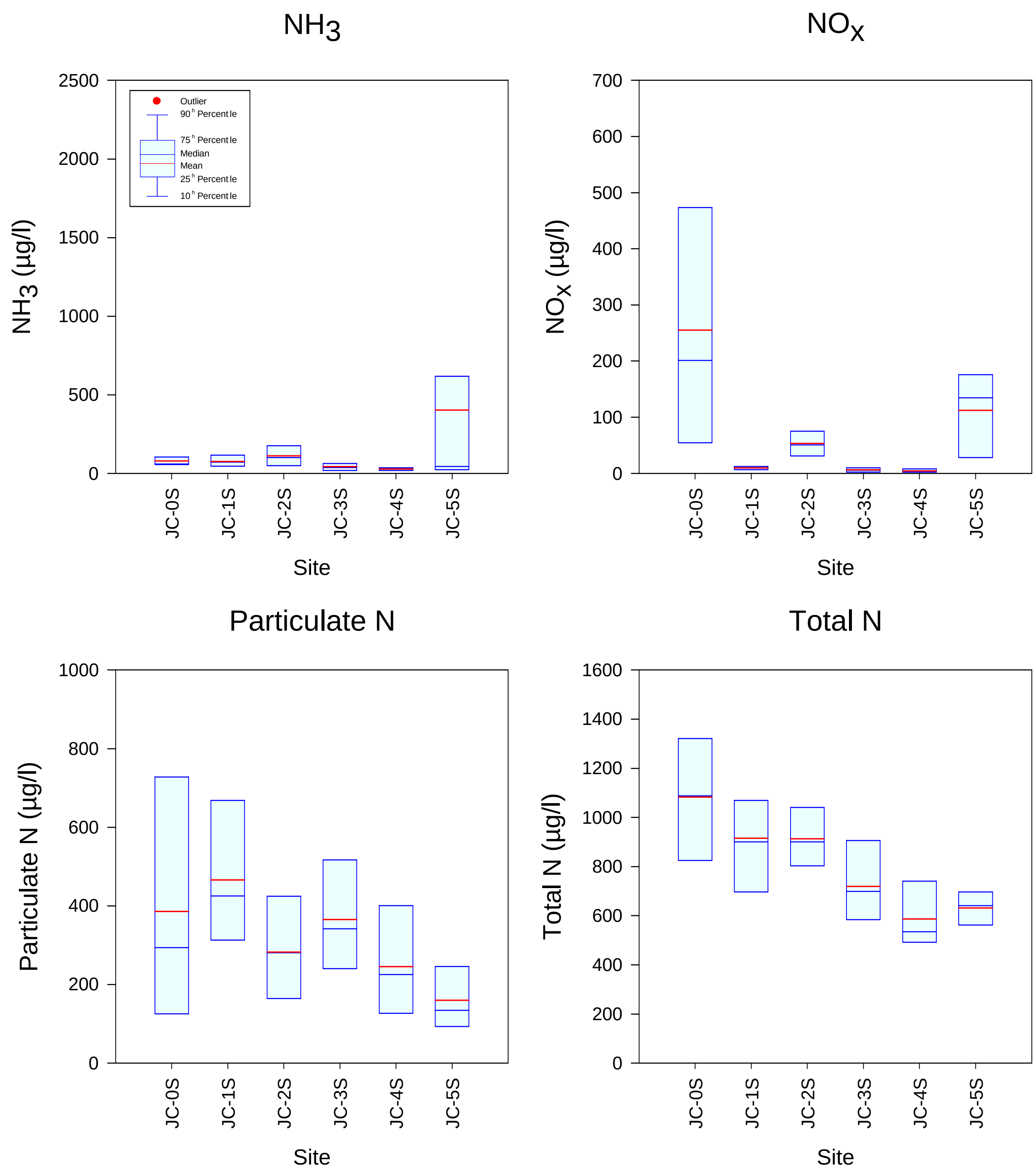


Figure 4-15. Statistical Comparison of Nitrogen Species in Surface Water Samples Collected in the Joe's Creek Watershed.

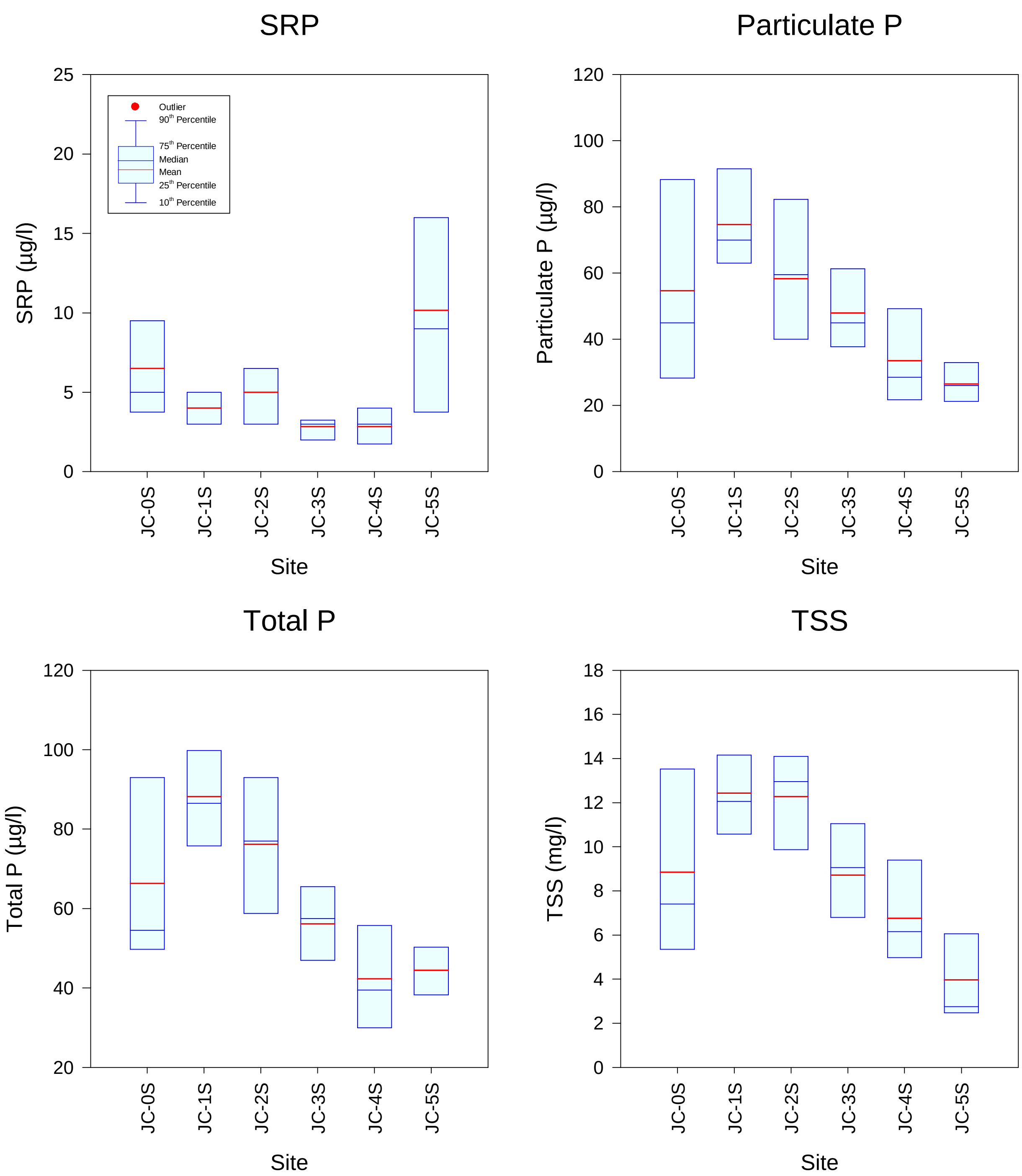


Figure 4-16. Statistical Comparison of Phosphorus Species and TSS in Surface Water Samples Collected in the Joe's Creek Watershed.

A graphical comparison of changes in concentrations of nitrogen species along Joe's Creek from July-September 2008 is given on Figure 4-17. As discussed previously, a gradual decrease in measured concentrations of nitrogen species, as well as total nitrogen, was observed between the headwaters of Joe's Creek and monitoring Site 4S. However, between Sites 4S and 5S, substantial increases in concentrations were observed for ammonia, NO_x, and total nitrogen. However, an increase was not observed for particulate nitrogen, suggesting that the changes in concentrations are not stormwater related.

A graphical comparison of changes in concentrations of phosphorus species in Joe's Creek from July-September 2008 is given on Figure 4-18. Similar to the trend observed for nitrogen species, phosphorus concentrations appear to exhibit a steady decline in concentrations with increasing distance along Joe's Creek until reaching Site 4S. Increases in concentrations were observed for SRP, dissolved organic phosphorus, and total phosphorus between Sites 4S and 5S. However, as observed for nitrogen, a corresponding increase was not exhibited by particulate phosphorus, suggesting that the increases in phosphorus concentrations are not related to stormwater inputs.

A comparison of mean water quality characteristics at each of the Joe's Creek monitoring sites with typical urban runoff characteristics is given in Table 4-11. Mean values are provided for each of the six monitoring sites in Joe's Creek for a variety of general parameters and nutrients. A summary of typical runoff concentrations for each of the evaluated parameters is given in the final column of Table 4-11 for comparison purposes. In general, mean measured concentrations at the Joe's Creek monitoring sites are lower in value for virtually all parameters than typically observed in untreated urban runoff. The estimated characteristics for urban runoff were obtained from a 12-month field monitoring program (Harper, 1990) which evaluated typical runoff characteristics for a variety of urban land use types. Although the Joe's Creek system receives inputs primarily from urban runoff, removal processes within the creek result in lower concentrations than observed in the untreated runoff inflows.

TABLE 4-11

COMPARISON OF MEASURED WATER QUALITY CHARACTERISTICS IN JOE'S CREEK WITH TYPICAL URBAN RUNOFF

PARAMETER	UNITS	MEAN VALUE BY SITE						TYPICAL URBAN RUNOFF[1]
		0S	1S	2S	3S	4S	5S	
pH	s.u.	7.36	7.29	7.16	7.18	7.51	7.38	6-8
Conductivity	μmho/cm	399	307	346	319	295	320	150-350
Ammonia	μg/l	78	76	112	51	33	68	50-200
NO_x	μg/l	255	9	53	6	< 5	112	100-500
Diss. Org. N	μg/l	365	364	466	304	309	292	400-1000
Particulate N	μg/l	385	466	282	365	245	160	250-1000
Total N	μg/l	1083	914	913	718	586	631	1500-2500
SRP	μg/l	7	4	5	3	3	10	20-80
Diss. Org. P	μg/l	5	10	13	5	6	8	20-100
Particulate P	μg/l	55	75	58	48	34	27	75-200
Total P	μg/l	66	88	76	56	42	45	150-350
TSS	mg/l	8.9	12.4	12.3	8.7	6.8	4.0	25-100
Color	Pt-Co	36	32	35	30	26	27	20-60

1. Harper, H.H. (1990). "Effects of Stormwater Management Systems on Groundwater Quality." Final Report Prepared for FDEP Project No. WM190.

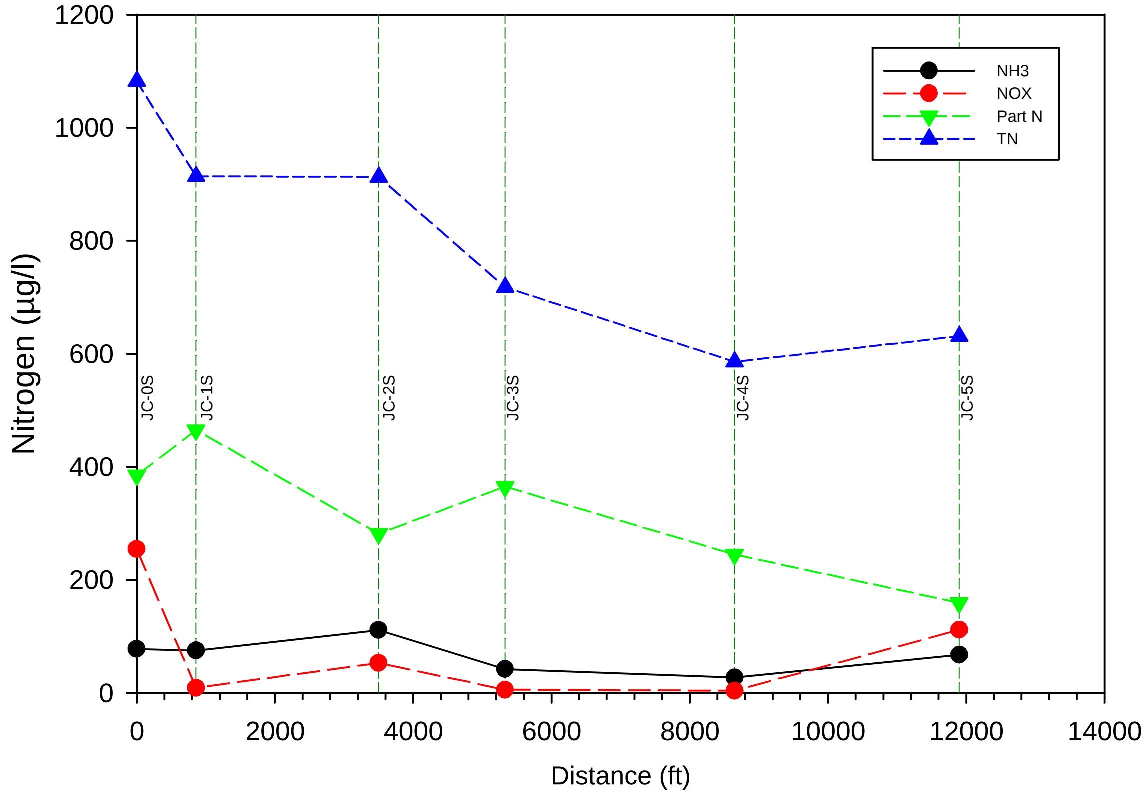


Figure 4-17. Changes in Concentrations of Nitrogen Species in Joe's Creek from July-September 2008.

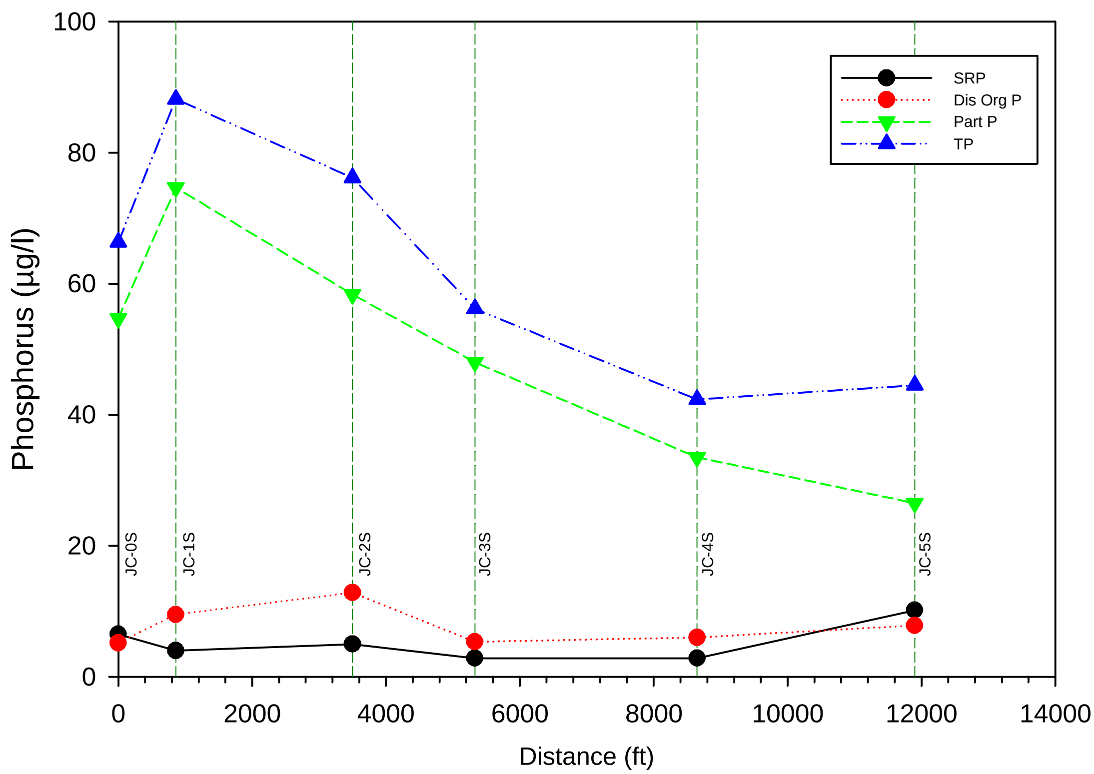


Figure 4-18. Changes in Concentrations of Phosphorus Species in Joe's Creek from July-September 2008.

4.2.3.3 Loading Estimates

Estimates of mass loadings discharging through Joe's Creek were calculated for total nitrogen, total phosphorus, and TSS at each of the six surface water monitoring sites. These estimates were generated by multiplying the measured discharge rates for each monitoring date and site (summarized in Table 4-8) times the measured total nitrogen, total phosphorus, or TSS concentration for each site (summarized in Table 4-10). A tabular summary of the results of this analysis is given in Table 4-12. Mass loadings are calculated for each monitoring date and site, with mean values provided for each site over the monitoring period from July-September 2008, as well as mean loadings for each monitoring date.

TABLE 4-12

CALCULATED LOADINGS OF TOTAL NITROGEN, TOTAL PHOSPHORUS, AND TSS ALONG THE FRESHWATER SEGMENT OF JOE'S CREEK FROM JULY – SEPTEMBER 2008

TOTAL NITROGEN LOADS (kg/day)							
SITE	**7/16/08**	**7/30/08**	**8/13/08**	**8/27/08**	**9/9/08**	**9/23/08**	**MEAN**
JC-0S	4.54	6.98	0.86	0.00	0.00	0.00	2.06
JC-1S	3.65	2.73	1.78	0.59	0.00	1.56	1.72
JC-2S	2.10	6.62	2.19	1.79	1.52	2.42	2.77
JC-3S	3.43	7.89	2.58	1.92	1.16	3.83	3.47
JC-4S	4.08	5.01	0.61	2.99	1.56	3.69	2.99
JC-5S	7.01	4.90	5.27	5.21	2.51	3.67	4.76
Mean	**4.13**	**5.69**	**2.22**	**2.08**	**1.12**	**2.53**	**2.96**

TOTAL PHOSPHORUS LOADS (kg/day)							
SITE	**7/16/08**	**7/30/08**	**8/13/08**	**8/27/08**	**9/9/08**	**9/23/08**	**MEAN**
JC-0S	0.218	0.218	0.057	0.000	0.000	0.000	0.082
JC-1S	0.525	0.291	0.154	0.051	0.000	0.127	0.191
JC-2S	0.299	0.420	0.142	0.115	0.158	0.197	0.222
JC-3S	0.493	0.529	0.193	0.144	0.075	0.266	0.283
JC-4S	0.448	0.285	0.034	0.255	0.107	0.245	0.229
JC-5S	0.873	0.281	0.358	0.329	0.139	0.264	0.374
Mean	**0.476**	**0.338**	**0.156**	**0.149**	**0.080**	**0.183**	**0.230**

TSS LOADS (kg/day)							
SITE	**7/16/08**	**7/30/08**	**8/13/08**	**8/27/08**	**9/9/08**	**9/23/08**	**MEAN**
JC-0S	24.4	20.3	6.9	0.0	0.0	0.0	8.6
JC-1S	73.6	42.7	20.5	7.1	0.0	18.6	27.1
JC-2S	45.8	66.7	28.7	19.9	23.9	28.9	35.6
JC-3S	77.4	83.6	32.2	22.3	8.1	45.1	44.8
JC-4S	58.4	35.2	6.1	41.8	27.4	30.4	33.2
JC-5S	122.5	33.8	22.0	19.8	10.5	15.4	37.3
Mean	**67.0**	**47.0**	**19.4**	**18.5**	**11.7**	**23.0**	**31.1**

As seen in Table 4-12, the highest nitrogen loadings were observed during the initial two July monitoring events. Nitrogen loadings decreased during August and early September before increasing during the final monitoring event. Similar trends are apparent for total phosphorus and TSS.

A graphical comparison of estimated mass loadings for nitrogen along Joe's Creek for each of the six monitoring dates is given on Figure 4-19. During 4 of the 6 monitoring events, nitrogen loadings were lowest in the most upstream portions of the Joe's Creek channel. After leaving Silver Lake, nitrogen loadings appear to increase slowly with increasing distance along Joe's Creek, with a slight decrease in loadings observed between monitoring Sites 3S and 4S during most events. These data suggest that most portions of Joe's Creek are a net source for nitrogen since mass loadings increase along the creek in spite of additional uptake mechanisms throughout the creek.

A graphical comparison of mass loadings of total phosphorus along the freshwater segment of Joe's Creek from July-September 2008 is given on Figure 4-20. Similar to the trends exhibited by total nitrogen, mass loadings of total phosphorus appear to be lowest in upstream portions of Joe's Creek during most monitoring events. A gradual increase in phosphorus loadings occurs with increasing distance along Joe's Creek, until reaching Site 3S, during most events. A decrease in phosphorus loadings occurs between Sites 3S and 4S during 4 of the 6 monitoring events. However, with the exception of the area in the vicinity of Site 4S, Joe's Creek appears to be a net source for phosphorus on most occasions. This suggests that the mass phosphorus loadings into Joe's Creek exceed the assimilative capacity along the creek, resulting in an increase in loading with increasing distance. Between Sites 4S and 5S, phosphorus inputs appear to substantially exceed the assimilative capacity of the creek, resulting in a 63% increase in mass loadings along this reach.

4.2.3.4 Performance Efficiency of the SWFWMD Retrofit Pond

One of the objectives of this project is to estimate the performance efficiency of the SWFWMD retrofit pond system constructed along the western portion of the freshwater segment of Joe's Creek. As discussed in Section 3, monitoring Site 3S is located immediately upstream of the retrofit pond, with monitoring Site 4S located immediately downstream of the pond. These sites were selected to provide estimates of inflow and outflow mass loadings for the pond. Estimates of inflow loadings for total nitrogen, total phosphorus, and TSS were calculated by multiplying the mean daily mass loadings for these parameters (summarized in Table 4-11) times 92 days, reflecting the period from July-September. These calculations were conducted for the mean mass loadings at both Sites 3S and 4S for comparison purposes.

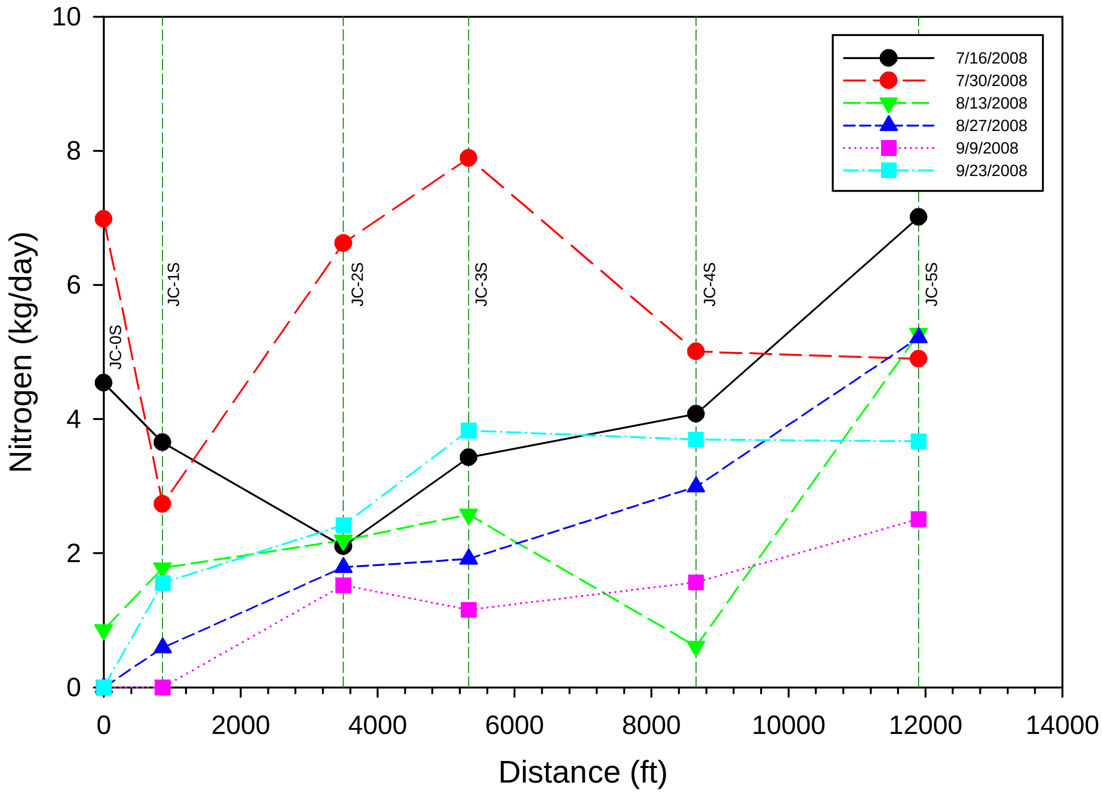


Figure 4-19. Comparison of Mass Loadings of Total Nitrogen Along the Freshwater Segment of Joe's Creek from July-September 2008.

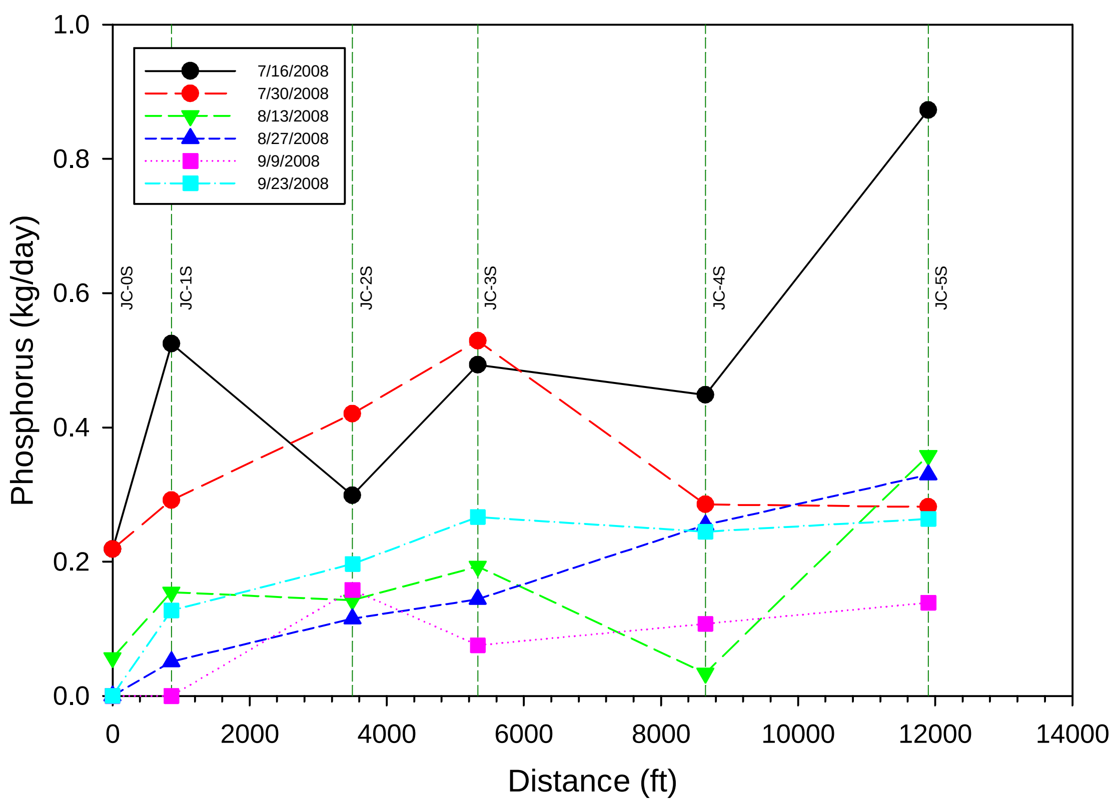


Figure 4-20. Comparison of Mass Loadings of Total Phosphorus Along the Freshwater Segment of Joe's Creek from July-September 2008.

A summary of estimated removal efficiencies for the SWFWMD pond from July-September 2008 is given in Table 4-13. During this period, the pond achieved a removal efficiency of approximately 14% for total nitrogen, 20% for total phosphorus, and 26% for TSS. The observed removal efficiencies within the pond are somewhat lower than removals commonly observed in wet detention systems. However, removals in wet detention systems are based upon treating raw runoff, while water discharging through Joe's Creek receives significant pre-treatment within the creek prior to reaching the SWFWMD retrofit pond. The relatively low removals observed for total nitrogen and total phosphorus are likely related to pre-treatment processes within the creek which remove much of the suspended matter before reaching the pond site. Approximately 50% of the total nitrogen and total phosphorus in urban runoff is comprised of particulate matter, and settling of this particulate matter is one of the largest removal processes which occur in wet ponds. If the particulate matter is removed, the pond only receives dissolved nutrients which are removed, relatively slowly, through biological processes.

TABLE 4-13

ESTIMATED REMOVAL EFFICIENCIES OF THE SWFWMD POND FROM JULY – SEPTEMBER 2008

PARAMETER	MASS INPUT (kg)	MASS OUTFLOW (kg)	MASS REMOVAL (%)
Total Nitrogen	319	275	14
Total Phosphorus	26.04	21.07	20
TSS	4122	3054	26

4.2.4 Groundwater Characteristics

A summary of the chemical characteristics of shallow groundwater samples collected in the Joe's Creek watershed is given on Table 4-14. Measurements for temperature, pH, conductivity, and TDS were performed in the field, with the remaining measurements conducted on collected samples in the laboratory. Groundwater monitoring Site GW-4 is located adjacent to Silver Lake in upstream portions of the watershed, with Site GW-5 located downstream of the SWFWMD retrofit detention pond.

In general, groundwater samples collected at Sites GW-4 and GW-5 are neutral to slightly acidic in pH, with moderate to elevated values for conductivity and TDS. Measured values for conductivity, TDS, and alkalinity are higher in value at the downstream monitoring well than observed at the upstream monitoring site, presumably due to periodic tidal influences in the downstream area. Groundwater samples collected at each of the two sites were found to be relatively low in total nitrogen, with a mean of 864 μg/l at Site GW-4 and 734 μg/l at GW-5. At the upstream groundwater monitoring site (GW-4), dissolved organic nitrogen is the dominant nitrogen species, contributing 56% of the total nitrogen measured. Somewhat elevated levels of ammonia were observed in groundwater at this location, with relatively low levels of NO_x. Organic nitrogen is also the dominant nitrogen species measured at Site GW-5, comprising approximately 78% of the total nitrogen measured at this site. Concentrations of both ammonia and NO_x at the downstream groundwater monitoring site are lower in value than observed at the upstream sites.

TABLE 4-14

CHEMICAL CHARACTERISTICS OF SHALLOW GROUNDWATER SAMPLES COLLECTED IN THE JOE'S CREEK WATERSHED

SITE	DATE	TEMP. (°C)	pH (s.u.)	COND. (µmho/cm)	TDS (mg/l)	ALK. (mg/l)	NH_3 (µg/l)	NO_X (µg/l)	DISS. ORG. N (µg/l)	TOTAL N (µg/l)	SRP (µg/l)	DISS. ORG. P (µg/l)	TOTAL P (µg/l)	COLOR (Pt-Co)
GW-4	7/16/08	25.74	6.03	335	214	14.8	461	30	557	1048	10	3	13	42
	7/30/08	26.62	5.97	153	98	23.4	458	43	567	1068	13	3	16	172
	8/13/08	29.39	6.19	342	219	34.4	331	14	332	677	16	21	37	125
	8/27/08	27.46	5.87	342	219	20.4	290	21	595	906	34	21	55	146
	9/9/08	--	--	--	--	24.2	296	21	361	678	18	13	31	119
	9/23/08	--	--	--	--	23.8	262	58	484	804	19	5	24	112
	Mean	**27.37**	**6.29**	**298**	**191**	**23.5**	**350**	**31**	**483**	**864**	**18**	**11**	**29**	**119**
GW-5	7/16/08	23.88	6.97	866	554	288	192	9	401	602	28	20	48	43
	7/30/08	28.21	6.87	451	289	307	74	8	822	904	42	10	52	37
	8/13/08	28.35	7.01	927	593	326	70	21	489	580	31	6	37	40
	8/27/08	29.15	7.04	996	637	392	55	<5	498	555	13	14	27	34
	9/9/08	28.14	6.69	832	532	352	217	<5	559	778	24	9	33	38
	9/23/08	27.30	6.55	822	526	213	304	9	673	986	11	11	22	44
	Mean	**27.51**	**6.86**	**816**	**522**	**313**	**152**	**9**	**574**	**734**	**25**	**12**	**37**	**39**

Groundwater collected at each of the two monitoring sites was characterized by relatively low levels of total phosphorus, with a mean of only 29 μg/l at Site GW-4 and 37 μg/l at Site GW-5. These values are lower than concentrations measured in surface water sites in the vicinity of these wells and suggests that groundwater is not a significant contributor of phosphorus loadings to Joe's Creek. The dominant phosphorus species measured at each of the two sites is SRP which comprises 62% of the phosphorus measured at Site GW-4 and 68% of the phosphorus measured at Site GW-5. A relatively high level of color was measured at the upstream monitoring well, with a mean color concentration of 119 Pt-Co units. Color concentrations in groundwater were substantially lower at the downstream monitoring site (GW-5), with a mean of 39 Pt-Co units.

4.2.5 Isotope Analyses

As mentioned previously, a report describing the results of the stable isotope analyses on surface and groundwater samples collected from Klosterman Bayou and Joe's Creek was prepared by Dr. Bruce Hungate. A complete version of this report is given in Appendix D, and a summary of the results is given in this section.

Isotope analyses involving nitrogen and oxygen compounds require minimum levels of nitrate for analysis. Samples collected from both groundwater wells and two of the six surface water sites from Joe's Creek (Sites 3S and 4S) had insufficient NO_3^- for isotope analysis, limiting isotope characterization to only four of eight sites along Joe's Creek.

Water samples with sufficient NO_3^- for isotope analysis showed greater variation in $\delta^{15}N$ in the Joe's Creek system (ranging from 2.18 to 6.49‰) than observed in the Klosterman Bayou system. Mean values of $\delta^{18}O\text{-}NO_3^-$ were slightly higher in Klosterman Bayou (3.94 to 21.3‰) than in Joe's Creek (7.54 to 23.98‰), but the range of variation was comparable.

Two lines of evidence could support *in situ* denitrification as a major pathway of NO_3^- removal, and thus as a confounding signal for interpreting isotopes in source partitioning. One sign of denitrification is a negative slope for the relationship between $[NO_3^-]$ and $\delta^{15}N\text{-}NO_3^-$, reflecting preferential removal of $^{14}N\text{-}NO_3^-$ through denitrification. Within the Joe's Creek system, no site exhibited a significant relationship (slope) between $[NO_3^-]$ and $\delta^{15}N$, suggesting that denitrification is not a significant factor along the creek.

A second sign of *in situ* denitrification is co-varying enrichment of $\delta^{15}N$ and $\delta^{18}O$ in nitrate, if the ratio of enrichments are between 1.3:1 and 2.1:1 (Aravena and Robertson, 1998; Fukada et al., 2003). The relationship tended to be negative within the Joe's Creek system. No mechanism has been proposed that causes opposing isotope effects for $\delta^{15}N$ and $\delta^{18}O$ in nitrate, so this may be a spurious trend, resulting from mixing of sources with varying isotopic signatures rather than a single biogeochemical mechanism. Furthermore, the negative relationship was driven by an anomalously high $\delta^{18}O\text{-}NO_3^-$ value (502.16‰), a sample with a relatively low $\delta^{15}N\text{-}NO_3^-$ and moderate $[NO_3^-]$ (0.12 mg N L^{-1}).

Signatures of $\delta^{15}N$ and $\delta^{18}O$ within the Joe's Creek system are consistent with nitrate derived from synthetic fertilizers, atmospheric deposition, and nitrification of native soil organic matter, but are lower in $\delta^{15}N$ than values typically associated with animal waste, manure, or wastewater. In general $\delta^{18}O$ values from Joe's Creek samples were highly variable. For example, Sites 0S and 2S had comparable $\delta^{15}N$ values, falling between 2.78 and 8.93. $\delta^{18}O$ values for samples from these same sites were considerably more variable, ranging from -0.99 to 52.16. This pattern may be explained by contributions of NO_3^- from multiple sources with similar $\delta^{15}N$ values, specifically, synthetic fertilizers, atmospheric deposition, and nitrification of native soil organic matter.

In general, the low NO_3^- concentrations recovered in the Joe's Creek samples limit the inferences about possible sources that can be drawn, but the ranges of $\delta^{15}N$ and $\delta^{18}O$ values provide some indication of the likely nature of the sources of NO_3^- to Joe's Creek.

4.2.6 Summary

Based upon the results of the field monitoring and laboratory analyses conducted from July-September 2008 along Joe's Creek, much of Joe's Creek appears to be a net source for both nitrogen and phosphorus, rather than a net sink. Inputs of nitrogen and phosphorus from watershed sources appear to exceed, on most occasions, removal mechanisms for nitrogen and phosphorus within the creek. The ambient concentrations of total nitrogen and total phosphorus measured within Joe's Creek appear to be relatively low in value compared with concentrations commonly observed in urban drainage systems. A general trend of decreasing concentrations and increasing mass loadings for total nitrogen and total phosphorus with increasing distance along the creek was observed during most events.

The isotope analyses conducted on surface water samples collected from the Joe's Creek watershed suggest that denitrification is not a significant factor for nitrogen removal along the main body of the creek. Nitrogen and oxygen isotopic signatures within the Joe's Creek system are consistent with nitrate derived from fertilizers, atmospheric deposition, and native soil organic matter. These conclusions provide evidence of the sources of inputs into the creek which include atmospheric deposition and wash-off from watershed areas as a result of stormwater runoff. The isotopic signatures are not consistent with inputs associated with animal wastes, cow manure, or wastewater. Inputs of nitrogen and phosphorus to Joe's Creek appear to originate from watershed processes rather than wastewater inputs.

Monitoring conducted upstream and downstream from Silver Lake suggests that the sediments within Silver Lake may be a source of phosphorus to the water discharging through Joe's Creek. This is the only portion of the watershed where phosphorus concentrations appear to increase significantly rather than decrease. This area also exhibits a substantial decrease in measured concentrations of NO_x, suggesting denitrification in an anaerobic environment within this lake.

Increases in both nitrogen (59%) and phosphorus (63%) loadings were observed between surface water Sites 4S and 5S, suggesting that the nutrient inputs within this section exceed the available uptake capacity. This is the largest relative increase in nutrient loadings observed within Joe's Creek after leaving Silver Lake.

Groundwater samples collected at the two monitoring sites exhibit relatively low concentrations of both total nitrogen and total phosphorus and suggest that groundwater may not be a significant source of phosphorus or nitrogen loadings into Joe’s Creek. The majority of soils within the Joe’s Creek watershed are classified in HSG D which suggests a low infiltration rate and slow horizontal movement.

In general, Joe’s Creek appears to be an urban drainage system which is impacted by processes occurring within adjacent watershed areas. The creek receives nutrient loadings which exceed the uptake potential for nitrogen and phosphorus. *In-situ* processes may be significant as a phosphorus source in Silver Lake.

SECTION 5

NUTRIENT MANAGEMENT RECOMMENDATIONS

Based upon the results of the analyses summarized in Section 4, nutrient management recommendations were developed for the Klosterman Bayou and Joe's Creek watersheds. These recommendations are primarily non-structural approaches to reduce nutrient loadings and nutrient transport in the two watersheds.

5.1 Klosterman Bayou Watershed

As discussed in Section 4.1, reuse irrigation water appears to have a significant impact on phosphorus concentrations in surface water within the IGC area. Reuse water used within the basin is characterized by elevated levels of total phosphorus which are 3-5 times higher than commonly observed in untreated stormwater runoff. In addition, a large percentage of the total phosphorus is present as SRP which represents a readily available phosphorus source to downstream waterbodies. Nitrogen concentrations measured throughout the IGC area appear to be higher in value than nitrogen concentrations in reuse water, suggesting that additional nitrogen inputs are occurring from fertilizer applications within the basin. The isotope analyses indicate that both fertilizer and reuse water are linked to nitrogen concentrations within the IGC area, with reuse primarily linked to nitrogen loadings at the project outfall. Enhancements in concentrations occur for both total nitrogen and total phosphorus during movement through the IGC area.

Management of nitrogen and phosphorus loadings within the IGC area can be reduced by several mechanisms, which include: (1) reduction of applied nutrients within the basin; (2) hydrologic manipulations to minimize off-site discharges from the IGC area; (3) irrigation management; and (4) enhancement of uptake mechanisms for nutrients within the basin. Each of these management techniques are discussed in the following sections.

5.1.1 Nutrient Management

Perhaps the most obvious technique to reduce nutrient discharges from the IGC area is to reduce the applied nutrient loadings within the basin. The monitoring conducted by ERD suggests that current nutrient applications within the basin exceed the assimilative capacity of the on-site vegetation and soils, resulting in an increase in nitrogen and phosphorus concentrations during movement through the IGC area and excess discharge of nutrients through the outfall. A significant source of potential nutrient loadings to the IGC area is reuse water which is used for irrigation. As discussed in Section 2, the IGC area receives approximately 1.77 mgd of reuse water which is used to irrigate 560 acres. This corresponds to an irrigation application rate of approximately 0.90 inches per week of reuse water over the basin. Nutrient concentrations in reuse water were measured directly by ERD during this project, and are summarized in Table 4-5. Based upon this analysis, reuse water applied within the IGC area is characterized by a mean total nitrogen concentration of approximately 1344 μg/l and a mean total phosphorus concentration of 1552 μg/l.

A summary of nutrient requirements for turf grasses in Florida is given in Table 5-1, based upon recommendations provided by the Florida Department of Agriculture and Consumer Services (FDACS). The current recommended fertilizer application rate for nitrogen ranges from 2-5 lbs/1000 ft^2-yr, with a recommended application of 0.5 lb/1000 ft^2-yr for phosphorus. Assuming an average nitrogen application of 3.5 lbs/1000 ft^2-yr, the annual nitrogen requirement is approximately 69.1 kg nitrogen per acre. Similarly, based upon a phosphorus application rate of 0.5 lbs/1000 ft^2-yr, the annual applied phosphorus load is approximately 4.25 kg phosphorus per acre.

TABLE 5-1

NUTRIENT REQUIREMENT FOR TURF GRASSES
(Source: FDACS)

NUTRIENT	**RECOMMENDED FERTILIZER LOAD**	
	Application Rate (lbs/100 ft^2-yr)	**Annual Load (kg/acre)**
Nitrogen	2-5 (assume 3.5)	69.1 kg N
Phosphorus	0.5 (as P_2O_5)	4.35 kg P

A summary of estimated nutrient loadings in the IGC area from reuse irrigation is given on Table 5-2. Assuming the current reuse application rate of 0.9 inch/week, the weekly applied reuse volume is approximately 24,437 gallons or 1,270,724 gallons/acre-yr. Assuming a reuse concentration of 1.34 mg/l for total nitrogen and 1.55 mg/l for total phosphorus, the annual applied nutrient load from reuse irrigation is approximately 6.44 kg/ac-yr of total nitrogen and 7.46 kg/ac-yr of total phosphorus. The annual loading provided by reuse irrigation is equivalent to approximately 10% of the annual nitrogen requirements and 171% of the recommended annual phosphorus requirements. The applied nitrogen in reuse water is sufficient to allow a 10% reduction in the recommended annual fertilizer usage within the golf course area. However, the applied phosphorus from reuse irrigation substantially exceeds the turf grass phosphorus requirements, indicating that the phosphorus application from reuse water within the IGC area is already in excess of the uptake ability of the turf grass, and additional phosphorus fertilization is not necessary within the IGC area.

Based upon this analysis, fertilizer applications containing phosphorus are not required at any time during the year within the IGC area, while nitrogen applications can be reduced by approximately 10% from the recommended application rates. Fertilizer application rates should be reviewed with the IGC management personnel to ensure that current fertilizer applications consider additional nutrient loadings from the applied reuse irrigation water. However, in the case of phosphorus, the application rate currently exceeds the uptake potential of the turf grass, resulting in significant discharges of phosphorus loadings from the IGC area.

TABLE 5-2

ESTIMATED ANNUAL NUTRIENT LOADINGS IN THE IGC AREA FROM REUSE IRRIGATION

NUTRIENT	REUSE IRRIGATION LOAD				
	Volume[1]		Reuse Conc. (mg/l)	Annual Load (kg)	Percent of Fertilizer Load
	(gal/week)	(gal/ac-yr)			
Nitrogen	24,437	1,270,724	1.34	6.44 kg N	10
Phosphorus	24,437	1,270,724	1.55	7.46 kg P	171

1. Assumptions:
   a. Irrigated area of 1.00 acre
   b. Reuse applied at rate of 0.9 inch/week

The results of the groundwater monitoring program and isotope analyses indicate that excess nitrogen is currently becoming enriched in groundwater beneath the IGC area, suggesting that the current application rate for nitrogen exceeds the ability of the plants to absorb this nutrient. Fertilizer application rates should be reviewed per Golf Course BMP recommendations and modified as appropriate to reduce surface water and groundwater impacts.

5.1.2 Hydrologic Manipulation

Another opportunity to reduce nutrient loadings discharging from the IGC area is to utilize on-site waterbodies as the primary source of irrigation water, with reuse irrigation used only to supplement existing available sources. This manipulation could be managed to substantially reduce the discharge rate and volume of discharges from the IGC property which would also reduce loadings discharging to downstream waters.

A graphical summary of historical discharge data measured at the concrete weir (Site 4S) in the Innisbrook Canal over the period from December 2005-September 2009 was given on Figure 2-14. The mean discharge rate at this site over this period is approximately 0.98 cfs. Unfortunately, no gauging stations are available immediately downstream from the IGC property to estimate the volume of discharges which actually leave the IGC property. However, it is reasonable to expect that an increase in discharge rates would occur between the discharge monitoring site at Site 4S and the IGC outfall at Site 5S due to the additional waterbodies and golf course areas between the two sites. During the surface water monitoring program conducted by ERD, a mean discharge of 3.23 cfs was measured at Site 4S, with a mean of 5.11 cfs at the IGC outfall, an increase of approximately 58%, due primarily to runoff and irrigation inputs. For purposes of this analysis, it is assumed that the discharge between the two sites increases by approximately 50% on an annual average basis. Since a mean discharge rate of 0.98 cfs was measured at Site 4S, the estimated discharge rate at the IGC outfall is assumed to be 1.47 cfs.

The mean estimated discharge rate of 1.47 cfs at the IGC outfall is equivalent to approximately 950,020 gallons per day (gpd). This value represents 54% of the 1.77 mgd of reuse water applied within the IGC area each day. Irrigation within the site should be managed to minimize off-site discharges to the minimum amount required to maintain the salt water balance in downstream areas. Assuming that the discharge could be safely cut in half without affecting downstream biological communities, the required reuse irrigation volume could be reduced by approximately 25%, also reducing the applied nutrient loadings by 25%. This modification would assist in reducing the current over-supply of phosphorus within the basin. The specific amount of flow reduction which could be achieved safely would need to be evaluated through a detailed biological assessment, although this modification appears to be an easy and inexpensive alternative for reducing downstream loadings.

Another hydrologic modification which could impact off-site loadings is to hydrologically isolate irrigation ponds used for storage of reuse water. These ponds should be isolated from the remaining waterbodies with discharge permitted only during high water level conditions. All irrigation should occur from these ponds only, and water levels within the ponds could be supplemented from other on-site waterbodies to minimize off-site discharges. Any additional irrigation requirements would then be supplemented by reuse application. This technique would minimize discharge of elevated nutrients downstream and contain much of the nutrient loadings on-site.

5.1.3 Irrigation Management

Numerous examples of irrigation water applied directly to surface waters were observed by ERD during this project. This occurs when irrigation systems overlap onto water surfaces, causing direct deposition of water containing elevated nutrient concentrations. All irrigation heads should be carefully adjusted to avoid overspray onto lake surfaces and impervious areas with a potential to discharge into on-site lakes. Irrigation rates should also be adjusted in areas where steep land surfaces terminate in waterbodies to minimize runoff potential.

5.1.4 Uptake Mechanisms

Another potential opportunity for reducing off-site nutrient discharges from the IGC area is to increase the opportunity for nutrient retention on-site. Since all surface runoff is ultimately directed to on-site storage ponds, one of the best opportunities for nutrient reduction is to increase the uptake capacity of the on-site waterbodies. Under current conditions, waterbodies within the IGC area contain virtually no littoral zone vegetation, with most of the ponds maintained in a weed-free condition through spraying and other maintenance activities. Littoral zone vegetation provides a diverse habitat which can support organisms that can be responsible for improving water quality in lakes.

Therefore, it is recommended that littoral zone vegetation be established within each of the on-site golf course ponds to the maximum water depth allowed by the selected vegetation. Although littoral zone plants have limited nutrient uptake capacity themselves, these areas will provide a diversity of aquatic habitats which are important in maintaining water quality. The use of herbicides of any kind, including both copper sulfate and organic compounds, should be discontinued within on-site waterbodies since herbicides kill aquatic plants as well as algae which are significant uptake mechanisms for nutrients in waterbodies. These activities will maximize the uptake potential of the on-site ponds and assist in reducing off-site discharges. If nuisance algae become problematic, aeration systems could be installed in deeper portions of the ponds to create water column turnover which reduces potential for algal growth.

5.2 Joe's Creek Watershed

As discussed in Section 4.2, most areas of Joe's Creek appear to be a net source for both nitrogen and phosphorus, rather than a net sink. A discussion of nutrient management recommendations for these areas, along with general watershed maintenance techniques, is given in the following sections.

5.2.1 Silver Lake

Monitoring conducted upstream and downstream from Silver Lake suggests that the sediments within Silver Lake may be a significant source of phosphorus to Joe's Creek. This is a portion of the watershed where phosphorus concentrations appear to increase significantly rather than decrease. However, this area also exhibits a substantial decrease in measured concentrations of NO_x, suggesting denitrification in an anaerobic environment within this lake. Unfortunately, this anaerobic environment is also the driving force for the apparent sediment phosphorus release.

Sediment phosphorus inactivation is a lake management technique which is designed to reduce sediment phosphorus release by combining available phosphorus in the sediments with a metal salt to form an insoluble inert precipitate, rendering the sediment phosphorus unavailable for release into the overlying water column. Although salts of aluminum, calcium, and iron have been used for sediment inactivation in previous projects, aluminum salts are the clear compounds of choice for this application. Inactivation of sediment phosphorus using aluminum is often a substantially less expensive option for reducing sediment phosphorus release since removal of the existing sediments is not required.

Sediment inactivation in Silver Lake would involve addition of liquid aluminum sulfate at the water surface. Upon entering the water, the alum would form insoluble precipitates which would settle onto the bottom while also clarifying the existing water column within the lakes. Upon entering the sediments, the alum will combine with existing phosphorus within the sediments, primarily saloid- and iron-bound associations, forming insoluble inert precipitates which will bind the phosphorus, making it unavailable for release into the overlying water column. It is generally recognized that the top 10 cm layer of the sediments is the most active in terms of release of phosphorus under anoxic conditions. Therefore, the objective of a sediment inactivation project is to provide sufficient alum to bind the saloid- and iron-bound phosphorus associations in the top 10 cm of the sediments.

A summary of estimated sediment inactivation requirements and costs for Silver Lake is given in Table 5-3. Silver Lake has an estimated surface area of approximately 8.59 acres. The amount of alum required to inactivate the existing sediments within the lake can only be determined by collection and evaluation of existing sediments at multiple locations throughout the lake. However, for purposes of this analysis, an alum application areal dose of 40 g Al/m^2 is assumed which reflects a median value for recent sediment inactivation projects conducted by ERD. Based upon this assumption, sediment inactivation in Silver Lake will require approximately 6275 gallons of alum, with an estimated chemical cost of approximately $7220, based on an assumed alum cost of $1.15/gallon. Application costs are estimated at approximately $5000, for a total estimated cost of $12,220. However, it should be emphasized that this cost is only an estimate which would be modified based upon the results of the sediment testing.

TABLE 5-3

SUMMARY OF ESTIMATED SEDIMENT INACTIVATION REQUIREMENTS AND COSTS FOR SILVER LAKE

SURFACE AREA (acres)	ASSUMED AREAL DOSE (g Al/m^2)	REQUIRED ALUM VOLUME (gallons)	CHEMICAL COST[1] ($)	APPLICATION COST[2] ($)	TOTAL COST ($)
8.59	40	6275	7220	5000	12,220

1. Based on an assumed alum cost of $1.15/gallon
2. Includes mobilization, application labor, clean-up, expenses, insurance, and demobilization

After initial application, the alum precipitate will form a visible floc layer on the surface of the sediments within the lake. This floc layer will continue to consolidate for approximately 30-90 days, reaching maximum consolidation during that time. Due to the likely unconsolidated nature of the sediments in the lake, it is anticipated that a large portion of the floc will migrate into the existing sediments rather than accumulate on the surface as a distinct layer. This process is beneficial since it allows the floc to sorb soluble phosphorus during migration through the surficial sediments. Any floc remaining on the surface will provide a chemical barrier for adsorption of phosphorus which may be released from the sediments.

Based on previous experiences by ERD, as well as research by others, it appears that a properly applied chemical treatment will be successful in inactivation of the available phosphorus in the sediments of Silver Lake as well as phosphorus inputs from groundwater seepage. However, several factors can serve to reduce the effectiveness and longevity of this treatment process. First, wind action can cause the floc to become prematurely mixed into deeper sediments, reducing the opportunity for maximum phosphorus adsorption. Significant wind re-suspension has been implicated in several alum applications in shallow lakes which exhibited reduced longevity. However, in the absence of wind re-suspension, alum inactivation in lake sediments has resulted in long-term benefits ranging from 3 to more than 20 years. Since the depth of Silver Lake is not known at this time, the potential for wind-induced resuspension of the alum floc cannot be evaluated.

Another factor which can affect the perceived longevity and success of the application process is recycling of nutrients by macrophytes from the sediments into the water column. This recycling will bypass the inactivated sediments since phosphorus will cross the sediment-water interface using vegetation rather than through the floc layer. Although this process will not affect the inactivation of phosphorus within the sediments, it may result in increases in dissolved phosphorus concentrations which are unrelated to sediment-water column processes. However, the degree of macrophyte growth in Silver Lake appears to be limited, confined primarily to shoreline areas, and recycling of phosphorus by macrophytes does not appear to be a significant concern.

A properly conducted alum surface treatment to Silver Lake would substantially reduce internal recycling of phosphorus from the sediments under anoxic conditions. This treatment will result in both short-term and long-term improvements in water clarity, allowing sunlight to penetrate into deeper portions of the water column and improve the existing anoxic conditions which appear to exist. However, the current anoxic conditions are favorable for denitrification processes which appear to be occurring within the lake. Although the sediment inactivation will reduce phosphorus release within the lake, it may have the unintended consequence of improving oxygen conditions and reducing denitrification within the lake, resulting in increased nitrogen loadings downstream. This potential should be further evaluated during the preliminary evaluation phase for any proposed alum treatment in Silver Lake.

5.2.2 Downstream Portions of Joe’s Creek

The monitoring program conducted by ERD began in the upstream portions of Joe’s Creek within Silver Lake and continued downstream to 49th Street North where the final monitoring site (Site 5S) is located. Since the freshwater segment of Joe’s Creek is assumed to end at 46th Street North, this downstream portion of Joe’s Creek is technically considered to be in the marine segment.

As discussed in Section 4.2, a steady decrease in mass loadings of nitrogen and phosphorus was observed with increasing distance downstream in Joe’s Creek with the exception of the segment located between Site 4S and Site 5S which includes the channel between the concrete weir downstream of the SWFWMD wet detention pond and 49th Street North. As summarized in Table 4-11, mean nitrogen loadings over this segment increased approximately 55% during the monitoring program from July-September 2008, with a 45% increase in total phosphorus loadings. However, a decrease in TSS loadings was observed between these two sites, suggesting that the increased loadings are primarily due to soluble nutrients rather than particulate matter.

A topographic map of the downstream portions of the Joe’s Creek study area is given on Figure 5-1. The SWFWMD wet detention pond is located near the center of the figure, with the downstream USGS station located at 46th Street North. As seen on Figure 5-1, the main channel for Joe’s Creek becomes deeper in profile with increasing distance downstream, with the channel bottom located approximately 10-15 ft below land surface near the intersection with 49th Street North. This deep cut into the existing topography enhances the opportunity for interception of groundwater which could be a contributing factor to the increased loadings observed in this area. However, as discussed previously, soils within the watershed are primarily classified in HSG D which consists of sandy soils with an underlying impermeable layer consisting of either clay or hardpan which should limit groundwater migration. However, it is possible that the deep cut of the channel extends below this impermeable layer into a lower more permeable sandy area.

In addition to groundwater impacts, nutrient input is also a possibility from adjacent watershed areas. Numerous small diameter culverts discharge through the side banks of Joe’s Creek between 46th Street North and 49th Street North, providing opportunities for nutrient additions. ERD could find no evidence of reuse irrigation within this area, which has a known potential to increase nutrient loadings. Areas adjacent to the creek also appear to be serviced by a centralized sewer system, eliminating potential impacts from large numbers of septic tanks, and the adjacent residential and commercial areas appear to be similar to other areas located along upstream portions of Joe’s Creek.

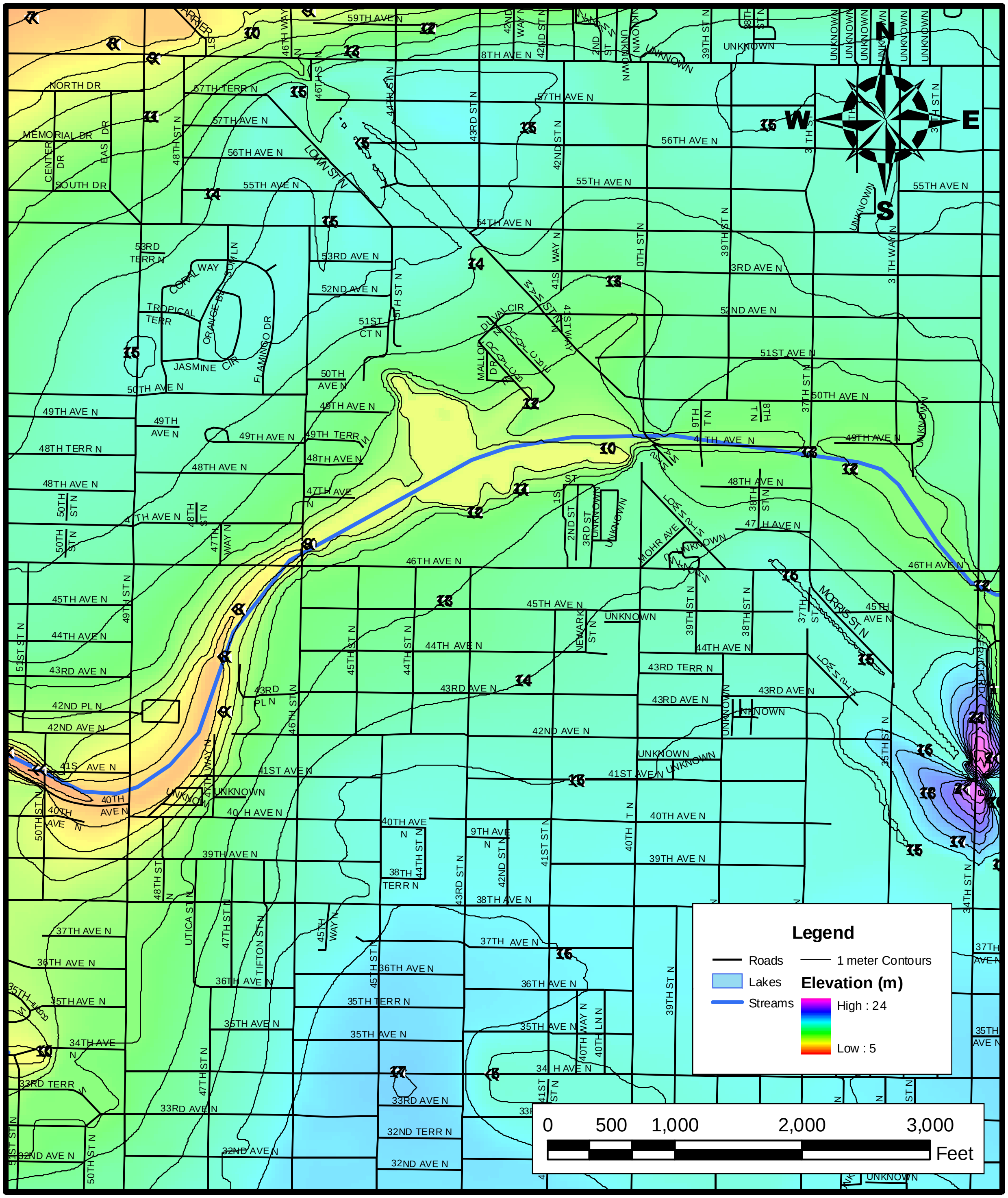


Figure 5-1. Topographic Map of Downstream Portions of the Joe's Creek Study Area.

A landscaping nursery facility is located along the west side of Joe's Creek between 46th Street North and 49th Street North. An aerial overview of the facility is given on Figure 5-2. The back portion of the nursery directly abuts Joe's Creek, and rear portions of the property appear to be used for storage of fertilizer, soils, mulch, and other landscaping materials. A stormsewer pipe discharges from the rear of the property directly into Joe's Creek. Even under careful operation, areas used for storage of fertilizers and other materials have been shown to contribute nutrient loadings to adjacent receiving waters. In view of the absence of other significant nutrient sources into Joe's Creek, this facility appears to be a potential source of additional nutrients within this segment. This is further supported by the isotope analyses which indicate that the nitrogen and oxygen measured within the creek are consistent with nitrates derived from synthetic fertilizers. A direct evaluation of this specific facility was outside of the scope of services provided by ERD. However, this facility should be further evaluated as a potential source of nutrient loadings into Joe's Creek, and management activities should be applied, as appropriate, to minimize potential impacts from this site.

Figure 5-2. Aerial Overview of the Nursery Along Downstream Portions of Joe's Creek.

5.2.3 General Watershed Maintenance

General observations of areas within the Joe's Creek watershed (conducted by ERD personnel during this project) suggests that many portions of the drainage basin are relatively "dirty" as indicated by excessive amounts of dust, soils, vegetation debris, and litter on both roadway and parking surfaces. These "dirty" areas are particularly prevalent in the upstream industrial and residential portions of the basin, as well as the primary corridor along U.S. 19. Virtually all of these areas are currently developed, and opportunities for nutrient reductions through structural projects are relatively limited. However, non-structural source control programs have been shown to be effective in reducing pollutant accumulations within watersheds and have a valid potential for improving the characteristics of stormwater runoff in the Joe's Creek watershed.

Source reduction programs have the potential to provide effective reductions in stormwater concentrations, particularly for nutrients and suspended solids. Source reduction techniques, such as street sweeping and public education, are capable of reducing loadings of pollutants entering receiving waterbodies by reducing pollutant accumulation within the watershed. If properly conducted, source reduction programs can be almost as effective as changes in stormwater regulations for reducing pollutant loadings to lakes. The two most common source reduction techniques are street sweeping and public education which are discussed in the following sections.

5.2.3.1 Street Sweeping

Street sweeping is an effective best management practice (BMP) for reducing total suspended solids and associated pollutant wash-off from urban streets. Street sweeping is well suited to an urban environment where little land is available for installation of structural controls. Street sweeping can be extremely effective in commercial business districts, industrial sites, and intensely developed areas in close proximity to receiving waters.

Street sweeping involves the use of machines which basically pick-up contaminants from the street surface and deposit them in a self-contained bin or hopper. Mechanical sweepers are the most commonly used sweeping devices and consist of a series of brooms which rotate at high speeds, forcing debris from the street and gutter into a collection hopper. Water is often sprayed on the surface for dust control during the sweeping process. The effectiveness of mechanical sweepers is a function of a number of factors, including: (1) particle size distribution of accumulated surface contaminants; (2) sweeping frequency; (3) number of passes during each sweeping event; (4) equipment speed; and (5) pavement conditions. Unfortunately, mechanical sweepers perform relatively poorly for collection of particle sizes which are commonly associated with total phosphorus loadings in stormwater runoff. During the 1980s, the U.S. EPA concluded that street sweeping using mechanical sweepers had no significant impact on runoff characteristics.

Over the past decade, improvements have been made to street sweeping devices which substantially enhance the performance efficiency. Vacuum-type sweepers, which literally vacuum the roadway surface, have become increasingly more popular, particularly for parking lots and residential roadways. The overall efficiency of vacuum-type sweepers is generally higher than that of mechanical cleaners, especially for particles larger than 3 mm. Estimated efficiencies of mechanical and vacuum-assisted sweepers are summarized in Table 5-4 based upon information provided by the Federal Highway Administration. Mechanical sweepers can provide approximately 40% removal of phosphorus in roadway dust and debris, while vacuum-assisted sweepers can provide removals up to 74%. Recent studies in Hamilton County, Ohio indicated a significant reduction in runoff concentrations of nutrients after implementation of a vacuum sweeper program in residential areas.

TABLE 5-4

EFFICIENCIES OF MECHANICAL (BROOM) AND VACUUM-ASSISTED SWEEPERS

CONSTITUENT	MECHANICAL SWEEPER EFFICIENCY (%)	VACUUM-ASSISTED SWEEPER EFFICIENCY (%)
Total Solids	55	93
Total Phosphorus	40	74
Total Nitrogen	42	77
COD	31	63
BOD	43	77
Lead	35	76

SOURCE: Federal Highway Administration (FHWA)

The efficiency of street sweepers is highly dependent upon the sweeping interval. To achieve a 30% annual removal of street dirt, the sweeping interval should be less than two times the average interval between storms. Since the average interval between storms in the St. Petersburg area is approximately three days, a sweeping frequency of once every six days is necessary to achieve a 30% removal of street dirt. To achieve a 50% annual removal, sweeping must occur at least once between storm events. In the St. Petersburg area, a 50% removal would require street sweeping to occur approximately once every three days.

Street sweeping activities can be particularly effective during periods of high leaf fall by removing solid leaf material and the associated nutrient loadings from roadside areas where they can easily become transported by stormwater flow. Previous research has indicated that leaves release large quantities of both nitrogen and phosphorus into surface water within 24-48 hours after becoming saturated in an aquatic environment. Loadings to waterbodies from leaf fall are often the most significant loadings to receiving waters during the fall and winter months. Street sweeping operations are typically performed on a monthly basis, with increased frequency during periods of high leaf fall.

Capital costs for street sweepers range from approximately $70,000-150,000, with the lower end of the range associated with mechanical street sweepers and the higher end of the range associated with vacuum-type sweepers. The useful life span is typically 4-8 years, with an operating cost of approximately $70/hour.

5.2.3.2 <u>Public Education</u>

Public education is one of the most important nonpoint source controls which can be used in a watershed. Many residents appear to be unaware of the direct link between watershed activities and the water quality in adjacent waterbodies. The more a resident or business owner understands the relationship between nonpoint source loadings and receiving water quality, the more that person may be willing to implement source controls.

Several national studies have indicated that it is an extremely worthwhile and cost-effective activity to periodically remind property owners of the potential for water quality degradation which can occur due to misapplication of fertilizers and pesticides. Periodic information pamphlets can be distributed by hand or enclosed with water and sewer bills which will reach virtually all residents within the watershed. These educational brochures should emphasize the fact that taxpayer funds are currently being utilized to treat nonpoint source water pollution, and the homeowners have the opportunity to reduce this tax burden by modifying their daily activities. A comprehensive public education program should concentrate, at a minimum, on the following topics:

1. Relationship between land use, stormwater runoff, and pollutants
2. Functions of stormwater treatment systems
3. How to reduce stormwater runoff volume
4. Impacts of water fowl and pets on runoff characteristics and surface water quality
5. County stormwater program goals and regulations
6. Responsible use of fertilizer, pesticides and herbicides
7. Elimination of illicit connections to the stormwater system
8. Controlling erosion and turbidity
9. Proper operation and maintenance of stormwater systems

The public education program can be implemented in a variety of ways, including homeowner and business seminars, newsletters, performing special projects with local schools (elementary, middle and high schools), Earth Day celebrations, brochures, and special signage at stormwater treatment construction sites. Many people do not realize that stormsewers eventually drain to area lakes. Many cities and counties in Florida have implemented a signage program which places a small engraved plaque on each stormsewer inlet indicating "Do Not Dump, Drains to Lake". ERD recommends that an aggressive public education program be implemented in the Joe’s Creek watershed which incorporates all of the elements discussed previously.

Anticipated load reductions for implementation of public education programs are difficult to predict and depend highly upon the degree of implementation by the homeowners within the basin. The impacts of public education programs also depend, to a large extent, on the degree to which water quality within the Joe’s Creek basin is currently being impacted by uneducated and uninformed activities by current homeowners. Several regional and national studies are currently being performed which will attempt to document the pollutant removal effectiveness of public education programs.

SECTION 6

RECOMMENDATIONS

Based upon the results and analyses discussed in previous sections, the following recommendations are made to improve water quality characteristics in the Klosterman Bayou and Joe's Creek watersheds.

6.1 Klosterman Bayou Watershed

1. The IGC maintenance staff should recognize the nutrient loading within the reuse irrigation water and adjust fertilization schedules accordingly. The reuse irrigation provides more phosphorus than can be assimilated by the golf course vegetation, and supplemental phosphorus fertilization should be discontinued.

2. Elevated concentrations of nitrate in groundwater suggest that current fertilization activities are in excess of the needs of the turf grass plants. Since the groundwater concentrations are higher than nitrogen concentrations in reuse water, these elevated concentrations can only come from excess fertilizer use. Fertilization applications and schedules should be reviewed specifically for nitrogen compounds.

3. Hydrologic modifications should be made to the IGC area to utilize all on-site surface waterbodies for irrigation purposes before supplementing with reuse water. The objective of this process should be to minimize off-site water discharges to the minimum level necessary to maintain downstream biological communities.

4. Waterbodies used for storage of reuse water should be hydrologically isolated from other on-site waterbodies except under extreme high water level conditions.

5. Irrigation practices should be monitored to eliminate overspray onto surface water or impervious surfaces within the IGC area.

6. Littoral zone vegetation should be established in all of the on-site waterbodies to enhance uptake mechanisms for nutrients prior to off-site discharge.

7. Applications of herbicides in on-site waterbodies should be eliminated since these activities are designed to kill algae and aquatic plants which provide significant uptake mechanisms for nutrients.

6.2 Joe's Creek Watershed

1. Consider an alum sediment inactivation project on Silver Lake to reduce the apparent internal phosphorus recycling within this waterbody. However, consideration must be given to potential loss of denitrification as a result of this application.

2. Investigate sources of additional phosphorus loadings between 46th Street North and 49th Street North (Sites 4S and 5S). The existing nursery along the west side of Joe's Creek appears to be a likely candidate for these additional loadings and should be further evaluated.

3. Street sweeping should be initiated in the industrial and residential portions of the Joe's Creek watershed to reduce current accumulations of dirt, dust, vegetation, and debris within these areas which can contribute to nutrient loadings within the creek.

4. A public education program should be initiated to residents and property owners within the Joe's Creek area to provide education on links between personal activities and water pollution.

SECTION 7

REFERENCES

APHA, AWWA, and WEF. (1995). *Standard Methods for the Examination of Water and Wastewater*, 19^{th} Ed.

Aravena, R. and Robertson, W.D. (1998). "Use of Multiple Isotope Tracers to Evaluate Denitrification in Ground Water: Study of Nitrate from a Large-flux Septic System Plume." *Ground Water 36:* 975–982.

Casciotti, K.L.; Sigman, D.M.; Galanter Hastings, M.; Bohlke, J.K.; and Hilkert, A. (2002). "Measurement of the Oxygen Isotopic Composition of Nitrate in Seawater and Freshwater Using the Denitrifier Method." *Anal. Chem. 74*: 4905–4912.

Coplen, T.B. (1996). "New Guidelines for Reporting Stable Hydrogen, Carbon, and Oxygen Isotope-ratio Data." *Geochimica et Cosmochimica Acta 60*: 3359-3360.

Fukada, T.; Hiscock, K.M.; Dennis, P.F.; and Grischek, T. (2003). "A Dual Isotope Approach to Identify Denitrification in Ground Water at a River Bank Infiltration Site." *Water Res. 37:* 3070–3078.

Harper, H.H. (1990). "Effects of Stormwater Management Systems on Groundwater Quality." Final Report Prepared for FDEP Project No. WM190.

Kellman, L. and Hillaire-Marcel, C. (1998). "Nitrate Cycling in Streams: Using Natural Abundances of NO_3^- $\delta^{15}N$ to Measure In-situ Denitrification." *Biogeochemistry 43*: 273–292.

Kendall, C. (1998). "Tracing Nitrogen Sources and Cycling in Catchments." *Isotope Tracers in Catchment Hydrology*, Edited by Kendall, C., and McDonnell, J.J. Amsterdam: Elsevier Science B.V., 839 pp.

Kendall, C.; Silva, S.R.; Chang, C.C.Y.; Burns, D.A.; Campbell, D.H.; and Shanley, J.B. (1996). Use of the $\delta^{18}O$ and $\delta^{15}N$ of Nitrate to Determine Sources of Nitrate in Early Spring Runoff in Forested Catchments. In *Proceedings of the International Atomic Energy Agency, Symposium on Isotopes in Water Resources Management.* Vienna, Austria, March 20-24, 1995, v. 1, p. 167-176.

Otero, N.; Torrento, C.; Soler, A.; Mencio, A.; and Jax-Pla, J. (2009). "Monitoring Groundwater Nitrate Attenuation in a Regional System Coupling Hydrogeology with Multi-isotopic Methods: The Case of Plana de Vic (Osona, Spain)." *Agriculture, Ecosystems and Environment 133*: 103-113.

Post, Buckley, Schuh & Jernigan (PBS&J). (2007). "Technical Memorandum: Model Set-up, Refinement, Calibration, and Validation." Prepared for Project WM913, Task Assignment 7, St. Joe's Creek/Pinellas Park Ditch No. 5 Watershed TMDL Model Development, December 14, 2007.

Révész, K. and Casciotti, K. (2007). "Determination of the $\delta(^{15}N/^{14}N)$ and $\delta(^{18}O/^{16}O)$ of Nitrate in Water: RSIL Lab Code 2900." In Chapter C17 of *Methods of the Reston Stable Isotope Laboratory: Reston, Virginia,* Edited by Révész, Kinga, and Coplen, Tyler B. U.S. Geological Survey, Techniques and Methods, book 10, sec. C, chap. 17, 24 p.

Sigman, D.M.; Casciotti, K.L.; Andreani, M.; Barford, C.; Galanter, M.; and Bohlke, J.K. (2001). "A Bacterial Method for the Nitrogen Isotopic Analysis of Nitrate in Seawater and Freshwater." *Anal. Chem. 73*: 4145–4153.

URS and Dynamic Solutions, LLP. (2007). "Watershed Hydrologic Water Quality Model Calibration for Klosterman Bayou." Report prepared for the Florida Department of Environmental Protection, December 31, 2007.

U.S. EPA. (1983). *Methods for Chemical Analysis of Water and Wastes.* EPA 600/4-79-020.

Wassenaar, L.I. (1995). "Evaluation of the Origin and Fate of Nitrate in the Abbotsford Aquifer Using the Isotopes of ^{15}N and ^{18}O in NO_3^-." *Applied Geochemistry, 10:* 391-405.

Werner, R.A., and Brand, W.A. (2001). "Referencing Strategies and Techniques in Stable Isotope Ratio Analysis." *Rapid Communications In Mass Spectrometry 15*: 501-519.

APPENDICES

APPENDIX A

HISTORICAL WATER QUALITY DATA

1. **Klosterman Bayou**
2. **Joe's Creek**

1. <u>Klosterman Bayou</u>

WaterBodyName	Innisbrook Canal																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
280634082453500	INNISBROOK DITCH AT BRIDGE	USGS_NWIS	2/1/1989	7.20													
			3/3/1989	7.15				690		2,110	2,200	2,250	13,000		3,710		
280635082453300	SURFACE WATER SITE 3 AT INNISBROOK FL	USGS_NWIS	10/19/1971					11,000	2,500			780			320		
			5/20/1974	7.40		6.1		210		0		1,600	1,600		2,235		
			4/9/1975	8.00				400	260	365	860	4,700	5,560	1.300	2,300		
			4/10/1975			9.3											
			3/17/1976			6.4	80	2,200	1,200	250	1,600	2,000	3,600	1.400	1,500		
			6/14/1977	9.00		7.9	55	150	0	65	100	1,600	1,700	0.340	530		
			9/30/1977	7.30			120	1,800		200	500	2,700	11,050		2,335		
280651082454400	SURFACE WATER SITE 2 AT INNISBROOK FL	USGS_NWIS	10/18/1971					2,900	1,400			2,600			1,325		
280702082460000	SW-4 ALT 19 S OF TARPON SPRINGS NEAR INNISBROOK FL	USGS_NWIS	5/22/1974	6.30		36.0		1,000		20		2,000	2,020	0.470	700		
			3/22/1976			8.3	40	200	0	5	10	1,300	1,310		280		
02-02	(blank)	PINELLAS	3/26/1991 10:00	7.76	6.41												140
			5/22/1991 9:53	7.61	3.17						70			1.080		10	210
			7/17/1991 9:40	7.65	5.68	4.4					140			1.550		11	170
			9/11/1991 9:20	7.48	3.67	3.1					120			1.490		9	570
			10/30/1991 11:15	8.00	6.37	5.3					90			2.110		12	100
			1/15/1992 9:50	8.21	7.53	8.1					460			2.660		22	340
			3/11/1992 9:52	8.11	5.91	6.1					550	2,000	2,550	2.200	2,330	30	560
			5/6/1992 9:30	8.65	3.83	5.4					30	2,330	2,360	1.670	2,060	15	510
			6/30/1992 9:35	7.47	3.06	4.3						3,870		2.160	2,420	20	1,200
			8/26/1992 10:00	8.13	4.58	4.0					20	1,620	1,640	2.140	2,340	7	680
			10/14/1992 10:25	7.29	5.66	6.2					720	1,640	2,360	1.090	1,160	23	740
			10/14/1992 10:28	7.32	5.46												
			12/29/1992 9:33	7.87	6.03	3.8					20	2,340	2,360	1.400	1,440	12	400
			2/3/1993 9:50	8.15	9.57	5.0					30	1,870	1,900	1.820	1,970	11	120
			4/6/1993 9:50	7.60	6.56	4.9					150	3,280	3,430	1.420	1,620	16	380
			6/16/1993 9:36	8.49	3.32	6.0					60	7,250	7,310	1.130	1,510	16	180
			8/4/1993 10:10	8.15	3.88	3.8					80	1,480	1,560	1.050		16	770
			10/6/1993 9:28	7.82	3.86	6.3					90	2,780	2,870		1,610	12	370
			11/17/1993 9:25	8.43	12.27	2.4					2,680	3,070	5,750	1.770	1,890	3	80
			2/2/1994 12:25	7.96	9.73	8.5					220	5,040	5,260	2.270	2,610	36	360
			3/29/1994 9:35	8.32	6.68	4.0					20	3,430	3,450	2.440	3,060	30	230
			5/18/1994 10:12	8.18	3.34	4.2					20	1,780	1,800	2.630	2,790	6	840
			7/20/1994 9:32	7.74	2.11	3.5					90	2,170	2,260	0.310	2,070	11	1,200
			7/20/1994 9:34	7.71	1.93												
			9/7/1994 9:50	8.25	5.14	3.5					150	4,550	4,700	2.290	2,380	14	1,100
			11/8/1994 9:35	8.00	7.47	3.8					340	2,170	2,510	2.530	2,680	13	650
			1/25/1995 9:05	8.36	11.05	4.6					110	1,670	1,780	2.220	2,400	15	60
			3/22/1995 9:13	8.40	7.32	3.1					20	1,760	1,780	2.060	2,210	18	110
			5/17/1995 8:57	8.50	2.03	4.3					50	1,980	2,030	2.470	2,530	11	270

WaterBodyName	Innisbrook Canal																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
02-02	(blank)	PINELLAS	7/12/1995 9:23	8.00	2.96	2.5					40	1,820	1,860	1.530	1,580	15	200
			9/13/1995 9:14	7.91	6.68	2.2					210	2,000	2,210	0.910	1,050	8	290
			11/1/1995 9:55	8.21	6.89	1.0					570	2,250	2,820	1.030	1,190	9	600
			12/13/1995 11:01	8.29	11.15	2.6					320	1,680	2,000	0.220	410	12	80
			2/21/1996 9:44	8.20	10.46	5.6					100			0.330		12	66
			4/16/1996 9:20	8.16	7.86	5.3					140	2,260	2,400	0.680	750		220
			6/11/1996 10:00	8.21	3.36	3.4					20	1,790	1,810	0.980	990		110
			8/7/1996 9:25	8.04	3.61	5.0					200	2,570	2,770	1.180	1,130		25
			10/2/1996 9:33	8.16	6.08	4.0					30	2,210	2,240	1.640	1,770		150
			12/4/1996 11:11	8.27	8.65	4.0					20	1,580	1,600	1.020	850		240
			2/19/1997 10:05	8.14	9.48	4.0					70	1,370	1,440	1.550	1,580		
			4/16/1997 9:37	7.88	7.66	3.0					20	1,500	1,520	1.390	1,340		
			6/9/1997 10:47	8.50	4.62	5.0					20	1,740	1,760	1.680	830		
			6/9/1997 10:48	8.52	4.54												
			8/13/1997 10:59	7.61	0.00	3.0					20	1,510	1,530	0.730	900		
			9/24/1997 9:30	7.25	1.24	4.0					20	2,110	2,130	0.110	360		
			11/19/1997 8:57	7.94	9.22	3.0					800	1,310	2,110	0.840	1,020		
			2/4/1998 13:01	7.68	8.85	4.0					850	1,580	2,430	0.540	710		
			3/30/1998 9:46	7.93	7.93	2.0					80	1,700	1,780	1.480	1,780	13	
			5/27/1998 8:55	7.24	0.04	10.0					310	2,240	2,550	0.410	730	14	
			7/22/1998 9:04	8.05	4.96	2.0					180	1,510	1,690	0.570	750	6	
			9/16/1998 9:19	7.86	4.05	6.0					170	2,210	2,380	0.410	680	22	
			11/9/1998 9:35	8.21	6.22	5.0					320	2,020	2,340	1.320	1,540	11	
			1/27/1999 10:22	8.21	9.29	6.0					90	4,360	4,450	2.640	3,580	99	
			2/24/1999 9:23	8.25	10.17	1.0					20	940	960	2.610	2,380	8	
			3/24/1999 10:00	8.32	8.39	5.0					20	1,740	1,760	2.120	2,230	14	
			4/21/1999 9:26	8.44	7.70	6.0					20	1,620	1,640	1.750	1,780	13	
			5/20/1999 9:39	7.41	0.47	7.0					20	1,610	1,630	0.440	550	24	
			6/16/1999 10:04	7.16	1.03	4.0					20	1,240	1,260	0.640	780	16	
			7/13/1999 10:54	7.72	5.35	4.0					20	1,760	1,780	1.270	1,540	10	
			8/11/1999 9:27	8.00	3.14	4.0					20	1,640	1,660	0.950	1,040	9	
			9/1/1999 10:09	7.95	2.40	6.0					20	1,520	1,540	0.870	1,020	6	
			10/6/1999 8:59	7.60	3.60	2.0					280	1,730	2,010	0.860	1,040	9	
			11/3/1999 10:10	8.02	5.41	4.0					190	1,820	2,010	1.080	1,170	12	
			11/15/1999 11:32	8.39	8.43	5.0					1,060	1,710	2,770	0.960	1,110	14	
			12/1/1999 9:12	8.14	7.14	5.0					1,380	1,810	3,190	1.010	1,450	10	
			1/26/2000 11:04	8.40	10.58	5.0					300	1,530	1,830	0.960	1,150	18	
			2/23/2000 9:57	8.34	6.72	4.0					20	1,500	1,520	1.410	1,790	18	
			3/22/2000 10:36	8.29	7.63	5.0					310	2,130	2,440	1.140	1,420	18	
			4/18/2000 13:29	8.67	7.70	7.0					530	2,220	2,750	0.900	1,170	25	
			5/17/2000 10:03	7.65	1.76	8.0					40	4,320	4,360	0.230	610	48	

WaterBodyName	Innisbrook Canal																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
02-02	(blank)	PINELLAS	6/14/2000 9:37	7.63	1.77	4.0					20	1,030	1,050	0.050	180	30	
			7/12/2000 9:56	8.47	5.97	5.0					30	1,700	1,730		1,840	16	
			8/9/2000 10:19	7.86	3.76	3.6					5	2,100	2,105	1.100	1,100	11	
			9/6/2000 9:48	7.88	6.07												
			9/6/2000 9:49	7.87	6.01						68	1,306	1,374	0.839	898	9	
			10/4/2000 9:26	7.85	5.36	4.0					150	2,210	2,360	0.930	1,130	7	
			11/1/2000 9:59	8.33	7.84	4.0					610	1,920	2,530	1.400	1,580	9	
			11/27/2000 9:47	8.32	7.79	2.0					1,170	1,790	2,960	0.750	880	10	
			1/24/2001 10:05	8.51	11.01	6.0					150	1,810	1,960	0.960	1,100	13	
			2/21/2001 9:04	8.02	6.38	3.0					50	1,840	1,890	1.260	1,440	16	
			3/21/2001 9:45	8.14	8.15												
			3/21/2001 9:46	8.12	8.00	3.0					40	1,490	1,530	1.210	1,430	14	
			4/19/2001 8:59	8.36	7.07	3.0					20	1,590	1,610	1.650	1,630	14	
			5/16/2001 9:46	8.76	6.21	6.0					40	1,950	1,990	0.690	980	16	
			6/13/2001 9:00	8.27	2.37	6.0					20	2,130	2,150	1.020	1,280	6	
			7/12/2001 9:48	7.48	3.92	4.0					110	2,150	2,260	1.540	1,780	10	
			8/8/2001 9:59	8.00	6.92	3.0					220	1,830	2,050	1.030	1,270	10	
			9/5/2001 10:10	8.15	6.22	4.0					590	1,780	2,370	0.890	1,030	10	
			10/3/2001 9:45	8.18	8.87	4.0					160	1,570	1,730	0.690	940	13	
			10/31/2001 10:37	8.66	9.36						530	1,870	2,400	0.990	1,360	12	
			11/28/2001 9:28	8.13	6.24	5.0					320	2,260	2,580	0.720	910	10	
			1/23/2002 9:27	7.60	7.90	2.0					20	1,060	1,080	1.260	1,340	12	
			2/20/2002 9:25	7.95	9.38	3.0					20	1,290	1,310	0.830	1,030	12	
			3/20/2002 9:57	7.99	5.29						20	1,720	1,740	0.900	1,210	12	
			4/24/2002 9:02	9.26	3.97	3.0					60	1,620	1,680	0.460	640	9	
			5/15/2002 9:58	7.94	3.57	3.0					20	2,170	2,190	0.280	520	16	
			6/11/2002 9:22	8.15	4.69	5.0					100	2,330	2,430	0.340	580	11	
			7/24/2002 10:13	7.32	3.69												
			7/24/2002 10:14	7.27	3.58	3.0					400	1,990	2,390	0.610	790	3	
			8/7/2002 9:12	7.57	4.69	4.0					390	2,100	2,490	0.540	740	10	
			9/4/2002 9:10	8.33	3.33	1.0					20	1,270	1,290	0.020	190	14	
			10/2/2002 9:38	8.15	3.05												
			10/2/2002 9:40	8.16	2.87	2.0					30	1,090	1,120	0.070	190	11	
			10/30/2002 10:25	7.75	5.91	4.0					250	2,320	2,570	0.260	450	16	
			12/3/2002 9:21	8.08	9.34	5.0					610	1,860	2,470	0.270	450	15	
			1/14/2003 11:11	7.58	9.01						590	2,130	2,720	0.410	550	8	
			2/18/2003 10:58	7.74	7.85						130	2,080	2,210	0.360	600	14	
			3/25/2003 10:33	7.37	4.19						30	1,300	1,330	1.060	1,200	6	
			5/7/2003 11:05	7.63	5.01						20	1,300	1,320	0.680	840	9	
			6/17/2003 10:25	8.01	6.21						20	2,150	2,170	0.620	880	13	
			7/22/2003 10:58	7.60	5.51						20	1,650	1,670	0.360	530	8	

WaterBodyName	Innisbrook Canal																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
02-02	(blank)	PINELLAS	9/3/2003 10:32	7.55	4.74						520	1,990	2,510	0.550	760	9	
			10/15/2003 10:21	7.75	5.61						190	1,790	1,980	0.940	1,090	10	
			11/24/2003 9:36	8.03	8.95						180	1,750	1,930	0.610	810	9	
02-06	(blank)	PINELLAS	11/15/1999 8:47	7.85	5.49	3.0					240	970	1,210	0.250	380	10	
			11/15/1999 8:49	8.19	6.04												
02-07	(blank)	PINELLAS	11/15/1999 11:55	8.46	10.94	6.0					1,070	1,900	2,970	0.970	1,130	14	
			1/6/2004 9:11	8.00	7.15						120	1,520	1,640	0.680	850	21	
			2/11/2004 12:55	7.75	7.57						790	1,370	2,160	0.950	1,080	10	
			3/31/2004 12:49	8.15	7.46						20	1,120	1,140	0.660	790	20	
			5/4/2004 12:00	8.25	7.94						20	2,580	2,600	0.440	700	21	
			6/15/2004 12:21	8.09	6.65						20	2,140	2,160	0.420	680	17	
			7/22/2004 10:33	7.25	5.16						250	1,640	1,890	0.490	560	8	
			8/31/2004 14:17	7.37	4.93						2,300	1,600	3,900	0.860	950	5	
			10/12/2004 9:58	7.23	3.69						1,090	1,400	2,490	0.900	1,040	5	
			11/22/2004 10:46	8.29	9.15						20	1,530	1,550	0.370	540	8	
			1/4/2005 11:59	8.21	11.41						70	1,710	1,780	0.340	500	10	60
			2/22/2005 12:46	7.75	6.69	4.0					20	1,200	1,220	0.440	480	10	20
			4/25/2005 10:28	7.82	5.76						20	1,960	1,980	0.620	770	8	840
			5/2/2005 12:02	7.62	5.57	4.0					20	1,840	1,860	0.590	700	10	520
			6/20/2005 10:58	7.45	1.31						20	2,250	2,270	0.310	490	14	3,700
			7/27/2005 11:17	7.55	7.44	5.0					20	1,410	1,430	0.620	740	7	340
			9/1/2005 10:21	7.66	4.06						60	1,650	1,710	0.520	640	6	590
			10/12/2005 12:53	7.50	5.07	5.0					20	2,090	2,110	0.490	660	9	1,000
			12/1/2005 10:08	7.70	6.39						20	1,900	1,920	0.360	470	10	560
			1/4/2006 11:20	7.89	8.03						830	1,640	2,470	0.280	280	7	71
			3/6/2006 10:15	7.41	5.39	3.0					20	1,380	1,400	0.360	440	16	67
			5/4/2006 10:31	7.59	1.44	6.0					20	2,350	2,370	0.500	700	21	33
			6/20/2006 14:03	7.72	2.99						30	3,300	3,330	0.230	500	18	1,100
			10/19/2006 10:37	7.31	1.84	5.0					1,480	2,900	4,380	1.060	1,130	3	1,000
02-09	(blank)	PINELLAS	12/12/2006 10:36	7.94	4.50						530	1,610	2,140	1.030	1,050	1	110
			1/3/2007 10:10	7.48	3.91						430	1,340	1,770	1.290	1,390	3	310
			2/28/2007 12:57	7.43	3.87	4.0					150	3,070	3,220	0.600	730	7	190
			4/3/2007 10:51	8.19	5.37						20	2,400	2,420	0.600	750	25	100
			8/22/2007 12:06	7.43	0.29	4.0					160	2,000	2,160	0.860	870	4	25
			8/22/2007 12:07	7.22	0.18												
			10/1/2007 9:23	7.09	0.65						20	2,740	2,760	0.970	1,040	3	330
			10/23/2007 10:40	7.25	0.45												
			10/23/2007 10:41	7.21	0.90	4.0					80	2,310	2,390	0.970	1,060	4	1,400
			12/27/2007 11:44	7.31	2.35						80	1,350	1,430	1.400	1,510	1	14
			2/21/2008 10:37	7.26	1.46						140	2,360	2,500	1.010	1,170	4	
			3/26/2008 11:33	7.34	3.84	7.0					1,010	2,020	3,030	1.790	2,020	6	180

WaterBodyName	Innisbrook Canal																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
02-09	(blank)	PINELLAS	6/17/2008 10:58	8.02	3.09	9.0					20	2,640	2,660	0.810	1,170	21	270
			8/12/2008 13:29	7.41	2.97						400	2,380	2,780	1.360	1,530	7	
			9/16/2008 9:39	7.13	1.81	4.0					940	2,010	2,950	0.960	1,080	2	1,200
			11/5/2008 11:12	7.33	1.65												
			12/15/2008 11:03	7.61	4.28	6.0					30	2,430	2,460	0.860	1,050	6	600
			2/17/2009 10:34	7.64	3.16						50	2,950	3,000	0.940	1,200	32	210
02-01	INNISBROOK CNL	PINELLAS	1/17/1991 10:37	7.98	6.20												
			1/17/1991 10:38	8.00	6.19												
			1/17/1991 10:40	8.00	6.14												
			2/27/1991 9:50	7.82	4.91												40
			2/27/1991 9:55	7.76	5.20												
			3/26/1991 10:17	7.71	5.10												48
			3/26/1991 10:18	7.81	3.80												
			3/26/1991 10:19	7.83	3.98												
			4/24/1991 10:12	7.91	4.47												
			4/24/1991 10:13	7.90	4.34												
			4/24/1991 10:14	7.90	4.51						20			0.090		5	19
			5/22/1991 10:10	7.72	4.02												
			5/22/1991 10:11	7.71	3.81												
			5/22/1991 10:12	7.66	3.08						20			0.140		6	84
			6/19/1991 10:09	7.75	3.18												
			6/19/1991 10:10	7.72	3.25												
			6/19/1991 10:11	7.72	3.54						20			0.080		2	23
			7/17/1991 10:00	7.91	6.43	6.5					20			0.130		7	65
			7/17/1991 10:02	7.95	3.86												
			7/17/1991 10:03	7.92	4.73												
			8/14/1991 10:38	8.07	3.38												
			8/14/1991 10:40	8.02	3.54	5.0					20			0.300		6	28
			9/11/1991 9:36	8.20	4.17												
			9/11/1991 9:38	8.15	4.34												
			9/11/1991 9:40	8.11	4.50	3.8					20			0.220		5	270
			10/2/1991 9:43	8.35	5.12												
			10/2/1991 9:44	8.31	4.79												
			10/2/1991 9:45	8.23	4.43	2.2					20			0.190		4	350
			10/30/1991 11:27	8.10	6.47												
			10/30/1991 11:30	8.00	5.77	4.2					20			0.070		3	50
			12/4/1991 10:55	7.85	5.98	2.8					20			0.080		4	240
			1/15/1992 10:05	7.67	6.72	2.1					20			0.060		3	108
			1/15/1992 10:09	7.71	6.19												
			1/15/1992 10:11	7.71	6.14												
			2/12/1992 10:12	8.05	6.78												

WaterBodyName	Innisbrook Canal																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
02-01	INNISBROOK CNL	PINELLAS	2/12/1992 10:13	7.99	6.93	2.2					20	580	600	0.040	50	3	96
			2/12/1992 10:14	8.03	6.77												
			3/11/1992 10:10	7.81	4.74	3.7					20	470	490	0.050	140	4	40
			3/11/1992 10:12	7.80	5.11												
			3/11/1992 10:13	7.80	4.98												
			4/8/1992 9:55	7.91	3.46						20	590	610		80	2	330
			4/8/1992 9:56	7.97	3.34												
			4/8/1992 9:58	7.95	3.29												
			5/6/1992 9:50	7.98	3.11	2.3					20	460	480	0.060	150	2	8
			5/6/1992 9:51	7.92	1.26												
			5/6/1992 9:52	7.99	2.72												
			6/3/1992 10:27	8.11	2.79												
			6/3/1992 10:29	8.11	2.61												
			6/3/1992 10:30	8.11	2.55	2.7					20	560	580	0.040	50	2	76
			6/30/1992 9:45	7.84	5.11	3.6						1,270		0.040	310	3	160
			6/30/1992 9:47	7.82	3.99												
			6/30/1992 9:48	7.84	4.35												
			7/29/1992 10:10	8.23	4.08	3.3					20	720	740	0.040	130	5	8
			7/29/1992 10:11	8.21	2.42												
			7/29/1992 10:12	8.25	3.33												
			8/26/1992 10:15	8.58	4.46	3.3					20	760	780	0.040	80	5	4
			8/26/1992 10:16	8.45	2.06												
			8/26/1992 10:17	8.52	3.02												
			9/23/1992 11:00	8.43	5.55	2.4					20	760	780	0.110	200	5	52
			9/23/1992 11:02	8.47	4.58												
			9/23/1992 11:05	8.48	4.32												
			10/14/1992 10:48	8.12	7.00												
			10/14/1992 10:50	7.94	9.02	3.0					20	1,160	1,180	0.100	200	6	64
			10/14/1992 10:52	8.13	6.76												
			12/2/1992 10:15	8.07	7.86	1.5					20	570	590	0.080	50	2	150
			12/2/1992 10:17	8.23	9.11												
			12/2/1992 10:20	8.27	9.56												
			12/29/1992 9:50	7.53	4.76	1.6					20	700	720	0.140	210	4	160
			1/27/1993 10:15	7.89	5.11	1.0						670		0.090	190	3	190
			1/27/1993 10:18	7.96	5.89												
			2/3/1993 10:03	7.97	6.62												
			2/3/1993 10:04	7.94	6.33												
			2/3/1993 10:05	7.89	6.38	1.5					20	600	620	0.090	150	3	28
			3/24/1993 10:25	7.48	3.92	2.6					20	830	850	0.060	390	2	77
			3/24/1993 10:29	7.48	3.83												
			4/6/1993 10:05	7.55	5.36	2.0					20	700	720	0.060	120	4	50

WaterBodyName: Innisbrook Canal

Average of Result_Value

StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
02-01	INNISBROOK CNL	PINELLAS	5/19/1993 9:44	8.14	5.16												
			5/19/1993 9:45	8.16	5.04	3.2					20	950	970	0.040	120	3	8
			6/16/1993 9:50	8.27	3.50												
			6/16/1993 9:52	8.21	4.51	3.9					20	1,680	1,700	0.040	190	5	180
			7/14/1993 10:20	8.13	5.17	3.9					20	1,300	1,320	0.040	220	6	44
			7/14/1993 10:21	8.19	3.67												
			7/14/1993 10:24	8.21	4.58												
			8/4/1993 10:30	7.99	2.06	5.1					20	2,300	2,320	0.040	270	7	28
			8/4/1993 10:32	7.99	1.56												
			8/4/1993 10:33	8.00	1.88												
			9/8/1993 11:40	8.32	5.41	3.3					20	230	250	0.040	230	8	600
			9/8/1993 11:42	8.36	4.02												
			10/6/1993 9:40	8.01	3.62	2.5					20	1,200	1,220		210	7	40
			11/3/1993 10:33	7.95	8.83	2.5					110	1,100	1,210	0.200	250	6	64
			11/3/1993 10:35	8.05	9.68												
			11/17/1993 9:50	7.81	5.80	2.2					20	1,010	1,030	0.110	190	21	120
			11/17/1993 9:51	7.90	5.97												
			1/5/1994 10:55	8.04	7.89	2.8					1,010	1,510	2,520	0.040	170	13	600
			1/5/1994 10:57	8.00	7.47												
			2/2/1994 8:10	7.54	5.30	2.1					90	1,260	1,350	0.470	540	5	140
			2/2/1994 8:11	7.63	5.72												
			3/2/1994 11:37	7.92	6.83												
			3/2/1994 11:39	7.93	6.85												
			3/2/1994 11:40	7.93	6.96	1.9					20	920	940	0.040	80	5	52
			3/29/1994 9:48	7.90	5.11												
			3/29/1994 9:50	7.91	5.18	2.3					20	840	860	0.040	200	5	78
			4/27/1994 9:52	7.95	2.65	2.4					20	900	920	0.050	50	5	16
			5/18/1994 10:32	7.86	1.40												
			5/18/1994 10:35	7.85	2.53	2.8					20	1,190	1,210	0.190	420	5	40
			6/22/1994 10:05	8.22	2.95	2.7					20	1,290	1,310	0.040	80	5	6
			6/22/1994 10:06	8.22	2.64												
			7/20/1994 9:49	8.17	5.62	2.6					20	1,130	1,150	0.050	110	4	50
			7/20/1994 9:51	8.16	4.51												
			7/20/1994 9:54	8.18	5.11												
			8/17/1994 9:40	7.81	4.28	1.9					20	1,730	1,750	1.130	1,530	6	240
			8/17/1994 9:41	7.86	4.14												
			9/7/1994 10:05	7.79	3.26	1.8					20	1,300	1,320	0.070	190	4	40
			10/5/1994 9:57	7.83	5.07												
			10/5/1994 9:59	7.85	5.05	2.7					20	830	850	0.040	150	6	40
			11/8/1994 9:55	7.75	4.96	1.9					20	1,100	1,120	0.040	440	4	100
			11/8/1994 9:56	7.90	5.44												

WaterBodyName	Innisbrook Canal																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
02-01	INNISBROOK CNL	PINELLAS	12/21/1994 10:00	7.46	6.88	1.2					80	730	810	0.150	260	7	240
			1/25/1995 9:21	7.77	9.15	2.0					120	990	1,110	1.060	1,220	11	100
			1/25/1995 9:22	7.85	9.00												
			2/22/1995 9:57	7.71	6.91	1.9					180	1,330	1,510	1.500	1,700	4	170
			3/22/1995 9:34	7.58	4.17	1.7					20	780	800	0.140	210	2	32
			3/22/1995 9:37	7.52	3.70												
			3/22/1995 9:38	7.53	3.84												
			4/19/1995 9:35	7.69	2.87												
			4/19/1995 9:36	7.74	3.91	2.0					20	910	930	0.230	360	7	52
			5/17/1995 9:37	7.63	2.05	3.9					20	1,110	1,130	0.040	140	4	6
			5/17/1995 9:38	7.67	1.59												
			5/17/1995 9:39	7.70	1.28												
			6/14/1995 11:08	8.23	5.13	1.9					20	1,980	2,000	0.040	200	10	66
			6/14/1995 11:10	8.23	4.63												
			6/14/1995 11:11	8.20	3.90												
			7/12/1995 9:39	8.21	2.44	3.5					20	1,590	1,610	0.040	150	7	40
			7/12/1995 9:40	8.25	1.83												
			7/12/1995 9:41	8.25	1.80												
			8/16/1995 9:52	7.85	3.73	2.1					20	1,370	1,390	0.160	280	8	240
			8/16/1995 9:53	8.01	2.69												
			8/16/1995 9:54	8.03	3.15												
			9/13/1995 9:28	8.15	4.52												
			9/13/1995 9:29	8.02	5.37	2.1					20	1,560	1,580	0.280	420	8	140
			10/4/1995 9:56	7.98	4.34	1.6					20	1,470	1,490	0.060	180	3	360
			10/4/1995 9:57	8.11	3.70												
			10/4/1995 9:58	8.09	3.75												
			11/1/1995 10:17	7.69	5.92	1.4					130	1,300	1,430	0.270	320	4	240
			11/1/1995 10:19	7.81	6.06												
			11/1/1995 10:21	7.81	5.94												
			12/6/1995 10:27	7.48	5.28	3.4					20	810	830	0.040	50	5	40
			12/6/1995 10:28	7.49	5.01												
			12/13/1995 10:43	7.65	7.28	1.7					20	870	890	0.040	100	5	160
			1/24/1996 10:21	7.72	8.42	2.3					20	870	890	0.040	90	6	96
			1/24/1996 10:22	7.74	8.49												
			2/21/1996 10:00	8.00	6.65	2.0					20			0.040		9	36
			3/27/1996 9:40	7.82	5.56	2.7					170	900	1,070	0.080	100		130
			3/27/1996 9:41	7.87	5.02												
			4/16/1996 9:38	7.77	3.73	2.6					20	1,110	1,130	0.100	170		84
			4/16/1996 9:40	7.80	3.72												
			5/15/1996 10:08	8.18	3.22	4.9					20	640	660	0.040	40		36
			5/15/1996 10:09	8.19	2.95												

WaterBodyName	Innisbrook Canal																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
02-01	INNISBROOK CNL	PINELLAS	5/15/1996 10:10	8.19	3.02												
			6/11/1996 10:28	7.99	3.87	3.0					20	810	830	0.100	140		7
			6/11/1996 10:30	8.02	3.51												
			6/11/1996 10:31	8.03	3.36												
			7/17/1996 9:56	8.06	2.44	5.2					40	1,020	1,060	0.050	120		22
			7/17/1996 9:57	7.99	1.36												
			8/7/1996 9:41	8.11	4.11	2.9					130	1,310	1,440	0.390	370		50
			8/7/1996 9:43	8.27	2.48												
			9/4/1996 9:55	8.17	4.04	2.6					20	670	690	0.040	70		36
			9/4/1996 9:56	8.25	3.99												
			10/2/1996 9:57	7.99	3.93	3.0					20	1,260	1,280	0.230	320		98
			10/30/1996 11:26	8.13	6.94	2.1					20	490	510	0.050	50		15
			10/30/1996 11:28	8.17	6.91												
			12/4/1996 9:31	7.89	4.87	2.0					20	590	610	0.190	90		66
			12/4/1996 9:32	8.01	5.66												
			12/17/1996 9:42	8.02	8.08	1.0					20	630	650	0.160	20		54
			12/17/1996 9:43	8.06	8.34												
			1/29/1997 10:11	7.85	7.59	2.0					20	810	830	0.020	180		
			2/19/1997 10:21	7.25	7.03												
			2/19/1997 10:22	7.48	4.92	3.0					20	650	670	0.070	80		
			3/26/1997 9:48	7.95	5.28	3.0					20	810	830	0.060	60		
			3/26/1997 9:50	7.96	4.97												
			4/16/1997 9:52	7.48	4.69	2.0					20	740	760	0.240	270		
			4/16/1997 9:53	7.52	4.58												
			5/21/1997 9:47	8.02	3.08												
			5/21/1997 9:48	8.07	3.86												
			5/21/1997 9:49	8.10	4.25	3.0					20	830	850	0.100	30		
			6/9/1997 10:28	7.83	2.16	3.0					20	770	790	0.100	40		
			6/9/1997 10:29	7.86	2.13												
			7/16/1997 10:58	7.75	5.20	1.0					20	1,090	1,110	0.190	220		
			7/16/1997 10:59	7.95	5.04												
			7/16/1997 11:00	7.99	4.69												
			8/13/1997 10:02	8.31	4.30												
			8/13/1997 10:03	8.26	4.36												
			8/13/1997 10:04	8.04	4.34	2.0					20	1,100	1,120	0.110	250		
			9/3/1997 10:05	7.89	2.94	3.0					20	830	850	0.020	70		
			9/3/1997 10:06	7.96	2.91												
			9/24/1997 9:41	8.23	4.65												
			9/24/1997 9:42	8.28	4.91	3.0					20	1,110	1,130	0.020	50		
			10/22/1997 11:00	7.98	7.43	2.0					20	550	570	0.020	60		
			10/22/1997 11:02	8.19	7.99												

WaterBodyName	Innisbrook Canal																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
02-01	INNISBROOK CNL	PINELLAS	11/19/1997 9:13	7.86	7.38	1.0					300	880	1,180	0.330	440		
			1/7/1998 9:56	7.86	6.80	2.0					180	700	880	0.140	240		
			1/7/1998 9:57	7.92	5.75												
			2/4/1998 9:15	7.70	8.79												
			2/4/1998 9:16	7.70	6.87												
			2/4/1998 9:17	7.71	6.86	1.0					110	760	870	0.070	160		
			3/4/1998 9:58	7.91	8.48	5.0					120	730	850	0.490	620	12	
			3/30/1998 10:05	7.82	5.40												
			3/30/1998 10:07	7.92	5.75	1.0					20	800	820	0.120	220	10	
			4/29/1998 9:34	8.41	3.57												
			4/29/1998 9:35	8.37	3.47	2.0					20	1,400	1,420	0.030	70	11	
			5/27/1998 9:08	7.87	0.99	4.0					20	960	980	0.040	120	14	
			5/27/1998 9:09	7.91	0.73												
			6/24/1998 9:36	8.07	1.42	4.0					40	1,200	1,240	0.020	50	17	
			6/24/1998 9:37	8.08	1.37												
			6/24/1998 9:38	8.09	1.28												
			7/22/1998 9:17	8.14	1.65												
			7/22/1998 9:18	8.19	1.74												
			7/22/1998 9:19	8.22	2.03	7.0					20	1,790	1,810	0.040	140	13	
			8/19/1998 10:45	8.52	2.65												
			8/19/1998 10:48	8.50	2.83												
			8/19/1998 10:50	8.46	3.48	5.0					60	1,010	1,070	0.070	230	10	
			9/16/1998 9:31	8.17	5.20	3.0					20	720	740	0.040	110	16	
			9/16/1998 9:32	8.26	4.49												
			9/16/1998 9:33	8.28	4.95												
			10/14/1998 9:58	8.08	5.23												
			10/14/1998 9:59	8.11	5.40												
			10/14/1998 10:00	8.10	5.94	1.0					40	700	740	0.330	410	29	
			11/9/1998 9:51	7.89	7.01	3.0					30	1,030	1,060	0.080	190	14	
			12/2/1998 9:40	8.05	4.38												
			12/2/1998 9:42	8.05	4.23	2.0					20	590	610	0.020	20	19	
			1/27/1999 10:45	7.90	6.03												
			1/27/1999 10:47	7.80	5.92	2.0					50	680	730	0.940	1,040	7	
			2/24/1999 9:38	7.77	8.07	1.0					20	490	510	0.550	680	8	
			2/24/1999 9:41	7.86	8.49												
			3/24/1999 10:15	7.83	4.14	2.0					20	570	590	0.350	370	6	
			4/21/1999 9:40	7.94	5.78	3.0					20	600	620	0.150	240	11	
			4/21/1999 9:41	7.98	4.34												
			5/20/1999 10:01	7.77	1.94												
			5/20/1999 10:02	7.80	2.85	4.0					20	760	780	0.020	90	16	
			6/16/1999 10:16	7.96	2.20	4.0					20	690	710	0.020	100	16	

WaterBodyName	Innisbrook Canal																	
Average of Result_Value				Parameter														
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
02-01	INNISBROOK CNL	PINELLAS	6/16/1999 10:17	7.97	1.95												
			6/16/1999 10:18	7.97	1.97												
			7/13/1999 11:06	8.25	5.05	3.0					20	830	850	0.030	20	10	
			7/13/1999 11:08	8.28	4.86												
			7/13/1999 11:09	8.29	4.92												
			8/11/1999 9:43	8.18	2.87												
			8/11/1999 9:44	8.19	2.93												
			8/11/1999 9:46	8.20	2.92	4.0					20	1,090	1,110	0.020	130	15	
			9/1/1999 10:30	8.11	4.90												
			9/1/1999 10:32	8.15	4.73	5.0					20	830	850	0.060	150	15	
			10/6/1999 9:14	7.60	3.68	5.0					190	1,520	1,710	0.380	570	8	
			10/6/1999 9:15	7.90	2.41												
			10/6/1999 9:16	7.91	2.41												
			11/3/1999 10:23	8.30	6.87	3.0					20	750	770	0.230	250	8	
			11/3/1999 10:24	8.39	6.49												
			11/15/1999 10:45	8.29	7.17	2.0					30	530	560	0.030	100	6	
			12/1/1999 9:34	8.45	6.51												
			12/1/1999 9:35	8.36	6.46	2.0					100	900	1,000	0.070	710	9	
			1/26/2000 11:23	7.88	9.03	2.0					40	780	820	0.250	340	8	
			2/23/2000 10:21	8.12	5.43												
			2/23/2000 10:23	8.11	5.62	2.0					20	470	490	0.090	80	9	
			3/22/2000 10:53	8.12	6.22												
			3/22/2000 10:54	8.12	6.43												
			3/22/2000 10:55	8.13	6.51	2.0					20	640	660	0.030	60	43	
			4/18/2000 13:04	8.03	5.99												
			4/18/2000 13:05	8.01	5.61												
			4/18/2000 13:07	7.99	5.61	5.0					20	720	740	0.020	90	11	
			5/17/2000 10:20	8.40	2.95												
			5/17/2000 10:21	8.39	3.00												
			5/17/2000 10:22	8.39	3.08	3.0					20	720	740	0.020	30	31	
			6/14/2000 9:54	8.18	3.04												
			6/14/2000 9:55	8.23	3.27												
			6/14/2000 9:56	8.24	3.60	4.0					20	1,010	1,030	0.020	50	18	
			7/12/2000 10:11	8.42	6.36	3.0					10	1,400	1,410	0.080	16,000		
			7/12/2000 10:12	8.42	2.87												
			7/12/2000 10:13	8.46	4.84												
			8/9/2000 10:37	8.32	4.35												
			8/9/2000 10:38	8.23	5.20	2.8					5	740	745	0.020	280	43	
			9/6/2000 10:04	8.07	2.57												
			9/6/2000 10:05	8.03	2.53												
			9/6/2000 10:06	7.94	2.64						9	1,135	1,144	0.219	294	6	

WaterBodyName	Innisbrook Canal																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
02-01	INNISBROOK CNL	PINELLAS	10/4/2000 11:17	8.20	6.33												
			10/4/2000 11:18	8.00	4.95	2.0					20	1,070	1,090	0.100	190	10	
			11/1/2000 10:10	7.86	5.92	3.0					90	1,130	1,220	0.140	260	6	
			11/1/2000 10:11	7.99	6.21												
			11/27/2000 10:02	7.99	5.77												
			11/27/2000 10:03	8.01	4.88	2.0					40	850	890	0.030	70	22	
			1/24/2001 10:25	7.84	8.09												
			1/24/2001 10:26	7.84	8.16	3.0					20	820	840	0.070	140	23	
			2/21/2001 9:18	7.97	6.77												
			2/21/2001 9:19	8.00	6.06	1.0					20	630	650	0.030	130	21	
			3/21/2001 9:59	7.74	7.44												
			3/21/2001 10:00	7.76	7.13												
			3/21/2001 10:01	7.76	7.08	2.0					20	670	690	0.050	70	12	
			4/19/2001 9:14	8.04	6.92												
			4/19/2001 9:17	7.92	6.03	1.0					20	820	840	0.050	110	15	
			5/16/2001 10:10	7.73	3.51												
			5/16/2001 10:11	7.72	3.04												
			5/16/2001 10:12	7.73	2.82	5.0					20	1,090	1,110	0.020	110	14	
			6/13/2001 9:14	7.93	2.84												
			6/13/2001 9:15	8.03	3.04												
			6/13/2001 9:16	8.07	3.60	3.0					20	1,080	1,100	0.020	130	12	
			7/12/2001 10:02	7.58	5.32	4.0					80	1,520	1,600	0.800	970	5	
			7/12/2001 10:03	7.55	3.27												
			7/12/2001 10:04	7.63	1.90												
			8/8/2001 10:16	8.05	3.61												
			8/8/2001 10:17	8.01	4.38	2.0					40	1,270	1,310	0.430	550	6	
			9/5/2001 10:25	8.19	3.01	6.0					60	1,480	1,540	0.020	190	12	
			9/5/2001 10:29	8.18	2.13												
			10/3/2001 9:56	8.51	6.46												
			10/3/2001 9:57	8.48	6.33	3.0					40	870	910	0.030	80	14	
			10/31/2001 10:53	8.28	6.91						20	800	820	0.020	50	4	
			10/31/2001 10:54	8.30	6.69												
			10/31/2001 10:55	8.35	6.91												
			11/28/2001 9:49	7.84	3.38	2.0					20	720	740	0.020	40	8	
			11/28/2001 9:50	7.89	3.12												
			11/28/2001 9:51	7.90	3.06												
			1/23/2002 9:40	7.64	4.94												
			1/23/2002 9:41	7.60	5.97	1.0					40	790	830	0.470	540	6	
			2/20/2002 9:45	7.86	7.21												
			2/20/2002 9:47	7.75	6.88	1.0					20	720	740	0.200	240	6	
			3/20/2002 10:10	7.80	1.88												

WaterBodyName	Innisbrook Canal																	
Average of Result_Value				Parameter														
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
02-01	INNISBROOK CNL	PINELLAS	3/20/2002 10:11	7.81	3.09						20	720	740	0.120	170	6	
			4/24/2002 9:15	8.81	2.75												
			4/24/2002 9:16	8.86	2.63	3.0					20	760	780	0.020	50	13	
			5/15/2002 10:15	8.04	3.25	3.0					20	960	980	0.020	70	15	
			5/15/2002 10:16	8.07	3.00												
			6/11/2002 9:37	8.07	3.00												
			6/11/2002 9:38	8.07	3.07	4.0					20	1,050	1,070	0.020	40	15	
			7/24/2002 10:27	8.10	3.67												
			7/24/2002 10:28	8.09	2.68												
			7/24/2002 10:29	8.04	3.20	3.0					180	1,350	1,530	0.240	350	2	
			8/7/2002 9:29	8.50	3.00												
			8/7/2002 9:30	8.48	3.28												
			8/7/2002 9:31	8.39	4.14	3.0					80	1,220	1,300	0.130	230	14	
			9/4/2002 9:27	8.66	3.91												
			9/4/2002 9:28	8.68	4.19												
			9/4/2002 9:29	8.62	5.42	2.0					20	1,150	1,170	0.020	180	10	
			10/2/2002 10:01	8.47	3.74												
			10/2/2002 10:02	8.49	4.44												
			10/2/2002 10:03	8.44	5.21	3.0					40	890	930	0.070	180	6	
			10/30/2002 10:41	8.33	4.40												
			10/30/2002 10:42	8.33	4.41	2.0					20	990	1,010	0.030	60	12	
			12/3/2002 9:33	8.15	8.09	2.0					30	850	880	0.040	70	13	
02-05	(blank)	PINELLAS	11/15/1999 10:14	8.19	7.56												
			11/15/1999 10:15	8.19	7.36	3.0					20	760	780	0.020	140	8	

2. Joe's Creek

WaterBodyName	Saint Joes Creek																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
2308929	SAINT JOES CREEK AT ST.PETERSBURG FL	USGS_NWIS	8/29/75 0:00	7.30		6.3	46	722	85	1,129	2,600	774	3,700	0.112	243		
			3/23/77 0:00			1.0		110		0		430	430		87		
			2/13/80 0:00			2.2		190		630	660	735	4,050		96		
			3/14/80 0:00			8.6		120		310	360	1,250	4,550		142		
			3/21/80 0:00			9.4		197		1,046	1,132	2,045	8,509		472		9,250
2308931	SAINT JOE CREEK AT LEALMAN FL	USGS_NWIS	8/18/86 0:00	7.10	3.70	2.0		140		90	130	750	2,575		341		
			12/17/86 0:00	7.00	4.40	2.0		270		380	420	695	3,350		224		
			9/25/89 0:00			3.5		145		183	193	731	2,695		113		
			9/26/89 0:00			7.7		137		180	190	660	2,360		94		
			9/27/89 0:00			2.6		150		170	180	785	2,800		86		
			11/29/89 0:00			1.9		160		65	75	860	2,748		108		
			2/23/90 0:00			2.8		30		85	95	633	2,021		210		
			2/24/90 0:00			1.9		90		110	120	655	2,210		152		
			2/27/90 0:00					110		130	140	785	2,640		86		
			6/26/90 0:00	7.90	1.60	3.2		70		20	30	1,350	3,850		147		
			9/26/90 0:00	7.20	1.90	1.5		20			20	660	690		76		
			10/11/90 0:00	7.15		3.9		30		40	37	735	2,142		223		
			10/12/90 0:00	7.10		1.7		100		40	50	600	1,900		168		
			11/28/90 0:00		5.30	1.9		25			75	608	1,497		55		
			12/12/90 0:00	6.90													
			3/6/91 0:00	7.10	5.70	1.5		20		30	40	680	1,965		81		
			4/25/91 0:00	7.00		6.5		117		170	180	1,636	5,525		234		
			4/26/91 0:00	7.20		5.1		30		70	80	1,100	3,200		152		
			5/8/91 0:00	7.30		1.4		20			30	620	1,780		56		
			7/29/91 0:00	7.00	4.10	2.5						920			40		
			8/20/91 0:00	6.95		4.1		210		55	65	852	2,763		108		
			8/21/91 0:00	7.00		3.3		350		50	60	925	3,150		137		
			8/22/91 0:00	7.10		1.5		290		50	60	755	2,580		117		
2308935	SAINT JOE CREEK AT PINELLAS PARK FL	USGS_NWIS	11/19/84 0:00		5.10	2.2		470		20	30	965	3,300		198		
			1/16/85 0:00		8.70	1.6		80			50	1,250	3,700		96		
			4/23/85 0:00		8.70	4.0		30			20	865	2,450		71		
			6/9/85 0:00					500		415	430	2,825	9,425		1,356		
			6/15/85 0:00					82		167	175	945	3,385		243		
			6/18/85 0:00					270		140	160	845	3,050		182		
			7/18/85 0:00		5.40	2.4		80			50	940	2,800		102		
			10/31/85 0:00					195		105	125	1,318	4,342		323		
			11/1/85 0:00			4.3		140		150	170	560	2,150		244		
			11/12/85 0:00		4.70	1.0		460		100	110	770	3,000		198		
			4/9/86 0:00	7.20	6.50	2.1		20			10	1,100	1,110		81		
			8/18/86 0:00		5.50	1.2		150		110	130	585	2,145		244		
			12/17/86 0:00	7.00	3.70	2.1		220		360	400	630	3,050		203		

WaterBodyName	Saint Joes Creek																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
2308935	SAINT JOE CREEK AT PINELLAS PARK FL	USGS_NWIS	3/9/87 0:00	7.40	8.00	2.2		130		360	380	535	2,640		152		
			3/30/87 0:00			2.8		90		230	265	1,750	5,600		575		
			4/2/87 0:00			0.8		250		430	450	725	3,550		173		
			6/11/87 0:00	7.00	4.80	1.7		80		60	70	580	1,895		56		
			7/20/87 0:00	7.50				40		90	100	850	2,760		205		
			7/21/87 0:00	7.40				40		120	130	770	2,510		132		
			7/22/87 0:00	7.50		0.9		130		200	220	485	2,085		71		
			8/12/87 0:00			1.9		114		116	147	1,304	4,213		290		
			8/13/87 0:00			2.0		150		170	190	655	2,510		86		
			8/14/87 0:00			1.7		190		190	210	785	2,950		81		
			9/1/87 0:00			3.3		10			30	1,200	3,300		56		
			9/2/87 0:00			4.2		145		83	100	1,078	3,634		177		
			9/3/87 0:00			3.2		110		80	100	815	2,635		91		
			9/4/87 0:00		2.60	1.8		200		130	150	720	2,635		81		
			9/10/87 0:00	7.50				160		290	350	920	3,700		182		
			9/12/87 0:00	7.60		2.3		40		110	120	680	2,210		167		
			9/14/87 0:00	7.30		2.1		40		140	150	710	2,390		112		
			1/5/88 0:00	7.10	7.70	2.2		150		110	120	755	2,575		51		
			1/25/88 0:00			3.9		140		130	140	670	2,390		198		
			1/26/88 0:00			2.3		120		150	160	820	2,800		76		
			4/28/88 0:00	7.20	5.00	2.8		30		10	20	565	1,650		81		
			8/3/88 0:00	7.50	4.20	3.1		220		100	150	1,300	4,200		290		
			8/13/88 0:00	7.50				100		140	190	1,350	4,300		380		
			8/16/88 0:00	7.30		2.6		100		90	160	1,750	5,350		452		
			8/17/88 0:00	7.60	4.80	2.0		140		150	200	690	2,580		203		
			11/14/88 0:00	7.20	4.20	2.8		170		510	570	815	4,000		300		
			11/22/88 0:00					275		157	210	2,000	6,283		440		
			11/23/88 0:00					90		143	207	1,350	4,425		551		
			11/25/88 0:00					200		270	420	2,000	6,850		711		
			3/9/89 0:00	7.30	9.40	2.4		20		130	140	580	1,965		76		
			6/26/89 0:00	7.20	5.70	1.4		70		110	130	1,150	3,600		102		
			7/23/89 0:00	7.60		1.2		10		40	80	1,600	4,550		385		
			7/24/89 0:00	7.50		2.8		35		36	80	1,156	3,778		307		
			7/25/89 0:00	7.50		3.8		10		50	70	775	2,325		152		
			9/25/89 0:00			2.3		103		241	251	957	3,449		113		
			9/26/89 0:00			1.2		100		710	720	770	4,175		98		
			9/27/89 0:00			2.5		30		110	120	725	2,330		81		
			11/29/89 0:00			3.1		20			20	690	800		82		
			2/23/90 0:00			3.2		48		50	70	754	2,281		155		
			2/24/90 0:00			3.7		20		60	70	510	1,595		147		
			2/27/90 0:00					60			30	590	1,775		61		

WaterBodyName	Saint Joes Creek																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
2308935	SAINT JOE CREEK AT PINELLAS PARK FL	USGS_NWIS	6/26/90 0:00	7.90	3.40	2.3		20			20	920	950		36		
			9/26/90 0:00	7.40	1.10	1.5		90			20	615	680		147		
			10/11/90 0:00	7.20		3.8		25			25	685	1,960		53		
			10/12/90 0:00	7.40		1.2		20			50	420	1,290		76		
			11/28/90 0:00	7.50	8.00	0.7		10			40	700	2,020		30		
			12/12/90 0:00	7.70													
			3/6/91 0:00	7.70	11.90	0.4		10			20	445	470		21		
			4/25/91 0:00	7.17		2.2		15			20	1,065	1,720		84		
			4/26/91 0:00	7.40		3.1		10			20	1,300	1,320		110		
			5/8/91 0:00	7.30		0.9		10			30	585	1,660		36		
			7/29/91 0:00	7.20	3.40	1.2		20			20	540	570		46		
			8/20/91 0:00	7.30		2.2		20			20	645	700		61		
			8/21/91 0:00	7.25		2.0		115			20	593	700		63		
			8/22/91 0:00	7.20		2.1		150			20	685	780		76		
			9/20/00 0:00	8.40	6.40	3.4		30			70	845	2,515		85		
			10/25/00 0:00	7.50	5.00	2.6		60			20	1,450	1,520		72		
			1/9/01 0:00	7.00	8.10	3.0		250			140	805	2,900		66		
			2/26/01 0:00	6.30	5.50	1.2		90			30	615	1,895		86		
			3/6/01 0:00	6.50	3.50	2.2		200			130	1,100	3,600		168		
			4/10/01 0:00	6.30	3.90	2.4		70			60	915	2,750		167		
			6/26/01 0:00	6.20	1.90	2.5		150			20	915	1,010		198		
			7/31/01 0:00	6.40	3.20	2.6		100			190	860	3,000		76		
			8/14/01 0:00	6.40	4.30	2.6		110			40	825	2,510		46		
			8/22/01 0:00	6.90	2.00	2.0		150			40	665	2,140		71		
			9/4/01 0:00	6.40	4.00	4.1		170			200	1,200	4,050		140		
			9/26/01 0:00	6.70	2.80	1.7		220			110	790	2,750		59		
			10/30/01 0:00	7.20	6.40	1.2		40			200	780	2,700		9		
			11/19/01 0:00	7.50	3.80	1.8		160			210	720	2,750		58		
			12/11/01 0:00	6.20	3.00	1.2		100			180	650	2,390		62		
			1/30/02 0:00	6.60	4.00	0.7		30			20	585	620		68		
			4/3/02 0:00	6.10	4.10	0.9		20			20	590	620		92		
			4/29/02 0:00	6.20	3.10	2.7		60			20	1,050	1,120		140		
			6/25/02 0:00	6.20	4.70	4.0		50			20	875	920		103		
			7/31/02 0:00	6.30	5.60	4.3		20			20	1,100	1,120		99		
			8/12/02 0:00	6.20	4.80	1.8		80			20	960	1,020		57		
			8/28/02 0:00	6.20	4.30	2.7		110			80	845	2,640		101		
			9/11/02 0:00	6.20	5.60	1.8		100			180	850	2,950		72		
			9/23/02 0:00	6.30	3.80	3.2		140			80	1,350	4,050		53		
			10/28/02 0:00	6.40	4.90	2.6		60			20	970	1,020		55		
			11/25/02 0:00	6.30		2.1		90			110	955	3,000		48		
			12/10/02 0:00	6.40	8.00	1.5		90			180	555	2,140		122		

WaterBodyName	Saint Joes Creek																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
2308935	SAINT JOE CREEK AT PINELLAS PARK FL	USGS_NWIS	1/28/03 0:00	6.20	8.90	2.8		70			180	1,050	3,500		25		
			2/25/03 0:00	6.20	7.30	2.5		50			20	875	920		52		
			4/29/03 0:00	7.40	6.80	3.3		30			20	785	820		38		
24040409	5 KM JOE CREEK OFF CROSS BAYOU	LEGACYSTORET_21FLA	4/30/75 0:00		0.80	12.0			8			7,810		5.560		10	
			5/28/75 0:00	7.40	1.50	9.2			15	70	85	5,920	6,005	2.650		13	3,400
			7/30/75 0:00	7.60	2.30	7.2			107	90	197	5,700	5,897	4.840		6	1,000
			8/27/75 0:00	7.90	2.20	5.5			46	470	516	5,700	6,216	1.900	2,200	7	100
24040424	JOES CREEK AT 54TH AVE	LEGACYSTORET_21FLA	10/2/73 0:00			5.0				290				0.170		14	
			10/3/73 0:00			2.0				340				0.160		16	
			10/4/73 0:00			2.0				250				1.900		14	
27483438243412	TP343-St Joe Creek	STORET_21FLTPA	3/29/04 0:00	7.55	8.23			34			45	510	555	0.010	69	4	180
			6/14/04 0:00	7.73	9.48			10			80	950	1,030	0.010	100	7	85
			9/20/04 0:00	7.07	5.52			73			170	520	690	0.024	79	4	40
			11/15/04 0:00	6.97	6.13												
			12/13/04 0:00	7.34	12.31			38			200	450	650	0.006	70	4	40
			1/18/05 0:00	7.41	11.12												25
			1/21/09 0:00	6.95	6.18	2.2		37			140	710	850	0.008	37		
27483668242429	TP342-St Joe Creek	STORET_21FLTPA	3/29/04 0:00	7.50	5.33			67			78	610	688	0.024	83	4	180
			6/14/04 0:00	7.72	8.38			10			80	1,000	1,080	0.010	120	8	115
			9/20/04 0:00	7.26	5.57			55			240	540	780	0.030	67	4	55
			11/15/04 0:00	7.26	6.35												300
			12/13/04 0:00	7.50	10.76			60			250	530	780	0.013	79	4	50
			1/21/09 0:00	7.32	8.44	1.1		33			46	630	676	0.020	42		
27484788240469	TP339-St Joe Creek	STORET_21FLTPA	3/29/04 0:00	7.63	8.11			60			65	560	625	0.019	67	4	210
			6/14/04 0:00	7.93	8.92			10			20	1,400	1,420	0.020	180	19	40
			9/20/04 0:00	7.11	4.19			240			200	820	1,020	0.022	80	4	40
			9/22/04 0:00	7.16	5.32												114
			11/15/04 0:00	7.17	6.69												416
			12/13/04 0:00	7.11	12.27			260			92	1,000	1,092	0.012	100	4	25
27485048241453	TP341-St Joe Creek	STORET_21FLTPA	3/29/04 0:00	7.97	9.13			10			7	910	917	0.007	110	12	30
			6/14/04 0:00	7.82	8.78			10			40	1,200	1,240	0.020	160	12	35
			9/20/04 0:00	7.26	5.07			120			46	860	906	0.010	78	7	1
			11/15/04 0:00	7.14	5.56												336
			12/13/04 0:00	7.35	10.84			140			98	820	918	0.019	95	4	15
			1/21/09 0:00	7.94	11.76	1.4		15			18	640	658	0.007	32		
27485898241143	TP340-St Joe Creek	STORET_21FLTPA	3/29/04 0:00	7.33	9.65			45			86	470	556	0.013	48	4	50
			6/14/04 0:00					10			60	1,400	1,460	0.030	180	17	
			9/20/04 0:00	6.93	4.40			88			180	570	750	0.036	38	4	20
			11/15/04 0:00	6.73	4.07												944
			12/13/04 0:00	7.24	6.86			69			470	580	1,050	0.022	95	4	80
			1/21/09 0:00	6.98	6.55	2.0		96			170	830	1,000	0.007	49	4	

WaterBodyName	Saint Joes Creek																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
27491948244327	TP336-St. Joe Creek	STORET_21FLTPA	3/29/04 0:00	7.45	9.20			36			170	1,700	1,870	0.180	350	7	180
			6/14/04 0:00	7.48	4.80			50			150	970	1,120	0.090	210	10	60
			6/22/04 0:00	7.48	6.90			20			30	980	1,010	0.140	260	4	40
			7/6/04 0:00	7.29	2.79												
			8/9/04 0:00	7.30	5.75			140			200	900	1,100	0.070	140	8	115
			9/20/04 0:00	7.51	7.68			55			160	850	1,010	0.043	120	6	90
			10/25/04 0:00	7.35	5.94			110			170	1,000	1,170	0.070	150	6	40
			11/15/04 0:00	7.26	5.95												800
			12/6/04 0:00	7.64	8.55			110			160	1,200	1,360	0.089	170	14	60
			1/18/05 0:00	7.61	10.06												105
27494288244346	TP337-St. Joe Creek	STORET_21FLTPA	3/29/04 0:00	7.85	10.04			26			440	2,000	2,440	0.280	490	16	60
			6/14/04 0:00	7.30	1.61			130			1,200	1,300	2,500	0.340	460	6	70
			6/22/04 0:00	7.36	4.66			20			850	1,100	1,950	0.260	350	5	35
			7/6/04 0:00	7.27	2.40												
			8/9/04 0:00	7.24	5.03			150			470	1,000	1,470	0.110	170	6	110
			9/20/04 0:00	7.47	6.85			50			650	1,000	1,650	0.430	470	4	50
			10/25/04 0:00	7.29	2.37			120			450	1,100	1,550	0.290	360	14	15
			11/15/04 0:00	7.25	7.07												252
			12/6/04 0:00	7.54	8.61			89			1,300	1,400	2,700	0.480	530	4	135
			1/18/05 0:00	7.63	10.15												30
27500218244488	TP338-St. Joe Creek	STORET_21FLTPA	3/29/04 0:00	7.58	6.56			18			100	1,200	1,300	0.220	300	7	20
			6/14/04 0:00	7.31	1.80			190			550	1,200	1,750	0.250	320	11	20
			6/22/04 0:00	7.42	5.30			80			10	1,200	1,210	0.300	410	5	75
			7/6/04 0:00	7.28	2.99												
			8/9/04 0:00	7.23	6.08			130			1,100	1,300	2,400	0.130	190	7	210
			9/20/04 0:00	7.47	6.71			74			400	1,100	1,500	0.370	460	6	55
			10/25/04 0:00	7.38	3.96			110			420	1,000	1,420	0.270	320	9	40
			11/15/04 0:00	7.31	6.66												1,860
			12/6/04 0:00	7.55	8.63			140			360	1,400	1,760	0.340	500	6	195
			1/18/05 0:00	7.65	9.63												90
274914082443100	JOES CREEK AT 54TH AVE N AT ST PETE FL	USGS_NWIS	10/19/73 0:00					170		150	200	815	3,000		330		
274932082443700	10J JOES CREEK AT SCB POL PLANT AT ST PETE FL	USGS_NWIS	2/5/74 0:00		5.60	6.4		950		20		1,200	2,200		579		
			10/30/74 0:00				20										
			11/3/74 0:00				30										
35-01	JOES CREEK	PINELLAS	1/16/91 11:41	7.60	2.76												
			2/20/91 11:00	7.50	3.85												890
			3/13/91 10:20	7.36	4.82												240
			4/17/91 12:20	7.39	1.99									0.050			600
			5/8/91 10:54	7.54	1.61						110			0.040		7	600
			6/5/91 10:38	7.06	0.34												
			6/5/91 10:40	7.01	0.52						50			0.330		6	750

WaterBodyName	Saint Joes Creek																
Average of Result_Value			Parameter														
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-01	JOES CREEK	PINELLAS	7/2/91 9:20	7.13	1.50	2.0					20			0.150		4	1,200
			8/7/91 12:00	7.15	1.60	2.9					170			0.080		2	1,600
			8/28/91 10:20	7.28	1.71	1.0					20			0.040		5	1,000
			9/25/91 11:03	7.31	2.57	1.9					20			0.050		53	940
			10/16/91 10:10	7.25	3.01	1.9					50			0.040		5	2,300
			11/20/91 11:40	7.36	9.19	1.8					110			0.040		15	350
			12/18/91 10:34	7.18	9.73	1.0					20			0.040		24	100
			2/5/92 12:30	7.79	5.37	3.4					290	640	930	0.070	110	6	4,000
			2/26/92 11:55	7.28	3.87	2.0						490			90	1	1,000
			4/1/92 12:25	7.37	5.12	1.3						1,310		0.040	220	78	2,600
			4/22/92 10:39	7.29	5.17	1.0					30	790	820	0.040	110	22	2,800
			5/27/92 11:55	7.47	7.09	3.1					20	1,130	1,150	0.080	150	34	300
			6/17/92 10:50	7.23	2.67	3.4						1,470		0.040	200	68	1,100
			7/22/92 10:50	7.32	2.94	1.6					20	660	680	0.110	200	3	4,900
			8/12/92 9:43	7.32	2.50	1.2					30	1,060	1,090	0.040	180	22	2,100
			9/9/92 10:20	7.39	2.92	1.0					180	620	800	0.070	50	6	5,200
			10/7/92 11:55	7.46	5.75	1.2					180	490	670	0.040	90	4	2,100
			11/18/92 9:15	7.51	4.50	4.7					180	630	810	0.040	290	11	4,000
			12/16/92 11:48	7.57	7.40	1.4						930		0.040	140	35	300
			1/20/93 12:30	7.84	12.00	1.5					20	680	700	0.040	70	9	580
			2/17/93 10:30	7.37	3.66	4.4						910		0.040	440	17	460
			3/17/93 10:40	7.27	3.92	1.0					20	650	670	0.040	240	1	220
			4/21/93 10:54	7.30	3.96	1.0					20	660	680	0.070	70	1	150
			5/12/93 11:10	7.49	6.95	2.1					40	860	900	0.040	130	7	580
			6/2/93 11:30	7.32	0.92	2.7					20	1,010	1,030	0.070	220	11	640
			7/7/93 11:30	7.38	1.65	5.9					20	1,450	1,470	0.080	320	21	1,000
			7/28/93 11:13	7.52	3.30	6.9					30	3,970	4,000	0.110	620	81	1,200
			9/1/93 12:00	7.26	1.55	1.0					20	1,120	1,140	0.060	160	1	2,000
			9/22/93 11:50	7.39	1.44	1.8					30	1,170	1,200	0.100	150	2	1,400
			10/27/93 13:02	7.22	4.46	1.6					60	770	830	0.070	90	3	2,600
			12/1/93 11:10	7.72	7.47	1.1					20	890	910	0.040	60	13	560
			12/21/93 11:30	7.50	5.45	3.5					100	670	770	0.040	250	22	3,000
			1/18/94 9:30	7.45	6.02	1.2					120	190	310	0.040	200	2	2,400
			2/23/94 10:45	7.51	4.07	1.0					20	580	600	0.040	100	4	200
			3/16/94 10:45	8.29	8.23	1.0					30	560	590	0.040	50	1	120
			4/20/94 10:48	7.33	3.47	6.0					20	820	840	0.040	250	16	3,000
			5/11/94 10:40	7.68	5.57	3.6					20	2,250	2,270	0.040	350	92	50
			6/15/94 11:20	7.79	5.62	3.6					20	600	620	0.090	250	19	2,800
			7/6/94 10:50	7.53	1.65	2.4					40	1,140	1,180	0.070	200	4	300
			8/10/94 11:00	7.18	2.64	1.4					20	570	590	0.040	200	1	2,300
			8/31/94 11:52	7.28	3.99	1.1					20	880	900	0.040	60	1	6,700

WaterBodyName	Saint Joes Creek																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-01	JOES CREEK	PINELLAS	9/28/94 12:01	7.25	4.05	1.0					270	830	1,100	0.090	90	16	5,900
			10/26/94 8:53	7.29	2.59	1.4					20	570	590	0.040	120	60	3,900
			12/14/94 11:18	7.60	7.35	1.0					50	700	750	0.040	140	10	9,600
			1/11/95 11:22	7.94	6.55												
			1/11/95 11:23	7.75	6.31	1.0					150	540	690	0.040	50	1	1,600
			2/8/95 10:45	7.57	6.67	3.2					140	690	830	0.040	50	2	2,800
			3/8/95 9:41	8.04	6.33	5.5					440	1,640	2,080	0.100	260	53	6,000
			3/8/95 9:42	7.81	5.76												
			4/12/95 11:50	8.30	5.77	2.7					310	1,190	1,500	0.040	260	84	6,400
			5/2/95 10:51	8.11	3.91	1.5					20	750	770	0.040	120	1	200
			6/7/95 10:33	8.28	8.12	1.3					20	690	710	0.050	130	2	800
			6/28/95 10:19	7.47	2.33	1.5					20	780	800	0.040	370	5	2,400
			8/9/95 10:37	7.74	5.42	1.6					20	980	1,000	0.040	100	3	1,100
			8/29/95 11:33	7.83	4.02	3.1					20	1,310	1,330	0.040	240	13	12,000
			9/27/95 9:44	7.46	0.84	1.6					20	1,510	1,530	0.050	160	6	800
			9/27/95 9:45	7.40	0.53												
			10/18/95 11:30	7.59	2.67	1.4					150	1,200	1,350	0.040	80	4	6,500
			11/29/95 10:54	7.77	4.61	3.7					90	1,220	1,310	0.040	90	19	6,000
			11/29/95 10:55	7.70	4.27												
			1/17/96 11:02	7.64	3.69	1.0					40	660	700	0.040	50	3	400
			1/17/96 11:03	7.49	2.21												
			2/7/96 11:27	6.56	6.73	1.0					20	530	550	0.040	20	1	230
			2/7/96 11:28	6.44	5.29												
			3/13/96 11:20	7.62	5.82	1.9					20	430	450	0.020	60		20
			3/13/96 11:21	7.44	4.05												
			4/3/96 11:01	7.58	2.99	1.5					90	480	570	0.030	20		940
			4/3/96 11:03	7.46	2.14												
			5/8/96 10:25	7.33	2.75	3.8					20	660	680	0.020	170		510
			5/8/96 10:26	7.22	0.12												
			5/29/96 10:48	7.76	1.42	5.8					20	1,160	1,180	0.040	340		2,200
			7/10/96 11:29	6.72	6.15	1.1					20	540	560	0.130	140		780
			7/24/96 9:51	7.47	2.77	3.5					20	980	1,000	0.020	110		2
			8/27/96 11:00	7.46	2.84	1.5					20	620	640	0.020	90		1,800
			9/18/96 12:50	7.59	6.40	2.2					20	740	760	0.050	160		2,100
			10/23/96 11:01	7.58	4.70	1.0					20	700	720	0.020	20		240
			11/13/96 10:32	7.80	10.31	1.2					20	510	530	0.020	20		90
			1/22/97 10:25	7.36	4.62	3.0					20	570	590	0.020	80		
			2/12/97 10:13	8.03	6.24	4.0					20	710	730	0.020	80		
			3/19/97 10:49	7.04	0.18	7.0					20	18,030	18,050	1.280	2,760		
			4/9/97 12:26	7.50	7.39	2.0					20	760	780	0.040	180		
			5/12/97 13:27	7.67	6.65	2.0					70	410	480	0.070	250		

WaterBodyName	Saint Joes Creek																
Average of Result_Value			Parameter														
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-01	JOES CREEK	PINELLAS	5/28/97 13:09	7.28	5.13	1.0					20	1,000	1,020	0.080	20		
			6/25/97 12:56	7.54	2.08												
			6/25/97 12:58	7.62	1.95	3.0					20	770	790	0.030	50		
			7/30/97 11:00	8.35	2.05	2.0					20	870	890	0.040	170		
			8/26/97 10:46	7.66	4.26	2.0					20	960	980	0.030	150		
			9/17/97 13:24	7.19	0.86												
			9/17/97 13:26	7.15	0.87	1.0					20	660	680	0.070	230		
			10/15/97 11:04	7.46	2.27	1.0					20	750	770	0.040	40		
			11/12/97 12:11	7.67	6.62	1.0					50	800	850	0.020	30		
			12/17/97 10:32	7.54	7.52	1.0					270	620	890	0.020	70		
			1/28/98 11:27	7.51	10.71	1.0					190	560	750	0.020	30		
			2/25/98 11:44	7.46	8.96	1.0					100	540	640	0.020	30		
			3/25/98 11:43	7.52	5.05	1.0					100	500	600	0.020	60	1	
			4/20/98 10:32	7.59	3.86	3.0					20	1,240	1,260	0.020	130	40	
			5/18/98 11:53	7.22	4.60	7.0					20	1,860	1,880	0.030	160	31	
			6/17/98 9:51	7.57	0.30	6.0					20	1,480	1,500	0.060	360	20	
			7/15/98 11:05	7.42	1.58	1.0					20	980	1,000	0.020	110	12	
			8/12/98 11:42	7.54	5.96	7.0					20	1,940	1,960	0.030	220	24	
			9/9/98 13:02	7.35	4.68	2.0					20	580	600	0.030	140	8	
			10/7/98 11:19	7.44	3.50	1.0					20	630	650	0.020	40	5	
			11/3/98 11:59	7.66	10.67	2.0					20	900	920	0.020	60	29	
			12/2/98 10:03	7.88	9.52	1.0					20	930	950	0.040	40	5	
			2/22/07 10:40	8.05	12.27	2.0					20	590	610	0.020	30	1	1,200
			8/2/07 15:30	8.07	4.58	2.0					90	360	450	0.080	120	16	5
			10/10/07 10:03	7.77	3.98	2.0					180	620	800	0.060	80	8	4,600
			12/18/08 11:26	8.15	8.34	2.0					20	690	710	0.020	40	8	450
35-02	JOES CREEK	PINELLAS	1/16/91 13:25	7.76	7.16												
			1/16/91 13:26	7.39	5.28												
			2/13/91 13:08	7.69	7.41												230
			2/13/91 13:10	7.61	7.92												
			3/13/91 11:43	7.79	7.45												
			3/13/91 11:45	7.75	8.16												260
			4/17/91 11:28	7.39	4.96									0.120			190
			5/8/91 11:24	7.45	5.31						20			0.090		14	400
			5/8/91 11:25	7.28	2.39												
			6/5/91 11:39	7.21	3.54												
			6/5/91 11:40	7.25	4.30						80			0.160		5	220
			7/2/91 8:25	7.31	3.96	1.1					170			0.040		2	400
			8/7/91 10:56	7.46	4.39	3.3					150			0.040		7	260
			8/7/91 11:00	7.40	5.17												
			8/7/91 11:01	7.38	3.70												

WaterBodyName	Saint Joes Creek																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-02	JOES CREEK	PINELLAS	8/28/91 10:30	7.20	2.78	2.3					310			0.040		6	500
			9/25/91 10:38	6.97	2.88												
			9/25/91 10:40	7.04	3.55	3.8					100			0.050		6	1,400
			10/16/91 10:45	7.26	3.49	2.7					180			0.040		6	6,000
			11/20/91 10:45	7.19	5.18	2.7					20			0.040		4	100
			11/20/91 10:46	7.21	4.32												
			12/18/91 11:00	7.23	6.25	1.0					70			0.060		4	140
			2/5/92 11:52	7.84	7.52												
			2/5/92 11:55	7.91	7.94	4.2					300	800	1,100	0.090	170	12	4,000
			2/26/92 12:20	7.41	7.23	2.8						670			120	13	2,300
			4/1/92 10:39	7.43	5.67												
			4/1/92 10:40	7.45	6.21	1.6						870		0.060	150	5	300
			4/22/92 11:02	7.29	4.50	1.6					100	800	900	0.070	180	12	600
			5/27/92 11:30	7.53	7.75	3.9					20	570	590	0.070	150	6	120
			5/27/92 11:31	7.53	4.85												
			6/17/92 11:18	7.21	5.29	2.2						660		0.040	140	5	410
			6/17/92 11:19	7.35	4.32	2.2						660		0.040	140	5	410
			7/22/92 10:33	7.30	4.72												
			7/22/92 10:35	7.34	4.65	2.0					160	710	870	0.060	110	8	3,000
			8/12/92 10:00	7.19	4.75	1.5					180	760	940	0.070	160	5	1,800
			8/12/92 10:05	7.17	3.97												
			9/9/92 10:50	7.49	2.87												
			9/9/92 10:52	7.49	2.85												
			9/9/92 10:55	7.49	2.88	1.3					20	460	480	0.070	50	14	1,000
			10/7/92 11:23	7.68	6.35												
			10/7/92 11:25	7.48	6.16	2.1					390	650	1,040	0.050	150	7	300
			11/18/92 9:00	7.61	7.42	1.6					210	620	830	0.040	360	2	750
			12/16/92 12:46	7.37	8.03	1.8						1,240		0.040	120	10	650
			1/20/93 12:00	7.49	6.79	1.0					220	610	830	0.040	130	1	760
			2/17/93 10:50	7.22	4.56	4.1						1,120		0.060	460	4	3,500
			3/17/93 11:40	7.47	6.72	2.2					120	1,080	1,200	0.040	340	6	1,000
			3/17/93 11:43	7.39	6.64												
			4/21/93 11:15	7.48	8.57	2.9					20	1,020	1,040	0.080	130	6	560
			4/21/93 11:30	7.48	7.87												
			5/12/93 10:18	7.34	6.33												
			5/12/93 10:20	7.27	6.81	3.2					40	1,130	1,170	0.080	170	3	360
			6/2/93 11:50	7.35	4.47	5.2					20	1,220	1,240	0.060	200	6	1,500
			6/2/93 11:52	7.16	1.85												
			7/7/93 10:50	7.27	0.73	2.5					480	920	1,400	0.090	180	4	1,700
			7/28/93 11:39	7.47	2.22												
			7/28/93 11:40	7.27	3.24	1.6					110	920	1,030	0.140	200	4	2,800

WaterBodyName	Saint Joes Creek																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-02	JOES CREEK	PINELLAS	9/1/93 11:25	7.30	4.50	1.0					210	940	1,150	0.040	120	5	2,700
			9/1/93 11:28	7.34	4.74												
			9/22/93 12:10	7.18	3.83	1.3					140	770	910	0.080	100	3	1,100
			9/22/93 12:13	7.19	3.62												
			10/27/93 12:35	7.23	4.23	2.0					220	880	1,100	0.100	130	9	6,000
			10/27/93 12:36	7.19	3.44												
			12/1/93 12:35	7.68	8.54	1.3					110	820	930	0.080	100	9	300
			12/21/93 11:00	7.38	7.12	4.3					20	1,110	1,130	0.040	170	14	2,000
			12/21/93 11:05	7.40	7.05												
			1/18/94 10:07	7.34	7.89	2.1					160	1,010	1,170	0.120	680	111	3,400
			1/18/94 10:08	7.30	7.70												
			2/23/94 11:45	7.81	7.73	3.3					20	1,150	1,170	0.040	190	9	100
			2/23/94 11:49	7.66	5.68												
			3/16/94 11:07	7.75	7.14	1.0					40	910	950	0.040	130	9	220
			4/20/94 11:56	7.55	5.45	3.4					20	1,050	1,070	0.080	270	26	3,000
			4/20/94 11:57	7.59	3.97												
			5/11/94 11:23	7.78	6.36												
			5/11/94 11:25	7.73	6.12	3.8					40	1,050	1,090	0.040	210	14	450
			6/15/94 12:30	7.47	5.32	2.7					680	720	1,400	0.080	180	9	6,000
			7/6/94 11:28	7.84	3.32												
			7/6/94 11:29	7.89	3.19												
			7/6/94 11:30	8.00	4.27	2.9					20	1,050	1,070	0.040	150	13	750
			8/10/94 12:09	7.45	6.51	1.6					100	540	640	0.040	180	12	1,600
			8/10/94 12:10	7.43	6.49												
			8/31/94 12:19	7.29	5.33												
			8/31/94 12:20	7.28	5.37												
			8/31/94 12:21	7.28	5.39	1.0					310	600	910	0.070	180	23	2,900
			9/28/94 11:37	7.24	5.07	1.1					230	620	850	0.050	90	9	13,000
			9/28/94 11:38	7.24	5.09												
			10/26/94 8:28	7.39	7.56	1.6					20	1,180	1,200	0.050	130	9	450
			10/26/94 8:29	6.99	1.42												
			10/26/94 8:31	7.42	7.14												
			12/14/94 10:53	7.61	7.85	2.4					190	1,050	1,240	0.050	190	8	1,000
			12/14/94 10:54	7.59	7.64												
			1/11/95 11:02	7.43	10.23	2.8					160	930	1,090	0.040	90	12	200
			1/11/95 11:03	7.75	10.39												
			2/8/95 11:32	7.78	10.56	5.7					20	1,140	1,160	0.040	120	12	500
			2/8/95 11:33	7.76	10.58												
			3/8/95 8:44	7.68	6.04	4.7					60	1,230	1,290	0.050	180	25	2,600
			3/8/95 8:45	7.55	5.22												
			4/12/95 11:03	7.73	7.30	3.4					20	1,150	1,170	0.050	160	11	560

WaterBodyName	Saint Joes Creek																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-02	JOES CREEK	PINELLAS	4/12/95 11:04	7.60	6.07												
			5/2/95 11:27	7.71	6.07	5.1					20	1,230	1,250	0.050	190	8	260
			5/2/95 11:28	7.64	5.88												
			6/7/95 11:08	7.90	5.45	1.2					150	870	1,020	0.070	200	3	700
			6/7/95 11:09	7.74	5.39												
			6/28/95 11:21	7.56	6.38	1.9					240	1,130	1,370	0.040	270	9	3,900
			6/28/95 11:22	7.45	6.28												
			8/9/95 11:21	7.87	6.56	2.2					160	1,370	1,530	0.050	180	10	3,400
			8/9/95 11:22	7.62	5.86												
			8/9/95 11:23	7.62	5.82												
			8/29/95 10:36	7.71	4.54	1.3					200	850	1,050	0.080	150	2	6,200
			9/27/95 10:24	7.50	5.00	2.4					40	1,250	1,290	0.040	110	7	1,400
			9/27/95 10:25	7.40	6.09												
			10/18/95 10:31	7.36	3.10												
			10/18/95 10:34	7.43	5.85	1.1					160	1,020	1,180	0.040	90	3	8,600
			11/29/95 11:36	7.57	5.66	3.0					90	890	980	0.040	70	5	6,000
			11/29/95 11:37	7.41	6.67												
			1/17/96 10:36	7.64	9.91	4.8					50	1,210	1,260	0.040	90	6	400
			2/7/96 10:50	7.24	8.58	1.1					60	660	720	0.050	80	2	650
			3/13/96 10:53	7.70	8.49	1.8					160	870	1,030	0.020	170		540
			4/3/96 10:24	7.82	6.32	2.1					180	590	770	0.060	60		280
			5/8/96 11:09	7.78	6.84	3.6					20	750	770	0.100	190		480
			5/29/96 11:23	7.57	3.32	2.6					140	960	1,100	0.100	200		1,200
			5/29/96 11:24	7.45	2.74												
			7/10/96 9:04	7.93	1.48	1.3					70	890	960	0.200	140		500
			7/10/96 9:06	7.40	0.89												
			7/24/96 11:05	7.46	4.22	1.0					20	970	990	0.070	130		280
			7/24/96 11:06	7.47	3.77												
			8/27/96 11:48	7.65	5.63	3.0					30	1,160	1,190	0.090	150		1,200
			8/27/96 11:49	7.51	3.59												
			9/18/96 14:33	7.61	0.00	5.1					20	800	820	0.160	80		70
			10/23/96 11:39	7.60	5.70	1.6					20	900	920	0.060	20		330
			10/23/96 11:41	7.44	4.83												
			11/13/96 11:39	7.64	7.25	3.8					20	760	780	0.060	80		80
			1/22/97 11:44	7.57	7.78												
			1/22/97 11:45	7.61	7.93	4.0					20	980	1,000	0.060	100		
			2/12/97 12:14	7.64	4.85	2.0					20	1,120	1,140	0.080	140		
			3/19/97 12:01	7.91	11.02	1.0					20	290	310	0.020	20		
			3/19/97 12:02	7.93	10.03												
			4/9/97 11:18	7.37	2.97	2.0					50	1,360	1,410	0.160	310		
			5/12/97 11:29	7.48	4.57	4.0					130	840	970	0.060	190		

WaterBodyName	Saint Joes Creek																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-02	JOES CREEK	PINELLAS	5/12/97 11:30	7.34	3.62												
			5/28/97 11:47	7.35	6.07	2.0					20	1,000	1,020	0.060	60		
			6/25/97 10:41	7.36	2.35												
			6/25/97 10:43	7.29	2.10	2.0					50	960	1,010	0.110	80		
			7/30/97 10:22	8.01	3.41												
			7/30/97 10:26	8.16	3.24	1.0					50	740	790	0.110	150		
			8/26/97 11:24	7.53	4.69	2.0					90	700	790	0.040	140		
			8/26/97 11:25	7.42	3.71												
			9/17/97 11:42	7.21	4.38	1.0					50	1,020	1,070	0.110	220		
			9/17/97 11:43	7.15	3.46												
			10/15/97 11:34	7.59	6.83	5.0					20	1,200	1,220	0.030	160		
			10/15/97 11:35	7.41	4.78												
			11/12/97 10:59	7.55	6.61	2.0					90	680	770	0.040	80		
			11/12/97 11:00	7.38	4.69												
			12/17/97 11:57	7.26	7.03	1.0					480	710	1,190	0.050	140		
			1/28/98 11:41	7.60	7.83	1.0					280	670	950	0.030	120		
			2/25/98 11:32	7.35	7.02	1.0					330	650	980	0.020	90		
			3/25/98 11:29	7.23	7.51	1.0					220	590	810	0.040	140	4	
			4/20/98 10:59	7.39	6.61	4.0					20	1,160	1,180	0.120	300	8	
			4/20/98 11:00	7.30	3.85												
			5/18/98 12:55	7.27	5.35	3.0					20	1,240	1,260	0.060	270	16	
			5/18/98 12:56	7.12	3.74												
			6/17/98 10:34	7.62	2.45												
			6/17/98 10:35	7.58	3.85	2.0					20	900	920	0.120	220	6	
			7/15/98 10:38	7.43	5.21	2.0					80	810	890	0.030	130	4	
			7/15/98 10:39	7.41	5.10												
			8/12/98 11:13	7.49	4.90	2.0					20	830	850	0.050	140	2	
			9/9/98 11:56	7.38	4.97												
			9/9/98 11:58	7.39	5.47	3.0					160	600	760	0.030	120	5	
			10/7/98 11:02	7.35	5.09	3.0					20	780	800	0.030	160	9	
			11/3/98 11:09	7.45	3.27												
			11/3/98 11:10	7.46	3.45	6.0					20	830	850	0.030	160	14	
			12/2/98 10:40	7.50	3.97	2.0					30	950	980	0.070	130	9	
			1/13/99 12:05	7.63	6.84	1.0					80	600	680	0.020	90	4	
			2/10/99 11:47	7.64	10.07	4.0					20	830	850	0.120	220	13	
			3/3/99 11:31	7.49	6.03												
			3/3/99 11:33	7.55	7.77	9.0					20	950	970	0.060	180	19	
			4/7/99 11:29	7.54	4.64	4.0					20	580	600	0.070	180	5	
			5/3/99 12:01	7.70	5.24	5.0					20	610	630	0.020	160	7	
			6/2/99 13:31	7.65	4.12												
			6/2/99 13:33	8.19	0.00	17.0					20	1,120	1,140	0.080	230	24	

WaterBodyName	Saint Joes Creek																
Average of Result_Value			Parameter														
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-02	JOES CREEK	PINELLAS	6/30/99 11:38	7.47	1.54												
			6/30/99 11:39	7.48	4.33	3.0					30	950	980	0.100	220	7	
			7/28/99 12:06	7.56	2.46												
			7/28/99 12:08	7.70	4.41	2.0					80	820	900	0.050	140	6	
			8/25/99 10:54	7.71	5.23	2.0					170	840	1,010	0.060	130	5	
			8/25/99 10:56	7.56	4.43												
			9/22/99 12:18	7.75	4.54												
			9/22/99 12:20	7.69	5.51	2.0					250	810	1,060	0.030	140	5	
			10/20/99 11:55	7.70	6.92	2.0					90	760	850	0.020	80	3	
			10/20/99 11:56	7.60	7.27												
			11/15/99 12:11	7.89	9.40	8.0					20	650	670	0.020	180	20	
			1/5/00 11:11	7.40	7.40	13.0					20	1,290	1,310	0.020	170	12	
			2/16/00 13:26	7.62	6.22	1.0					50	670	720	0.040	70	6	
			3/8/00 12:06	7.71	4.18												
			3/8/00 12:08	7.54	4.42	1.0					20	820	840	0.020	110	7	
			4/12/00 10:46	7.75	6.30	4.0					20	1,160	1,180	0.020	160	11	
			4/12/00 10:47	7.75	3.78												
			5/3/00 12:44	7.29	3.41												
			5/3/00 12:46	7.35	5.18	4.0					20	680	700	0.040	150	10	
			6/8/00 12:01	7.44	3.25												
			6/8/00 12:02	7.55	5.02	4.0					20	1,020	1,040	0.100	210	8	
			6/28/00 11:43	7.42	1.10												
			6/28/00 11:45	7.53	3.62	2.0					80	1,600	1,680	0.090	180	4	
			8/8/00 11:56	7.30	0.48												
			8/8/00 11:57	7.57	3.58	1.2					80	840	920	0.020	100	5	
			8/21/00 10:21	7.34	2.07												
			8/21/00 10:22	7.27	2.37						399	1,701	2,100	0.086	195	6	
			9/27/00 11:53	7.42	4.59	2.0					150	1,000	1,150	0.020	70	4	
			10/18/00 10:43	7.17	4.76	5.0					60	1,400	1,460	0.040	140	6	
			11/21/00 12:48	7.70	8.49	5.0					20	1,200	1,220	0.020	170	16	
			3/7/01 11:34	7.69	6.52												
			3/7/01 11:35	7.67	6.32	3.0					140	1,150	1,290	0.060	200	8	
			4/11/01 11:48	7.35	5.33	2.0					40	780	820	0.070	190	4	
			4/11/01 11:49	7.21	3.76												
			4/11/01 11:50	7.28	4.73												
			5/2/01 11:11	7.42	4.42												
			5/2/01 11:13	7.40	3.73	4.0					20	960	980	0.030	160	11	
			6/6/01 11:04	7.27	2.28												
			6/6/01 11:05	7.43	2.85												
			6/6/01 11:06	7.63	4.91	6.0					20	1,120	1,140	0.100	300	13	
			7/3/01 11:06	7.59	4.30	1.0					130	680	810	0.060	140	3	

WaterBodyName	Saint Joes Creek																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-02	JOES CREEK	PINELLAS	7/3/01 11:07	7.33	2.14												
			7/3/01 11:08	7.32	1.81												
			8/1/01 11:31	7.48	3.36												
			8/1/01 11:32	7.40	3.22												
			8/1/01 11:33	7.46	3.68	2.0					290	790	1,080	0.040	140	6	
			8/22/01 11:59	7.26	4.94	2.0					60	720	780	0.040	130	3	
			8/22/01 12:00	7.26	4.87												
			9/20/01 12:27	7.21	1.66												
			9/20/01 12:28	7.44	4.62												
			9/20/01 12:29	7.47	3.00	2.0					310	790	1,100	0.020	100	3	
			10/17/01 12:00	7.30	5.12	2.0					80	870	950	0.020	140	4	
			10/17/01 12:01	7.25	3.25												
			10/17/01 12:02	7.17	0.38												
			11/19/01 11:54	7.42	0.00	6.0					50	1,030	1,080	0.020	130	8	
			11/19/01 11:56	7.29	0.00												
			1/3/02 11:32	7.63	3.40												
			1/3/02 11:33	7.55	3.52												
			1/3/02 11:34	7.83	6.35	2.0					320	890	1,210	0.060	140	5	
			2/11/02 12:06	7.39	2.41												
			2/11/02 12:08	7.43	3.51												
			2/11/02 12:09	7.59	4.96	1.0					140	1,080	1,220	0.040	150	5	
			3/4/02 10:17	7.11	3.92												
			3/4/02 10:18	7.27	5.97						100	1,420	1,520	0.050	250	21	
			4/9/02 11:55	7.93	9.49	9.0					20	980	1,000	0.070	260	12	
			5/1/02 12:38	7.62	6.33	6.0					20	1,240	1,260	0.190	360	9	
			5/1/02 12:39	7.15	2.17												
			5/1/02 12:41	7.28	3.20												
			6/5/02 12:44	7.68	6.26	7.0					20	1,520	1,540	0.280	490	12	
			6/5/02 12:45	7.40	2.42												
			6/26/02 11:45	7.24	1.36												
			6/26/02 11:47	7.31	2.18												
			6/26/02 11:48	7.31	3.53	4.0					120	1,080	1,200	0.100	220	4	
			7/31/02 10:16	7.24	1.56												
			7/31/02 10:17	7.34	3.81												
			7/31/02 10:18	7.36	3.76	2.0					170	910	1,080	0.090	190	4	
			8/21/02 12:11	7.40	3.83												
			8/21/02 12:12	7.66	4.83	3.0					340	880	1,220	0.080	290	4	
			9/25/02 12:31	7.27	1.35												
			9/25/02 12:32	7.52	2.89												
			9/25/02 12:33	7.51	3.31	2.0					210	840	1,050	0.020	140	4	
			10/16/02 10:03	7.56	4.57												

WaterBodyName: Saint Joes Creek

Average of Result_Value — Parameter

StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-02	JOES CREEK	PINELLAS	10/16/02 10:04	7.58	3.76												
			10/16/02 10:05	7.53	3.47	3.0					250	890	1,140	0.130	220	5	
			11/20/02 12:22	7.53	6.89	1.0					230	800	1,030	0.020	110	3	
			11/20/02 12:23	7.24	3.29												
			11/20/02 12:24	7.38	5.41												
35-03	JOES CREEK	PINELLAS	2/20/91 10:05	7.30	7.50												160
			4/17/91 10:23	7.20	4.93												20
			6/5/91 10:20	7.02	5.39						30			0.060		1	240
			8/7/91 9:52	7.28	4.48	1.2					50			0.040		3	630
			9/25/91 10:10	6.82	2.75	1.0					50			0.040		1	520
			11/20/91 11:15	7.08	5.83	1.0					260			0.040		5	60
			2/5/92 10:50	7.26	7.28	2.0					60	640	700	0.040	70	6	1,200
			4/1/92 10:15	7.41	8.34	1.2						630		0.040	50	1	400
			5/27/92 10:30	7.09	5.39	1.0					50	530	580	0.040	70	1	160
			7/22/92 9:50	7.12	5.02	2.2					150	660	810	0.050	110	9	3,000
			9/9/92 9:15	7.13	4.81	1.0					50	110	160	0.040	50	3	1,100
			11/18/92 9:55	7.33	6.45	2.1					190	380	570	0.040	250	2	2,000
			1/20/93 10:50	7.17	7.21	1.1					110	300	410	0.040	40	1	280
			3/17/93 12:00	7.20	7.33	1.1					90	350	440	0.040	310	2	260
			5/12/93 10:00	7.08	6.07	1.4					40	530	570	0.040	50	1	180
			7/7/93 9:55	7.18	5.55	1.0					30	490	520	0.040	70	1	660
			9/1/93 10:25	6.86	2.74	1.0					110	600	710	0.030	60	2	920
			10/27/93 11:15	6.88	5.56	3.5					140	540	680	0.040	100	4	820
			12/21/93 10:37	7.24	8.01	1.0					30	300	330	0.040	50	1	4,300
			2/23/94 9:55	7.37	6.98	1.0					150	250	400	0.040	50	1	200
			4/20/94 13:00	8.00	9.83	1.0					20	690	710	0.040	70	1	450
			6/15/94 10:55	7.49	7.56	1.0					50	480	530	0.040	60	1	1,400
			8/10/94 10:25	7.03	5.85	1.0					150	220	370	0.040	100	1	660
			9/28/94 10:23	7.11	4.29	1.0					200	440	640	0.040	50	4	1,200
			12/14/94 10:12		0.00	1.0					250	450	700	0.040	200	2	240
			2/8/95 11:57	8.00	11.16	1.0					80	370	450	0.040	50	1	50
			4/12/95 10:37	7.44	6.93	0.6					60	470	530	0.040	50	3	220
			6/7/95 11:32	7.86	7.16	1.0					150	490	640	0.050	110	1	1,400
			8/9/95 10:16	7.68	5.73	1.4					120	610	730	0.040	50	2	320
			9/27/95 11:25		0.00	1.0					110	460	570	0.040	50	1	480
			11/29/95 10:31	8.20	5.62	1.0					30	420	450	0.040	50	1	420
			1/17/96 10:15	7.93	7.81	1.0					80	370	450	0.040	50	1	15
			3/13/96 10:28	7.44	9.48	1.0					100	430	530	0.020	80		20
			5/8/96 11:35	7.20	8.13	1.0					20	400	420	0.020	50		150
			7/10/96 11:46	7.63	7.34	1.0					50	160	210	0.040	90		300
			8/27/96 10:10	7.23	1.87	1.0					20	520	540	0.030	110		1,700

WaterBodyName	Saint Joes Creek																
Average of Result_Value			Parameter														
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-03	JOES CREEK	PINELLAS	10/23/96 10:43	7.64	5.02	1.0					80	490	570	0.020	20		110
			1/22/97 10:42	7.87	8.96	1.0					20	200	220	0.020	40		
			3/19/97 11:30	7.42	7.48	4.0					20	1,310	1,330	0.060	210		
			5/12/97 13:49	7.88	6.46	4.0					80	590	670	0.040	150		
			5/12/97 13:50	7.81	6.45												
			6/25/97 12:19	7.46	7.09	2.0					20	640	660	0.020	40		
			8/26/97 10:27	7.40	5.01	1.0					20	510	530	0.020	60		
			10/15/97 12:05	7.25	6.73	1.0					140	490	630	0.020	20		
			12/17/97 10:50	7.38	7.35	1.0					570	590	1,160	0.040	80		
			2/25/98 10:19	7.55	7.32	2.0					350	580	930	0.020	50		
			4/20/98 12:21	7.28	9.47	1.0					20	440	460	0.020	20	1	
			6/17/98 11:10	7.54	5.94	2.0					20	840	860	0.030	110	9	
			8/12/98 10:46	7.18	4.24	1.0					100	410	510	0.030	70	2	
			10/7/98 10:42	7.33	4.36	1.0					220	700	920	0.020	70	4	
			12/2/98 11:16	7.59	6.35	1.0					80	460	540	0.020	20	1	
			1/13/99 10:49	7.33	8.15	5.0					20	840	860	0.020	70	8	
			3/3/99 10:44	8.23	4.53	1.0					20	290	310	0.020	20	1	
			5/3/99 12:26	7.44	8.13	1.0					20	440	460	0.020	20	1	
			6/30/99 12:24	7.84	7.35	3.0					60	810	870	0.020	80	3	
			8/25/99 10:33	7.30	5.47	2.0					170	680	850	0.020	50	4	
			10/20/99 10:48	7.35	4.05	1.0					210	720	930	0.020	30	2	
			1/5/00 10:50	7.55	6.36	1.0					70	580	650	0.020	40	1	
			5/3/00 13:11	7.69	6.11	1.0					20	480	500	0.040	60	1	
			6/28/00 10:49	7.30	5.23	2.0					40	1,200	1,240	0.020	100	4	
			8/21/00 11:36	7.38	5.83						132	1,159	1,291	0.016	66	6	
			10/18/00 11:06	7.23	5.92	1.0					110	660	770	0.020	20	2	
			1/11/01 10:29	7.59	7.58	1.0					160	520	680	0.020	20	5	
			3/7/01 10:27	7.44	7.75												
			3/7/01 10:39	7.39	6.99	1.0					170	660	830	0.020	50	1	
			5/2/01 11:35	7.52	8.37	2.0					20	630	650	0.020	80	3	
			7/3/01 10:05	7.11	3.79	1.0					20	660	680	0.020	100	3	
			8/22/01 10:52	7.06	4.56	2.0					20	1,000	1,020	0.020	160	20	
			10/17/01 10:43	7.29	3.71	2.0					20	630	650	0.020	60	2	
			1/3/02 10:33	8.10	10.05	5.0					80	1,080	1,160	0.020	80	6	
			3/4/02 9:57	7.46	7.24						70	450	520	0.020	20	1	
			5/1/02 12:13	7.14	6.33	2.0					20	710	730	0.020	70	2	
			6/26/02 10:46	7.27	6.20	5.0					30	1,160	1,190	0.020	120	12	
			8/21/02 11:11	7.21	5.33	3.0					140	980	1,120	0.020	90	7	
			10/16/02 9:44	7.57	5.13	3.0					180	1,200	1,380	0.040	140	12	
35-06	JOES CREEK	PINELLAS	1/11/95 10:16	7.91	5.96	2.2					20	1,010	1,030	0.040	60	5	150
			1/11/95 10:17	7.71	5.50												

WaterBodyName: Saint Joes Creek

Average of Result_Value

StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-06	JOES CREEK	PINELLAS	3/8/95 9:08	7.65	4.12	2.9					120	1,110	1,230	0.040	150	13	2,800
			5/2/95 9:59	8.09	4.71	4.8					20	1,360	1,380	0.040	140	12	140
			6/28/95 10:55	7.45	2.22	4.1					140	740	880	0.040	380	6	3,000
			6/28/95 10:56	7.30	2.50												
			8/29/95 10:56	7.84	4.37	2.9					160	1,030	1,190	0.040	90	7	5,200
			10/18/95 10:50	7.56	5.77	1.0					220	460	680	0.040	50	1	50
			2/7/96 10:29	7.90	8.33												
			2/7/96 10:30	7.98	8.22	2.4					100	870	970	0.040	50	6	2,400
			4/3/96 9:55	7.71	3.69	2.5					150	670	820	0.020	20		520
			5/29/96 10:26	7.03	2.55	4.4					70	910	980	0.020	140		2,800
			7/24/96 10:35	7.05	3.08	3.3					30	770	800	0.020	70		5,100
			9/18/96 11:57	7.48	6.43	6.4					20	840	860	0.030	130		200
			11/13/96 11:07	7.52	5.76	2.1					40	550	590	0.020	20		340
			2/12/97 10:56	7.88	6.26	3.0					20	530	550	0.020	120		
			2/12/97 10:57	7.77	6.76												
			4/9/97 11:40	7.65	4.28												
			4/9/97 11:41	7.54	4.16	4.0					20	960	980	0.020	130		
			5/28/97 12:24	7.16	3.58	5.0					20	1,240	1,260	0.050	60		
			7/30/97 11:38	8.42	4.70	4.0					20	790	810	0.020	100		
			9/17/97 12:41	7.42	6.73	2.0					20	1,360	1,380	0.020	170		
			11/12/97 11:50	7.58	4.92	2.0					60	960	1,020	0.020	50		
			1/28/98 11:07	7.35	7.29	2.0					180	840	1,020	0.020	60		
			1/28/98 11:08	7.32	7.31												
			3/25/98 12:18	7.72	6.27												
			3/25/98 12:19	7.49	6.30	3.0					200	560	760	0.020	80	4	
			5/18/98 12:36	7.46	7.67	8.0					20	1,490	1,510	0.020	200	24	
			7/15/98 10:17	7.06	1.94	2.0					140	840	980	0.030	110	6	
			9/9/98 11:32	8.05	6.84	7.0					160	570	730	0.040	140	26	
			11/3/98 11:33	7.88	4.59												
			11/3/98 11:34	7.67	4.04	2.0					60	1,020	1,080	0.020	80	12	
			2/10/99 11:10	7.74	5.42	1.0					70	640	710	0.080	90	2	
			6/2/99 11:17	7.65	1.30												
			6/2/99 11:18	7.69	0.37												
			7/28/99 10:45	7.63	3.49	4.0					20	1,280	1,300	0.020	120	11	
			9/22/99 11:39	7.69	4.08	2.0					230	930	1,160	0.020	90	7	
			11/15/99 11:52	7.29	2.92												
			11/15/99 11:53	7.32	3.61	2.0					80	1,130	1,210	0.020	90	11	
			2/16/00 12:40	7.16	3.24												
			2/16/00 12:41	7.60	7.73	1.0					20	640	660	0.020	30	2	
			4/12/00 12:52	7.50	0.22												
			4/12/00 12:53	7.36	2.63	4.0					20	1,070	1,090	0.020	60	4	

WaterBodyName: Saint Joes Creek

Average of Result_Value

StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-06	JOES CREEK	PINELLAS	6/8/00 12:29	8.02	7.95	8.0					20	2,740	2,760	0.020	200	20	
			8/8/00 11:16	7.65	2.86												
			8/8/00 11:17	7.55	4.11	2.6					5	1,100	1,105	0.020	60	8	
			9/27/00 11:13	7.67	5.60	6.0					49	1,000	1,049	0.020	90	13	
			11/21/00 12:02	7.57	7.56	4.0					30	1,410	1,440	0.020	100	10	
			2/13/01 11:09	7.60	4.90	4.0					20	1,540	1,560	0.020	120	13	
			4/11/01 11:02	7.63	6.71	2.0					20	880	900	0.020	120	9	
			4/11/01 11:03	7.44	5.16												
			6/6/01 11:43	7.63	9.14	3.0					20	770	790	0.020	30	2	
			8/1/01 10:27	7.30	3.46	3.0					120	1,070	1,190	0.040	130	5	
			8/1/01 10:28	7.16	2.69												
			9/20/01 11:35	7.35	6.81	2.0					430	870	1,300	0.020	60	3	
			11/19/01 11:10	7.17	0.00												
			11/19/01 11:11	7.12	0.00	1.0					20	540	560	0.020	70	1	
			2/11/02 11:24	7.48	3.05												
			2/11/02 11:25	7.54	4.08						20	690	710	0.020	50	1	
			4/9/02 11:17	7.91	5.61	2.0					20	750	770	0.020	70	1	
			6/5/02 11:54	7.68	5.70	7.0					20	2,030	2,050	0.110	330	13	
			6/5/02 11:55	7.38	3.71												
			7/31/02 11:54	7.54	5.56	6.0					40	1,370	1,410	0.020	160	12	
			9/25/02 11:40	7.50	4.46	3.0					120	1,220	1,340	0.020	100	10	
			9/25/02 11:41	7.50	4.61												
			11/20/02 11:42	7.26	7.72	1.0					240	570	810	0.020	60	2	
35-07	JOES CREEK	PINELLAS	1/11/95 10:40	7.68	4.61	1.0					190	630	820	0.040	50	1	150
			3/8/95 9:25	7.72	5.11	5.2					160	890	1,050	0.060	150	10	3,900
			5/2/95 10:26	8.03	2.81	1.2					20	800	820	0.040	90	1	200
			6/28/95 10:32	7.47	3.40	1.8					240	720	960	0.070	280	5	6,000
			8/29/95 11:16	7.82	4.42	1.1					150	760	910	0.060	100	2	4,100
			10/18/95 11:11	7.61	4.75	1.0					110	840	950	0.040	70	2	2,400
			2/7/96 11:10	6.83	7.83	1.2					40	660	700	0.040	30	6	200
			4/3/96 10:44	7.83	9.69	1.6					110	450	560	0.050	20		540
			5/29/96 11:01	7.53	4.32	1.6					20	580	600	0.060	170		400
			7/24/96 10:06	7.30	1.07	2.1					60	600	660	0.030	60		120
			9/18/96 12:31	7.43	3.47	3.2					20	3,470	3,490	0.100	700		500
			11/13/96 10:46	7.59	6.04	1.0					30	440	470	0.020	20		120
			12/17/96 12:25	7.80	8.55	1.0					50	430	480	0.020	20		80
			2/12/97 10:27	7.72	6.66	1.0					20	810	830	0.030	70		
			4/9/97 12:04	7.77	7.35	4.0					20	1,300	1,320	0.040	360		
			5/28/97 12:40	7.34	3.04	2.0					50	1,220	1,270	0.090	60		
			7/30/97 11:13	8.49	2.73	2.0					20	610	630	0.090	130		
			9/17/97 12:07	7.46	3.38	1.0					20	860	880	0.140	250		

WaterBodyName	Saint Joes Creek																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-07	JOES CREEK	PINELLAS	11/12/97 11:21	7.31	3.34	1.0					40	740	780	0.030	130		
			1/28/98 10:46	7.32	6.47	1.0					230	590	820	0.050	60		
			3/25/98 11:55	7.70	12.68	1.0					80	430	510	0.030	90	2	
			5/18/98 12:12	7.55	6.52	2.0					20	920	940	0.030	80	2	
			9/9/98 12:44	7.27	4.95	1.0					40	1,130	1,170	0.090	200	5	
			11/3/98 12:17	7.53	3.89	2.0					20	730	750	0.020	70	9	
35-08	JOES CREEK	PINELLAS	1/13/99 11:30	7.48	6.19	1.0					170	750	920	0.020	40	4	
			2/10/99 12:06	7.83	7.74	4.0					130	910	1,040	0.040	90	10	
			4/7/99 11:43	7.10	2.26	14.0					20	780	800	0.060	240	15	
			5/3/99 11:43	7.33	5.90	14.0					20	990	1,010	0.020	160	16	
			6/2/99 12:24	7.40	0.40												
			6/2/99 12:26	7.40	3.63	10.0					20	1,530	1,550	0.230	480	18	
			6/30/99 11:57	7.61	3.80	6.0					20	1,270	1,290	0.080	250	7	
			6/30/99 11:59	7.42	3.50												
			7/28/99 11:26	7.63	4.60												
			7/28/99 11:28	7.62	5.00	6.0					20	1,150	1,170	0.020	120	9	
			8/25/99 11:08	7.54	3.47												
			8/25/99 11:09	7.54	3.50	1.0					190	760	950	0.020	60	2	
			9/22/99 12:32	7.60	4.82												
			9/22/99 12:33	7.56	4.59	1.0					350	810	1,160	0.020	80	2	
			10/20/99 11:12	7.48	4.11												
			10/20/99 11:15	7.60	4.76	1.0					330	890	1,220	0.020	50	4	
			11/15/99 12:27	7.55	3.58	2.0					290	800	1,090	0.020	90	18	
			1/5/00 11:24	7.79	6.35	6.0					210	1,180	1,390	0.020	70	7	
			2/16/00 13:44	7.69	9.24	1.0					120	960	1,080	0.020	70	10	
			3/8/00 12:26	7.47	5.26	3.0					110	1,190	1,300	0.020	130	8	
			4/12/00 11:31	7.50	6.74	12.0					20	4,000	4,020	0.030	1,230	44	
			5/3/00 11:53	7.12	2.14	7.0					20	1,510	1,530	0.200	490	13	
			6/8/00 11:16	7.38	9.90	8.0					20	1,860	1,880	0.130	400	15	
			6/28/00 12:02	7.42	2.82												
			6/28/00 12:03	7.49	3.27	5.0					390	900	1,290	0.040	120	5	
			8/8/00 12:11	7.70	5.23	1.0					250	810	1,060	0.020	50	6	
			8/21/00 9:39	7.57	5.25												
			8/21/00 9:40	7.55	5.44						228	1,180	1,408	0.041	77	6	
			9/27/00 12:08	7.64	6.38	2.0					130	1,100	1,230	0.020	60	4	
			10/18/00 10:11	7.33	4.45	1.0					270	950	1,220	0.020	40	3	
			11/21/00 13:09	7.75	6.57	2.0					160	1,280	1,440	0.050	110	4	
			1/11/01 9:34	7.73	7.87	1.0					200	770	970	0.020	40	5	
			2/13/01 11:55	7.50	4.49	1.0					150	960	1,110	0.020	40	4	
			3/7/01 11:48	7.66	7.79	2.0					210	930	1,140	0.020	70	5	
			4/11/01 12:02	7.58	6.69	3.0					170	1,360	1,530	0.020	120	7	

WaterBodyName	Saint Joes Creek																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-08	JOES CREEK	PINELLAS	5/2/01 10:27	7.16	4.00	15.0					40	1,580	1,620	0.020	220	17	
			6/6/01 10:45	7.35	3.26	6.0					20	1,770	1,790	0.110	310	12	
			7/3/01 11:24	7.51	4.66												
			7/3/01 11:25	7.44	4.08	2.0					160	930	1,090	0.020	80	4	
			8/1/01 12:13	7.49	3.87	4.0					90	1,310	1,400	0.030	140	6	
			9/20/01 12:48	7.56	5.27	3.0					370	1,580	1,950	0.020	100	23	
			10/17/01 12:16	7.60	5.84	3.0					270	850	1,120	0.020	100	7	
			11/19/01 13:10	7.64	0.00	2.0					260	780	1,040	0.020	80	4	
			1/3/02 11:49	7.75	7.02	12.0					470	1,020	1,490	0.040	130	24	
			2/11/02 12:19	7.71	5.35	1.0					430	900	1,330	0.020	100	6	
			3/4/02 11:00	7.45	7.05						180	940	1,120	0.060	220	8	
			4/9/02 12:11	7.66	3.20	2.0					160	1,110	1,270	0.100	280	6	
			5/1/02 12:57	7.22	2.51												
			5/1/02 12:59	7.27	2.54	7.0					20	1,520	1,540	0.370	930	30	
			6/5/02 13:02	7.50	0.50												
			6/5/02 13:03	7.60	1.25	3.0					20	980	1,000	0.270	440	5	
			6/26/02 12:03	7.30	2.25												
			6/26/02 12:04	7.34	3.36												
			6/26/02 12:05	7.48	3.65	1.0					30	1,220	1,250	0.180	450	9	
			7/31/02 9:46	7.03	3.36												
			7/31/02 9:47	7.13	1.85	1.0					220	1,040	1,260	0.030	120	6	
			8/21/02 12:27	7.31	3.16												
			8/21/02 12:28	7.39	3.40	2.0					210	980	1,190	0.020	100	3	
			9/25/02 12:55	7.51	3.69	2.0					290	1,050	1,340	0.020	140	11	
			10/16/02 10:20	7.44	3.78	2.0					250	820	1,070	0.050	100	4	
			11/20/02 12:40	7.58	5.90	1.0					370	780	1,150	0.020	70	2	
35-09	Joe's Creek	PINELLAS	2/10/99 11:31	7.60	4.27	1.0					40	540	580	0.060	90	2	
			4/7/99 11:13	7.59	5.22	1.0					20	560	580	0.050	90	1	
			6/2/99 11:47	7.65	3.07	1.0					20	750	770	0.130	150	8	
			7/28/99 11:12	7.56	4.93	1.0					20	670	690	0.020	70	1	
			9/22/99 11:58	7.70	6.85	2.0					280	680	960	0.040	120	1	
			11/15/99 12:44	7.90	9.54	1.0					20	490	510	0.020	20	1	
			2/16/00 13:08	7.66	9.13	1.0					30	710	740	0.020	30	3	
			4/12/00 11:16	7.60	5.05	1.0					20	940	960	0.030	120	2	
			6/8/00 11:39	7.64	0.65	4.0					20	1,490	1,510	0.120	250	8	
			8/8/00 11:40	7.62	5.71	1.0					110	820	930	0.020	60	1	
			9/27/00 11:36	7.53	5.23												
			9/27/00 11:37	7.48	5.05	1.0					330	820	1,150	0.060	90	1	
			11/21/00 12:28	7.62	6.34												
			11/21/00 12:29	7.58	6.20	1.0					60	750	810	0.020	40	1	
			2/13/01 11:34	7.51	4.99	2.0					60	740	800	0.020	60	4	

WaterBodyName	Saint Joes Creek																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-09	Joe's Creek	PINELLAS	4/11/01 11:25	7.43	5.52	1.0					20	690	710	0.020	60	2	
			6/6/01 11:22	7.32	1.94	2.0					20	920	940	0.020	80	1	
			8/1/01 11:50	7.47	5.08	2.0					220	830	1,050	0.060	110	3	
			8/1/01 11:51	7.71	6.82												
			9/20/01 12:11	7.50	7.13	1.0					260	950	1,210	0.020	120	38	
			11/19/01 11:33	7.59	0.00	1.0					50	870	920	0.020	60	5	
			2/11/02 11:50	7.57	5.76												
			2/11/02 11:53	7.56	6.69						160	820	980	0.020	60	1	
			4/9/02 11:40	7.60	4.60	1.0					20	770	790	0.020	80	2	
			6/5/02 12:22	7.57	4.22	1.0					20	890	910	0.110	120	4	
			7/31/02 10:01	7.32	3.99	1.0					80	760	840	0.020	60	1	
			9/25/02 12:11	7.62	4.36	2.0					270	1,230	1,500	0.020	320	15	
			11/20/02 12:02	7.66	6.80	1.0					270	720	990	0.020	80	2	
			1/7/03 12:50	7.72	10.31						520	790	1,310	0.020	50	1	
			3/4/03 12:50	7.46	6.82												
			3/4/03 12:51	7.41	6.55						250	960	1,210	0.020	100	1	
			4/10/03 12:10	7.72	7.82						170	820	990	0.020	110	4	
			5/19/03 12:05	7.53	5.66						20	860	880	0.020	60	1	
			7/1/03 11:21	7.21	7.88												
			7/1/03 11:22	7.24	8.37						150	680	830	0.050	90	1	
			8/12/03 12:22	7.32	5.68												
			8/12/03 12:23	7.32	5.74						370	960	1,330	0.080	130	2	
			9/23/03 12:35	7.50	5.30						150	650	800	0.020	80	1	
			11/3/03 13:29	7.76	6.35												
			11/3/03 13:30	7.78	6.52						130	690	820	0.020	60	2	
			12/8/03 10:58	7.62	7.99						240	630	870	0.020	20	7	
			1/21/04 11:25	7.49	7.61												
			1/21/04 11:26	7.45	7.62						180	960	1,140	0.020	100	3	
			3/2/04 12:05	7.58	8.71						300	630	930	0.040	60	2	
			4/15/04 11:28	7.61	7.59												
			4/15/04 11:29	7.64	7.38						170	600	770	0.020	70	2	
			5/24/04 11:22	7.51	4.66						20	1,100	1,120	0.060	120	9	
			6/30/04 11:27	7.62	5.82												
			6/30/04 11:28	7.53	5.57						50	1,070	1,120	0.060	120	13	
			8/11/04 11:49	7.37	6.57												
			8/11/04 11:50	7.37	6.37						300	740	1,040	0.060	100	4	
			9/22/04 10:10	7.47	4.45						320	900	1,220	0.050	100	4	
			11/8/04 8:24	7.48	5.38						350	870	1,220	0.030	60	4	
			12/9/04 12:09	7.51	6.05						340	710	1,050	0.050	110	10	
			1/19/05 11:53	7.51	8.38						200	660	860	0.020	50	5	640
			3/3/05 12:08	7.56	7.29	3.0					130	640	770	0.040	60	2	20

WaterBodyName	Saint Joes Creek																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-09	Joe's Creek	PINELLAS	4/14/05 12:36	7.58	7.33						90	820	910	0.040	40	3	20
			5/19/05 10:55	7.52	4.64	1.0					90	830	920	0.040	60	3	10
			7/5/05 13:10	7.84	9.37						160	830	990	0.050	40	1	10
			8/15/05 10:37	7.50	4.64	1.0					160	900	1,060	0.060	80	1	4
			9/19/05 11:21	7.51	4.22						90	860	950	0.040	60	2	4
			10/31/05 11:06	7.55	6.13	1.0					120	1,090	1,210	0.030	40	1	3
			11/16/05 10:38	7.51	4.60						140	1,300	1,440	0.040	50	1	4
			1/19/06 11:23	7.71	7.90						50	810	860	0.030	20	1	4
			3/2/06 11:47	7.67	8.04	1.0					90	570	660	0.030	50	1	240
			4/10/06 11:06	7.44	5.71						30	890	920	0.020	50	2	
			5/10/06 11:52	7.55	4.99	4.0					20	910	930	0.050	110	3	6,600
			7/20/06 10:58	7.44	5.33						130	920	1,050	0.050	80	3	4,300
			8/7/06 13:23	7.93	7.86	2.0					40	840	880	0.020	40	3	2,700
			9/14/06 11:32	7.32	6.30						320	880	1,200	0.060	100	3	6,900
			10/31/06 11:28	7.29	4.65	2.0					120	770	890	0.030	40	6	2,100
			11/29/06 11:54	7.49	6.50						300	1,420	1,720	0.060	90	2	
			1/23/07 13:10	7.71	7.71						120	680	800	0.040	50	2	1,600
			2/22/07 13:22	7.82	7.81	2.0					70	830	900	0.020	50	1	170
			4/10/07 12:30	7.50	5.88												
			4/10/07 12:31	7.52	5.66						50	730	780	0.060	50	3	
			5/23/07 10:34	7.75	3.19	2.0					20	950	970	0.060	90	6	2,000
			5/23/07 10:35	7.71	3.04												
			6/25/07 13:20	7.70	5.93						30	660	690	0.020	70	7	2,400
			8/2/07 13:23	7.65	4.81	4.0					110	1,900	2,010	0.150	640	410	1
			8/2/07 13:24	7.65	4.92												
			8/2/07 13:25	7.61	4.95												
			9/13/07 13:14	7.62	6.36						110	540	650	0.030	80	4	9,900
			10/10/07 12:57	7.85	5.48	3.0					200	960	1,160	0.040	90	8	5,100
			12/4/07 13:14	7.67	6.36						50	670	720	0.030	20	2	540
			2/4/08 11:45	7.55	6.16						120	850	970	0.030	60	15	
			3/20/08 11:33	7.65	5.55	3.0					30	810	840	0.040	80	4	2,000
			5/1/08 12:44	7.62	5.65						20	630	650	0.030	40	2	170
			7/1/08 10:23	7.53	4.38	2.0					20	600	620	0.040	50	2	580
			8/7/08 14:22	7.61	9.01						240	1,030	1,270	0.060	110	2	3,100
			9/9/08 11:35	7.82	5.28	3.0					100	680	780	0.020	30	4	400
			10/22/08 13:02	7.71	6.25						20	620	640	0.060	190	22	
			12/18/08 12:06	7.58	4.25	3.0					150	900	1,050	0.040	90	5	430
			1/27/09 10:59	7.60	5.19						50	860	910	0.020	100	6	290
			4/8/09 12:14	7.60	4.76	4.0					40	740	780	0.040	60	16	230
35-10	Joe's Creek	PINELLAS	1/7/03 11:38	7.47	8.62						470	660	1,130	0.020	40	3	
			3/4/03 13:56	7.34	6.55						160	770	930	0.020	60	1	

WaterBodyName: Saint Joes Creek

Average of Result_Value — Parameter

StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-10	Joe's Creek	PINELLAS	4/10/03 10:56	7.53	6.50						120	740	860	0.020	70	4	
			5/19/03 10:46	7.25	6.25						80	900	980	0.020	90	3	
			7/1/03 10:05	6.97	6.18												
			7/1/03 10:06	6.94	6.38						170	660	830	0.020	60	4	
			8/12/03 11:05	7.18	6.41						290	910	1,200	0.050	120	4	
			9/23/03 14:07	7.18	6.09						250	560	810	0.020	60	1	
			11/3/03 12:26	7.22	5.91						290	540	830	0.020	60	2	
			12/8/03 9:52	7.23	6.90						200	460	660	0.020	30	2	
			1/21/04 10:16	7.37	7.65						200	680	880	0.020	70	4	
			3/2/04 13:32	7.32	9.63						230	430	660	0.030	50	3	
			4/15/04 13:12	7.32	7.64						150	670	820	0.020	70	2	
			5/24/04 12:12	6.18	7.18						20	570	590	0.020	60	3	
			6/30/04 12:35	7.51	7.51						60	760	820	0.040	70	3	
			8/11/04 10:52	7.18	5.93												
			8/11/04 10:53	7.13	5.82						210	510	720	0.020	50	1	
			9/22/04 11:00	7.19	5.77						260	620	880	0.020	50	2	
			11/8/04 9:35	7.28	6.46						220	480	700	0.020	30	1	
			12/9/04 10:40	7.06	5.19						250	500	750	0.020	30	1	
			1/19/05 10:28	7.30	8.00						180	490	670	0.020	20	1	100
			3/3/05 10:22	7.55	7.33	3.0					100	420	520	0.020	40	1	120
			4/14/05 11:02	7.52	7.40						20	580	600	0.020	40	5	80
			5/19/05 9:24	7.18	3.76	2.0					20	530	550	0.020	50	2	80
			7/5/05 10:50	7.35	6.10						20	940	960	0.020	70	7	1,400
			8/15/05 11:37	7.07	5.51	2.0					150	680	830	0.020	70	2	3,500
			9/19/05 9:48	7.04	3.67						60	470	530	0.020	50	3	500
			10/31/05 9:54	7.07	5.47												
			10/31/05 9:55	7.02	5.17	1.0					140	950	1,090	0.020	40	1	920
			11/16/05 9:27	6.92	4.15						80	580	660	0.020	50	1	57
			1/19/06 10:50	7.22	7.67						30	650	680	0.020	60	3	43
			3/2/06 10:40	7.18	6.51	2.0					100	360	460	0.020	60	2	97
			4/10/06 10:07	7.44	5.62						30	930	960	0.020	40	3	1,300
			5/10/06 13:52	7.54	6.58	4.0					20	850	870	0.030	90	4	1,000
			7/20/06 9:50	7.42	5.23						90	810	900	0.030	70	3	2,000
			8/7/06 12:19	5.55	7.53												
			8/7/06 12:20	5.45	7.33	2.0					90	860	950	0.020	20	2	1,200
			9/14/06 10:50	7.21	6.17						220	590	810	0.020	80	2	18,000
			10/31/06 10:21	6.93	5.43	2.0					200	770	970	0.020	40	1	370
			11/29/06 10:29	7.07	5.24						200	540	740	0.020	50	1	930
			1/23/07 10:58	7.25	4.45						250	990	1,240	0.070	130	3	
			2/22/07 14:58	7.71	12.00	2.0					60	550	610	0.020	30	1	230
			4/10/07 10:53	7.11	2.55						110	590	700	0.030	60	1	

WaterBodyName	Saint Joes Creek																
Average of Result_Value				Parameter													
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-10	Joe's Creek	PINELLAS	5/23/07 14:00	7.71	7.54	2.0					20	390	410	0.020	50	2	230
			6/25/07 11:35	7.48	5.92						20	440	460	0.020	50	1	540
			8/2/07 11:19	7.61	6.53	3.0					80	850	930	0.040	150	42	5
			9/13/07 10:35	7.48	6.16						80	560	640	0.040	70	2	19,000
			10/10/07 11:16	7.63	5.06	2.0					100	500	600	0.020	60	2	540
			12/4/07 10:18	7.35	3.62						180	510	690	0.020	30	4	73
			2/4/08 10:16	7.10	5.08						140	460	600	0.020	50	1	
			3/20/08 9:48	7.58	4.16	4.0					80	640	720	0.050	100	1	
			5/1/08 10:45	7.38	4.17						20	390	410	0.020	20	1	33
			7/1/08 13:35	7.78	6.81	2.0					20	530	550	0.030	60	1	450
			8/7/08 11:12	7.24	6.66						80	760	840	0.020	50	4	1,800
			9/9/08 14:36	7.34	7.50	4.0					90	600	690	0.020	30	5	170
			10/22/08 11:03	7.18	3.38						20	610	630	0.060	80	14	
			12/18/08 13:20	7.27	5.09	2.0					130	540	670	0.020	40	2	60
			1/27/09 9:54	7.18	5.55						60	400	460	0.020	50	2	120
			4/8/09 10:35	7.43	4.53	3.0					20	550	570	0.020	80	1	94
35-11	Joe's Creek	PINELLAS	1/7/03 11:23	7.68	8.42						340	710	1,050	0.020	50	4	
			3/4/03 14:21	7.45	7.72						20	950	970	0.020	80	5	
			3/4/03 14:22	7.37	7.47												
			4/10/03 10:40	7.62	5.39						40	850	890	0.020	90	8	
			4/10/03 10:42	7.76	5.84												
			5/19/03 10:30	7.55	5.74												
			5/19/03 10:31	7.56	6.06						20	1,000	1,020	0.020	90	9	
			7/1/03 9:43	7.19	6.29												
			7/1/03 9:44	7.19	6.79						50	940	990	0.020	90	9	
			8/12/03 10:44	7.27	4.78						220	860	1,080	0.050	120	6	
			8/12/03 10:45	7.24	5.08												
			9/23/03 14:41	7.30	4.82						90	770	860	0.020	70	6	
			11/3/03 11:51	7.45	5.00												
			11/3/03 11:53	7.32	4.27						80	760	840	0.020	70	6	
			12/8/03 9:36	7.72	7.86												
			12/8/03 9:37	7.63	7.72						20	1,070	1,090	0.020	100	12	
			1/21/04 9:46	7.48	6.03												
			1/21/04 9:47	7.37	5.81						200	920	1,120	0.020	80	6	
			3/2/04 13:43	7.45	8.63						200	490	690	0.020	40	7	
			4/15/04 13:46	7.59	6.88						100	750	850	0.020	70	10	
			5/24/04 13:38	7.28	4.72												
			5/24/04 13:39	7.30	5.52						20	1,090	1,110	0.020	120	9	
			6/30/04 13:08	7.78	7.32						20	1,320	1,340	0.020	90	13	
			8/11/04 10:32	7.29	6.33												
			8/11/04 10:33	7.24	6.22						86	840	926	0.020	70	8	

WaterBodyName: Saint Joes Creek

Average of Result_Value

StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-11	Joe's Creek	PINELLAS	9/22/04 10:43	7.33	4.34						100	850	950	0.020	50	4	
			9/22/04 10:44	7.28	3.72												
			11/8/04 10:07	7.40	4.83						30	690	720	0.020	40	2	
			12/9/04 10:05	7.25	4.96												
			12/9/04 10:06	7.20	4.96						140	650	790	0.020	40	3	
			1/19/05 10:06	7.50	8.75												
			1/19/05 10:07	7.43	8.31						20	600	620	0.030	30	1	20
			3/3/05 11:04	7.70	6.00	4.0					20	700	720	0.020	70	3	20
			4/14/05 10:34	7.78	4.56												
			4/14/05 10:35	7.64	5.10						20	1,130	1,150	0.020	110	12	80
			5/19/05 9:01	7.20	1.46												
			5/19/05 9:02	7.24	1.64	4.0					20	1,400	1,420	0.030	140	7	180
			7/5/05 10:24	7.68	5.83												
			7/5/05 10:25	7.57	6.00						20	1,050	1,070	0.020	90	11	650
			8/15/05 11:16	7.18	4.46	4.0					60	970	1,030	0.020	90	9	3,500
			9/19/05 9:06	7.04	3.51						20	710	730	0.030	50	3	640
			10/31/05 10:31	7.21	6.40	1.0					40	1,030	1,070	0.020	50	5	460
			11/16/05 9:12	7.21	4.95												
			11/16/05 9:13	7.13	4.94						30	870	900	0.030	70	3	28
			1/19/06 9:43	7.60	7.84												
			1/19/06 9:44	7.64	7.93						20	940	960	0.020	70	8	120
			3/2/06 10:16	7.50	7.06												
			3/2/06 10:17	7.41	6.59	2.0					20	540	560	0.020	40	2	26
			4/10/06 9:41	7.55	5.03						20	790	810	0.020	20	4	420
			5/10/06 14:26	7.80	7.66												
			5/10/06 14:27	7.95	8.80	7.0					20	980	1,000	0.020	80	4	
			7/20/06 9:29	7.53	4.94												
			7/20/06 9:30	7.29	4.51						30	930	960	0.020	80	5	3,700
			8/7/06 11:51	4.34	7.07	2.0					20	800	820	0.020	60	4	1,400
			9/14/06 9:42	6.97	4.13												
			9/14/06 9:43	6.91	4.01						110	760	870	0.020	60	4	2,500
			10/31/06 10:54	7.02	5.34	4.0					100	730	830	0.030	60	1	33
			11/29/06 10:08	7.37	5.25						110	630	740	0.030	50	3	1,400
			1/23/07 10:31	7.50	6.35												
			1/23/07 10:32	7.43	6.27						50	790	840	0.020	50	4	100
			2/22/07 14:13	7.74	9.28	2.0					80	720	800	0.020	70	1	33
			2/22/07 14:14	7.65	9.53												
			4/10/07 11:41	7.43	4.88						30	540	570	0.020	70	2	80
			4/10/07 11:43	7.40	4.90												
			5/23/07 14:34	7.49	4.19	2.0					20	740	760	0.040	70	3	750
			6/25/07 11:01	7.48	3.22												

WaterBodyName	Saint Joes Creek																
Average of Result_Value			Parameter														
StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-11	Joe's Creek	PINELLAS	6/25/07 11:02	7.44	3.15						20	650	670	0.040	90	3	1,100
			8/2/07 12:02	7.63	5.66	3.0					90	530	620	0.040	90	20	5
			8/2/07 12:03	7.60	5.53												
			9/13/07 10:10	7.52	4.60						40	570	610	0.040	80	4	19,000
			10/10/07 10:53	7.90	3.87	2.0					50	830	880	0.050	80	2	450
			12/4/07 9:53	7.70	5.12						90	730	820	0.030	40	2	240
			2/4/08 9:51	7.45	5.81						80	750	830	0.020	60	2	
			2/4/08 9:52	7.39	5.70												
			3/20/08 10:47	7.67	4.49	2.0					20	550	570	0.030	60	1	23
			5/1/08 10:16	7.61	5.62						20	560	580	0.030	60	1	37
			7/1/08 13:01	7.87	5.05	3.0					20	840	860	0.030	70	6	
			7/1/08 13:02	7.85	4.78												
			8/7/08 10:24	7.43	6.83						20	810	830	0.020	60	6	600
			8/7/08 10:25	7.43	6.83												
			9/9/08 15:08	8.08	9.46	7.0					20	1,040	1,060	0.020	60	10	13
			10/22/08 10:04	7.59	5.09						20	760	780	0.020	70	13	
			10/22/08 10:22	7.64	4.64						20	760	780	0.020	170	18	
			12/18/08 12:41	7.64	7.07	2.0					40	640	680	0.020	50	3	40
			4/8/09 10:01	7.77	6.28	4.0					20	760	780	0.020	40	6	43
			4/8/09 10:02	7.71	6.83												
35-12	Joe's Creek	PINELLAS	1/7/03 12:26	7.42	9.51						370	750	1,120	0.020	50	2	
			3/4/03 13:26	7.26	7.59						310	970	1,280	0.020	60	2	
			4/10/03 11:24	7.50	7.42						250	750	1,000	0.020	60	3	
			5/19/03 11:11	7.30	7.19						80	1,020	1,100	0.020	130	6	
			7/1/03 10:44	6.89	6.44												
			7/1/03 10:45	6.88	6.64						240	730	970	0.020	60	3	
			8/12/03 11:29	7.19	6.21												
			8/12/03 11:30	7.15	5.89						310	1,110	1,420	0.050	130	6	
			9/23/03 13:27	7.25	6.31						340	720	1,060	0.020	60	2	
			11/3/03 12:48	7.27	6.86						290	620	910	0.020	60	4	
			1/21/04 10:55	7.36	8.11												
			1/21/04 10:56	7.26	7.78						310	810	1,120	0.020	70	9	
			3/2/04 12:30	7.40	10.76						280	580	860	0.030	40	1	
			4/15/04 12:29	7.55	10.18												
			4/15/04 12:30	7.51	10.17						250	600	850	0.020	40	2	
			5/24/04 12:56	8.89	7.45						20	540	560	0.020	30	1	
			6/30/04 12:03	7.36	5.29						30	750	780	0.100	120	1	
			8/11/04 11:17	7.16	5.84												
			8/11/04 11:18	7.08	5.64						260	610	870	0.040	60	2	
			9/22/04 11:30	6.18	7.14						280	700	980	0.030	50	1	
			11/8/04 9:06	7.12	5.25						190	500	690	0.020	30	1	

WaterBodyName: Saint Joes Creek

Average of Result_Value — Parameter

StationID	StationName	DataSource	SampleDate	pH	DO_mgl	BOD5_mgl	Color_pcu	NH3_N_ugl	NO2_ugl	NO3_ugl	Nox_ugl	TKN_UGL	TN_ugl	OP_mgl	TP_ugl	TSS_mgl	Fcoli_100ml
35-12	Joe's Creek	PINELLAS	12/9/04 11:21	7.17	5.99						180	540	720	0.020	100	14	
			1/19/05 11:11	7.22	7.37												
			1/19/05 11:12	7.24	7.34						380	810	1,190	0.020	40	1	560
			3/3/05 9:40	7.38	5.97	3.0					220	560	780	0.020	50	1	2,100
			4/14/05 11:43	7.48	7.75						190	640	830	0.030	40	2	620
			5/19/05 10:01	7.25	4.87	2.0					140	1,080	1,220	0.030	80	3	440
			7/5/05 11:43	7.25	6.59						180	750	930	0.040	70	1	860
			8/15/05 12:02	7.06	4.88	2.0					250	1,150	1,400	0.050	110	4	5,300
			9/19/05 10:27	7.15	3.71						180	810	990	0.020	60	2	400
			10/31/05 9:13	7.20	5.18	1.0					220	1,200	1,420	0.030	70	3	660
			11/16/05 10:03	7.19	4.66						210	1,080	1,290	0.030	70	2	86
			1/19/06 10:14	7.23	6.56						250	830	1,080	0.020	40	2	330
			3/2/06 11:04	7.35	8.57	2.0					290	500	790	0.020	50	2	690
			4/10/06 10:33	7.21	4.17						90	1,120	1,210	0.020	80	4	
			5/10/06 12:44	7.25	4.20	7.0					180	1,380	1,560	0.080	270	3	7,300
			7/20/06 10:18	7.32	4.73						290	1,030	1,320	0.040	80	2	5,100
			8/7/06 12:41	8.01	7.41	2.0					200	880	1,080	0.030	50	3	4,100
			9/14/06 10:15	7.13	4.60						300	790	1,090	0.020	100	7	16,000
			10/31/06 9:45	7.08	5.82	4.0					320	950	1,270	0.020	50	3	1,900
			11/29/06 10:57	7.26	6.38						290	590	880	0.030	50	3	1,200
			1/23/07 11:30	7.39	6.23						200	940	1,140	0.040	100	4	7,600
			2/22/07 15:22	7.88	13.79	3.0					240	950	1,190	0.020	150	3	270
			4/10/07 9:43	7.15	1.22						50	860	910	0.050	110	4	
			5/23/07 11:29	8.06	4.58	2.0					20	650	670	0.020	60	4	170
			6/25/07 12:03	7.34	4.76						120	630	750	0.030	100	3	700
			8/2/07 9:46	7.74	6.58												
			8/2/07 9:48	7.73	6.56	2.0					90	360	450	0.090	130	19	5
			9/13/07 11:19	7.34	2.45												
			9/13/07 11:20	7.24	2.32						300	1,000	1,300	0.200	220	1	0
			10/10/07 11:45	7.71	5.45	2.0					220	710	930	0.040	70	2	1,200
			12/4/07 11:05	7.38	5.93						180	530	710	0.020	30	2	170
			2/4/08 10:46	7.24	6.37						330	760	1,090	0.040	80	4	
			3/20/08 9:05	7.62	4.65	12.0					290	1,850	2,140	0.250	380	7	
			5/1/08 11:15	7.42	6.47						50	510	560	0.020	40	1	100
			7/1/08 14:07	7.46	9.44	3.0					240	870	1,110	0.040	120	6	
			8/7/08 12:09	7.13	6.73						340	780	1,120	0.020	60	4	3,500
			9/9/08 13:20	7.50	7.07	3.0					210	830	1,040	0.020	50	6	530
			10/22/08 11:41	7.36	5.30						20	1,160	1,180	0.020	160	16	
			12/18/08 13:01	7.34	7.24	2.0					320	680	1,000	0.030	60	3	1,600
			1/27/09 9:18	7.22	4.19						180	710	890	0.020	50	4	800
			4/8/09 11:21	7.53	5.36	4.0					140	730	870	0.050	90	4	330

APPENDIX B

FIELD AND LABORATORY QA / QC DATA

METHOD BLANK RECOVERY STUDY

PARAMETERS	UNITS	DATE ANALYZED	MEASURED CONC.	MDL
Alkalinity	mg/l	07/17/08	1.0	0.5
Alkalinity	mg/l	07/18/08	1.0	0.5
Alkalinity	mg/l	08/01/08	1.0	0.5
Alkalinity	mg/l	08/01/08	1.0	0.5
Alkalinity	mg/l	08/18/08	1.0	0.5
Alkalinity	mg/l	08/29/08	1.0	0.5
Alkalinity	mg/l	09/02/08	1.0	0.5
Alkalinity	mg/l	09/10/08	1.0	0.5
Alkalinity	mg/l	09/10/08	1.0	0.5
Alkalinity	mg/l	09/24/08	1.0	0.5
Alkalinity	mg/l	09/24/08	1.0	0.5
Turbidity	NTU	07/17/08	0.1	0.1
Turbidity	NTU	07/31/08	0.1	0.1
Turbidity	NTU	08/14/08	0.1	0.1
Turbidity	NTU	08/28/08	0.1	0.1
Turbidity	NTU	08/28/08	0.1	0.1
Turbidity	NTU	09/10/08	0.1	0.1
Turbidity	NTU	09/24/08	0.1	0.1
Turbidity	NTU	09/24/08	0.1	0.1
TSS	mg/l	07/18/08	0.2	0.7
TSS	mg/l	07/31/08	0.3	0.7
TSS	mg/l	08/13/08	0.2	0.7
TSS	mg/l	08/14/08	0.2	0.7
TSS	mg/l	08/14/08	0.3	0.7
TSS	mg/l	08/31/08	0.2	0.7
TSS	mg/l	09/10/08	0.3	0.7
TSS	mg/l	09/24/08	0.3	0.7
SRP	µg/l	09/24/08	<1	1
SRP	µg/l	09/25/08	<1	1
SRP	µg/l	08/01/08	<1	1
SRP	µg/l	08/01/08	<1	1
SRP	µg/l	08/14/08	<1	1
SRP	µg/l	08/14/08	<1	1
SRP	µg/l	08/30/08	<1	1
SRP	µg/l	08/30/08	1	1
NOX-N	µg/l	09/24/08	<1	5
NOX-N	µg/l	09/25/08	1	5
NOX-N	µg/l	08/01/08	1	5
NOX-N	µg/l	08/01/08	<1	5
NOX-N	µg/l	08/14/08	<1	5
NOX-N	µg/l	08/14/08	<1	5
NOX-N	µg/l	08/30/08	<1	5
NOX-N	µg/l	08/30/08	<1	5

METHOD BLANK RECOVERY STUDY

PARAMETERS	UNITS	DATE ANALYZED	MEASURED CONC.	MDL
Ammonia	µg/l	08/05/08	1	5
Ammonia	µg/l	08/05/08	2	5
Ammonia	µg/l	08/06/08	<1	5
Ammonia	µg/l	08/06/08	1	5
Ammonia	µg/l	08/06/08	2	5
Ammonia	µg/l	08/28/08	1	5
Ammonia	µg/l	08/28/08	2	5
Ammonia	µg/l	09/04/08	3	25
Total N	µg/l	08/04/08	4	25
Total N	µg/l	08/04/08	4	25
Total N	µg/l	08/04/08	2	25
Total N	µg/l	08/27/08	5	25
Total N	µg/l	08/27/08	4	25
Total N	µg/l	09/08/08	2	25
Total N	µg/l	09/08/08	5	25
Total N	µg/l	09/08/08	5	25
Total N	µg/l	09/08/08	3	25
Total P	µg/l	08/04/08	<1	1
Total P	µg/l	08/04/08	<1	1
Total P	µg/l	08/04/08	<1	1
Total P	µg/l	08/27/08	<1	1
Total P	µg/l	08/27/08	<1	1
Total P	µg/l	09/08/08	<1	1
Total P	µg/l	09/08/08	<1	1
Total P	µg/l	09/08/08	<1	1
Total P	µg/l	09/08/08	<1	1
Color	PCU	07/16/08	<1	1
Color	PCU	07/16/08	<1	1
Color	PCU	07/18/08	<1	1
Color	PCU	08/01/08	<1	1
Color	PCU	08/01/08	<1	1
Color	PCU	08/14/08	<1	1
Color	PCU	08/14/08	<1	1
Color	PCU	08/28/08	<1	1
Color	PCU	08/28/08	<1	1
Color	PCU	08/28/08	<1	1
Color	PCU	09/10/08	<1	1
Color	PCU	09/10/08	<1	1
Color	PCU	09/10/08	<1	1
Color	PCU	09/24/08	<1	1
Color	PCU	09/24/08	<1	1

CONTINUING CALIBRATION VERIFICATION RECOVERY STUDY

PARAMETERS	UNITS	DATE ANALYZED	INITIAL CONC.	INITIAL VOLUME (ml)	SPIKE CONC.	SPIKE VOLUME ADDED (ml)	FINAL CONC.	MEASURED CONC.	PERCENT RECOVERY	ACCEPT RANGE
TSS	mg/l	07/18/08	0.2	1000	32.3	1000	32.5	32.3	99%	91-105
TSS	mg/l	07/31/08	0.2	1000	33.4	1000	33.6	33.4	99%	91-105
TSS	mg/l	08/13/08	0.3	1000	31.1	1000	31.4	31.1	99%	91-105
TSS	mg/l	08/14/08	0.2	1000	32.3	1000	32.5	32.3	99%	91-105
TSS	mg/l	08/14/08	0.3	1000	31.1	1000	31.4	31.1	99%	91-105
TSS	mg/l	08/31/08	0.2	1000	32.3	1000	32.5	32.3	99%	91-105
TSS	mg/l	09/10/08	0	10	10000	0.225	225.0	218	97%	91-105
TSS	mg/l	09/24/08	0	10	10000	0.200	200.0	202	101%	91-105
TSS	µg/l	09/24/08	0	10	10000	0.400	400.0	410	103%	91-105
SRP	µg/l	09/24/08	0	10	10000	0.225	225.0	211	94%	92-111
SRP	µg/l	09/25/08	0	10	10000	0.100	100.0	99	99%	92-111
SRP	µg/l	08/01/08	0	10	10000	0.225	225.0	229	102%	92-111
SRP	µg/l	08/01/08	0	10	10000	0.400	400.0	388	97%	92-111
SRP	µg/l	08/14/08	0	10	10000	0.400	400.0	388	97%	92-111
SRP	µg/l	08/14/08	0	10	100000	0.200	2000.0	1918	96%	92-111
SRP	µg/l	08/30/08	0	10	100000	0.200	2000.0	1936	97%	92-111
SRP	µg/l	08/30/08	0	10	100000	0.150	1500.0	1480	99%	92-111
NOX-N	µg/l	09/24/08	0	10	100000	0.200	2000.0	1860	93%	92-108
NOX-N	µg/l	09/25/08	0	10	100000	0.100	1000.0	976	98%	92-108
NOX-N	µg/l	08/01/08	0	10	100000	0.100	1000.0	966	97%	92-108
NOX-N	µg/l	08/01/08	0	10	100000	0.400	4000.0	3711	93%	92-108
NOX-N	µg/l	08/14/08	0	10	100000	0.400	4000.0	3711	93%	92-108
NOX-N	µg/l	08/14/08	0	10	100000	0.300	3000.0	3018	101%	92-108
NOX-N	µg/l	08/30/08	0	10	100000	0.100	1000.0	1028	103%	92-108
NOX-N	µg/l	08/30/08	0	10	100000	0.100	1000.0	992	99%	92-108
Ammonia	µg/l	08/05/08	0	10	100000	0.300	3000.0	3018	101%	88-120
Ammonia	µg/l	08/05/08	0	10	100000	0.100	1000.0	1028	103%	88-120
Ammonia	µg/l	08/06/08	0	10	100000	0.100	1000.0	992	99%	88-120
Ammonia	µg/l	08/06/08	0	10	100000	0.100	1000.0	1028	103%	88-120
Ammonia	µg/l	08/06/08	0	10	100000	0.100	1000.0	992	99%	88-120
Ammonia	µg/l	08/28/08	0	5	22600	0.200	904.0	894	99%	88-120
Ammonia	µg/l	08/28/08	0	5	100000	0.200	4000.0	4096	102%	88-120
Ammonia	µg/l	09/04/08	0	5	100000	0.200	4000.0	3986	100%	88-120
Total N	µg/l	08/04/08	0	5	10000	0.500	1000.0	948	95%	92-110
Total N	µg/l	08/04/08	0	5	10000	0.050	100.0	104	104%	92-110
Total N	µg/l	08/04/08	0	5	200	5.000	200.0	190	95%	92-110
Total N	µg/l	08/27/08	0	5	8000	5.000	8000.0	7595	95%	92-110
Total N	µg/l	08/27/08	0	5	8000	5.000	8000.0	7595	95%	92-110
Total N	µg/l	09/08/08	0	5	10000	0.500	1000.0	1019	102%	92-110
Total N	µg/l	09/08/08	0	5	10000	0.050	100.0	93	93%	92-110
Total N	µg/l	09/08/08	0	5	10000	0.050	100.0	102	102%	92-110
Total N	µg/l	09/08/08	0	5	10000	0.500	1000.0	1042	104%	92-110
Total P	µg/l	08/04/08	0	5	10000	0.500	1000.0	954	95%	93-109
Total P	µg/l	08/04/08	0	5	10000	0.500	1000.0	1047	105%	93-109
Total P	µg/l	08/04/08	0	5	2000	5.000	2000.0	2043	102%	93-109
Total P	µg/l	08/27/08	0	5	2000	5.000	2000.0	2043	102%	93-109
Total P	µg/l	08/27/08	0.1	50	1000	0.9	18.1	17.9	99%	93-109
Total P	µg/l	09/08/08	0.1	50	1000	0.9	18.1	18.2	101%	93-109
Total P	µg/l	09/08/08	0.1	50	1000	0.9	18.1	17.9	99%	93-109
Total P	µg/l	09/08/08	0.1	50	1000	0.9	18.1	18.2	101%	93-109
Total P	µg/l	09/08/08	0.1	50	1000	0.9	18.1	17.9	99%	93-109

BLANK SPIKE RECOVERY STUDY

PARAMETERS	UNITS	DATE ANALYZED	INITIAL CONC.	FINAL VOLUME (ml)	SPIKE CONC.	SPIKE VOLUME ADDED (ml)	FINAL CONC.	MEASURED CONC.	PERCENT RECOVERY	ACCEPT RANGE
Alkalinity	mg/l	07/17/08	1.0	50	1000	0.5	11.0	10.8	98%	91-105
Alkalinity	mg/l	07/18/08	1.0	50	1000	0.5	11.0	10.6	96%	91-105
Alkalinity	mg/l	08/01/08	1.0	50	1000	0.5	11.0	10.4	95%	91-105
Alkalinity	mg/l	08/18/08	1.0	50	1000	0.5	11.0	10.4	95%	91-105
Alkalinity	mg/l	09/02/08	1.0	50	1000	0.5	11.0	10.6	96%	91-105
Alkalinity	mg/l	09/10/08	1.0	50	1000	0.5	11.0	10.8	98%	91-105
Alkalinity	mg/l	09/10/08	1.0	50	1000	0.5	11.0	10.2	93%	91-105
Alkalinity	mg/l	09/24/08	1.0	50	1000	0.5	11.0	10.4	95%	91-105
Turbidity	NTU	07/17/08	0	50	18	50	18.0	18.1	101%	87-104
Turbidity	NTU	07/31/08	0	50	18	50	18.0	18.2	101%	87-104
Turbidity	NTU	08/14/08	0	50	18	50	18.0	18.1	101%	87-104
Turbidity	NTU	08/28/08	0	50	18	50	18.0	18	100%	87-104
Turbidity	NTU	08/28/08	0	50	18	50	18.0	18	100%	87-104
Turbidity	NTU	09/10/08	0	50	18	50	18.0	18.2	101%	87-104
Turbidity	NTU	09/24/08	0	50	18	50	18.0	18.1	101%	87-104
Turbidity	NTU	09/24/08	0	50	18	50	18.0	18.1	101%	87-104
TSS	mg/l	07/18/08	0.2	1000	33.4	1000	33.6	33.4	99%	91-105
TSS	mg/l	07/31/08	0.3	1000	31.1	1000	31.4	31.1	99%	91-105
TSS	mg/l	08/13/08	0.2	1000	32.3	1000	32.5	32.3	99%	91-105
TSS	mg/l	08/14/08	0.2	1000	32.3	1000	32.5	32.3	99%	91-105
TSS	mg/l	08/14/08	0.2	1000	33.4	1000	33.6	33.4	99%	91-105
TSS	mg/l	08/31/08	0.3	1000	31.1	1000	31.4	31.1	99%	91-105
TSS	mg/l	09/10/08	0.2	1000	32.3	1000	32.5	32.3	99%	91-105
TSS	mg/l	09/24/08	0.3	1000	31.1	1000	31.4	31.1	99%	91-105
TSS	mg/l	09/24/08	0.2	1000	32.3	1000	32.5	32.3	99%	91-105
SRP	µg/l	09/24/08	0	10	10000	0.150	150	147	98%	92-111
SRP	µg/l	09/25/08	0	10	10000	0.125	125	126	101%	92-111
SRP	µg/l	08/01/08	0	10	10000	0.150	150	151	101%	92-111
SRP	µg/l	08/01/08	0	10	10000	0.150	150	149	99%	92-111
SRP	µg/l	08/14/08	0	10	10000	0.150	150	149	99%	92-111
SRP	µg/l	08/14/08	0	10	10000	0.150	150	152	101%	92-111
SRP	µg/l	08/30/08	0	10	10000	0.150	150	157	105%	92-111
SRP	µg/l	08/30/08	0	10	10000	0.175	175	170	97%	92-111
NOX-N	µg/l	09/24/08	0	10	9040	0.150	136	134	99%	92-108
NOX-N	µg/l	09/25/08	0	10	10000	0.150	150	145	97%	92-108
NOX-N	µg/l	08/01/08	0	10	10000	0.150	150	152	101%	92-108
NOX-N	µg/l	08/01/08	0	10	10000	0.150	150	153	102%	92-108
NOX-N	µg/l	08/14/08	0	10	10000	0.150	150	143	95%	92-108
NOX-N	µg/l	08/14/08	0	10	10000	0.150	150	149	99%	92-108
NOX-N	µg/l	08/30/08	0	10	9040	0.150	136	140	103%	92-108
NOX-N	µg/l	08/30/08	0	10	10000	0.150	150	149	99%	92-108
Ammonia	µg/l	08/05/08	0	10	100000	0.300	3000	2987	100%	88-120
Ammonia	µg/l	08/05/08	0	10	100000	0.100	1000	1033	103%	88-120
Ammonia	µg/l	08/06/08	0	10	100000	0.100	1000	1025	103%	88-120
Ammonia	µg/l	08/06/08	0	10	100000	0.300	3000	2987	100%	88-120
Ammonia	µg/l	08/06/08	0	10	100000	0.100	1000	1033	103%	88-120
Ammonia	µg/l	08/28/08	0	10	100000	0.100	1000	1025	103%	88-120
Ammonia	µg/l	08/28/08	0	10	100000	0.100	1000	1033	103%	88-120
Ammonia	µg/l	09/04/08	0	10	100000	0.100	1000	1025	103%	88-120

BLANK SPIKE RECOVERY STUDY

PARAMETERS	UNITS	DATE ANALYZED	INITIAL CONC.	FINAL VOLUME (ml)	SPIKE CONC.	SPIKE VOLUME ADDED (ml)	FINAL CONC.	MEASURED CONC.	PERCENT RECOVERY	ACCEPT RANGE
Total N	µg/l	08/04/08	0	5	6950	5.000	6950	6451	93%	92-110
Total N	µg/l	08/04/08	0	5	3475	5.000	3475	3248	93%	92-110
Total N	µg/l	08/04/08	0	5	6780	5.000	6780	6569	97%	92-110
Total N	µg/l	08/27/08	0	5	6780	5.000	6780	6819	101%	92-110
Total N	µg/l	08/27/08	0	5	6780	5.000	6780	6528	96%	92-110
Total N	µg/l	09/08/08	0	5	6780	5.000	6780	6730	99%	92-110
Total N	µg/l	09/08/08	0	5	6780	5.000	6780	6528	96%	92-110
Total N	µg/l	09/08/08	0	5	6780	5.000	6780	6730	99%	92-110
Total P	µg/l	09/08/08	0	5	383	5.000	383	374	98%	93-109
Total P	µg/l	08/04/08	0	5	400	5.000	400	392	98%	93-109
Total P	µg/l	08/04/08	0	5	400	5.000	400	417	104%	93-109
Total P	µg/l	08/04/08	0	5	450	5.000	450	443	98%	93-109
Total P	µg/l	08/27/08	0	5	1100	5.000	1100	1065	97%	93-109
Total P	µg/l	08/27/08	0	5	1100	5.000	1100	1064	97%	93-109
Total P	µg/l	09/08/08	0	5	1100	5.000	1100	1065	97%	93-109
Total P	µg/l	09/08/08	0	5	1100	5.000	1100	1064	97%	93-109
Color	PCU	09/08/08	0	25	500	4.0	80	73.1	91%	87-104
Color	PCU	09/08/08	0	25	500	4.0	80	74	93%	87-104
Color	PCU	07/18/08	0	25	500	4.0	80	74.6	93%	87-104
Color	PCU	08/01/08	0	25	500	4.0	80	72.9	91%	87-104
Color	PCU	08/01/08	0	25	500	4.0	80	72.9	91%	87-104
Color	PCU	08/14/08	0	25	500	4.0	80	80.1	100%	87-104
Color	PCU	08/14/08	0	25	500	4.0	80	80	100%	87-104
Color	PCU	08/28/08	0	25	500	4.0	80	77	96%	87-104
Color	PCU	08/28/08	0	25	500	4.0	80	77	96%	87-104
Color	PCU	09/10/08	0	25	500	4.0	80	77	96%	87-104
Color	PCU	09/10/08	0	25	500	4.0	80	77	96%	87-104
Color	PCU	09/24/08	0	25	500	4.0	80	73	91%	87-104
Color	PCU	09/24/08	0	25	500	4.0	80	74	93%	87-104

SAMPLE DUPLICATE RECOVERY

PARAMETERS	UNITS	SAMPLE ID	DATE ANALYZED	REPEAT 1	REPEAT 2	MEAN	s	% RELATIVE STD. DEVIATION (RSD)	ACCEPTANCE RANGE (% RSD)
Alkalinity	mg/l	08-1378	07/17/08	288	282	285.00	4.243	1.49	0-4
Alkalinity	mg/l	08-1388	07/18/08	8.6	8.8	8.70	0.141	1.63	0-4
Alkalinity	mg/l	08-1465	08/01/08	45.0	44.8	44.90	0.141	0.31	0-4
Alkalinity	mg/l	08-1476	08/01/08	77	77	76.80	0.283	0.37	0-4
Alkalinity	mg/l	08-1613	08/18/08	101	100	100.50	0.707	0.70	0-4
Alkalinity	mg/l	08-1749	08/29/08	392	393	392.50	0.707	0.18	0-4
Alkalinity	mg/l	08-1760	09/02/08	223	223	223.00	0.000	0.00	0-4
Alkalinity	mg/l	08-1919	09/10/08	243	244	243.50	0.707	0.29	0-4
Alkalinity	mg/l	08-1929	09/10/08	13.8	13.4	13.60	0.283	2.08	0-4
Alkalinity	mg/l	08-2107	09/24/08	105	105	105.00	0.000	0.00	0-4
Alkalinity	mg/l	08-2117	09/24/08	213	215	214.00	1.414	0.66	0-4
Alkalinity	mg/l	08-2119	09/24/08	258	256	257.00	1.414	0.55	0-4
Turbidity	NTU	08-1376	07/17/09	3.6	3.6	3.60	0.000	0.00	0-4
Turbidity	NTU	08-1473	07/31/08	6.1	6.3	6.20	0.141	2.28	0-4
Turbidity	NTU	08-1613	08/14/08	4	3.9	3.95	0.071	1.79	0-4
Turbidity	NTU	08-1762	08/28/08	3.4	3.3	3.35	0.071	2.11	0-4
Turbidity	NTU	08-1919	09/10/08	5.8	5.6	5.70	0.141	2.48	0-4
Turbidity	NTU	08-2114	09/24/08	3.4	3.2	3.32	0.113	3.41	0-4
Turbidity	NTU	08-2119	09/24/08	4.1	4.2	4.15	0.071	1.70	0-4
TSS	mg/l	08-1380	07/18/08	1.9	1.7	1.80	0.078	4.33	0-5
TSS	mg/l	08-1472	07/31/08	11.0	11.5	11.25	0.354	3.14	0-5
TSS	mg/l	08-1606	08/13/08	14.7	15.2	14.95	0.354	2.36	0-5
TSS	mg/l	08-1616	08/14/08	11.2	11.4	11.30	0.141	1.25	0-5
TSS	mg/l	08-1618	08/14/08	2.7	2.9	2.78	0.106	3.82	0-5
TSS	mg/l	08-1759	08/31/08	1.0	1.1	1.06	0.028	2.67	0-5
TSS	mg/l	08-1910	09/10/08	10.2	10.9	10.55	0.495	4.69	0-5
TSS	mg/l	08-2112	09/24/08	9.2	9.4	9.30	0.141	1.52	0-5
TSS	mg/l	08-2119	09/24/08	13	13	12.95	0.354	2.73	0-5
SRP	µg/l	08-2110	09/24/08	0.1	0.1	0.10	0.000	0.00	0-5
SRP	µg/l	08-2120	09/25/08	0	0	0.10	0.000	0.00	0-5
SRP	µg/l	08-1472	08/01/08	4	4	4.00	0.000	0.00	0-5
SRP	µg/l	08-1482	08/01/08	0	0	0.10	0.000	0.00	0-5
SRP	µg/l	08-1601	08/14/08	16	15	15.50	0.707	4.56	0-5
SRP	µg/l	08-1611	08/14/08	0	0	0.10	0.000	0.00	0-5
SRP	µg/l	08-1752	08/30/08	4	4	4.00	0.000	0.00	0-5
SRP	µg/l	08-1762	08/30/08	347	348	347.50	0.707	0.20	0-5
NOX-N	µg/l	08-2110	09/24/08	0	0	0.10	0.000	0.00	0-4
NOX-N	µg/l	08-2120	09/25/08	1	1	1.00	0.000	0.00	0-4
NOX-N	µg/l	08-1472	08/01/08	14	15	14.25	0.354	2.48	0-4
NOX-N	µg/l	08-1482	08/01/08	5	4	4.50	0.141	3.14	0-4
NOX-N	µg/l	08-1601	08/14/08	25	24	24.50	0.707	2.89	0-4
NOX-N	µg/l	08-1611	08/14/08	14	14	14.00	0.000	0.00	0-4
NOX-N	µg/l	08-1752	08/30/08	95	96	95.50	0.707	0.74	0-4
NOX-N	µg/l	08-1762	08/30/08	1	1	1.00	0.000	0.00	0-4
Ammonia	µg/l	08-1377	08/05/08	461	439	450.0	15.556	3.46	0-10
Ammonia	µg/l	08-1387	08/05/08	45	43	44.00	1.414	3.21	0-10
Ammonia	µg/l	08-1463	08/06/08	0	0	0.1	0.000	0.00	0-10
Ammonia	µg/l	08-1473	08/06/08	136	136	136.00	0.000	0.00	0-10
Ammonia	µg/l	08-1483	08/06/08	458	457	457.5	0.707	0.15	0-10
Ammonia	µg/l	08-1600	08/28/08	2	2	2.00	0.000	0.00	0-10
Ammonia	µg/l	08-1610	08/28/08	423	412	417.5	7.778	1.86	0-10
Ammonia	µg/l	08-1752	09/04/08	49	47	48.00	1.414	2.95	0-10

MATRIX SPIKE RECOVERY STUDY

PARAMETERS	UNITS	SAMPLE ID	DATE ANALYZED	INITIAL CONC.	INITIAL VOLUME (ml)	SPIKE CONC.	SPIKE VOLUME ADDED (ml)	FINAL CONC.	MEASURED CONC.	PERCENT RECOVERY	ACCEPTANCE RANGE
TSS	mg/l	08-1477	07/31/08	5.4	500	30.1	500	65.6	63.6	97%	91-105
TSS	mg/l	08-1606	08/13/08	14.7	350	32.6	350	108	100	93%	91-105
TSS	mg/l	08-1616	08/14/08	11.2	300	27.6	300	103	98.3	95%	91-105
TSS	mg/l	08-1618	08/14/08	2.7	350	28.8	350	85.0	80.8	95%	91-105
TSS	mg/l	08-1759	08/31/08	1.0	300	32.4	300	109	102	94%	91-105
TSS	mg/l	08-1910	09/10/08	12.8	350	32.6	350	106	98.8	93%	91-105
TSS	mg/l	08-2112	09/24/08	9.2	300	30.0	300	109	102	93%	91-105
TSS	mg/l	08-2119	09/24/08	13.2	300	28.6	300	109	102	94%	91-105
SRP	µg/l	08-2110	09/24/08	0	10	10000	0.150	150	144	96%	92-111
SRP	µg/l	08-2120	09/25/08	0	10	10000	0.150	150	139	93%	92-111
SRP	µg/l	08-1472	08/01/08	4	10	10000	0.150	154	142	92%	92-111
SRP	µg/l	08-1482	08/01/08	0	10	10000	0.150	150	147	98%	92-111
SRP	µg/l	08-1601	08/14/08	16	10	10000	0.100	116	115	99%	92-111
SRP	µg/l	08-1611	08/14/08	0	10	10000	0.150	150	156	104%	92-111
SRP	µg/l	08-1752	08/30/08	4	10	10000	0.100	104	112	108%	92-111
SRP	µg/l	08-1762	08/30/08	347	10	10000	0.150	497	475	96%	92-111
NOX-N	µg/l	08-2110	09/24/08	0	10	9040	0.150	136	130	96%	92-108
NOX-N	µg/l	08-2120	09/25/08	0	10	9040	0.150	136	147	108%	92-108
NOX-N	µg/l	08-1472	08/01/08	14	10	9040	0.150	150	151	101%	92-108
NOX-N	µg/l	08-1482	08/01/08	0	10	9040	0.150	136	145	107%	92-108
NOX-N	µg/l	08-1601	08/14/08	14	10	9040	0.200	195	195	100%	92-108
NOX-N	µg/l	08-1611	08/14/08	0	10	9040	0.200	181	190	105%	92-108
NOX-N	µg/l	08-1752	08/30/08	95	10	9040	0.020	113	107	95%	92-108
NOX-N	µg/l	08-1762	08/30/08	13	10	9040	0.150	149	142	96%	92-108
Ammonia	µg/l	08-1377	08/05/08	461	10	100000	0.050	961	933	97%	88-120
Ammonia	µg/l	08-1387	08/05/09	45	10	100000	0.050	545	505	93%	88-120
Ammonia	µg/l	08-1463	08/06/08	0	10	100000	0.050	500	454	91%	88-120
Ammonia	µg/l	08-1473	08/06/08	136	10	100000	0.050	636	618	97%	88-120
Ammonia	µg/l	08-1483	08/06/08	458	10	100000	0.050	958	917	96%	88-120
Ammonia	µg/l	08-1600	08/28/08	0	10	100000	0.200	2000	2187	109%	88-120
Ammonia	µg/l	08-1610	08/28/08	419	10	100000	0.200	2419	2271	94%	88-120
Ammonia	µg/l	08-1752	09/04/08	49	10	100000	0.200	2049	2030	99%	88-120
Total N	µg/l	08-1467F	08/04/08	1709	5	100000	0.150	4709	4497	95%	92-110
Total N	µg/l	08-1606F	08/27/09	1570	5	100000	0.075	3070	2849	93%	92-110
Total N	µg/l	08-1750F	09/08/08	0	5	100000	0.075	1500	1464	98%	92-110
Total N	µg/l	08-1765F	09/08/08	1471	5	100000	0.050	2471	2619	106%	92-110
Total N	µg/l	08-1927F	09/22/08	0	5	100000	0.050	1000	1008	101%	92-110
Total N	µg/l	08-2124	10/18/08	804	5	100000	0.050	1804	1801	100%	92-110
Total N	µg/l	08-2104F	10/18/08	561	5	100000	0.050	1561	1588	102%	92-110
Total P	µg/l	08-1467F	08/04/08	261	5	50000	0.150	1761	1772	101%	93-109
Total P	µg/l	08-1606F	08/27/09	25	5	50000	0.150	1525	1584	104%	93-109
Total P	µg/l	08-1750F	09/08/08	0	5	50000	0.150	1500	1448	97%	93-109
Total P	µg/l	08-1765	09/08/08	931	5	50000	0.125	2181	2133	98%	93-109
Total P	µg/l	08-1927F	09/22/08	0	5	50000	0.150	1500	1541	103%	93-109
Total P	µg/l	08-2124	10/18/08	24	5	50000	0.120	1224	1142	93%	93-109
Total P	µg/l	08-2104F	10/18/08	7	5	50000	0.120	1207	1118	93%	93-109
Color	PCU	08-1378	07/16/08	43	25	500	4	123	115	93%	80-120
Color	PCU	08-1482	08/01/08	0	25	500	4	80	73	91%	80-120
Color	PCU	08-1605	08/14/08	19	25	500	4	99	99	100%	80-120
Color	PCU	08-1753	08/28/08	33	25	500	4	113	110	97%	80-120
Color	PCU	08-1928	09/10/08	59	25	500	4	139	135	97%	80-120
Color	PCU	08-2121	09/24/08	46	25	500	4	126	120	95%	80-120

APPENDIX C

HISTORICAL RAINFALL RECORDS IN THE VICINITY OF THE KLOSTERMAN BAYOU AND JOE'S CREEK WATERSHEDS

Monthly Rainfall Recorded at the Tarpon Springs Sewage Plant (088824) from 1971 - 2008

Year	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		ANN
1971	2.19		7.36		1.51		1.84		2.42		1.83		6.96		15.83		15.54		3.36		1.7		2.97		63.51
1972	1.29		6.18		1.9		0.07		3.71		5.2		3.67		7.37		0.58		2.25		0	z	3.63		35.85
1973	3.96		2.85		4.18		3.7		1.03		2.62		8.98		7.72		6.81		0.9		1.72		7.48		51.95
1974	0.07		1.44		5.31		0.85		3.2		18.29		4.11		9.38		7.33		0.07		0.3		2.23		52.58
1975	3.82		2.84		3.08		0.42		1.52		7.61		9.3		4.87		11.25		9.49		0.69		1.71		56.6
1976	0.53		0.78		1.24		1.24		10.13		6.45		2.45		5.9		5.21		2.89		1.73		1.95		40.5
1977	3.2		2.93		1.31		0.6		0.91		3.27		9.98		11.24		4.47		0.36		3.73		2.74		44.74
1978	4.04		5.62		3.01		0.89		3.01		3.4		11.92		6.92		2.69		0.62		0.02		4.85		46.99
1979	5.87		3.13		3.94		1.09		15.17		1.73		4.87		12.68		11.18		0.31		1.34		2.86		64.17
1980	3.83		1.84		4.32		3.05		3.08		1.63		5.8		6.74		9.9		1.76		3.99		0.45		46.39
1981	0.83		2.65		2.63		0.07		1.81		9.22		4.09		10		3.47		0.45		2.07		4.49		41.78
1982	3.74		1.84		5.47		2.77		4.6		11.47		7.64		7.8		9.5		4.06		1.02		1.09		61
1983	2.8		8.45		9.68		3.01		3.02		3.34		5.44		8.29		12.79		6.13		2.79		9.08		74.82
1984	2.82		5.57		2.56		4.31		4.61		3.77		12.96		8.24		7.08		2.44		1.29		0.02		55.67
1985	1.97		1.58		2.24		1.67		1.41		8.76		5.95		10.22		4.19		2.05		3.01		3.9		46.95
1986	7.96		2.47		4.74		1		2.96		4.17		5.56		7.39		4.5		3.65		2.1		2.99		49.49
1987	4.24		2.06		14.21		0.66		4.04		3.26		12.35		6.09		5.37		1.21		3.08		0.36		56.93
1988	3.76		2.3		6.57		1.71		1.89		2.44		4.79		7.55		18.13		1.08		9.13		1.2		60.55
1989	2.7		0.41		1.81		0.91		1.27		9.68		4.77		4.45		6.61		0.96		3.26		5.47		42.3
1990	1.31		3.53		0.6		0.42		1.79		4.37		8.59		7.93		5.85		4.73		1.08		1.29		41.49
1991	3.57		0.87		5.71		3.98		10.14		0.62		9.56		15.31		3.14		2.91		0.74		0.61		57.16
1992	2.74		4.36		1.55		2.86		1.4		8.82		5.85		9.68		4.56		9.2		6.63		0.63		58.28
1993	4.29		4.11	a	4.05		4.07		0.5	a	3.71		2.47		8.99		7.44		5.69		1.07		2.76		49.15
1994	5.88		0.98		1.6		2.18		0.14		3.6		5.89		9.69		5.27		4.89		0.85		1.6		42.57
1995	4.34		1.41		1.51		4.24		0.54		10.73		8.25		8.92		5.16		14.13		1.49		0.78		61.5
1996	3.6		3.86		8.12		3.97		0.92		4.89		6.7		7.09		4.05		3.61		0.84		4.38		52.03
1997	1.51		0.38		3.37		4.9		0.55	b	8.84		4.09	a	5.12		9.74		5.52		6.99		15.6		66.61
1998	3.14		10.91		6.14		0.16		2.53		0.72		9.49		6.74		9.4		2.55		1.74		0.72		54.24
1999	3.88		0.32		2.44		1.32		2.27		9.97		6.89		6.2		6.86		3.35		1.8		1.24		46.54
2000	1.29		1.03		0.62		0.78		0		8.87		12.68		9.63		9.47		0.04		2.26		0.19		46.86
2001	1.01		1.17		4.81	a	0.79		0		11.69		12.9		2.57		11.06	b	1.29		0.54		0.92		48.75
2002	2.68		2.6		1.14	a	1.58		1.07		9.76		10.31		8.42	a	3.08	a	4.36		1.82		12.27		59.09
2003	2.14		3	a	1.77		2.78		0.83		10.04		0.94	d	6.2		3.8		2.37		1.2		1.58		36.65
2004	5.3		6.31		1.05		2.46		1.72		6.47		11.12	c	10.28	b	12.57		0.81		2.2		0.92		61.21
2005	2.14	a	1.97	c	5		4.63		2.31		9.04		8.77	a	5.76	a	0.44	c	1.02		0.39	a	3.22		44.69
2006	1.13		2.1	c	0.02		0.43		0.98		6.15		7.42		3.7		15.8		0.94		1.14		2.1		41.91
2007	0.59		1.01	e	0.75		2.62		0.01		8.16		2.71	m	9.67		2.16		4.4		0.17		2.33		31.87
2008	3.48		3.06		4.79		4.23		0.29		7.93		15.12		7.02		0.82		3.04		0.76		0.88		51.42

Period of Record Statistics

MEAN	2.99		3.03		3.55		2.06		2.57		6.38		7.40		8.09		7.03		3.13		2.02		2.99		51.18
S.D.	1.68		2.38		2.84		1.49		3.09		3.82		3.44		2.76		4.32		2.94		1.95		3.30		9.45
SKEW	0.58		1.50		1.74		0.41		2.66		0.69		0.30		0.81		0.71		1.88		2.11		2.35		0.22
MAX	7.96		10.91		14.21		4.90		15.17		18.29		15.12		15.83		18.13		14.13		9.13		15.60		74.82
MIN	0.07		0.32		0.02		0.07		0.00		0.62		0.94		2.57		0.44		0.04		0.00		0.02		31.87
NO YRS	38		38		38		38		38		38		38		38		38		38		38		38		38

Monthly Rainfall Recorded at the St. Petersburg Airport (087886) from 1971 - 2008

Year	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		ANN
1971	0.50		4.75		1.20		1.12		2.80		5.00		10.97		16.65		11.02		2.41		3.33		0.91		60.66
1972	1.38		6.37		3.50		0.58		4.59		3.80		2.78		9.23		1.48		0.73		4.16		2.09		40.69
1973	5.91		2.13		3.85		4.88		0.19		2.05		8.34		5.04		5.31		2.30		1.59		6.77		48.36
1974	0.44		0.77		1.50		0.01		4.40		23.00		3.96		7.53		9.64		0.14		0.12		3.39		54.90
1975	1.26		2.58		0.82		0.75		3.53		5.15		9.16		6.25		6.72		6.27		0.51		1.14		44.14
1976	0.16		0.24		1.14		1.20		8.17		7.61		5.30		5.54		4.58		1.16		2.48		2.26		39.84
1977	3.29		2.75		0.58		0.25		0.90		2.56		7.74		6.50		7.04		0.95		1.36		4.11		38.03
1978	2.94		3.77		3.87		0.36		4.07		5.15		3.87		8.81		5.09		1.78		0.10		4.29		44.10
1979	5.45		1.43		2.66		0.40		9.21		0.90		4.52		13.98		10.77		0.37		1.08		3.75		54.52
1980	2.16		2.64		2.15		3.57		3.58		2.63		9.01		6.34		8.92		1.37		3.43		0.75		46.55
1981	0.89		3.94		1.33		0.00		2.25		7.71		6.43		14.98		6.36		0.63		0.58		5.09		50.19
1982	2.44		1.49		6.81		3.81		5.03		7.66		2.40		7.45		9.88		4.16		0.95		0.67		52.75
1983	2.00		9.06		8.20		1.65		2.19		6.09		3.66		7.29		8.31		2.26		2.15		7.00		59.86
1984	0.61		2.32		3.12		2.85		1.48		4.01		4.25		3.01		5.68		0.55		2.56		0.07		30.51
1985	2.01		1.64		3.23		1.86		1.21		8.29		8.52		9.98		7.14		2.84		1.70		0.61		49.03
1986	2.74		3.76		4.71		1.13		3.05		5.26	b	5.52		7.16	b	6.32		17.63	a	2.06	b	3.50		62.84
1987	2.75		2.64		11.79		0.07		4.45		4.92	c	6.61		10.49		6.40		1.72		6.80		0.56		59.20
1988	3.40		1.98		5.69		2.63		1.82		2.76		7.65		10.21		25.51		0.30		6.94		0.67		69.56
1989	1.98		0.43		2.47		0.35		1.05		8.46		7.72		5.73		7.70		1.52		1.68		2.92		42.01
1990	0.47		5.35		1.17		0.69		1.95		11.02		7.57		5.44		1.84		1.28		0.88		0.24		37.90
1991	6.20		0.55		4.76		2.11		7.16		2.74		10.31		6.47		6.21		1.08		0.30		0.62		48.51
1992	2.80		4.68		2.41		2.89		0.22		6.94		4.55		4.31		6.72		4.35		3.42		0.81		44.10
1993	4.58		2.29		2.96		4.03		0.89	a	2.21		3.26		7.67		5.60		4.63		0.31		1.43		39.86
1994	3.40		0.69		1.69		3.46		0.24		4.24		7.65		6.10		9.31		2.53		0.81		1.86		41.98
1995	4.59		1.88		1.53		2.77		2.01		16.60		6.64		17.75		3.10		5.37		1.47		1.16		64.87
1996	6.37		1.00		4.42		3.30		2.27		7.34		2.09		3.67		2.75		3.50		1.06		3.62		41.39
1997	0.83		1.37		1.94		9.73		1.93		3.15		8.61		8.80	a	12.63		4.37		4.83		14.62		72.81
1998	5.03		12.71		7.18		0.11		1.77		4.43		7.40		3.89		9.58		0.15		1.53		0.82		54.60
1999	4.14		0.10		1.12		0.66		1.49		4.50		8.05		11.20		9.73		2.72		1.17		1.62		46.50
2000	2.09		0.69		0.83		0.47		0.00		6.60		16.86		10.21		6.49		0.09		1.87		0.61		46.81
2001	0.92		0.39		7.31		0.00		0.00		6.49		12.72		6.17		17.15		2.91		0.03		0.81		54.90
2002	1.90		3.67		0.28		1.09		1.31		6.06		7.43		10.37		7.91		1.98		1.93		18.36		62.29
2003	0.16		2.73		5.89		7.23		1.89		13.95		3.25		13.90		8.71		1.18		1.15		2.13		62.17
2004	3.50		3.77		1.30		2.28		3.81		3.52		13.56	b	12.94		12.39		1.68		1.32		1.63		61.70
2005	0.56		1.38		4.83		3.19		2.98		10.40	b	5.17		3.35		2.06		3.63		1.73		1.28		40.56
2006	0.74		1.92		0.06		0.30		0.77		6.14		5.76		6.71		8.23		1.18		2.02		2.96		36.79
2007	2.16		2.97		0.66		2.64		0.04		6.27		7.04		10.73		5.38		3.40		0.20		1.30		42.79
2008	5.00		3.78		4.39		3.03		0.57		7.52		9.79		4.94		1.20		3.81		0.52		1.65		46.20

Period of Record Statistics

MEAN	2.57		2.81		3.25		2.04		2.51		6.40		7.00		8.34		7.65		2.60		1.85		2.84		49.85
S.D.	1.82		2.49		2.59		2.08		2.20		4.24		3.20		3.70		4.46		2.95		1.65		3.70		10.07
SKEW	0.56		2.18		1.27		1.78		1.38		2.10		0.89		0.84		1.83		3.74		1.68		3.01		0.43
MAX	6.37		12.71		11.79		9.73		9.21		23.00		16.86		17.75		25.51		17.63		6.94		18.36		72.81
MIN	0.16		0.10		0.06		0.00		0.00		0.90		2.09		3.01		1.20		0.09		0.03		0.07		30.51
NO YRS	38.00		38.00		38.00		38.00		38.00		38.00		38.00		38.00		38.00		38.00		38.00		38.00		38.00

APPENDIX D

ISOTOPE ANALYSIS REPORT FROM CLIMATE-WISE SOLUTIONS, LLC

CLIMATE-WISE SOLUTIONS, LLC

Stable Isotope ($\delta^{15}N$ and $\delta^{18}O$) Composition of Nitrate from Surface and Groundwater Samples from Klosterman Bayou and Joe's Creek, Pinellas County, FL

Nutrient source implications

Bruce Hungate

9/2/2009

Introduction

Nitrate (NO_3^-) in surface waters can originate from multiple sources, including fertilizer application, animal waste, septic systems, and soil and natural deposition. Stable isotope analysis can help distinguish which of the sources is more likely to contribute to contamination in a given site, because these multiple sources often differ in stable isotope composition. For example, high $\delta^{15}N$ values can be traced to animal waste and sewage inputs (e.g., Wassenaar 1995; Kendall 1998; Kendall et al. 1996). Atmospheric N deposition as NO_3^- or NH_4^+, N derived from synthetic fertilizers, and soil-derived N typically differ in $\delta^{15}N$ and $\delta^{18}O$ (Table 1). Stable isotopes of oxygen are also useful in source partitioning, in some cases increasing resolution when combined with $\delta^{15}N$. Atmospherically derived NO_3^- is enriched in $\delta^{18}O$ compared to synthetic fertilizer, and both tend to be enriched compared to NO_3^- produced in soils through microbial nitrification (Table 1).

One complication of source partitioning using stable isotopes of N and O in nitrate is that microbial transformations of nitrate can alter its isotopic signature, potentially obscuring the identity of the original source (Kellman 2005). Nitrification and denitrification are the major fractionating processes altering the isotopic composition of nitrate. Both processes preferentially utilize the lighter substrate, such that nitrification produces NO_3^- isotopically depleted compared to the NH_4^+ substrate, whereas denitrification preferentially utilizes isotopically depleted NO_3^-, leaving behind NO_3^- relatively enriched in $\delta^{15}N$ and $\delta^{18}O$. Predictable relationships among NO_3^- concentration, $\delta^{15}N$- NO_3^-, and $\delta^{18}O$-NO_3^- provide one means of detecting whether denitrification is influencing the isotopic composition of NO_3^-. For example, co-varying enrichment of $\delta^{15}N$ and $\delta^{18}O$ in nitrate provides evidence for denitrification, if the ratio of enrichments are between 1.3:1 and 2.1:1 (Aravena and Robertson 1998, Fukada et al. 2003). In a system where nitrate inputs are negligible, a negative relationship between [NO_3^-] and $\delta^{15}N$-NO_3^- with a slope consistent with microbial fractionation during denitrification can also be used as diagnostic for the importance of denitrification as a loss pathway, or, in source identification, for the need to consider internal changes to $\delta^{15}N$ values observed in situ to the expected $\delta^{15}N$ signature of the NO_3^- source. Analysis of $\delta^{15}N$-NH_4^+, and nitrification and denitrification rates at a given site can also constrain the influence of these processes on the observed isotopic signatures.

In the study conducted here, surface and ground waters in the Klosterman Bayou and in Joe's Creek were analyzed for $\delta^{15}N$-NO_3^- and $\delta^{18}O$-NO_3^-, along with putative sources. Two general questions were addressed: 1) are there changes in NO_3^-, d15N, and d18O signatures within these systems that is consistent with internal microbial processing, and if so, is it possible to constrain the $\delta^{15}N$ and $\delta^{18}O$ signature of NO_3^- entering these systems? And 2) do the estimates of the $\delta^{15}N$ and $\delta^{18}O$ signature of source NO_3^- match any of the putative sources identified?

Methods

Samples were collected in the field and shipped to the Colorado Plateau Stable Isotope Laboratory at Northern Arizona University for preparation and analysis. Samples were measured for NO_3^- concentrations using automated colorimetry on a Lachat QuikChem 8000, to determine appropriate volumes for isotope analyses. The denitrifier method was used to measure the $\delta^{15}N$ and $\delta^{18}O$ composition of nitrate in each water sample (Sigman et al. 2001, Casciotti et al. 2002, Révész and Casciotte 2007). In this method, isotopes of both elements are measured simultaneously after the nitrate is converted to nitrous oxide (N_2O). Mass ratios of 45:44 and 46:44 distinguish $\delta^{15}N$ and $\delta^{18}O$ signatures, respectively. *Pseudomonas aureofaciens* lacks N_2O reductase, the enzyme that converts N_2O to N_2 during denitrification, so the reaction stops at N_2O, unlike normal denitrification which converts most of the NO_3^- to N2. *P. aureofaciens* cultures were grown in tryptic soy broth, centrifuged to concentrate bacterial cells, and then concentrated suspensions of cells are added to sealed vials with headspace. The headspace vials were purged with He gas to promote the anaerobic conditions suitable for denitrification, and then environmental samples containing NO_3^- were added to the vials, the volume of sample adjusted to obtain sufficient N_2O for analysis. Several drops of antifoaming agent were added to each vial to reduce bubble formation during the reaction. The vials were allowed to incubate for 8 hours, during which time NO_3^- is converted completely to N_2O. After the 8-hour period, 0.1 mL of 10N NaOH was added to each vial to stop the reaction, and to absorb CO_2, which can interfere with N_2O analysis (since CO_2 has the same masses as N_2O, 44, 45, and 46). The samples were then placed on an autosampler tray interfaced with the mass spectrometer, and interspersed with standards with known $\delta^{15}N$ and $\delta^{18}O$ composition (USGS32, USGS 34, USGS 35, and IAEA NO3).

Results

Overview

All samples collected from both groundwater and two surface water sites from Joe's Creek (JC-3S, JC-4S) had insufficient NO_3^- for isotope analysis, whereas only one site in the Klosterman Bayou system consistently yielded insufficient NO_3^- (upstream groundwater monitoring well, KB-1G). Thus, eight of the nine sites sampled in Klosterman Bayou were characterized for isotopic composition of NO_3^-, whereas isotope characterization was possible for only four of eight sites along Joe's Creek.

Water samples with sufficient NO_3^- for isotope analysis showed greater variation in $\delta^{15}N$ in the Kloseterman Bayou system (means ranged from -0.95 to 13.21‰) than along Joe's Creek (from 2.18 to 6.49 ‰). Mean values of $\delta^{18}O$-NO_3^- were slightly higher in Klosterman Bayou (3.94 to 21.3 ‰) than in Joe's Creek (7.54 to 23.98 ‰), but the range of variation was comparable.

Evidence for in situ denitrification

Two lines of evidence could support *in situ* denitrification as a major pathway of NO_3^- removal, and thus as a confounding signal for interpreting isotopes in source partitioning. One sign of denitrification is a negative slope for the relationship between [NO_3^-] and $\delta^{15}N$-NO_3^-, reflecting preferential removal of ^{14}N-NO_3^- through denitrification. Within the Joe's Creek system, no site exhibited a significant relationship (slope) between [NO_3^-] and $\delta^{15}N$ (Figure 1A). For the Klosterman Bayou system, only site KB-3G showed the expected relationship (Figure 1B), consistent with denitrification.

A second sign of *in situ* denitrification is co-varying enrichment of $\delta^{15}N$ and $\delta^{18}O$ in nitrate, if the ratio of enrichments are between 1.3 and 2.1 to 1 (Aravena and Robertson 1998, Fukada et al. 2003). The relationship tended to be negative within the Joe's Creek system (Figure 2A). No mechanism has been proposed that causes opposing isotope effects for $\delta^{15}N$ and $\delta^{18}O$ in nitrate, so this may be a spurious trend, resulting from mixing of sources with varying isotopic signatures rather than a single biogeochemical mechanism. Furthermore, the negative relationship was driven by an anomalously high $\delta^{18}O$-NO_3^- value (502.16‰), a sample with a relatively low $\delta^{15}N$-NO_3^- and moderate [NO_3^-] (0.12 mg N L^{-1}).

For the surface water Klosterman Bayou samples considered together, the slope of the relationship between $\delta^{15}N$ and $\delta^{18}O$ in nitrate was 1.6 (Figure 2B), consistent with enrichment caused by denitrification. A number of sites considered separately also exhibited the expected positive relationship, including site KB-3G. For the groundwater site KB-3G, these two lines of evidence indicate that denitrification enriches the NO_3^- in $\delta^{15}N$ and $\delta^{18}O$ at site KB-3G. For the other sites, evidence for *in situ* denitrification as a major NO_3^- removal pathway is equivocal.

Source partitioning

Joe's Creek

$\delta^{15}N$ and $\delta^{18}O$ signatures within the Joe's Creek system (Table 2) are consistent with nitrate derived from synthetic fertilizers, atmospheric deposition, and nitrification of native soil organic matter, but are lower in $\delta^{15}N$ than values typically associated with animal waste, manure, or wastewater (Table 1). In general $\delta^{18}O$ values from Joe's Creek samples were highly variable (note standard deviations in Table 2). For example, JC-0S and JC-2S had comparable $\delta^{15}N$ values, falling between 2.78 and 8.93. $\delta^{18}O$ values for samples from these same sites were considerably more variable, ranging from -0.99 to 52.16. This pattern may be explained by contributions of NO_3^- from multiple sources with similar $\delta^{15}N$ values, specifically, synthetic fertilizers, atmospheric deposition, and nitrification of native soil organic matter.

Klosterman Bayou

Nitrate from sites KB-2Sa, KB-3S, KB-4S and for the most part KB-5S had similar $\delta^{15}N$ and $\delta^{18}O$ signatures, ranging from 9.34 to 15.25 for $\delta^{15}N$ and from 9.25 to 26.09 for $\delta^{18}O$, in general consistent with expected isotope signatures from animal waste, sewage, and wastewater sources (Table 1). Two samples from site KB-5S occurred outside of this range, with considerably lower $\delta^{15}N$ and $\delta^{18}O$ values more likely to reflect in situ NO_3^- production from nitrification. Nitrate from site KB-1S also had low $\delta^{15}N$ and $\delta^{18}O$ signatures, consistent with microbial production via nitrification from native soil organic matter (Table 1).

The two groundwater sites with sufficient NO_3^- for isotopic characterization had similar $\delta^{18}O$ values, ranging from -3.65 to 18.17, but differed in $\delta^{15}N$: site KB-2G had consistently lower d15N than site KB-3G (Table 2). The positive relationship between $\delta^{15}N$ and $\delta^{18}O$ for site KB-3G was indistinguishable from that found for the other surface water samples within the Klosterman Bayou system (excepting site KB-1S), suggesting that these samples shared a common NO_3^- source. Denitrification of NO_3^- found in site KB-3G would be expected to produce NO_3^- enriched in $\delta^{15}N$ and $\delta^{18}O$, such as that found in the majority of surface water sites (specifically, sites KB-2Sa, KB-3S, and KB-4S, as well as several samples from KB-5S and KB-IP).

Finally, the irrigation water used for the golf course (KB-IP and KB-IW) have d15N values (8.73 to 13.39) similar to KB-2SA, KB-3S, and KB-4S, but $\delta^{18}O$ values are equivocal, with two samples considerably lower (1.76 and 2.56 ‰) and one well within the range (20.87 ‰) of the other surface water samples (Figure 3B). These samples also fall on the same $\delta^{15}N$ and $\delta^{18}O$ relationship typical for other surface water samples and by KB-3G.

Based on isotope values, surface water samples within the Klosterman Bayou map together, with the exception of site KB-1S. Therefore, nitrate found within the system is unlikely to originate from inputs occurring through KB-1S. In contrast, the consistency of isotopic signatures of sites KB-2Sa, KB-3S, and KB-4S suggest that they share a common NO3- source. In addition to inputs from KB-2Sa, this source could include NO3- derived from the nearby golf course, as indicated by the combination of isotope signatures from KB-5S, KB-3G, and KB-IP.

Conclusions and Future Directions

These findings constrain the identity of the source of NO_3^- in the Klosterman Bayou system, but are not definitive, because a number of sources remain viable. For Joe's Creek, the low NO_3^- concentrations recovered in the samples limited the inferences about possible sources that could be drawn, but the ranges of d15N and d18O values provide some indication of the likely nature of the sources of NO_3^- to Joe's Creek. Future directions that could constrain the NO_3^- sources include, 1) continued monitoring of $\delta^{15}N$ and $\delta^{18}O$ in NO_3^-, in particular capturing high [NO_3^-] periods, and with improved methods allowing isotope measurements at low [NO_3^-], 2) measuring $\delta^{15}N$-NH_4^+ to provide insight on internal nitrification as a source of NO_3^-, 3) combining isotope monitoring with measurements of chemical fingerprints that provide additional resolution (e.g., Otero et al. 2009), and 4) including process studies, for example measurements of nitrification and denitrification to constrain the influences of internal transformations on the resulting isotope signatures.

Table 1. Typical values and ranges (10-90% confidence limits) for $\delta^{15}N$ of ammonium and nitrate and $\delta^{18}O$ of nitrate from various sources.

Source	Species	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
Synthetic Fertilizer	Ammonium	-1.0 (-5.6 to 4.8)	
	Nitrate	1.0 (-4.4 to 6.1)	22.1(15.5 to 25.6)
Precipitation	Ammonium	-1.6 (-13.4 to 12.8)	
	Nitrate	0.2 (-7.8 to 8.7)	57.9 (25.6 to 77.2)
Manure	Ammonium	10.5 (5.3 to 25.3)	
Sewage and Wastewater	Ammonium	10.0 (4.3 to 19.6)	
Nitrification	Nitrate	3.5 (-4.1 to 7.9)	7.4 (0.4 to 15.1)[+]
Soils	Bulk	4.0 (-2.0 to 8.0)[*]	

*Unpublished data of Hungate et al. from Florida spodosols shows typical values of -6 to -2 for soil organic nitrogen in the region. Negative $\delta^{15}N$ values are typical of surface horizons with low clay content.

+ For the region in question, the $\delta^{18}O$ of precipitation is -2 to -6 ‰ vs SMOW (GNIP, www-naweb.iaea.org/napc/ih/GNIP/). In nitrification, two atoms of oxygen are derived from local water, and one from atmospheric O_2 (22.5 ‰), allowing theoretical prediction of the $\delta^{18}O$ of nitrate derived from nitrification, after allowing for 5 per mil enrichment of local water due to evaporative enrichment (Mayer et al. 2001). Therefore, the expected $\delta^{18}O$ of nitrate produced by nitrification is 3.8 to 11.5 ‰. Values within this range are consistent with *in situ* microbial origin.

Table 2. $\delta^{15}N$ and $\delta^{18}O$ values of NO_3^- collected in the Klosterman Bayou and Joe's Creek systems. Values are means ± standard deviations (n.d. indicates insufficient NO_3^- for isotope analysis)

Klosterman Bayou			
Surface Water	Site No.	$\delta^{15}N$-N_2O ‰	$\delta^{18}O$-N_2O ‰
	KB-1S	-0.95 ± 1.11	3.94 ± 0.78
	KB-2S	13.21 ± 127	21.30 ± 6.50
	KB-3S	12.02 ± 1.87	18.48 ± 3.26
	KB-4S	10.76 ± 1.24	16.37 ± 4.33
	KB-5S	8.84 ± 2.08	8.14 ± 8.78
Irrigation water		10.80 ± 2.37	8.40 ± 10.81
Groundwater	KB-1G	n.d.	
	KB-2G	4.12 ± 0.65	8.27 ± 9.26
	KB-3G	8.36 ± 2.16	8.77 ± 5.54
Joe's Creek			
Surface Water	JC-0S	6.49 ± 1.30	11.89 ±11.59
	JC-1S	2.18 ± 0.27	23.98 ± 9.07
	JC-2S	5.76 ± 2.61	20.57 ± 22.52
	JC-3S	n.d.	
	JC-4S	n.d.	
	JC-5S	4.57 ± 0.92	7.54 ± 8.41
Groundwater	JC-1G	n.d.	
	JC-2G	n.d.	

Table 3 Data for each site and collection date analyzed at the Colorado Plateau Analytical Laboratory at Northern Arizona University

Location	Sample ID No.	Site number	Collection Date	$[NO_3^-]$ mg N L^{-1}	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
Klosterman Bayou	1380	KB-1S	7/17/08	<0.02	nd	nd
	1464	KB-1S	7/30/08	<0.02	nd	nd
	1604	KB-1S	8/13/08	<0.02	nd	nd
	1759	KB-1S	8/27/08	<0.02	nd	nd
	1918	KB-1S	9/9/08	0.04	-1.73	3.39
	2111	KB-1S	9/23/08	0.08	-0.16	4.49
	1381	KB-2S (a)	7/17/08	0.09	11.81	24.58
	1465	KB-2S (a)	7/30/08	0.48	14.63	18.36
	1606	KB-2S (a)	8/13/08	0.13	14.15	24.68
	1761	KB-2S (a)	8/27/08	0.46	11.80	9.25
	1920	KB-2S (a)	9/9/08	0.98	12.69	24.83
	2112	KB-2S (a)	9/23/08	1.08	14.16	26.09
	1382	KB-3S	7/17/08	0.03	15.25	24.40
	1466	KB-3S	7/30/08	0.19	12.45	16.43
	1607	KB-3S	8/13/08	0.14	11.01	17.08
	1762	KB-3S	8/27/08	0.07	12.02	16.25
	1921	KB-3S	9/9/08	0.16	11.77	20.21
	2113	KB-3S	9/23/08	0.06	9.62	16.51
	1385	KB-4S	7/17/08	0.08	10.96	19.28
	1468	KB-4S	7/30/08	0.35	9.34	16.10
	1608	KB-4S	8/13/08	0.47	10.78	10.71
	1763	KB-4S	8/27/08	0.33	9.40	11.75
	1922	KB-4S	9/9/08	0.64	11.56	21.33
	2114	KB-4S	9/23/08	0.73	12.54	19.02
	1386	KB-5S	7/17/08	0.07	10.39	14.84
	1469	KB-5S	7/30/08	<0.02	nd	nd
	1610	KB-5S	8/13/08	0.06	6.07	-0.46
	1765	KB-5S	8/27/08	0.35	10.38	14.57
	1924	KB-5S	9/9/08	0.18	10.23	14.17
	2116	KB-5S	9/23/08	0.11	7.12	-2.43
	1605	KB-IP	8/13/08	0.19	13.39	20.87
	1760	KB-IP	8/27/08	<0.02	nd	nd
	1919	KB-IP	9/9/08	<0.02	nd	nd
	2117	KB-IP	9/23/08	0.06	8.73	1.76
	1925	KB-IW	9/9/08	<0.02	nd	nd

	2118	KB-IW	9/23/08	0.26	10.28	2.56
	1926	KB-IW-PC	9/9/08	<0.02	nd	nd
Table 3, continued, Klosterman Bayou						
	2119	KB-IW-PC	9/23/08	<0.02	nd	nd
	1387	KB-1G	7/17/08	<0.02	nd	nd
	1479	KB-1G	7/30/08	<0.02	nd	nd
	1597	KB-1G	8/13/08	<0.02	nd	nd
	1744	KB-1G	8/27/08	<0.02	nd	nd
	1928	KB-1G	9/9/08	<0.02	nd	nd
	2121	KB-1G	9/23/08	<0.02	nd	nd
	1388	KB-2G	7/17/08	0.73	3.83	17.27
	1480	KB-2G	7/30/08	0.56	4.52	18.17
	1598	KB-2G	8/13/08	0.63	4.81	7.59
	1745	KB-2G	8/27/08	0.15	3.26	-1.49
	1929	KB-2G	9/9/08	0.12	4.73	11.73
	2122	KB-2G	9/23/08	0.17	3.57	-3.65
	1389	KB-3G	7/17/08	2.19	8.33	16.59
	1481	KB-3G	7/30/08	3.59	6.63	5.32
	1599	KB-3G	8/13/08	1.81	7.18	5.91
	1746	KB-3G	8/27/08	1.43	11.84	10.92
	1930	KB-3G	9/9/08	1.32	9.89	12.45
	2123	KB-3G	9/23/08	4.37	6.26	1.43
Joe's Creek						
	1369	JC-0S	7/16/08	0.67	7.32	6.21
	1471	JC-0S	7/30/08	0.39	7.34	
	1612	JC-0S	8/13/08	0.06	7.45	6.06
	1751	JC-0S	8/27/08	0.06	6.38	-0.99
	1910	JC-0S	9/9/08	0.05	6.41	14.52
	2103	JC-0S	9/23/08	0.08	4.02	32.67
	1371	JC-1S	7/16/08	<0.02	nd	nd
	1472	JC-1S	7/30/08	<0.02	nd	nd
	1614	JC-1S	8/13/08	<0.02	2.37	30.39
	1753	JC-1S	8/27/08	<0.02	nd	nd
	1912	JC-1S	9/9/08	<0.02	nd	nd
	2105	JC-1S	9/23/08	0.03	1.99	17.57
	1372	JC-2S	7/16/08	<0.02	nd	nd
	1473	JC-2S	7/30/08	0.03	4.82	12.19
	1615	JC-2S	8/13/08	0.06	8.93	18.56
	1754	JC-2S	8/27/08	0.06	6.51	-0.62
	1913	JC-2S	9/9/08	<0.02	nd	nd
	2106	JC-2S	9/23/08	0.12	2.78	52.16
	1374	JC-3S	7/16/08	<0.02	nd	nd
	1474	JC-3S	7/30/08	<0.02	nd	nd

1616	JC-3S	8/13/08	<0.02	nd	nd
1755	JC-3S	8/27/08	<0.02	nd	nd

Table 3, continued
Joe's Creek

1914	JC-3S	9/9/08	<0.02	nd	nd
2107	JC-3S	9/23/08	<0.02	nd	nd
1375	JC-4S	7/16/08	<0.02	nd	nd
1475	JC-4S	7/30/08	<0.02	nd	nd
1617	JC-4S	8/13/08	<0.02	nd	nd
1756	JC-4S	8/27/08	<0.02	nd	nd
1915	JC-4S	9/9/08	<0.02	nd	nd
2108	JC-4S	9/23/08	<0.02	nd	nd
1376	JC-5S	7/16/08	<0.02	nd	nd
1477	JC-5S	7/30/08	<0.02	nd	nd
1618	JC-5S	8/13/08	0.10	4.87	5.46
1757	JC-5S	8/27/08	0.18	3.32	-3.49
1916	JC-5S	9/9/08	0.18	5.52	14.51
2109	JC-5S	9/23/08	0.21	4.57	13.67
1377	JC-1G	7/16/08	<0.02	nd	nd
1483	JC-1G	7/30/08	<0.02	nd	nd
1601	JC-1G	8/13/08	<0.02	nd	nd
1748	JC-1G	8/27/08	<0.02	nd	nd
1931	JC-1G	9/9/08	<0.02	nd	nd
2124	JC-1G	9/23/08	<0.02	nd	nd
1378	JC-2G	7/16/08	<0.02	nd	nd
1484	JC-2G	7/30/08	<0.02	nd	nd
1602	JC-2G	8/13/08	<0.02	nd	nd
1749	JC-2G	8/27/08	<0.02	nd	nd
1932	JC-2G	9/9/08	<0.02	nd	nd
2125	JC-2G	9/23/08	<0.02	nd	nd

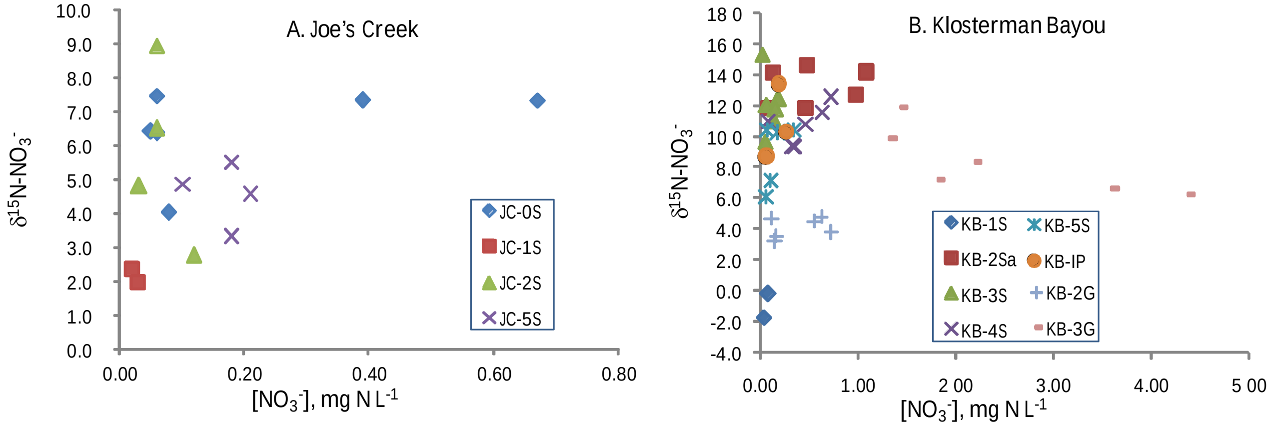


Figure 1. Relationships between $\delta^{15}N\text{-}NO_3^-$ and NO_3^- concentration for Joe's Creek (A), and Kosterman Bayou (B).

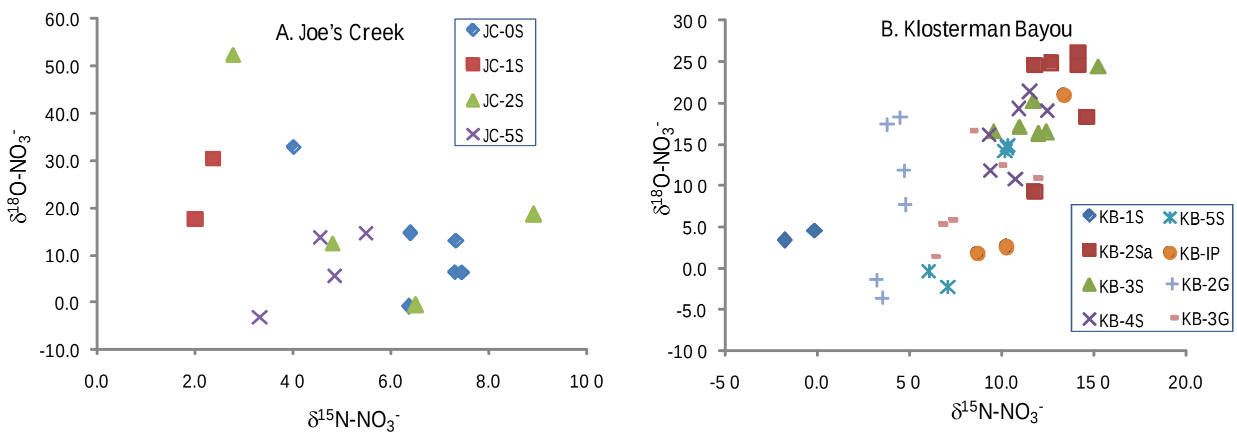


Figure 2. Relationships between $\delta^{15}N\text{-}NO_3^-$ and $\delta^{18}O\text{-}NO_3^-$ for Joe's Creek (A), and Kosterman Bayou (B).

Citations

Aravena, R., Robertson, W.D., 1998. Use of multiple isotope tracers to evaluate denitrification in ground water: study of nitrate from a large-flux septic system plume. Ground Water 36, 975–982.

Casciotti, K.L., Sigman, D.M., Galanter Hastings, M., Bohlke, J.K., Hilkert, A., 2002. Measurement of the oxygen isotopic composition of nitrate in seawater and freshwater using the denitrifier method. Anal. Chem. 74, 4905–4912.

Fukada, T., Hiscock, K.M., Dennis, P.F., Grischek, T., 2003. A dual isotope approach to identify denitrification in ground water at a river bank infiltration site. Water Res. 37, 3070–3078.

Kellman, L., Hillaire-Marcel, C., 1998. Nitrate cycling in streams: using natural abundances of NO_3^- $\delta^{15}N$ to measure in-situ denitrification. Biogeochemistry 43, 273–292

Kendall, C., Silva, S.R., Chang, C.C.Y., Burns, D.A., Campbell, D.H., and Shanley, J.B., 1996, Use of the $\delta^{18}O$ and $\delta^{15}N$ of nitrate to determine sources of nitrate in early spring runoff in forested catchments: International Atomic Energy Agency, *Symposium on Isotopes in Water Resources Management*, Vienna, Austria, March 20-24, 1995, v. 1, p. 167-176.

Kendall, C., 1998, Tracing nitrogen sources and cycling in catchments, *in* Kendall, C., and McDonnell, J.J., eds., *Isotope tracers in catchment hydrology*. Elsevier Science B.V., Amsterdam, 839 p.

Otero N, Torrento C, Soler A. Mencio A, Jax-Pla J, 2009. Monitoring groundwater nitrate attenuation in a regional system coupling hydrogeology with multi-isotopic methods: The case of Plana de Vic (Osona, Spain). Agriculture, Ecosystems and Environment 133:103-113.

Révész K., Casciotti K. 2007, Determination of the $\delta(^{15}N/^{14}N)$ and $\delta(^{18}O/^{16}O)$ of Nitrate in Water: RSIL Lab Code 2900, chap. C17 of Révész, Kinga, and Coplen, Tyler B., eds., Methods of the Reston Stable Isotope Laboratory: Reston, Virginia, U.S. Geological Survey, Techniques and Methods, book 10, sec. C, chap. 17, 24 p.

Sigman, D.M., Casciotti, K.L., Andreani, M., Barford, C., Galanter, M., Bohlke, J.K., 2001. A bacterial method for the nitrogen isotopic analysis of nitrate in seawater and freshwater. Anal. Chem. 73, 4145–4153.

Wassenaar, L.I., 1995. Evaluation of the origin and fate of nitrate in the Abbotsford Aquifer using the isotopes of ^{15}N and ^{18}O in NO_3^-. *Applied Geochemistry*, v.10, p. 391-405.