FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Division of Water Resource Management, Bureau of Watershed Management

NORTHEAST DISTRICT • UPPER EAST COAST BASIN

Final TMDL Report

Dissolved Oxygen and Nutrient TMDL for Spruce Creek, WBID 2674A

Wayne Magley, Ph.D., P.E.

April 2008

Acknowledgments

Editorial assistance provided by: Jan Mandrup-Poulsen and Linda Lord.
Geographic information assistance (GIS) provided by: Janis Paulsen and Latrincy Whitehurst.

For additional information on the watershed management approach and impaired waters in the Upper East Coast Basin, contact:

Jennifer Gihring
Florida Department of Environmental Protection
Bureau of Watershed Management
Watershed Planning and Coordination Section
2600 Blair Stone Road, Mail Station 3565
Tallahassee, FL 32399-2400
Email: jennifer.gihring@dep.state.fl.us
Phone: (850) 245–8418
Fax: (850) 245–8434

Access to all data used in the development of this report can be obtained by contacting:

Wayne Magley
Florida Department of Environmental Protection
Bureau of Watershed Management
Watershed Assessment Section
2600 Blair Stone Road, Mail Station 3555
Tallahassee, FL 32399-2400
Email: wayne.magley@dep.state.fl.us
Phone: (850) 245–8463
Fax: (850) 245–8444

Contents

List of Tables

List of Figures

Websites

Florida Department of Environmental Protection, Bureau of Watershed Management

TMDL Program

http://www.dep.state.fl.us/water/tmdl/index.htm

Identification of Impaired Surface Waters Rule

http://www.dep.state.fl.us/water/tmdl/docs/AmendedIWR.pdf

STORET Program

http://www.dep.state.fl.us/water/storet/index.htm

2006 305(b) Report

http://www.dep.state.fl.us/water/tmdl/docs/2006_Integrated_Report.pdf

Criteria for Surface Water Quality Classifications

http://www.dep.state.fl.us/water/wqssp/classes.htm

Basin Status Report for the Upper East Coast Basin

http://www.dep.state.fl.us/water/basin411/uppereast/status.htm

U.S. Environmental Protection Agency, National STORET Program

http://www.epa.gov/storet/

Chapter 1: INTRODUCTION

1.1 Purpose of Report

This report presents the Total Maximum Daily Load (TMDL) for dissolved oxygen (DO) and nutrients for Spruce Creek in the Halifax River Planning Unit of the Upper East Coast Basin. The creek was verified as impaired for both DO and nutrients, and was included on the Verified List of impaired waters for the Upper East Coast Basin that was adopted by Secretarial Order in December 2007. This TMDL establishes the allowable loadings to Spruce Creek that would restore the waterbody so that it meets its applicable water quality criteria for both DO and nutrients.

1.2 Identification of Waterbody

Spruce Creek is located in Volusia County, in east-central Florida, near New Smyrna Beach. It forms in wetlands west of New Smyrna Beach and flows north, then turns east and discharges to the Intracoastal Waterway (ICWW) (**Figures 1.1** and **1.2**). Spruce Creek is approximately 20.1 miles long and is a second-order stream that is tidally influenced in its lower reaches. Additional information about the creek's hydrology and geology are available in the Basin Status Report for the Upper East Coast Basin (Florida Department of Environmental Protection [Department], 2005).

Spruce Creek and certain tributaries were designated as Outstanding Florida Waters (OFWs) in 1991. Volusia County initiated a study in May 1994 to evaluate the impact of stormwater on overall water quantity and water quality in the designated OFW areas of Spruce Creek and Rose Bay (Volusia County, 1996). OFW provisions require 50 percent greater treatment for the direct discharge of stormwater to an OFW. Volusia County is currently working on an update to the Spruce Creek/Rose Bay master plan.

For assessment purposes, the Department has divided the Upper East Coast Basin into water assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each watershed or stream reach. Spruce Creek consists of two segments, WBIDs 2674 and 2674A, as shown in **Figure 1.1**; this TMDL addresses the DO and nutrient impairments in WBID 2674A. The combined drainage area of WBIDs 2674 (17.67 square miles) and 2674A (13.10 square miles) is 30.77 square miles. Note that the USGS gaging site on Spruce Creek (Gage 02248053) discussed in Chapter 5 has a drainage area of 60.7 square miles and represents additional contributions outside these two WBIDs.

Spruce Creek is part of the Halifax River Planning Unit. Planning units are groups of smaller watersheds (WBIDs) that are part of a larger basin unit, in this case the Upper East Coast Basin. The Halifax River Planning Unit consists of 53 WBIDs. **Figure 1.3** shows the locations of these WBIDs, Spruce Creek's location in the planning unit, and a list of the other WBIDs in the planning unit. Since both WBIDs are listed as Spruce Creek, for clarity a number of the figures refer to WBID 2674A as Spruce Creek North.

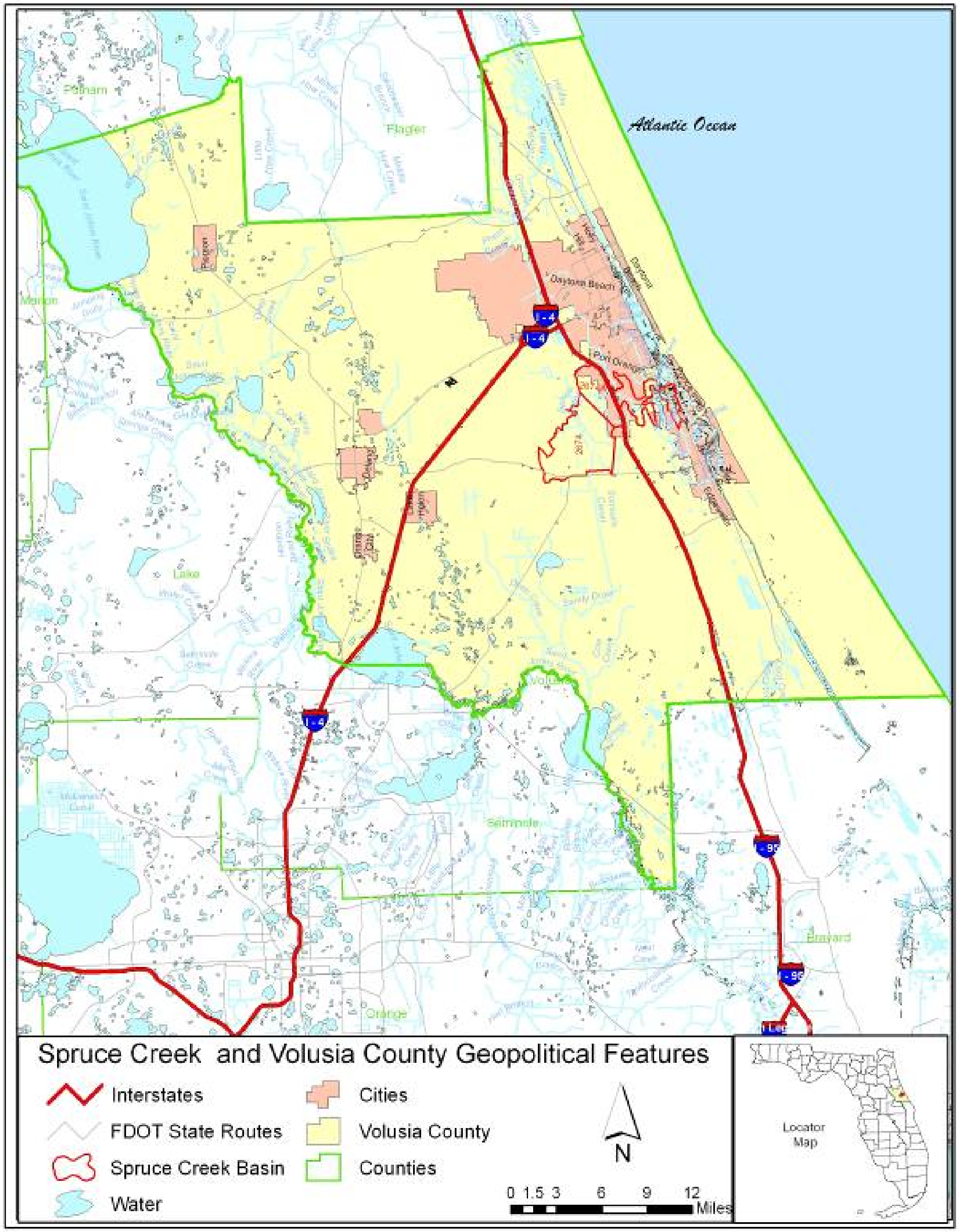


Figure 1.1. Location of Spruce Creek and Major Geopolitical Features in the Upper East Coast Basin

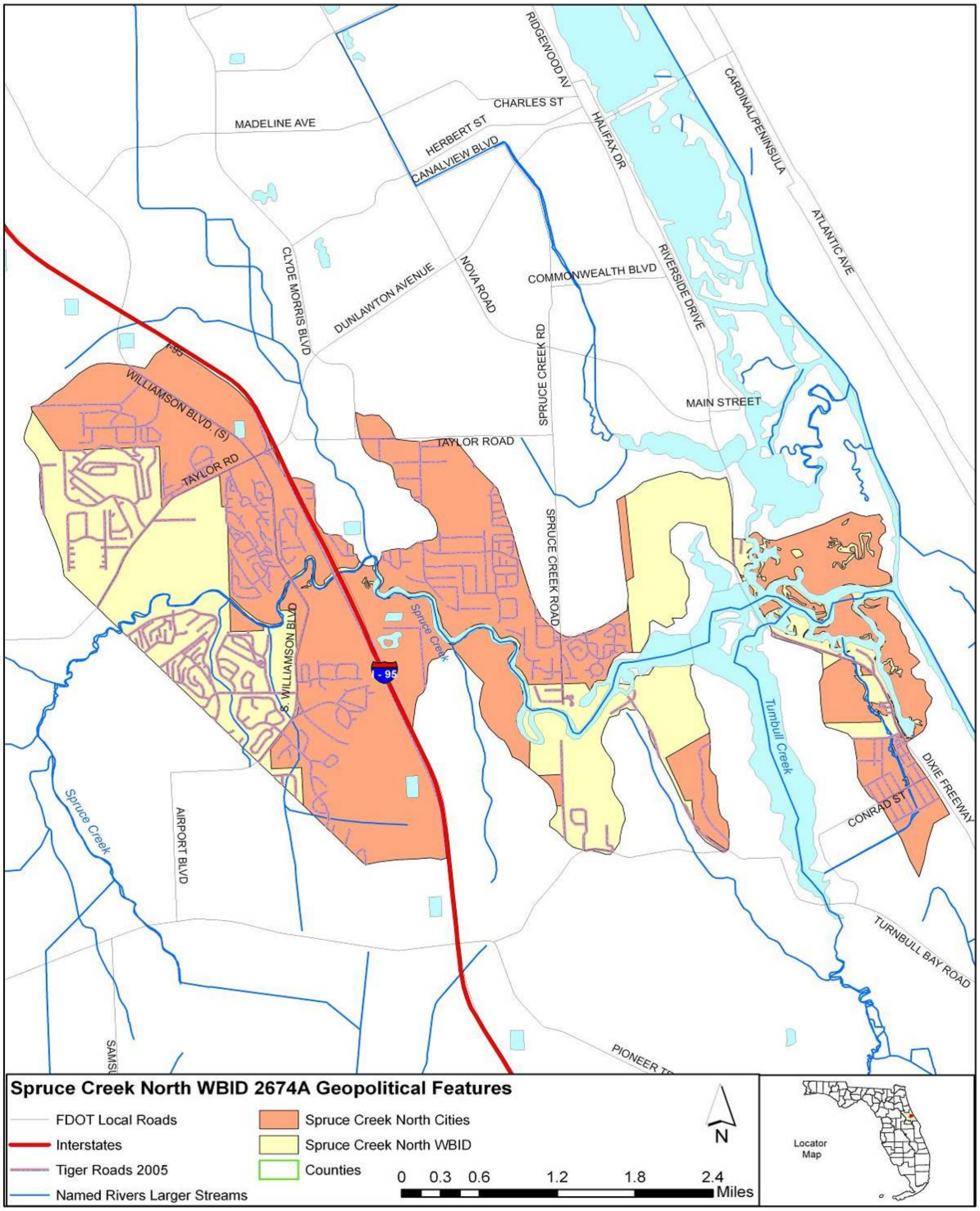


Figure 1.2. Spruce Creek, WBID 2674A

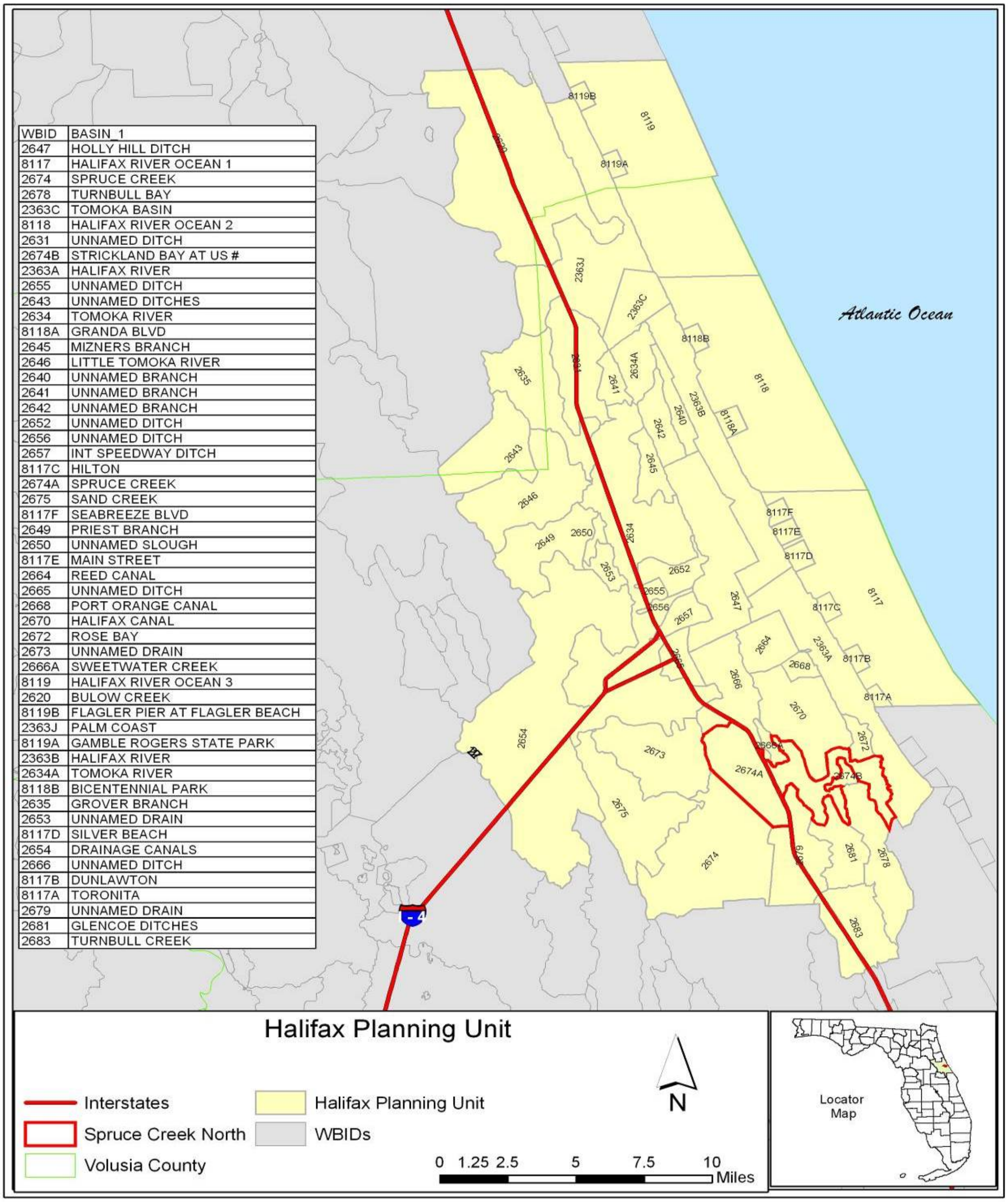


Figure 1.3. WBIDs in the Halifax River Planning Unit

1.3 Background

This report was developed as part of the Department's watershed management approach for restoring and protecting state waters and addressing TMDL Program requirements. The watershed approach, which is implemented using a cyclical management process that rotates through the state's 52 river basins over a 5-year cycle, provides a framework for implementing the TMDL Program–related requirements of the 1972 federal Clean Water Act and the 1999 Florida Watershed Restoration Act (FWRA) (Chapter 99-223, Laws of Florida).

A TMDL represents the maximum amount of a given pollutant that a waterbody can assimilate and still meet water quality standards, including its applicable water quality criteria and its designated uses. TMDLs are developed for waterbodies that are verified as not meeting their water quality standards. They provide important water quality restoration goals that will guide restoration activities.

This TMDL Report will be followed by the development and implementation of a Basin Management Action Plan, or BMAP, to reduce the amount of nutrients that caused the verified impairment of Spruce Creek. These activities will depend heavily on the active participation of the St. Johns River Water Management District (SJRWMD), Volusia County, local governments, local businesses, and other stakeholders. The Department will work with these organizations and individuals to undertake or continue reductions in the discharge of pollutants and achieve the established TMDLs for impaired waterbodies.

Chapter 2: DESCRIPTION OF WATER QUALITY PROBLEM

2.1 Statutory Requirements and Rulemaking History

Section 303(d) of the federal Clean Water Act requires states to submit to the U.S. Environmental Protection Agency (EPA) a list of surface waters that do not meet applicable water quality standards (impaired waters) and establish a TMDL for each pollutant causing impairment of these waters on a schedule. The Department has developed such lists, commonly referred to as 303(d) lists, since 1992. The list of impaired waters in each basin, referred to as the Verified List, is also required by the FWRA (Subsection 403.067[4], Florida Statutes [F.S.]), and the state's 303(d) list is amended annually to include basin updates.

Florida's 1998 303(d) list included 15 waterbodies and 50 parameters in the Upper East Coast Basin. However, the FWRA (Section 403.067, F.S.) stated that all previous Florida 303(d) lists were for planning purposes only and directed the Department to develop, and adopt by rule, a new science-based methodology to identify impaired waters. After a long rule-making process, the Environmental Regulation Commission adopted the new methodology as Rule 62-303, Florida Administrative Code (F.A.C.) (Identification of Impaired Surface Waters Rule, or IWR), in April 2001; the rule was revised in 2006 and 2007.

2.2 Information on Verified Impairment

The Department used the IWR to assess water quality impairments in Spruce Creek and has verified that the creek is impaired for DO and nutrients, based on data in the Department's IWR database. **Tables 2.1** through **2.3** summarize the DO data for the verification period, which for Group 5 waters was January 1, 1999, through June 30, 2006, by month, season, and year, respectively.

There is a 23.4 percent overall exceedance rate for DO in Spruce Creek during the verified period. Exceedances occur in all seasons and in all months except March (**Tables 2.1** and **2.2**). During the verified period, samples ranged from 0.01 to 9.20 milligrams per liter (mg/L). As DO solubility is influenced by both salinity and water temperature, ranges in DO saturation were also evaluated. DO saturation ranged from 0.1 to 120.9 percent, with fewer than 10 percent of the saturation values greater than 100 percent. Fewer than 10 percent of the DO saturation values were less than 34 percent.

When aggregating data by season, the lowest percentage of exceedances occurred in the winter and the highest in spring. Possible relationships between DO and other water quality parameters will be further assessed using the complete historical dataset in Chapter 5.

Of the 17 sites with historical data, 10 were sampled during the verified period. **Section 5.1** discusses the sampling stations further.

Table 2.1. Summary of DO Data by Month for the Verified Period (January 1, 1999 – June 30, 2006)

Month	N	Minimum	Maximum	Median	Mean	No. of Exceedances	% Exceedance	Mean Precipitation
January	11	2.43	8.72	6.64	5.70	4	36.36%	2.51
February	21	0.01	8.97	5.73	5.75	3	14.29%	2.89
March	12	1.83	9.2	7.13	6.78	1	8.33%	3.61
April	15	4.13	7.72	6.38	6.03	0	0.00%	2.35
May	15	0.53	7.18	4.92	4.19	6	40.00%	2.86
June	17	0.95	7.1	3.76	4.11	9	52.94%	6.15
July	7	0.79	6.03	4.10	3.96	2	28.57%	5.65
August	24	0.22	6.93	4.33	4.45	3	12.50%	6.48
September	7	0.28	6.69	4.40	3.85	3	42.86%	6.92
October	11	2.77	6.17	3.54	4.06	6	54.55%	4.9
November	16	2.64	7.4	5.74	5.51	2	12.50%	2.66
December	15	3.51	9.2	6.42	6.21	1	6.67%	2.48

DO units are mg/L.
Mean precipitation is for Daytona Beach International Airport, in inches.

Table 2.2. Summary of DO Data by Season for the Verified Period (January 1, 1999 – June 30, 2006)

Season	N	Minimum	Maximum	Median	Mean	No. of Exceedances	% Exceedance	Mean Total Precipitation
Winter	44	0.01	9.2	6.22	6.020568	8	18.18%	9.01
Spring	47	0.53	7.72	5.19	4.750213	15	31.91%	11.36
Summer	38	0.22	6.93	4.33	4.248026	8	21.05%	19.05
Fall	42	2.64	9.2	5.46	5.382143	9	21.43%	10.04

DO units are mg/L.
Mean total precipitation is for Daytona Beach International Airport, in inches.

Table 2.3. Summary of DO Data by Year for the Verified Period (January 1, 1999 – June 30, 2006)

Year	N	Minimum	Maximum	Median	Mean	No. of Exceedances	% Exceedance	Total Precipitation
1999	44	0.22	8.31	4.39	4.46	14	31.82%	46.37
2000	14	0.79	8.14	4.22	4.41	6	42.86%	40.16
2001	16	0.01	8.97	4.84	4.28	5	31.25%	58.27
2002	7	4.69	7.73	7.02	6.43	0	0.00%	59.94
2003	27	2.53	8.5	5.28	5.23	7	25.93%	57.3
2004	14	3.08	9.2	5.56	5.71	3	21.43%	62.97
2005	43	3.68	8.52	5.95	5.64	5	11.63%	65.77
2006	6	5.34	8.72	6.45	6.74	0	0.00%	31.36

DO units are mg/L.
Total precipitation is for Daytona Beach International Airport, in inches.

Table 2.4 summarizes annual average corrected chlorophyll *a* (chla) concentrations based on the IWR. During the verified period, the 11 micrograms per liter (µg/L) threshold was exceeded in 2003. In 2002, 2004, and 2006, there were insufficient data to calculate an annual average.

Table 2.4. Summary of Annual Average Corrected Chla for the Verified Period (January 1, 1999 – June 30, 2006)

Year	Mean	Exceedance
1999	5.30	no
2000	3.82	no
2001	5.96	no
2002		
2003	12.05	yes
2004		
2005	2.95	no
2006		

Corrected chla units are ug/L.
Historical threshold is 5.60 µg/L based on the 1991–1995 period.

Chapter 3. DESCRIPTION OF APPLICABLE WATER QUALITY STANDARDS AND TARGETS

3.1 Classification of the Waterbody and Criteria Applicable to the TMDL

Florida's surface waters are protected for five designated use classifications, as follows:

Class I	**Potable water supplies**
Class II	**Shellfish propagation or harvesting**
Class III	**Recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife**
Class IV	**Agricultural water supplies**
Class V	**Navigation, utility, and industrial use (there are no state waters currently in this class)**

Spruce Creek (WBID 2674A) is a Class III marine waterbody, with a designated use of recreation, propagation, and the maintenance of a healthy, well-balanced population of fish and wildlife. The Class III water quality criteria applicable to the impairment addressed by this TMDL are for DO and nutrients.

3.2 Applicable Water Quality Standards and Numeric Water Quality Target

3.2.1 Dissolved Oxygen Criterion

Numeric criteria for DO are expressed in terms of minimum and daily average concentrations. The water quality criterion for the protection of Class III marine waters, as established by Rule 62-302, F.A.C., states the following:

> ***Dissolved Oxygen Criteria:***
> *Shall not average less than 5.0 in a 24-hour period and shall never be less than 4.0. Normal daily and seasonal fluctuations above these levels shall be maintained.*

The nutrient criterion in Rule 62-302, F.A.C., is expressed as a narrative:

> ***Nutrients:***
> *In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna [Note: For Class III waters in the Everglades Protection Area, this criterion has been numerically interpreted for phosphorus in Section 62-302.540, F.A.C.].*

To assess whether this narrative criterion was being exceeded, the IWR provides thresholds for nutrient impairment in estuaries based on annual average chla levels. The following language is found in Rule 62-303, F.A.C.:

62-303.353 Nutrients in Estuaries and Open Coastal Waters.
Estuaries, estuary segments, or open coastal waters shall be included on the planning list for nutrients if their annual mean chlorophyll a for any year is greater than 11 μg/l or if data indicate annual mean chlorophyll a values have increased by more than 50% over historical values for at least two consecutive years.

62-303.450 Interpretation of Narrative Nutrient Criteria.
(1) A water shall be placed on the verified list for impairment due to nutrients if there are sufficient data from the last five years preceding the planning list assessment, combined with historical data (if needed to establish historical chlorophyll a levels or historical TSIs), to meet the data sufficiency requirements of subsection 62-303.350(2), FA.C. If there are insufficient data, additional data shall be collected as needed to meet the requirements. Once these additional data are collected, the Department shall determine if there is sufficient information to develop a site-specific threshold that better reflects conditions beyond which an imbalance in flora or fauna occurs in the water segment. If there is sufficient information, the Department shall re-evaluate the data using the site-specific thresholds. If there is insufficient information, the Department shall re-evaluate the data using the thresholds provided in Rules 62-303.351-.353, F.A.C., for streams, lakes, and estuaries, respectively. In any case, the Department shall limit its analysis to the use of data collected during the five years preceding the planning list assessment and the additional data collected in the second phase. If alternative thresholds are used for the analysis, the Department shall provide the thresholds for the record and document how the alternative threshold better represents conditions beyond which an imbalance in flora or fauna is expected to occur.

Chapter 4: ASSESSMENT OF SOURCES

4.1 Types of Sources

An important part of the TMDL analysis is the identification of pollutant source categories, source subcategories, or individual sources of pollutants in the watershed and the amount of pollutant loading contributed by each of these sources. Sources are broadly classified as either “point sources” or “nonpoint sources.” Historically, the term “point sources” has meant discharges to surface waters that typically have a continuous flow via a discernable, confined, and discrete conveyance, such as a pipe. Domestic and industrial wastewater treatment facilities (WWTFs) are examples of traditional point sources. In contrast, the term “nonpoint sources” was used to describe intermittent, rainfall-driven, diffuse sources of pollution associated with everyday human activities, including runoff from urban land uses, agriculture, silviculture, and mining; discharges from failing septic systems; and atmospheric deposition.

However, the 1987 amendments to the Clean Water Act redefined certain nonpoint sources of pollution as point sources subject to regulation under the EPA’s National Pollutant Discharge Elimination System (NPDES) Program. These nonpoint sources included certain urban stormwater discharges, including those from local government master drainage systems, construction sites over five acres, and a wide variety of industries (see **Appendix A** for background information on the federal and state stormwater programs).

To be consistent with Clean Water Act definitions, the term “point source” will be used to describe traditional point sources (such as domestic and industrial wastewater discharges) **AND** stormwater systems requiring an NPDES stormwater permit when allocating pollutant load reductions required by a TMDL (see **Section 6.1**). However, the methodologies used to estimate nonpoint source loads do not distinguish between NPDES stormwater discharges and non-NPDES stormwater discharges, and as such, this source assessment section does not make any distinction between the two types of stormwater.

4.2 Potential Sources of Nutrients in the Spruce Creek Watershed

4.2.1 Point Sources

There are no NPDES wastewater facilities located in the watershed. **Figure 4.1** shows the location of a state-permitted industrial facility along with partial coverage of septic tanks. The Volusia County Department of Public Works Spruce Creek Reverse Osmosis Facility (FLA0185086) discharges demineralization concentrate to a land application system (a 2.3-acre impoundment). It has a monthly design discharge flow of 0.15 million gallons per day (mgd). As shown in **Figure 4.1**, the city of Port Orange provides sewer service to portions of the watershed. There are currently approximately 4,700 households connected to the city’s wastewater system in WBID 2674A, and there are also private sewer lines in the Spruce Creek Fly-In subdivision (a portion of which is included in this WBID) (C. Craig, city of Port Orange, personal communication).

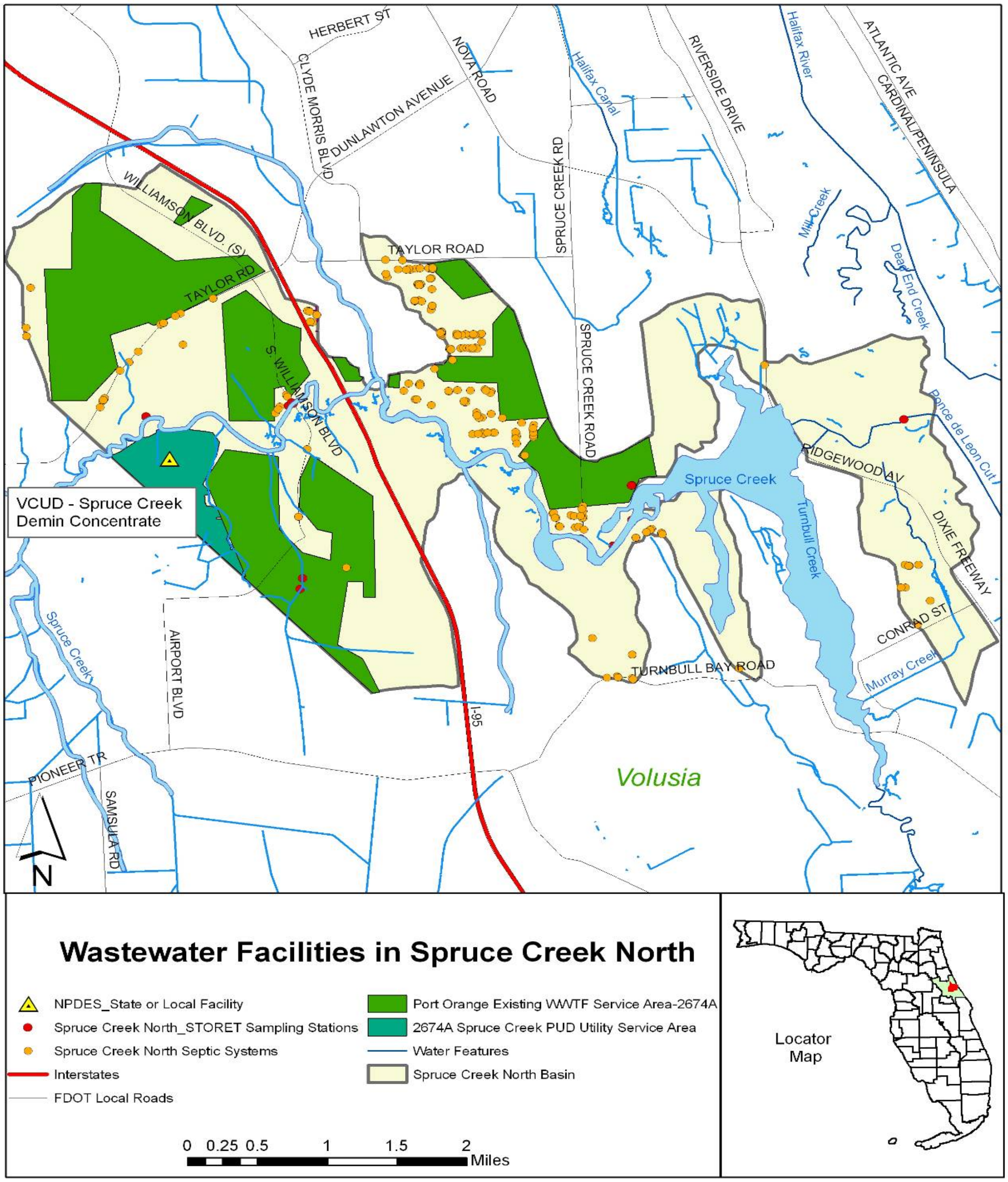
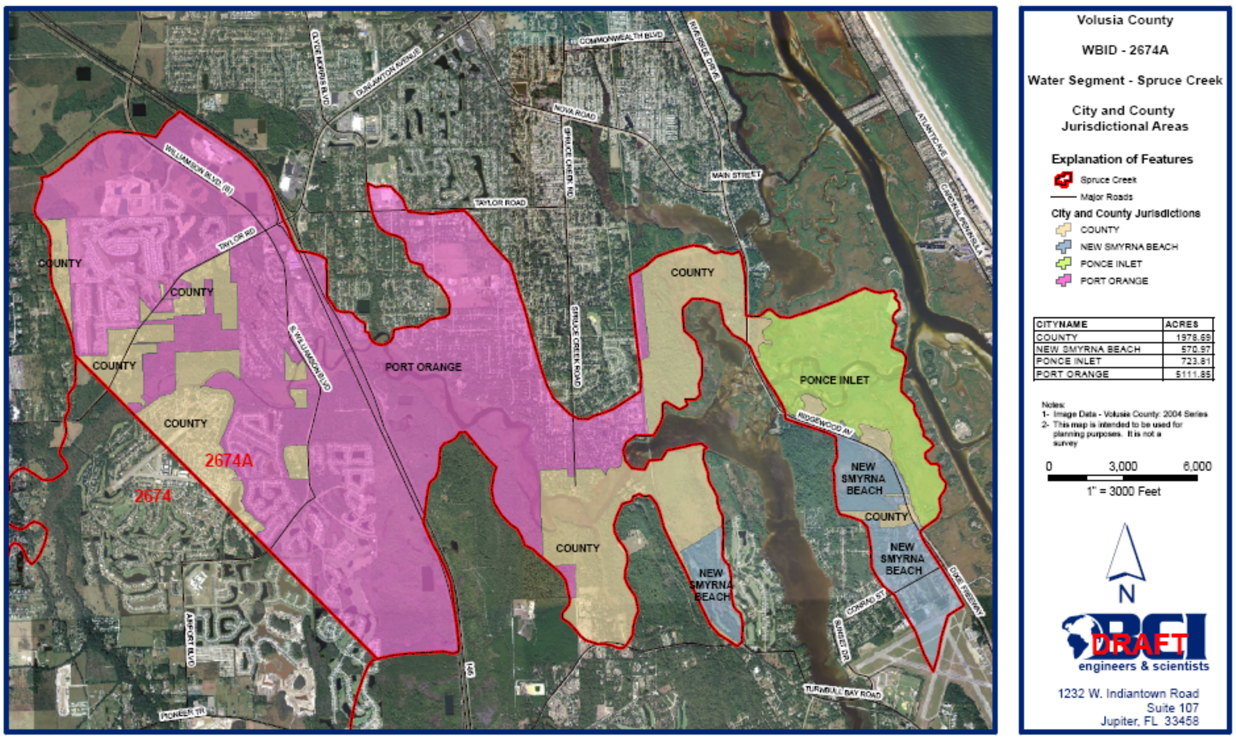


Figure 4.1. Location of Permitted Facilities in the Spruce Creek Watershed

Municipal Separate Storm Sewer System Permittees

Volusia County, Port Orange, Ponce Inlet, and New Smyrna Beach have Phase II NPDES municipal separate storm sewer system (MS4) permits (FLR04E033, FLR04E014, FLR04E071, and FLR04E035, respectively) that may cover portions of the Spruce Creek watershed. **Figure 4.2,** provided by BCI Engineers & Scientists, Inc. (C. Farmer, personal communication), illustrates the juridictional areas for each permittee.

Figure 4.2. Jurisdictional Areas of Phase II NPDES MS4 Permits in the Spruce Creek Watershed



4.2.2 Land Uses and Nonpoint Sources

Nutrient loadings to Spruce Creek are generated from nonpoint sources in the watershed. These potential sources include loadings from surface runoff, ground water inflow, leakage from collection systems, and septic tanks.

Land Uses

The spatial distribution and acreage of different land use categories were identified using the 2004 land use coverage contained in the Department's geographic information system (GIS) library, initially provided by the SJRWMD. Land use categories and acreages in the watershed were aggregated using the Level 3 codes tabulated in **Table 4.1.** **Figure 4.3** shows the principal land uses in the watershed aggregated to the Level 1 land use codes.

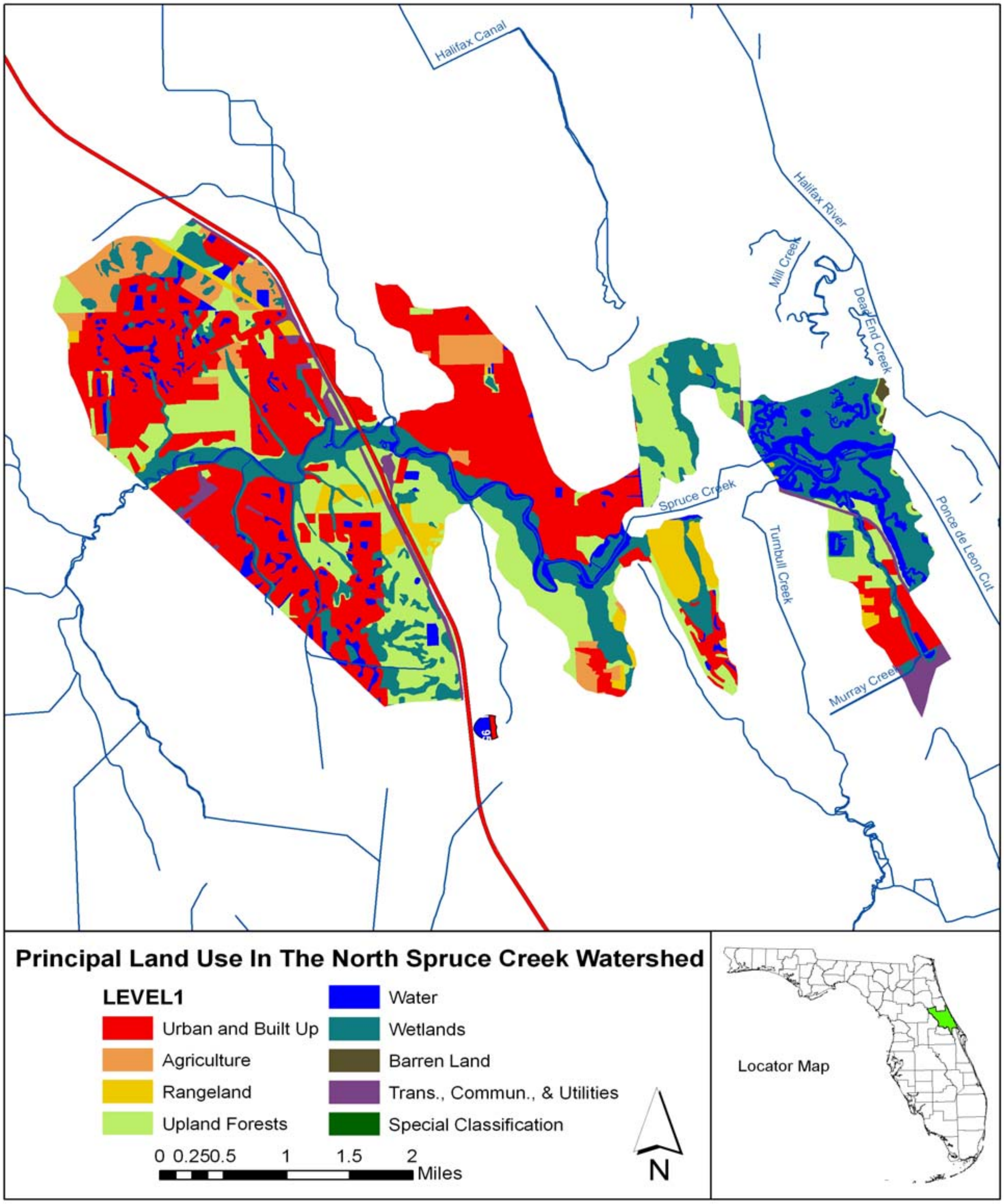
The Spruce Creek watershed is an area that is facing increased development pressures. As **Table 4.1** shows, urban and built-up areas represent 38.4 percent of the area (medium-density residential, 14.7 percent) followed by forest (22.2 percent), and wetlands (21.3 percent).

Table 4.1. Classification of Land Use Categories in the Spruce Creek Watershed

Level 3 Land Use Code	Attribute	Acres	% of Total
1200	Residential, medium density–2-5 dwelling units/acre	1,174.93	14.73
4110	Pine flatwoods	786.93	9.87
4340	Upland mixed coniferous/hardwood	782.61	9.81
6420	Saltwater marshes	752.96	9.44
1100	Residential, low density–less than 2 dwelling units/acre	593.39	7.44
1300	Residential, high density–6 or more dwelling units/acre	398.58	5.00
6170	Mixed wetland hardwoods	384.12	4.82
5300	Reservoirs–pits, retention ponds, dams	251.94	3.16
1820	Golf courses	233.09	2.92
1180	Rural residential	227	2.85
2130	Woodland pastures	187.42	2.35
6300	Wetland forested mixed	176.85	2.22
8140	Roads and highways (divided 4-lanes with medians)	174.32	2.19
1290	Medium density under construction	170.21	2.13
2110	Improved pastures (monoculture, planted forage crops)	167.94	2.11
6120	Mangrove swamps	151.72	1.90
3200	Shrub and brushland (wax myrtle or saw palmetto, occasionally scrub)	126.83	1.59
5100	Streams and waterways	123.03	1.54
1400	Commercial and services	109.41	1.37
3300	Mixed upland nonforested	106.02	1.33
3100	Herbaceous upland nonforested	91.91	1.15
8110	Airports	86.42	1.08
6460	Mixed scrub-shrub wetland	85.51	1.07
6210	Cypress	70.64	0.89
4200	Upland hardwood forests	69.52	0.87
1700	Institutional	57.13	0.72
4130	Sand pine	53.55	0.67
4410	Coniferous pine	52.89	0.66
2510	Horse farms	48.97	0.61
1390	High density under construction	40.1	0.50
1190	Low density under construction	30.79	0.39

Level 3 Land Use Code	Attribute	Acres	% of Total
6410	Freshwater marshes	30.16	0.38
4430	Forest regeneration	25.28	0.32
1900	Open land	22.73	0.28
1850	Parks and zoos	19.87	0.25
6250	Hydric pine flatwoods	19.59	0.25
5200	Lakes	18.06	0.23
6440	Emergent aquatic vegetation	13.98	0.18
7430	Spoil areas	12.03	0.15
2430	Ornamentals	9.63	0.12
6180	Cabbage palm hammock	7.62	0.10
1860	Community recreational facilities	7.52	0.09
8330	Water supply plants	4.81	0.06
5400	Bays and estuaries	4.62	0.06
8310	Electrical power facilities	4.57	0.06
6430	Wet prairies	3.38	0.04
8370	Surface water collection basins	3.29	0.04
4400	Tree plantations	2.32	0.03
	TOTAL:	**7,976.19**	**100.00%**

Figure 4.3. Principal Land Uses in the Spruce Creek Watershed



Soil Characteristics

The Soil Survey Geographic Database (SSURGO) in the Department's GIS database from the SJRWMD was accessed to provide coverage of hydrologic soil groups in the Spruce Creek watershed (**Figure 4.4**). **Table 4.2** briefly describes the major hydrology soil classes. Soil groups A and B/D are the most common in the watershed, with type D found in the lower portion of the watershed and along the stream corridor.

Table 4.2. Description of Hydrologic Soil Classes from the SSURGO Database

Hydrology Class	Description
A	High infiltration rates. Soils are deep, well-drained to excessively drained sands and gravels.
A/D	Drained/undrained hydrology class of soils that can be drained and are classified.
B	Moderate infiltration rates. Deep and moderately deep, moderately well- and well-drained soils that have moderately coarse textures.
B/D	Drained/undrained hydrology class of soils that have moderately coarse textures.
C	Slow infiltration rates. Soils with layers impeding downward movement of water, or soils that have moderately fine or fine textures.
C/D	Drained/undrained hydrology class of soils that can be drained and classified.
D	Very slow infiltration rates. Soils are clayey, have a high water table, or are shallow to an impervious layer.

Population

According to the U.S Census Bureau, census block population densities in the Spruce Creek watershed in 2000 ranged from 0 to 12,019 persons per square mile, with an average of 600 persons per square mile (**Figure 4.5**). Based on this average, the estimated population in the Spruce Creek watershed is 7,472. A more detailed analysis was completed by obtaining population and housing unit information from the 2000 Census at the block level and using GIS to estimate the fraction of each block in the watershed. The fractional area was then applied to the block information to estimate the population and number of housing units. Based on **Table 4.3**, the population in the watershed is estimated at 8,587 along with 3,666 housing units.

The Census Bureau reports that, for all of Volusia County, the total population for 2000 was approximately 443,343, with 211,938 housing units and an average occupancy rate of 87.2 percent (184,723 units). For all of Volusia County, the bureau reported a housing density of 192 houses per square mile. Thus Volusia County ranks 13th in housing densities and population in Florida (U.S. Census Bureau Website, 2000). The estimated average housing density in Spruce Creek is 280 residences per square mile, based on population.

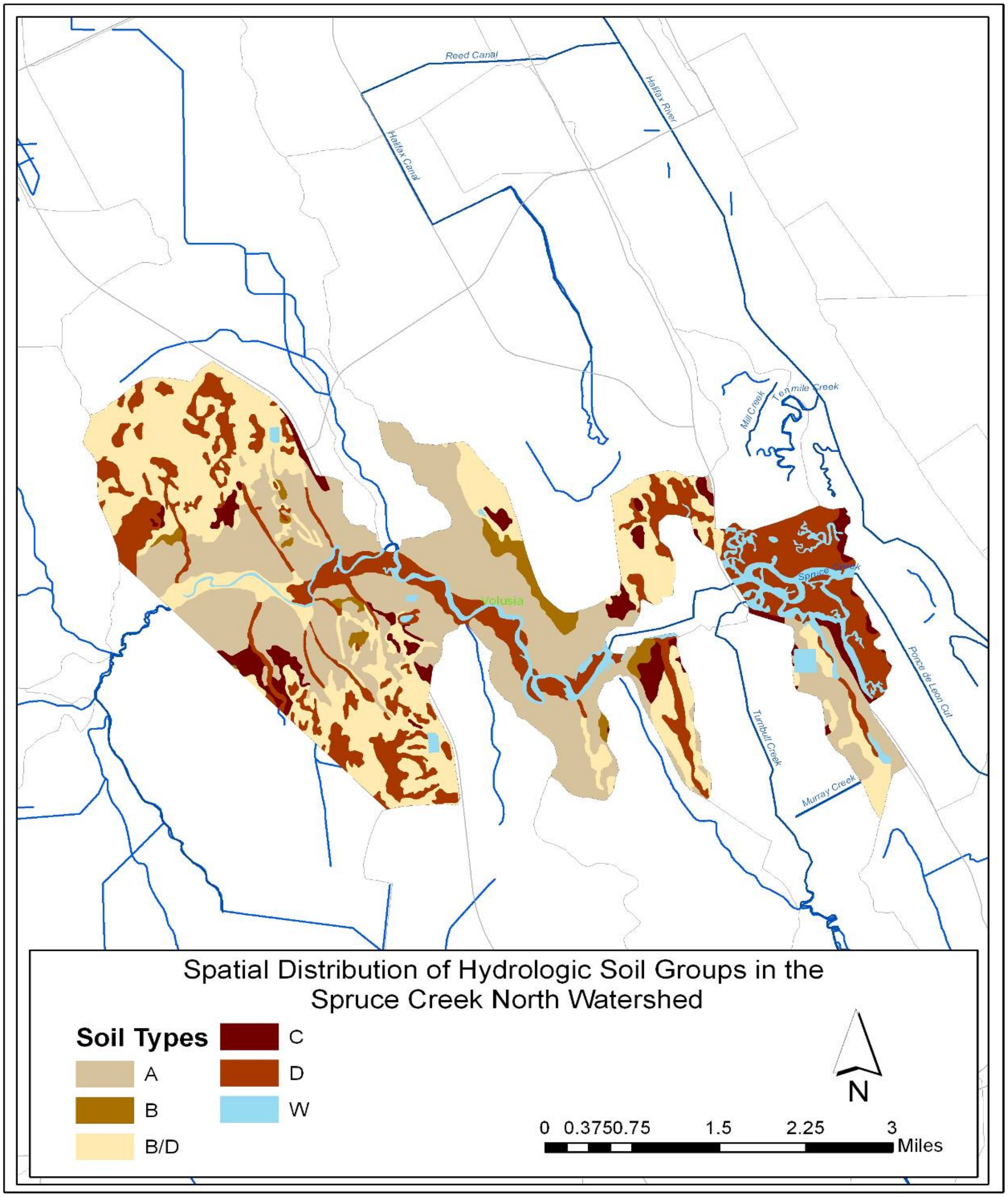


Figure 4.4. Hydrologic Soil Groups Distribution in the Spruce Creek Watershed

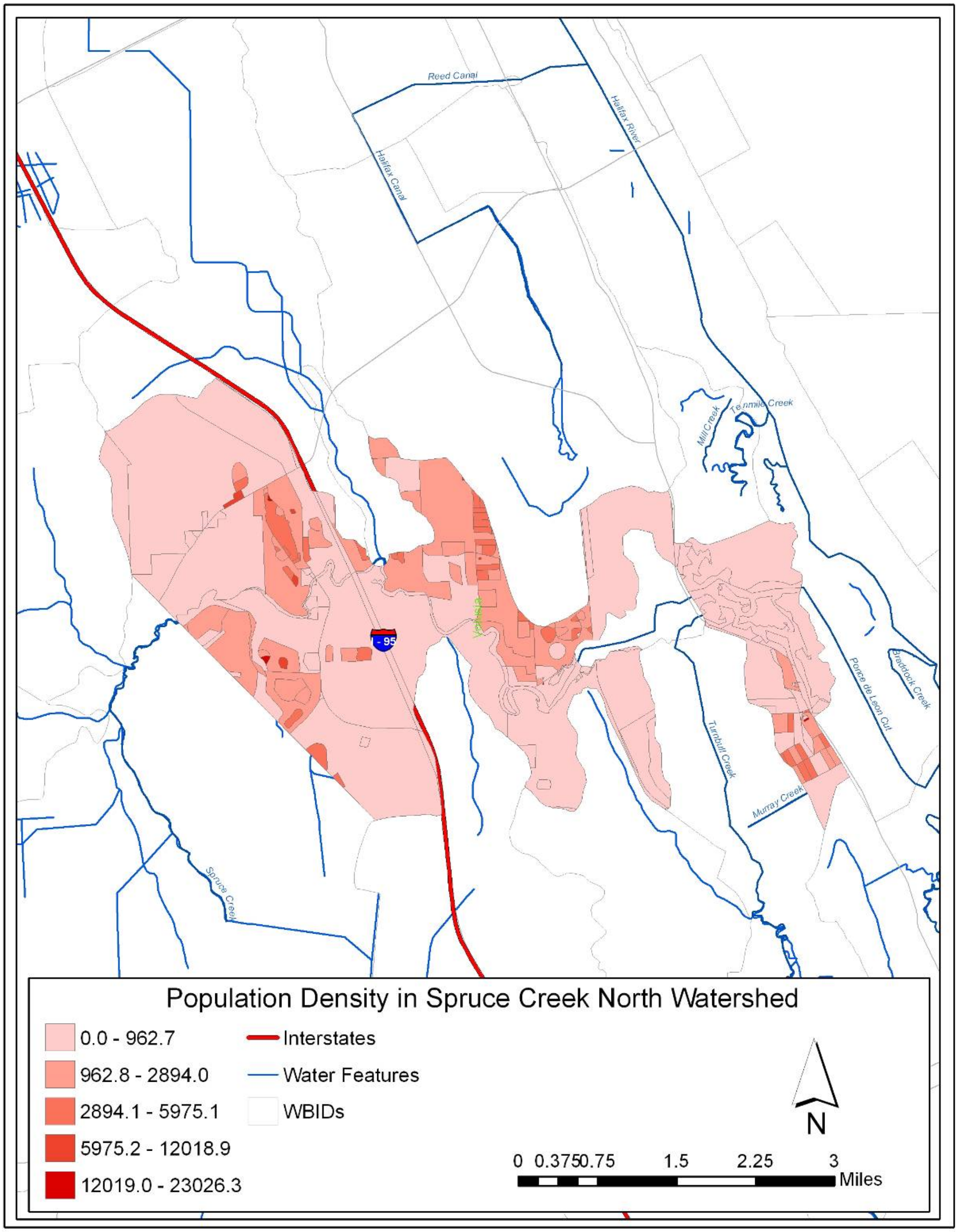


Figure 4.5. Population Density in the Spruce Creek Watershed

Septic Tanks

Based on the 2000 Census figure of 211,938 housing units and the Florida Department of Health (FDOH) estimate of 96,633 permitted septic tanks in Volusia County, approximately 45 percent of the households in the county are using septic tanks. FDOH reports that as of fiscal year 2005–06, there were 96,633 permitted septic tanks in Volusia County (FDOH Website, 2006). From fiscal years 1991–2006 (missing 1992–93), 13,436 permits for repairs were issued, for an average of approximately 960 repairs annually (FDOH Website, 2006) countywide. Simply dividing the number of septic tank repairs by the total number of septic tanks yields an estimated failure rate of 13.9 percent. Assuming that this failure rate is representative of the 14-year period for which data are available, this suggests a rate of 1 percent per year.

As noted previously, there were an estimated 8,587 persons and 3,666 households in the Spruce Creek watershed. The average household in the watershed has 2.34 persons (see **Table 4.3**). There are no permitted domestic wastewater facilities in the watershed; however, the city of Port Orange provides sewer service to portions of the watershed. Since the city is experiencing rapid population growth, information on its gravity sewer lines (C. Craig, personal communication) was overlaid on a 2004 aerial of the watershed to obtain an estimate of the number of households connected to the city wastewater system for comparison with the 2000 Census data. The number of residences connected to the city wastewater system was approximately 3,050.

Using this estimate, along with the 2000 Census calculation of 3,666 households, suggests that approximately 616 residences are using septic tanks (the partial coverage in **Figure 4.1** included 219 septic tanks). This indicates that approximately 17 percent of the households are using septic tanks, or about one-third of the countywide estimate. Using 70 gallons/day/person (EPA, 1999), and drainfield total nitrogen (TN) and total phosphorus (TP) concentrations of 36 mg/L and 15 mg/L, respectively, potential annual ground water loads of TN and TP were calculated. As in the case of earlier estimates, this is a screening level calculation, and soil types, the age of the system, vegetation, proximity to a receiving water, and other factors will influence the degree of attenuation of this load (**Table 4.4**).

Leaking or Overflowing Wastewater Collection Systems

Earlier it was estimated that approximately 3,050 households in the watershed are connected to the city of Port Orange wastewater facility. Using 2.34 people per home and a 70 gallon per person per day discharge, a daily flow of approximately 1.89×10^5 L is transported through the collection system. An EPA Region 4 memorandum on estimating water quality loadings from MS4 areas (EPA, 2002) suggests that a 5 percent leakage rate from collection systems is realistic. This information and EPA values for nitrogen and phosphorus concentrations in raw sewage yield potential annual loadings of nitrogen and phosphorus of 2,739 lbs/yr and 1,141 lbs/yr, respectively (**Table 4.5**).

Table 4.3. Estimated Average Household Size in the Spruce Creek Watershed

Tract	Block	Population	Housing Units
824.10	1	0	0
825.05	1	617	213
825.05	2	2188	757
825.05	3	835	225
825.07	1	101	51
828	1	744	397
829.01	1	65	22
832.04	3	4337	2001
	Total	**8,587**	**3,666**
		AVERAGE HOUSEHOLD SIZE:	**2.34**

Data from U.S. Census Bureau Website, 2005, based on Volusia County blocks that are present in the Spruce Creek watershed.

Table 4.4. Estimated Nitrogen and Phosphorus Annual Loading from Septic Tanks in the Spruce Creek Watershed

Estimated No. Households on Septic	Estimated No. Persons Per Household[1]	Gallons/ Person/ Day[2]	TN in Drainfield (mg/L)	TP in Drainfield (mg/L)	Estimated Annual TN Load (lbs/yr)	Estimated Annual TP Load (lbs/yr)
616	2.34	70	36	15	11,065	4,611

[1] U.S Census Bureau; see **Table 4.3** for more information on this estimate.
[2] EPA, 1999.

Table 4.5. Estimated Loading from Wastewater Collection Systems in the Spruce Creek Watershed

Parameter	Estimated Homes on Central Sewer	Estimated Daily Flow (L)	Daily Leakage (L)	Raw Sewage (mg/L)	Estimated Load (lbs/yr)
Nitrogen	3,050	1.89×10^6	9.45×10^4	36	2,739
Phosphorus	3,050	1.89×10^6	9.45×10^4	15	1,141

4.3 Source Summary

4.3.1 Summary of Nutrient Loadings to Spruce Creek from Various Sources

Agriculture

Aggregating land use to Level 1 for the Spruce Creek watershed yields 414 acres in agriculture. Harper et al. (2003) summarized a number of stormwater studies conducted in Florida, and based on those studies provided mean stormwater water quality parameters and hydrologic characteristics for a variety of land uses, including pastureland. According to Harper et al. (2003), mean stormwater concentrations for TN, TP, and biochemical oxygen demand (BOD) from pastureland are 2.48 mg/L, 0.476 mg/L, and 5.1 mg/L, respectively. The report also gave a mean runoff coefficient of 0.355.

A more detailed loading analysis could be performed based on soil types, annual rainfall amounts, and specific agricultural activities in the watershed. However, as a screening analysis, annual loads taken from the *BASINS 3.0 User Manual, Appendix IV* (EPA, 2001), for pasturelands in Florida were used as preliminary estimates (**Table 4.6**).

Table 4.6. Estimated Annual Average TN and TP Loads from Agriculture in the Spruce Creek Watershed

Agricultural Acreage	TN (lbs/ac/yr)	TN load (lbs/yr)	TP (lbs/ac/yr)	TP load (lbs/yr)
414	5.60	2,318	0.60	248

Source: EPA, 2001.

Urban Areas

There are 3,085 acres in the Level 1 category of urban and built-up in the watershed and 174 acres of highways. According to Harper et al. (2003), mean stormwater concentrations for TN, TP, and BOD from single-family residential lands are 2.18 mg/L, 0.335 mg/L, and 7.4 mg/L, respectively. The report also gave a mean runoff coefficient of 0.33. Mean stormwater concentrations for TN, TP, and BOD from multifamily residential lands are 2.42 mg/L, 0.49 mg/L, and 11.0 mg/L, respectively. The report also gave a mean runoff coefficient of 0.675.

A more detailed loading analysis could be performed based on soil types, annual rainfall amounts, and specific agricultural activities in the watershed. However, as a screening analysis, annual loads taken from the *BASINS 3.0 User Manual, Appendix IV* (EPA, 2001), for pasturelands in Florida were used (**Table 4.7)**. Medium- and high-density land uses were combined into the multifamily category, and some land uses in Level 1 were not included in the loading estimate (for example, golf courses).

Table 4.7. Estimated Urban and Built-up Annual Nitrogen and Phosphorus Loading in the Spruce Creek Watershed

Urban Category	Acreage	TN (lbs/ac/yr)	TN load (lbs/yr)	TP (lbs/ac/yr)	TP load (lbs/yr)
Low-Density residential	851.2	4.43	3,771	0.47	400
Multifamily residential	1,783.8	7.07	12,612	1.97	3,514
Commercial	109.4	9.48	1,037	2.05	224
Highway	174.3	6.25	1,089	2.50	436
Open Lands	22.7	2.32	53	0.16	4
Totals	**2,941.4**		**18,562**		**4,578**

Source: *BASINS 3.0 Users Manual, Appendix IV.*

Upstream Drainage Area of Spruce Creek

As discussed earlier, Spruce Creek is divided into two WBIDs, and this TMDL focuses on the lower WBID (2674A). A simple estimate of annual TN and TP loading from the upper WBID was obtained by multiplying annual average flows from U.S. Geological Survey (USGS) Gage 02248000 and nutrient concentrations (**Table 4.8**).

Table 4.8. Estimated Annual Nitrogen and Phosphorus Loading to WBID 2674A from WBID 2674, 1991–2005

Year	# TN Samples	Mean TN (mg/L)	# TP Samples	Mean TP (mg/L)	Avg. Flow (cfs)	TN Load (lbs/yr)	TP Load (lbs/yr)
1991	7	1.49	7	0.159	53.9	158,420.3	16,827.4
1992	5	1.42	5	0.152	23	64,301.3	6,883.0
1993	3	0.98	3	0.147	13.2	25,373.2	3,811.6
1995	40	1.23	40	0.213	41.1	99,911.6	17,261.9
1996	42	0.92	42	0.188	37.7	67,960.2	13,957.7
1997	43	0.99	43	0.141	15.3	29,759.2	4,241.0
1998	43	1.23	43	0.119	47.1	114,184.1	11,035.0
1999	43	1.00	42	0.118	41	80,790.7	9,515.5
2000	41	0.88	41	0.085	4.6	7,937.9	770.5
2001	42	1.08	42	0.120	63.7	135,359.7	15,048.1
2002	42	0.92	42	0.095	25.3	45,609.0	4,740.3
2003	42	1.08	42	0.101	39.1	82,778.6	7,805.3
2004	37	1.07	37	0.112	42.3	88,931.1	9,321.5
2005	50	1.32	50	0.141	50.5	131,241.9	14,020.9
Average		**1.08**		**0.131**		**80,897**	**9,660**

cfs – Cubic feet per second.

Table 4.9 summarizes the various estimates from various anthropogenic sources. It is important to note that this is not a complete list and represents estimates of potential loadings. In addition, proximity to the waterbody, soil characteristics, and rainfall frequency and magnitude are just a few of the factors that could influence and determine the actual loadings from these sources that reach Spruce Creek. For example, where are the improved pasture and high-density residential areas relative to Spruce Creek, and is there a riparian buffer area between these land uses and the stream? What types of best management practices (BMPs), both structural and nonstructural, have been implemented for specific land uses in the watershed that reduce the actual nutrient loads delivered to Spruce Creek? Finally, what is the age and condition of the septic and collection systems and drainage characteristics in the watershed compared with the county overall that could affect assumptions about the assimilation and/or retention of nutrients?

Table 4.9. Summary of Estimated Potential Annual Nitrogen and Phosphorus Loading from Various Sources in the Spruce Creek Watershed

Source	Total Nitrogen (lbs/yr)	Total Phosphorus (lbs/yr)
Septic Tanks	11,065	4,611
Urban and Built-up	18,562	4,578
Leaking Collection Systems	2,739	1.141
Agriculture	2,318	248
Upstream WBID	80,897	9,660

Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY

5.1 Determination of Loading Capacity

A USGS gaging site on Spruce Creek (02248053) has daily discharge data over the period from December 27, 2000, to September 30, 2006. As seen in **Figure 5.1**, the stream is tidally influenced at this location, with over 70 percent of the daily flows suggesting upstream transport. Another USGS gaging site farther upstream on Spruce Creek (02248000) has operated since 1951 and is not tidally influenced. **Table 5.1** provides physical and streamflow statistics for these two gages.

Due to the tidal influence and limited period of record, annual nutrient loads were not estimated for WBID 2674A based on flow and instream nutrient measurements. The upstream gage flows were paired with observations as part of the correlation analysis and for the calculation of nutrient loads contributed from WBID 2674 to WBID 2674A. To determine the TMDL, relationships between DO and nutrients were examined to identify the reductions that would be required to meet applicable criteria.

Figure 5.1. Daily Discharge Recorded at USGS Gage 02248053: Spruce Creek Near New Smyrna Beach

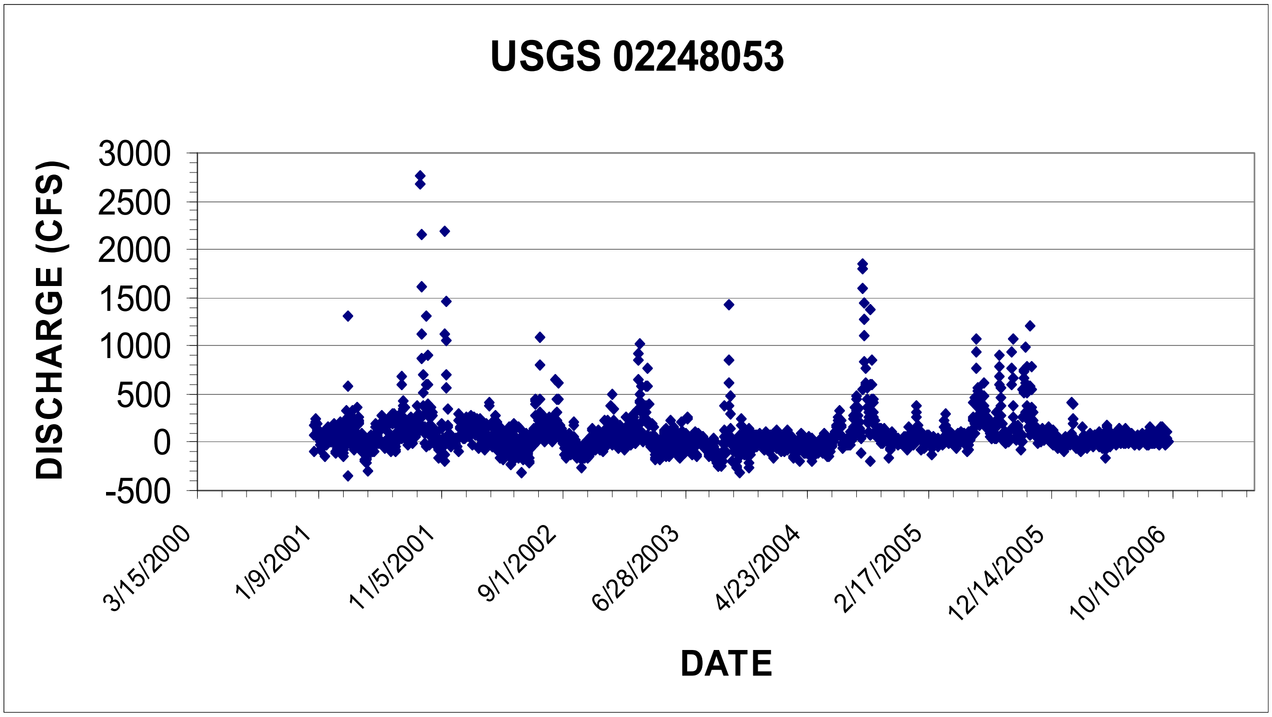


Table 5.1. Physical and Statistical Summaries for USGS Gaging Sites in the Spruce Creek Watershed

	USGS Gages	
Gage #	02248000	02248053
Drainage Area (square miles)	33.4	60.7
Period of Record	10/2/1951 – Present	12/27/2000 – 9/30/2006
Mean Basin Elevation (feet)	28	
Stream slope (feet/mile)	0.6	
Flow Duration		
1% (cfs)	372	1,102.6
5% (cfs)	160	379.3
10% (cfs)	83	255.7
20% (cfs)	35	180
25% (cfs)	25	154
50% (cfs)	6.3	47.5
70% (cfs)	2.4	-18
75% (cfs)	1.9	-36.5
90% (cfs)	0.92	-106.4
95% (cfs)	0.59	-138.3
99% (cfs)	0.29	-208.8

5.1.1 Data Used in the Determination of the TMDL

Seventeen sampling stations on Spruce Creek have historical DO observations (**Figure 5.2**). Five of the Department stations were established and sampled during 2005. **Table 5.2** contains summary information on each of the stations. **Table 5.3** provides a statistical summary of DO observations at each station, and **Appendix B** contains historical DO, corrected chla, TN, and TP observations from the sites for the planning and verified periods for WBID 2674A. **Figure 5.3** displays the historical observations of DO over time. DO exceedance rates by station range between 20 and 60 percent. A linear regression of DO versus sampling date in **Figure 5.3** indicates no significant trend over time (R^2 = 0.0009). **Appendix E** contains plots of DO by season, station, and year.

Figures 5.4 through **5.6** present historical corrected chla, TN, and TP observations, respectively. Linear regressions of each parameter versus sampling date indicate no significant trend over time (R^2 values for each < 0.08). **Appendix E** contains additional plots.

Table 5.2. Sampling Station Summary for the Spruce Creek Watershed

Station	STORET ID	Station Owner	Years With Data	N
Spruce Creek Center Bridge on U.S. Hwy 1	21FLVEMDSC01	Volusia County	1991–98	77
Spruce Creek West of SSC Railroad	21FLVEMDSC02	Volusia County	1991–98	77
Spruce Creek West of Airport Rd	21FLVEMDSC04	Volusia County	1991–98	78
Spruce Creek at Dock at Gamble Place	21FLVEMDSC05	Volusia County	1991–98	78
Spruce Creek 100 M Upstream from ICWW	21FLSJWMSPRCR	SJRWMD	1992	1
Spruce Creek at Airport Rd	21FLSJWMUEC014	SJRWMD	1992–93	5
Spruce Creek, from W. Side of Center Bridge on U.S. 1	21FLVEMDVC-071	Volusia County	1999–2006	35
Spruce Creek, from Dock at Riverwood, W. of SCL Railroad	21FLVEMDVC-072	Volusia County	1999–2006	39
Spruce Creek, from W. Side of Moody Bridge on Airport Rd	21FLVEMDVC-073	Volusia County	1999–2006	35
Spruce Creek, from Dock at Gamble Place	21FLVEMDVC-074	Volusia County	1999–2005	28
Spruce Creek @ Cypress Head Development	21FLWPB 20010737	Department	2003	6
Spruce Creek @ Airport Rd	21FLWPB 20010738	Department	2003	6
Spruce Creek @ 675M Upstream of RR Bridge	21FLCEN 27010193	Department	2005	5
Spruce Creek @ 0.68 Miles Upstream of RR Bridge	21FLCEN 27010194	Department	2005	6
Spruce Creek @ 0.87 Miles Upstream of RR Bridge	21FLCEN 27010195	Department	2005	5
Spruce Creek @ 1.07 Miles Upstream of RR Bridge	21FLCEN 27010196	Department	2005	5
Spruce Creek @ 1.3 Miles Upstream of RR Bridge	21FLCEN 27010197	Department	2005	6

Table 5.3. Statistical Summary of Historical Data for Spruce Creek

Station	N	Minimum	Maximum	Median	Mean	Exceedances	% Exceedance
Spruce Creek Center Bridge on U.S. Hwy 1	77	3.69	9.99	6.20	6.37	2	2.60%
Spruce Creek West of SSC Railroad	77	3.59	8.36	5.51	5.79	2	2.60%
Spruce Creek West of Airport Rd	78	0.07	7.99	3.23	3.29	49	62.82%
Spruce Creek at Dock at Gamble Place	78	0.15	7.99	3.96	3.78	42	53.58%
Spruce Creek 100 M Upstream from ICWW	1	5.1	5.1	5.10	5.10	0	0.00%
Spruce Creek at Airport Rd	5	1.7	6.4	2.70	3.48	3	60.00%
Spruce Creek, from W. Side of Center Bridge on U.S. 1	35	0.53	9.20	6.48	6.48	1	2.86%
Spruce Creek, from Dock at Riverwood, W. of SCL Railroad	39	3.34	9.2	5.99	6.00	2	5.13%
Spruce Creek, from W. Side of Moody Bridge on Airport Rd	35	0.04	7.09	4.16	3.86	16	45.71%
Spruce Creek, from Dock at Gamble Place	28	0.01	6.42	3.56	3.45	15	53.57%
Spruce Creek @ Cypress Head Development	6	6.17	7.505	6.93	6.89	0	0.00%
Spruce Creek @ Airport Rd	6	2.53	5.88	4.05	4.10	3	50.00%
Spruce Creek @ 675M Upstream of RR Bridge	5	3.68	6.5	6.05	5.34	1	20.00%
Spruce Creek @ 0.68 Miles Upstream of RR Bridge	6	3.7	6.38	5.82	5.35	1	16.67%
Spruce Creek @ 0.87 Miles Upstream of RR Bridge	5	3.72	6.44	5.65	5.29	1	20.00%
Spruce Creek @ 1.07 Miles Upstream of RR Bridge	5	3.76	6.42	5.73	5.27	1	20.00%
Spruce Creek @ 1.3 Miles Upstream of RR Bridge	6	3.7	6.54	4.73	5.06	1	16.67%

DO concentrations are mg/L.

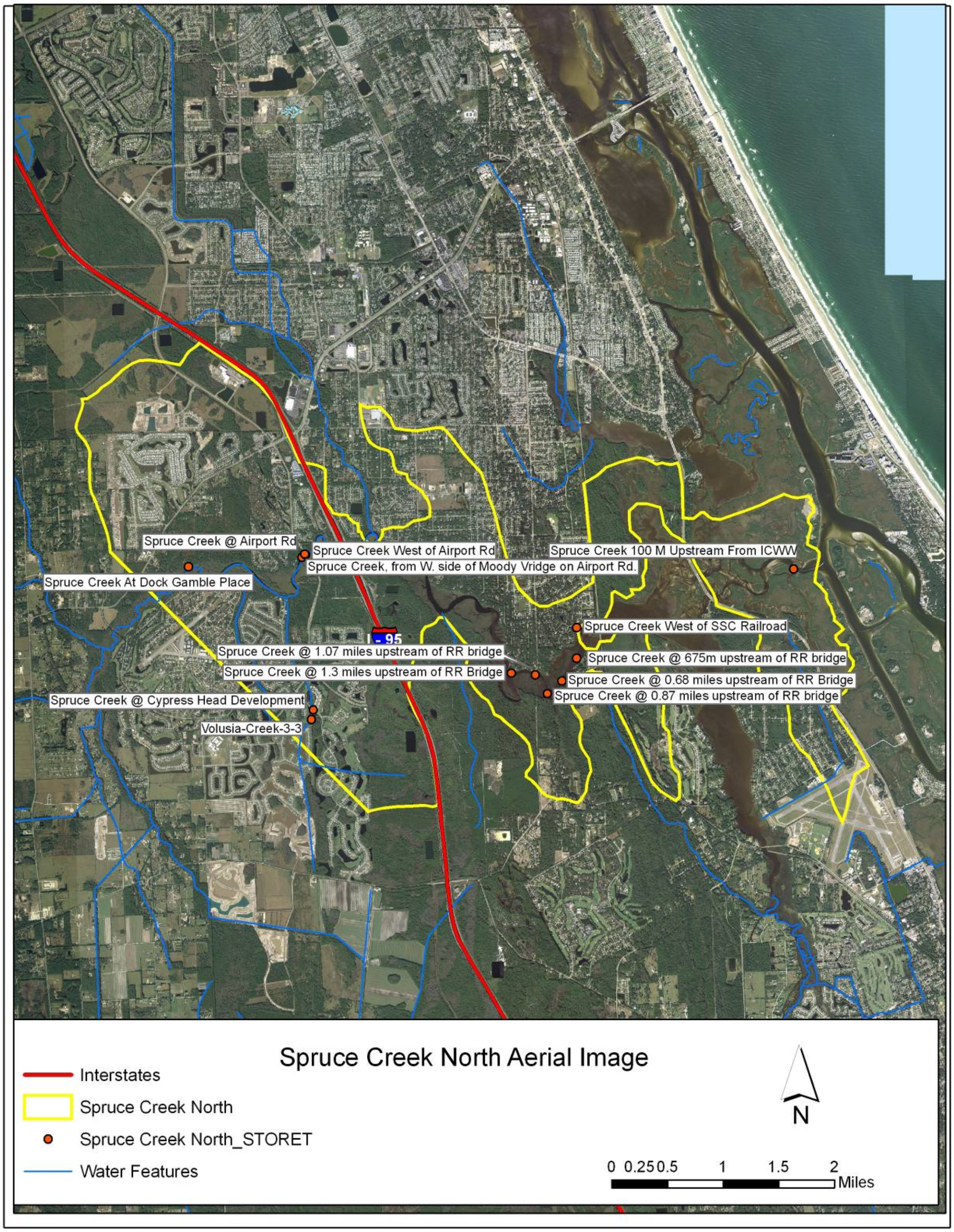


Figure 5.2. Historical Sampling Sites in the Spruce Creek Watershed

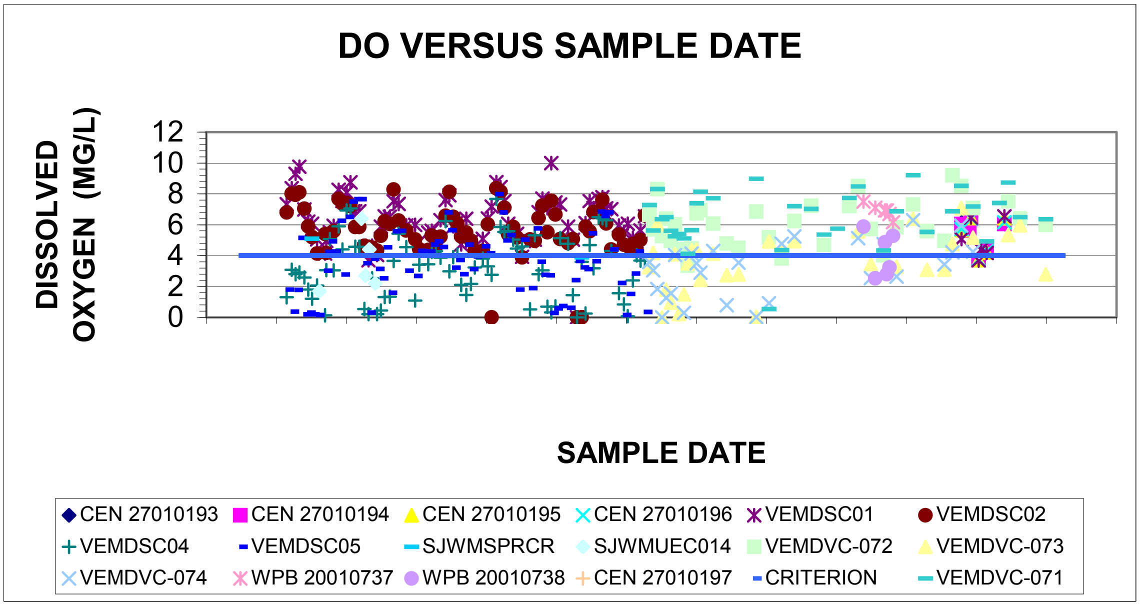


Figure 5.3. Historical DO Observations for Spruce Creek

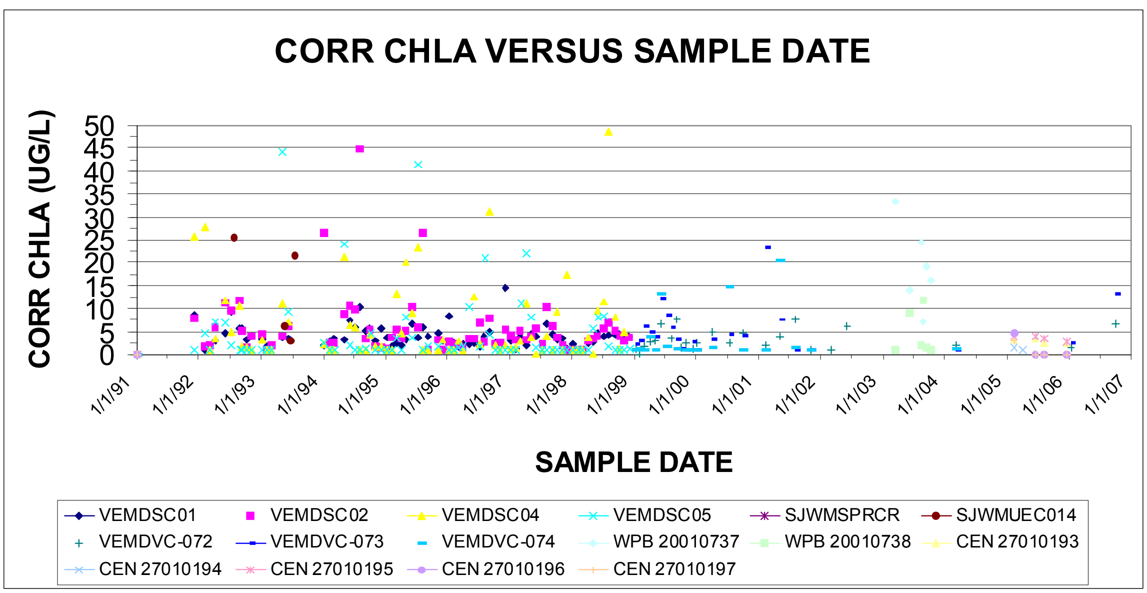


Figure 5.4. Historical Corrected Chla Observations for Spruce Creek

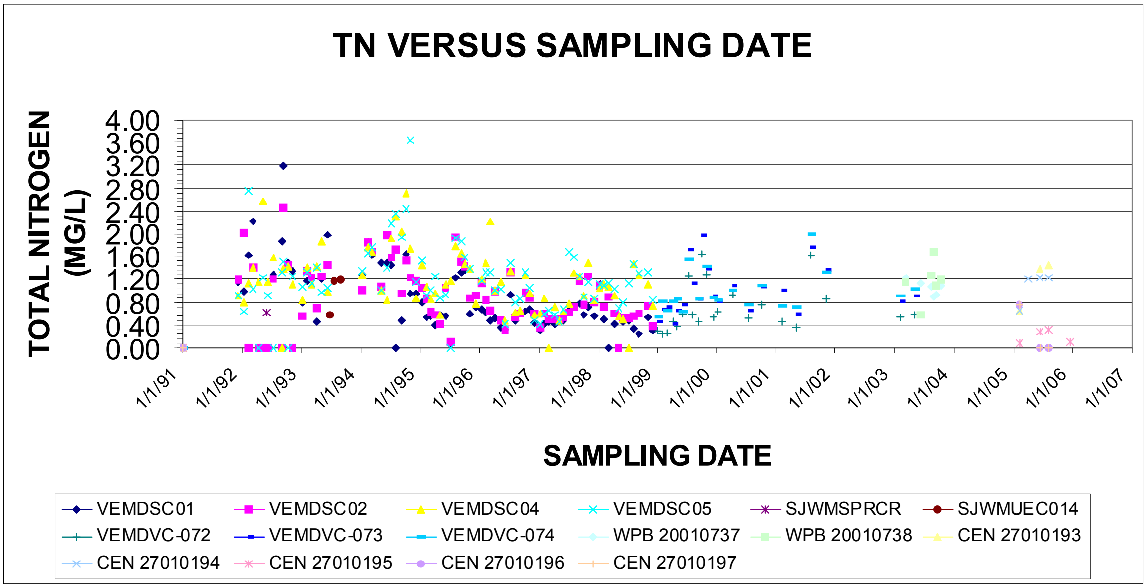


Figure 5.5. Historical TN Observations for Spruce Creek

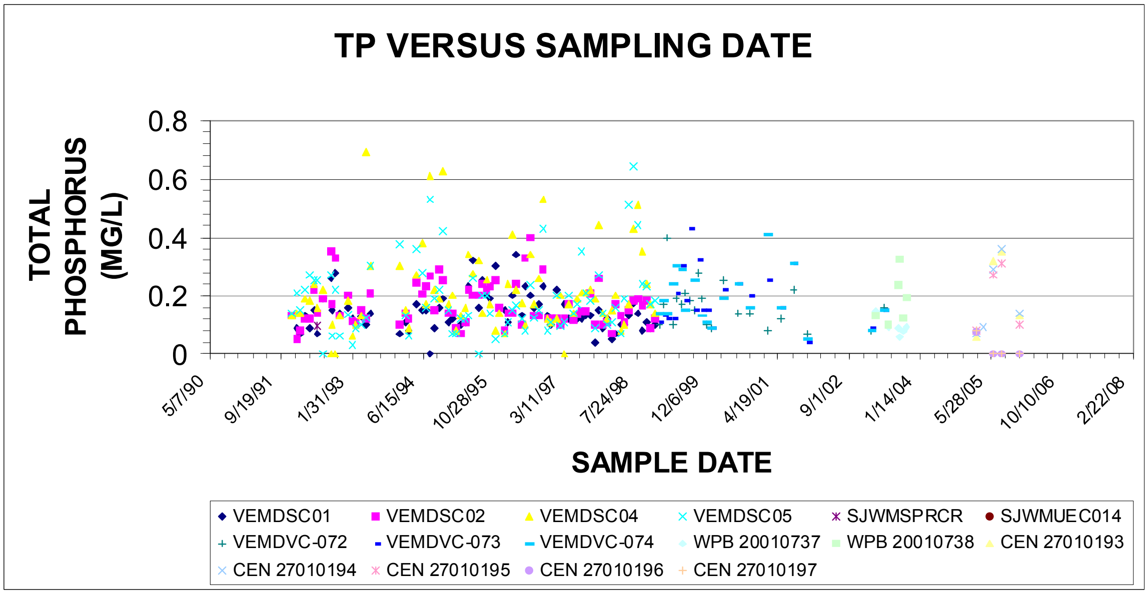


Figure 5.6. Historical TP Observations for Spruce Creek

5.1.2 TMDL Development Process

A Spearman correlation matrix was used to assess potential relationships between DO and other water quality parameters (**Appendix G**). At an alpha (α) level of 0.05, correlations between DO and TP, nitrogen ammonia (NH_4), and BOD were significant. **Figure 5.7** illustrates the relationship and the regression equation between DO and TP. As discussed in the standards section of the report, the DO criterion for Class III marine waters allows a minimum concentration of 4.0 mg/L, as long as a daily average of 5.0 mg/L is maintained. Although the impairment decision was based on exceedances below the 4.0 mg/L minimum, the TMDL target for TP was selected as the level predicted to achieve a minimum DO of 5.0 mg/L in order to add an implicit margin of safety and ensure that both components of the criteria are met. Based on the regression equation, DO concentrations of 5.0 mg/L or greater would be related to TP concentrations less than 0.16 mg/L. For each individual observation of TP greater than 0.16 mg/L, an individual required reduction was calculated using the following:

$$\frac{[(\text{observed value}) - (0.15)] \times 100}{(\text{observed value})}$$

After the individual results were calculated, the median of the individual values was calculated, which is 27 percent (**Table 5.4**). Use of the median was considered adequately protective since the calculations were based only on measurements above 0.16 mg/L and half of the observations were already at or below 0.16 mg/L.

Although the correlation between DO and NH_4 was significant at an alpha (α) level of 0.05 (68 paired samples), the correlation between DO and TN was not significant ($p = 0.172$, 343 paired samples). Ammonia represented 7 percent or less of the TN in 80 percent of the available observations. Consequently, requiring reductions in NH_4 as part of the TMDL would have minimal effects on improving DO or reducing algal biomass.

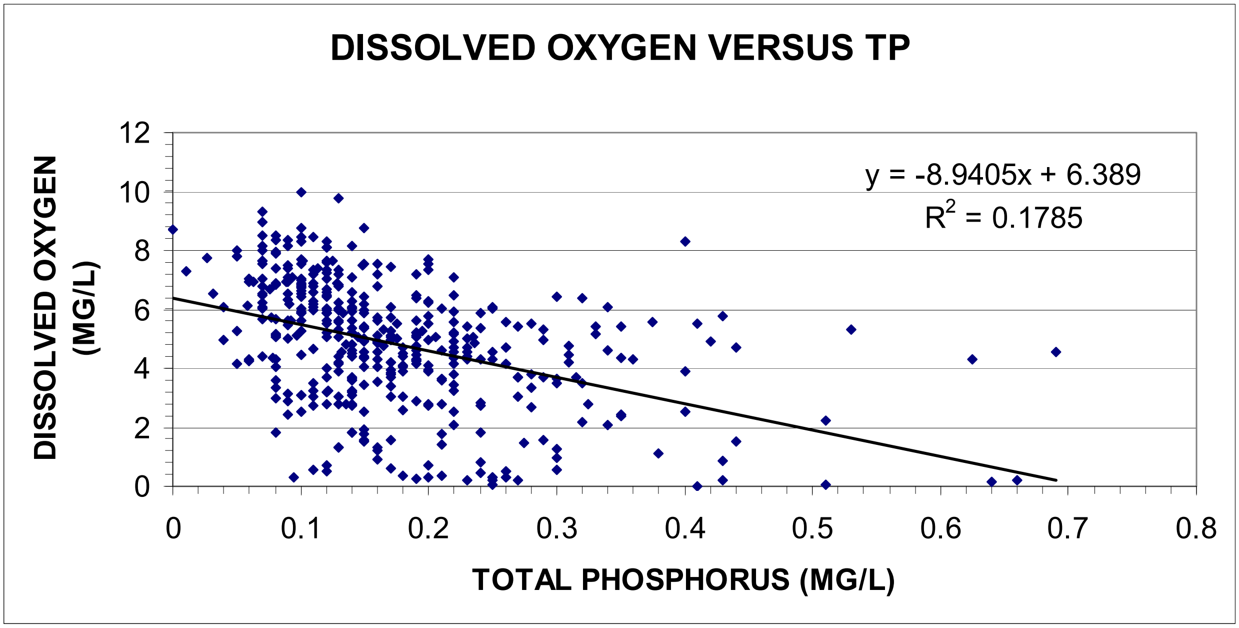
Figure 5.8 illustrates the relationship and the regression equation between DO and BOD. As in the case with TP, the TMDL considered BOD reductions necessary to achieve a DO concentration of 5.0 mg/L. Based on the regression equation, DO concentrations of 5.0 mg/L or greater would be related to BOD concentrations less than 2.17 mg/L. For each individual observation of BOD greater than 2.17 mg/L, an individual required reduction was calculated using the following:

$$\frac{[(\text{observed value}) - (2.17)] \times 100}{(\text{observed value})}$$

After the individual results were calculated, the median of the individual values was calculated, which is 25 percent (**Table 5.5**). Note there were only 27 measurements of BOD, and all of the samples were collected during 2005 over 7 sampling dates; where 5 stations were sampled on the same day for 5 of the 7 sampling dates. Additional BOD monitoring is recommended to augment the TMDL.

Spruce Creek was also impaired for nutrients based on an annual chlorophyll of 12.05 μg/l in 2003. Comparing the 2003 average with the 11 μg/L threshold suggests that less than a 9 percent reduction in the annual average is necessary to meet the threshold. A cumulative frequency distribution of corrected chlorophyll can be found in **Appendix E.** Ninety percent of the nearly 400 chlorophyll observations are less than 11.7 µg/L. The Spearman correlation between DO and corrected chla was negative (inverse relationship), and the linear regression was significant at an alpha (α) level of 0.05. A 27 percent reduction of total phosphorus to Spruce Creek will result in lower algal biomass and is believed to be sufficient to result in an annual average chla concentration below the 11 µg/L threshold.

Figure 5.7. Relationship Between DO and TP Observations for Spruce Creek



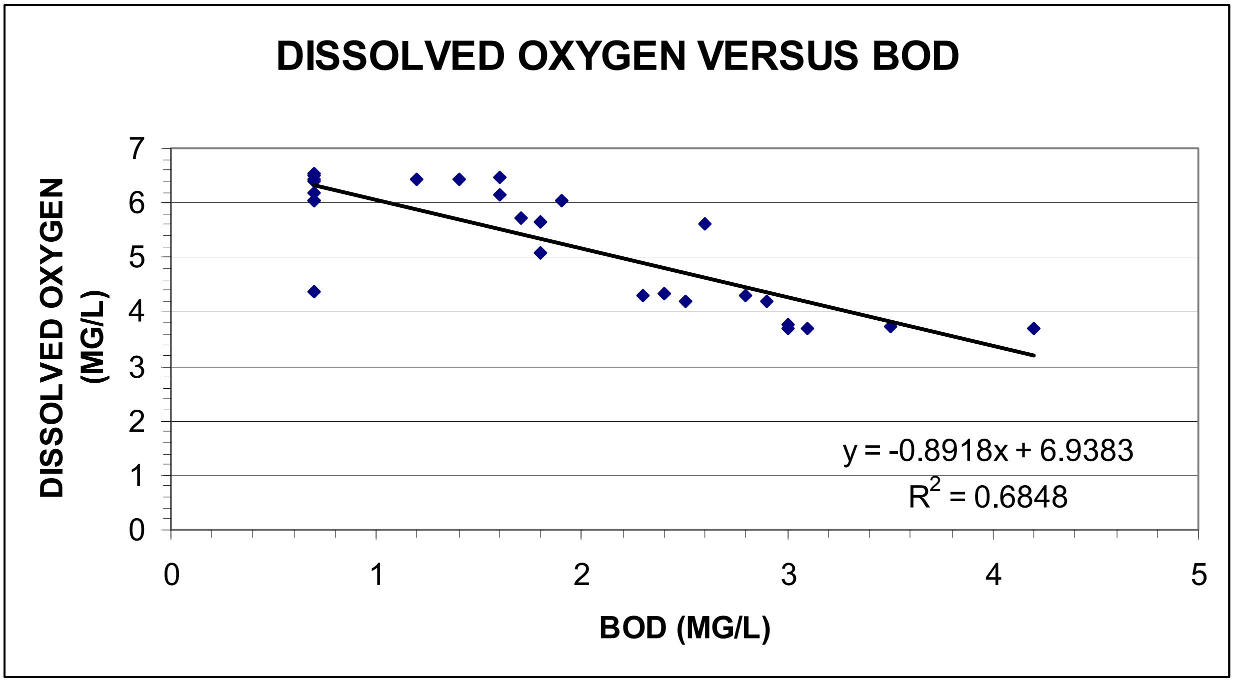


Figure 5.8. Relationship Between DO and BOD Observations for Spruce Creek

Table 5.4. Calculation of TP Reductions for the DO TMDL for Spruce Creek

Sample Date	Station	Observed TP Value (mg/L)	% Reduction
1/6/1992	VEMDSC05	0.21	23.81%
3/2/1992	VEMDSC04	0.19	15.79%
3/2/1992	VEMDSC05	0.22	27.27%
4/6/1992	VEMDSC04	0.18	11.11%
4/6/1992	VEMDSC05	0.27	40.74%
5/4/1992	VEMDSC02	0.22	27.27%
5/4/1992	VEMDSC04	0.24	33.33%
5/4/1992	VEMDSC05	0.25	36.00%
6/1/1992	VEMDSC05	0.25	36.00%
7/6/1992	VEMDSC02	0.19	15.79%
7/6/1992	VEMDSC01	0.19	15.79%
7/6/1992	VEMDSC04	0.22	27.27%
8/3/1992	VEMDSC01	0.26	38.46%
8/3/1992	VEMDSC05	0.27	40.74%
8/3/1992	VEMDSC02	0.35	54.29%
9/9/1992	VEMDSC02	0.17	5.88%
9/9/1992	VEMDSC02	0.17	5.88%
10/5/1992	VEMDSC05	0.22	27.27%
10/5/1992	VEMDSC01	0.28	42.86%
10/5/1992	VEMDSC02	0.33	51.52%
1/4/1993	VEMDSC04	0.18	11.11%
1/4/1993	VEMDSC02	0.2	20.00%
5/4/1993	VEMDSC04	0.69	76.81%
6/8/1993	VEMDSC02	0.21	23.81%
6/8/1993	VEMDSC04	0.3	46.67%
6/8/1993	VEMDSC05	0.3	46.67%
7/7/1993	VEMDSC04	0.23	30.43%
7/7/1993	VEMDSC05	0.26	38.46%
7/7/1993	VEMDSC01	0.27	40.74%
8/2/1993	VEMDSC02	0.18	11.11%
8/2/1993	VEMDSC05	0.28	42.86%
8/2/1993	VEMDSC04	0.4	60.00%
9/8/1993	VEMDSC04	0.66	75.76%
10/4/1993	VEMDSC02	0.17	5.88%
10/4/1993	VEMDSC05	0.22	27.27%
10/4/1993	VEMDSC04	0.24	33.33%
11/1/1993	VEMDSC05	0.23	30.43%
1/3/1994	VEMDSC04	0.3	46.67%
1/3/1994	VEMDSC05	0.375	57.33%
4/4/1994	VEMDSC05	0.17	5.88%
4/4/1994	VEMDSC04	0.22	27.27%
5/2/1994	VEMDSC01	0.17	5.88%
5/2/1994	VEMDSC02	0.245	34.69%

Sample Date	Station	Observed TP Value (mg/L)	% Reduction
5/2/1994	VEMDSC04	0.27	40.74%
5/2/1994	VEMDSC05	0.36	55.56%
6/6/1994	VEMDSC02	0.205	21.95%
6/6/1994	VEMDSC05	0.28	42.86%
6/6/1994	VEMDSC04	0.38	57.89%
7/6/1994	VEMDSC04	0.17	5.88%
7/6/1994	VEMDSC02	0.23	30.43%
8/1/1994	VEMDSC02	0.265	39.62%
8/1/1994	VEMDSC05	0.53	69.81%
8/1/1994	VEMDSC04	0.61	73.77%
9/6/1994	VEMDSC05	0.19	15.79%
9/6/1994	VEMDSC04	0.22	27.27%
10/3/1994	VEMDSC04	0.19	15.79%
10/3/1994	VEMDSC05	0.22	27.27%
10/3/1994	VEMDSC02	0.29	44.83%
11/1/1994	VEMDSC01	0.19	15.79%
11/1/1994	VEMDSC02	0.25	36.00%
11/1/1994	VEMDSC05	0.42	61.90%
11/1/1994	VEMDSC04	0.625	74.40%
12/5/1994	VEMDSC04	0.17	5.88%
1/9/1995	VEMDSC04	0.2	20.00%
5/1/1995	VEMDSC02	0.22	27.27%
5/1/1995	VEMDSC01	0.23	30.43%
5/1/1995	VEMDSC04	0.34	52.94%
6/5/1995	VEMDSC02	0.2	20.00%
6/5/1995	VEMDSC05	0.26	38.46%
6/5/1995	VEMDSC04	0.275	41.82%
6/5/1995	VEMDSC01	0.32	50.00%
7/10/1995	VEMDSC02	0.2	20.00%
7/10/1995	VEMDSC04	0.32	50.00%
8/7/1995	VEMDSC05	0.2	20.00%
8/7/1995	VEMDSC02	0.24	33.33%
8/7/1995	VEMDSC01	0.25	36.00%
9/5/1995	VEMDSC01	0.2	20.00%
9/5/1995	VEMDSC05	0.2	20.00%
9/5/1995	VEMDSC02	0.22	27.27%
9/5/1995	VEMDSC04	0.255	37.25%
10/2/1995	VEMDSC04	0.17	5.88%
10/2/1995	VEMDSC01	0.19	15.79%
10/2/1995	VEMDSC02	0.23	30.43%
11/6/1995	VEMDSC02	0.25	36.00%
11/6/1995	VEMDSC01	0.3	46.67%
2/5/1996	VEMDSC04	0.24	33.33%
3/4/1996	VEMDSC01	0.2	20.00%
3/4/1996	VEMDSC04	0.41	60.98%
4/1/1996	VEMDSC05	0.165	3.03%
4/1/1996	VEMDSC04	0.22	27.27%

Sample Date	Station	Observed TP Value (mg/L)	% Reduction
4/1/1996	VEMDSC02	0.24	33.33%
4/1/1996	VEMDSC01	0.34	52.94%
5/6/1996	VEMDSC04	0.175	8.57%
6/3/1996	VEMDSC01	0.23	30.43%
6/3/1996	VEMDSC02	0.33	51.52%
7/8/1996	VEMDSC01	0.2	20.00%
7/8/1996	VEMDSC05	0.235	31.91%
7/8/1996	VEMDSC04	0.34	52.94%
7/8/1996	VEMDSC02	0.4	60.00%
8/5/1996	VEMDSC04	0.17	5.88%
9/3/1996	VEMDSC01	0.17	5.88%
9/3/1996	VEMDSC04	0.26	38.46%
10/7/1996	VEMDSC01	0.23	30.43%
10/7/1996	VEMDSC02	0.29	44.83%
10/7/1996	VEMDSC05	0.43	62.79%
10/7/1996	VEMDSC04	0.53	69.81%
1/6/1997	VEMDSC05	0.2	20.00%
1/6/1997	VEMDSC01	0.22	27.27%
2/3/1997	VEMDSC04	0.2	20.00%
3/3/1997	VEMDSC01	0.17	5.88%
4/7/1997	VEMDSC02	0.17	5.88%
4/7/1997	VEMDSC04	0.17	5.88%
4/7/1997	VEMDSC05	0.2	20.00%
6/2/1997	VEMDSC05	0.17	5.88%
6/2/1997	VEMDSC04	0.19	15.79%
7/7/1997	VEMDSC04	0.21	23.81%
7/7/1997	VEMDSC05	0.35	54.29%
8/4/1997	VEMDSC05	0.21	23.81%
8/4/1997	VEMDSC04	0.21	23.81%
9/8/1997	VEMDSC05	0.18	11.11%
9/8/1997	VEMDSC02	0.21	23.81%
9/8/1997	VEMDSC04	0.22	27.27%
10/6/1997	VEMDSC04	0.19	15.79%
11/3/1997	VEMDSC02	0.26	38.46%
11/3/1997	VEMDSC05	0.27	40.74%
11/3/1997	VEMDSC04	0.44	63.64%
3/2/1998	VEMDSC02	0.17	5.88%
3/2/1998	VEMDSC04	0.2	20.00%
5/4/1998	VEMDSC05	0.19	15.79%
6/1/1998	VEMDSC04	0.17	5.88%
6/1/1998	VEMDSC05	0.51	68.63%
7/6/1998	VEMDSC01	0.175	8.57%
7/6/1998	VEMDSC02	0.18	11.11%
7/6/1998	VEMDSC04	0.43	62.79%
7/6/1998	VEMDSC05	0.64	75.00%
8/3/1998	VEMDSC02	0.19	15.79%
8/3/1998	VEMDSC05	0.44	63.64%

Sample Date	Station	Observed TP Value (mg/L)	% Reduction
8/3/1998	VEMDSC04	0.51	68.63%
9/8/1998	VEMDSC02	0.165	3.03%
9/8/1998	VEMDSC05	0.24	33.33%
9/8/1998	VEMDSC04	0.35	54.29%
10/6/1998	VEMDSC02	0.18	11.11%
10/6/1998	VEMDSC05	0.23	30.43%
10/6/1998	VEMDSC04	0.24	33.33%
11/2/1998	VEMDSC04	0.17	5.88%
11/2/1998	VEMDSC05	0.17	5.88%
12/2/1998	VEMDSC05	0.18	11.11%
2/1/1999	VEMDVC-072	0.17	5.88%
2/1/1999	VEMDVC-074	0.18	11.11%
3/1/1999	VEMDVC-072	0.4	60.00%
4/5/1999	VEMDVC-074	0.24	33.33%
5/3/1999	VEMDVC-071	0.19	15.79%
5/3/1999	VEMDVC-072	0.19	15.79%
5/3/1999	VEMDVC-073	0.21	23.81%
5/3/1999	VEMDVC-074	0.3	46.67%
6/7/1999	VEMDVC-072	0.17	5.88%
6/7/1999	VEMDVC-074	0.29	44.83%
6/7/1999	VEMDVC-073	0.3	46.67%
7/7/1999	VEMDVC-073	0.18	11.11%
7/7/1999	VEMDVC-071	0.19	15.79%
7/7/1999	VEMDVC-072	0.21	23.81%
8/2/1999	VEMDVC-072	0.18	11.11%
8/2/1999	VEMDVC-073	0.43	62.79%
9/7/1999	VEMDVC-074	0.25	36.00%
10/4/1999	VEMDVC-071	0.2	20.00%
10/4/1999	VEMDVC-072	0.28	42.86%
10/4/1999	VEMDVC-073	0.32	50.00%
11/1/1999	VEMDVC-072	0.19	15.79%
11/1/1999	VEMDVC-071	0.19	15.79%
4/3/2000	VEMDVC-074	0.19	15.79%
4/3/2000	VEMDVC-071	0.2	20.00%
4/3/2000	VEMDVC-073	0.22	27.27%
4/3/2000	VEMDVC-072	0.25	36.00%
7/10/2000	VEMDVC-074	0.24	33.33%
7/10/2000	VEMDVC-073	0.24	33.33%
10/2/2000	VEMDVC-073	0.2	20.00%
2/5/2001	VEMDVC-073	0.25	36.00%
2/5/2001	VEMDVC-074	0.41	60.98%
8/6/2001	VEMDVC-072	0.22	27.27%
8/6/2001	VEMDVC-071	0.22	27.27%
8/6/2001	VEMDVC-073	0.31	48.39%
8/6/2001	VEMDVC-074	0.31	48.39%
11/5/2001	VEMDVC-071	0.19	15.79%
9/9/2002	VEMDVC-071	0.2	20.00%

Sample Date	Station	Observed TP Value (mg/L)	% Reduction
5/5/2003	VEMDVC-071	0.18	11.11%
8/4/2003	VEMDVC-071	0.19	15.79%
8/13/2003	WPB 20010738	0.236	32.20%
8/26/2003	WPB 20010738	0.325	50.77%
10/9/2003	WPB 20010738	0.195	17.95%
6/13/2005	CEN 27010195	0.27	40.74%
6/13/2005	CEN 27010194	0.29	44.83%
6/13/2005	CEN 27010193	0.315	49.21%
8/8/2005	CEN 27010195	0.31	48.39%
8/8/2005	CEN 27010193	0.35	54.29%
8/8/2005	CEN 27010194	0.36	55.56%
4/3/2006	VEMDVC-071	0.22	27.27%
10/3/2006	VEMDVC-073	0.21	23.81%
		MEDIAN:	**27.27%**

Table 5.5. Calculation of BOD Reductions for the DO TMDL for Spruce Creek

Sample Date	Station	Observed BOD value (mg/L)	% Reduction
8/8/2005	CEN 27010194	2.3	5.65
8/8/2005	CEN 27010193	2.4	9.58
8/8/2005	CEN 27010195	2.5	13.20
4/5/2005	CEN 27010194	2.6	16.54
8/8/2005	CEN 27010196	2.8	22.50
8/8/2005	CEN 27010197	2.9	25.17
6/13/2005	CEN 27010196	3	27.67
6/13/2005	CEN 27010197	3	27.67
6/13/2005	CEN 27010193	3.1	30.00
6/13/2005	CEN 27010195	3.5	38.00
6/13/2005	CEN 27010194	4.2	48.33
		MEDIAN:	**25.17**

5.1.3 Critical Conditions/Seasonality

A nonparametric test (Kruskal-Wallis) was applied to the DO, DO saturation (DOSAT), corrected chla, TN, and TP datasets to determine whether there were significant differences among months or seasons. At an alpha (α) level of 0.05, there were significant differences among seasons or months for all the parameters (**Appendices C** and **D**). As seen in **Table 5.6**, all seasons had at least a 21 percent exceedance rate. All months had exceedance rates of at least 11 percent, while June, July, and September had the highest exceedance rates. Consequently, the percent reductions were calculated throughout the year and covered all months and seasons.

Rainfall records for Daytona Beach International Airport (**Appendices F** and **I)** were used to determine rainfall amounts associated with individual sampling dates. Rainfall recorded on the day of sampling (PRECIP) and the cumulative total for the day of and the previous two days (RAINDAY3) were paired with the respective DO observation. The simple correlations (r values in the Spearman correlation table) between both DO and the PRECIP and RAINDAY3 rainfall totals were negative (inverse relationship); however, they were not significant at an alpha (α) level of 0.05.

Table 5.6. Monthly and Seasonal Exceedance Rates for DO

	# of Observations	# of Exceedances	% Exceedance
Month			
January	36	10	27.8%
February	45	8	17.8%
March	33	6	18.2%
April	36	4	11.1%
May	30	9	23.3%
June	43	21	48.8%
July	32	14	43.8%
August	34	11	32.3%
September	24	12	50.0%
October	36	10	27.8%
November	36	8	22.2%
December	38	11	28.9%
	# of Observations	**# of Exceedances**	**% Exceedance**
Season			
Winter	114	24	21.0%
Spring	109	34	31.2%
Summer	90	37	41.1%
Fall	110	29	26.4%

Chapter 6: DETERMINATION OF THE TMDL

6.1 Expression and Allocation of the TMDL

The objective of a TMDL is to provide a basis for allocating acceptable loads among all of the known pollutant sources in a watershed so that appropriate control measures can be implemented and water quality standards achieved. A TMDL is expressed as the sum of all point source loads (Wasteload Allocations, or WLAs), nonpoint source loads (Load Allocations, or LAs), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$\mathbf{TMDL = \sum WLAs + \sum LAs + MOS}$$

As discussed earlier, the WLA is broken out into separate subcategories for wastewater discharges and stormwater discharges regulated under the NPDES Program:

$$\mathbf{TMDL \cong \sum WLAs_{wastewater} + \sum WLAs_{NPDES\ Stormwater} + \sum LAs + MOS}$$

It should be noted that the various components of the revised TMDL equation may not sum up to the value of the TMDL because (a) the WLA for NPDES stormwater is typically based on the percent reduction needed for nonpoint sources and is also accounted for within the LA, and (b) TMDL components can be expressed in different terms (for example, the WLA for stormwater is typically expressed as a percent reduction, and the WLA for wastewater is typically expressed as mass per day).

WLAs for stormwater discharges are typically expressed as “percent reduction” because it is very difficult to quantify the loads from MS4s (given the numerous discharge points) and to distinguish loads from MS4s from other nonpoint sources (given the nature of stormwater transport). The permitting of stormwater discharges also differs from the permitting of most wastewater point sources. Because stormwater discharges cannot be centrally collected, monitored, and treated, they are not subject to the same types of effluent limitations as wastewater facilities, and instead are required to meet a performance standard of providing treatment to the “maximum extent practical” through the implementation of BMPs.

This approach is consistent with federal regulations (40 CFR § 130.2[I]), which state that TMDLs can be expressed in terms of mass per time (e.g., pounds per day), toxicity, or **other appropriate measure**. TMDLs for Spruce Creek are expressed in terms of a percent reduction in total phosphorus, to meet both the DO and nutrient criteria (**Table 6.1**).

Table 6.1. TMDL Components for Spruce Creek

WBID	Parameter	TMDL (mg/L)	WLA		LA (% Reduction)[1]	MOS
			Wastewater (mg/L)	NPDES Stormwater (% Reduction)[1]		
2674A	TP	0.16	N/A	27%	27%	Implicit
2674A	BOD	2.17	NA	25%	25%	Implicit

[1] As the TMDL represents a percent reduction, it also complies with EPA requirements to express the TMDL on a daily basis.

6.2 Load Allocation

A TP reduction of 27 percent and a 25 percent reduction in BOD are required from nonpoint sources. It should be noted that the load allocation includes loading from stormwater discharges that are not part of the NPDES Stormwater Program.

6.3 Wasteload Allocation

6.3.1 NPDES Wastewater Discharges

There are currently no permitted NPDES discharges in the Spruce Creek watershed; however, any future discharge permits issued in the watershed will also be required to meet the state's Class III criterion for DO and contain appropriate discharge limitations on phosphorus that will comply with the TMDL as well as existing state requirements related to discharges to OFWs.

6.3.2 NPDES Stormwater Discharges

Volusia County (FLR04E033), Port Orange (FLR04E014), Ponce Inlet (FLR04E071), and New Smyrna Beach (FLR04E035) have Phase II MS4 permits that may include portions of the Spruce Creek watershed and would be responsible for a 27 percent reduction in current anthropogenic TP loading and a 25 percent reduction in current anthropogenic BOD loading. It should be noted that any MS4 permittee is only responsible for reducing the loads associated with stormwater outfalls that it owns or otherwise has responsible control over, and it is not responsible for reducing other nonpoint source loads in its jurisdiction.

6.4 Margin of Safety

Consistent with the recommendations of the Allocation Technical Advisory Committee (Department, 2001), an implicit MOS was used in the development of this TMDL. An MOS was included in the TMDL by not allowing any exceedances of the state criteria, even though intermittent natural exceedances of the criteria would be expected and would be taken into account when determining impairment. Additionally, the TMDL calculated for DO was based on meeting a DO of 5.0 mg/L, rather than the marine minimum of 4.0 mg/L.

Chapter 7: NEXT STEPS: IMPLEMENTATION PLAN DEVELOPMENT AND BEYOND

7.1 Basin Management Action Plan

Following the adoption of this TMDL by rule, the next step in the TMDL process is to develop an implementation plan for the TMDL, referred to as the BMAP. This document will be developed over the next year in cooperation with local stakeholders, who will attempt to reach consensus on detailed allocations and on how load reductions will be accomplished. The BMAP will include, among other things:

- Appropriate load reduction allocations among the affected parties,
- A description of the load reduction activities to be undertaken, including structural projects, nonstructural BMPs, and public education and outreach,
- A description of further research, data collection, or source identification needed in order to achieve the TMDL,
- Timetables for implementation,
- Confirmed and potential funding mechanisms,
- Any applicable signed agreement(s),
- Local ordinances defining actions to be taken or prohibited,
- Any applicable local water quality standards, permits, or load limitation agreements,
- Milestones for implementation and water quality improvement, and
- Implementation tracking, water quality monitoring, and follow-up measures.

An assessment of progress toward the BMAP milestones will be conducted every five years, and revisions to the plan will be made as appropriate, in cooperation with basin stakeholders.

Earlier in the document a Spruce Creek/Rose Bay Watershed Master Plan (Volusia County, 1996) was referenced, along with current plans for the county to update the document. Implementation measures that reduce stormwater impacts to both water quantity and water quality in the Spruce Creek watershed should be recognized in the BMAP. In addition, as noted in Chapter 5, the relationship developed between BOD and DO was based on measurements collected in a single year. Additional monitoring as part of the BMAP could improve the understanding of sources of BOD from the contributing watershed and impacts on DO. Chapter 4 summarized potential contributions of TN and TP from various sources in WBID 2674A and the upstream portion of Spruce Creek (WBID 2674). Elements of the BMAP can also focus efforts to better quantify the actual loads from the sources identified as well as evaluate contributions from the drainage area outside the two Spruce Creek WBIDs. As noted in Chapter 5, the USGS gage located on Spruce Creek near the railroad bridge (Gage 02248053) had an estimated drainage area of 60.7 square miles and was tidally influenced.

References

Florida Administrative Code. *Rule 62-302, Surface water quality standards.*

———. *Rule 62-303, Identification of impaired surface waters.*

Florida Department of Environmental Protection. February 2001. *A report to the Governor and the Legislature on the allocation of Total Maximum Daily Loads in Florida.* Tallahassee, Florida: Bureau of Watershed Management.

———. 2005. *Upper East Coast Basin status report.* Tallahassee, Florida. Available: http://www.dep.state.fl.us/water/basin411/uppereast/status.htm.

Florida Department of Health Website. 2006. Available: http://www.doh.state.fl.us/.

———. 2006. Available: http://www.doh.state.fl.us/environment/OSTDS/statistics/newInstallations.pdf.

———. 2006. Available: http://www.doh.state.fl.us/environment/OSTDS/statistics/repairs.pdf.

Florida Watershed Restoration Act. *Chapter 99-223, Laws of Florida.*

Harper, H.H., and D.M. Baker. 2003. *Evaluation of alternative stormwater regulations for southwest Florida.* Orlando, Florida: Environmental Research & Design, Inc.

U. S. Census Bureau Website. 2000. Available: http://www.census.gov/.

U. S. Environmental Protection Agency. 1999. *Protocol for developing nutrient TMDLs.* First Edition. EPA 841–B–99–007.

———. June 2001. *BASINS Version 3.0 user manual.* Office of Water. Available: http://www.epa.gov/waterscience/basins/bsnsdocs.html.

U. S. Environmental Protection Agency Region 4. 2002. *Estimating water quality loadings from MS4 areas.*

Volusia County. April 1996. *Spruce Creek/Rose Bay OFW watershed master plan.* Prepared by Marshall, Provost & Associates.

Appendices

Appendix A: Background Information on Federal and State Stormwater Programs

In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of nonpoint source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The Stormwater Rule, as authorized in Chapter 403, F.S., was established as a technology-based program that relies on the implementation of BMPs that are designed to achieve a specific level of treatment (i.e., performance standards) as set forth in Rule 62-40, F.A.C. In 1994, the Department's stormwater treatment requirements were integrated with the stormwater flood control requirements of the water management districts, along with wetland protection requirements, into the Environmental Resource Permit regulations.

Rule 62-40 also requires the state's water management districts to establish stormwater pollutant load reduction goals (PLRGs) and adopt them as part of a Surface Water Improvement and Management (SWIM) plan, other watershed plan, or rule. Stormwater PLRGs are a major component of the load allocation part of a TMDL. To date, stormwater PLRGs have been established for Tampa Bay, Lake Thonotosassa, the Winter Haven Chain of Lakes, the Everglades, Lake Okeechobee, and Lake Apopka.

In 1987, the U.S. Congress established Section 402(p) as part of the federal Clean Water Act Reauthorization. This section of the law amended the scope of the federal NPDES permitting program to designate certain stormwater discharges as "point sources" of pollution. The EPA promulgated regulations and began implementing the Phase I NPDES stormwater program in 1990. These stormwater discharges include certain discharges that are associated with industrial activities designated by specific standard industrial classification (SIC) codes, construction sites disturbing 5 or more acres of land, and master drainage systems of local governments with a population above 100,000, which are better known as MS4s. However, because the master drainage systems of most local governments in Florida are interconnected, the EPA implemented Phase I of the MS4 permitting program on a countywide basis, which brought in all cities (incorporated areas), Chapter 298 urban water control districts, and the Florida Department of Transportation throughout the 15 counties meeting the population criteria. The Department received authorization to implement the NPDES stormwater program in 2000.

An important difference between the federal NPDES and the state's stormwater/environmental resource permitting programs is that the NPDES Program covers both new and existing discharges, while the state's program focus on new discharges only. Additionally, Phase II of the NPDES Program, implemented in 2003, expands the need for these permits to construction sites between 1 and 5 acres, and to local governments with as few as 1,000 people. While these urban stormwater discharges are now technically referred to as "point sources" for the purpose of regulation, they are still diffuse sources of pollution that cannot be easily collected and treated by a central treatment facility, as are other point sources of pollution such as domestic and industrial wastewater discharges. It should be noted that all MS4 permits issued in Florida include a reopener clause that allows permit revisions to implement TMDLs when the implementation plan is formally adopted.

Appendix B: Historical DO, Corrected Chla, TN, and TP Observations in Spruce Creek, 1991–2006

Station	Sample Date	DO (mg/L)	DOSAT (%)	Corr Chla (µg/L)	TN (mg/L)	TP (mg/L)
VEMDSC04	12/2/1991	1.3	14.1304	25.8	0.92	0.13
VEMDSC05	12/2/1991	1.8	20.4545	1	0.91	0.14
VEMDSC02	12/2/1991	6.8	80	7.8	1.18	0.13
VEMDSC01	12/2/1991	7.33	87.2619	8.7	1.14	0.13
VEMDSC05	1/6/1992	0.37	3.9697		0.63	0.21
VEMDSC04	1/6/1992	3.08	31.7525		0.8	0.14
VEMDSC02	1/6/1992	8.01	78.5294		2.01	0.05
VEMDSC01	1/6/1992	8.37	83.7		1	0.09
VEMDSC05	2/3/1992	1.78	18.7368	4.7	2.76	0.15
VEMDSC04	2/3/1992	2.79	28.7628	27.6	1.12	0.14
VEMDSC02	2/3/1992	7.94	79.4	1.8		0.08
VEMDSC01	2/3/1992	9.31	93.1	1	1.63	0.07
VEMDSC04	3/2/1992	2.91	30.6315	1	1.41	0.19
VEMDSC05	3/2/1992	5.15	53.0928	1	1.03	0.22
VEMDSC02	3/2/1992	8.09	86.0638	2	1.4	0.12
VEMDSC01	3/2/1992	9.77	103.936	1.6	2.22	0.13
VEMDSC05	4/6/1992	0.2	2.22222	7.1		0.27
VEMDSC04	4/6/1992	2.58	28.6666	3.5	1.14	0.18
VEMDSC01	4/6/1992	6.98	74.2553	3		0.09
VEMDSC02	4/6/1992	7.04	74.8936	5.9		0.12
VEMDSC05	5/4/1992	0.3	3.44827		1.23	0.25
VEMDSC04	5/4/1992	1.8	21.1765		2.58	0.24
VEMDSC02	5/4/1992	5.9	69.4117			0.22
VEMDSC01	5/4/1992	6.2	71.2643			0.15
SJWMSPRCR	5/28/1992	5.1	75.9018		0.612	0.097
VEMDSC05	6/1/1992	0.19	2.2619	6.9	0.91	0.25
VEMDSC04	6/1/1992	1.21	14.9383	11.8	1.15	0.16
VEMDSC02	6/1/1992	5.2	65.8228	11.3		0.14
VEMDSC01	6/1/1992	6.06	76.7088	4.7		0.07
VEMDSC05	7/6/1992	0.15	1.85185	1.9		
VEMDSC04	7/6/1992	2.06	25.4321	4.9	1.58	0.22
VEMDSC02	7/6/1992	4.13	55.0666	9.5	1.21	0.19
VEMDSC01	7/6/1992	5.06	68.3783	9.2	1.29	0.19
SJWMUEC014	7/22/1992	1.7	20.9876	25.527		
VEMDSC04	8/3/1992	0.14	1.8421	10.6		
VEMDSC05	8/3/1992	3.03	36.0714	1.1	1.33	0.27
VEMDSC01	8/3/1992	4.14	53.0769	5.6	1.86	0.26

Station	Sample Date	DO (mg/L)	DOSAT (%)	Corr Chla (µg/L)	TN (mg/L)	TP (mg/L)
VEMDSC02	8/3/1992	5.4	71.0526	11.7		0.35
VEMDSC04	9/9/1992	3.07	36.5476	1.7	1.38	0.1
VEMDSC04	9/9/1992	3.1	38	1.7	1.36	0.1
VEMDSC05	9/9/1992	4.25	50.5952	1	1.51	0.06
VEMDSC05	9/9/1992	4.3	52.1	0.1	1.56	0.06
VEMDSC02	9/9/1992	4.18	52.9114	5.2	2.45	0.17
VEMDSC02	9/9/1992	4.2	59.5	5.2	2.45	0.17
VEMDSC01	9/9/1992	4.95	63.4615	5.6	3.19	0.15
VEMDSC01	9/9/1992	5	74.1	5.6	3.19	0.15
VEMDSC05	10/5/1992	4.92	56.5517	1		0.22
VEMDSC04	10/5/1992	5.07	59.647	1.4	1.43	
VEMDSC02	10/5/1992	5.43	63.8823	1.4	1.45	0.33
VEMDSC01	10/5/1992	5.54	65.9523	3.2	1.49	0.28
VEMDSC04	11/2/1992	3.05	33.8889	1.1	1.1	0.13
VEMDSC05	11/2/1992	4.26	47.3333	1	1.24	0.06
VEMDSC02	11/2/1992	5.59	66.5476	4		0.13
VEMDSC01	11/2/1992	5.94	70.7142	4	1.35	0.14
VEMDSC04	12/7/1992	5.89	57.7451			
VEMDSC05	12/7/1992	6.25	61.2745			
VEMDSC02	12/7/1992	7.67	79.0721			
VEMDSC01	12/7/1992	8.27	87.0526			
VEMDSC05	1/4/1993	2.77	30.10865	1	1.06	0.135
VEMDSC04	1/4/1993	4.41	47.9348	3.2	0.83	0.18
VEMDSC02	1/4/1993	7.36	81.7777	4.3	0.56	0.2
VEMDSC01	1/4/1993	7.54	83.7777	3.1	0.8	0.16
VEMDSC05	2/1/1993	6.51	62.59615	1	1.3335	0.031
VEMDSC04	2/1/1993	6.92	69.2	1	1.415	0.063
VEMDSC02	2/1/1993	7.41	76.3917	1	1.356	0.113
VEMDSC01	2/1/1993	8.1	81	1.6	1.171	0.12
VEMDSC04	3/1/1993	7.06	66.6037	1	1.11	0.1
VEMDSC02	3/1/1993	7.21	70.6862	1.9	1.236	0.11
VEMDSC05	3/1/1993	7.51	72.2115	1	1.125	0.09
VEMDSC01	3/1/1993	8.75	85.7843	1.4	1.22	0.1
VEMDSC04	4/5/1993	4.58	48.7234		1.42	0.132
VEMDSC02	4/5/1993	5.86	65.1111		0.688	0.149
VEMDSC01	4/5/1993	6.87	76.3333		0.463	0.129
VEMDSC05	4/5/1993	7.66	81.48935		1.4015	0.102
VEMDSC04	5/4/1993	4.58	48.7234	11	1.855	0.69
VEMDSC02	5/4/1993	5.86	65.1111	3.8	1.252	0.12
VEMDSC01	5/4/1993	6.87	76.3333	3.6	1.213	0.1
VEMDSC05	5/4/1993	7.66	81.48935	44.2	0.963	0.125

Station	Sample Date	DO (mg/L)	DOSAT (%)	Corr Chla (µg/L)	TN (mg/L)	TP (mg/L)
SJWMUEC014	5/19/1993	6.4	81.1523	6.148		
VEMDSC04	6/8/1993	0.54	6.92307	7	0.969	0.3
VEMDSC05	6/8/1993	3.51	42.80485	9.25	1.058	0.3
VEMDSC01	6/8/1993	4.43	56.7948	3.5	1.972	0.14
VEMDSC02	6/8/1993	4.63	60.921	6.2	1.441	0.21
SJWMUEC014	6/16/1993	2.7	36.0269	2.94	0.567	
VEMDSC04	7/7/1993	0.22	3.2	10.9	0.777	0.23
VEMDSC05	7/7/1993	0.31	4.1	19.5	1.014	0.26
VEMDSC01	7/7/1993	3.69	58.7	3.5	1.678	0.27
VEMDSC02	7/7/1993	4.57	70	8.9	1.176	0.16
SJWMUEC014	7/14/1993	4.4	57.7913	21.5	1.16	
VEMDSC04	8/2/1993	2.53	33.5	81.6	1.292	0.4
VEMDSC05	8/2/1993	3.79	47.1	2.3	1.085	0.28
VEMDSC02	8/2/1993	4.51	69.7	8.6	1.381	0.18
VEMDSC01	8/2/1993	4.66	74.3	4.5	2.055	0.11
SJWMUEC014	8/25/1993	2.2	27.7413		1.189	
VEMDSC04	9/8/1993	0.22	3	5.9	0.686	0.66
VEMDSC05	9/8/1993	3.14	38.2	3.3	0.797	
VEMDSC01	9/8/1993	4.03	61.1	6.6	0.504	0.08
VEMDSC02	9/8/1993	4.33	62.7	13.4	0.724	0.078
VEMDSC04	10/4/1993	0.44	5.9	36.3	1.186	0.24
VEMDSC05	10/4/1993	2.52	29.7	2.7	0.832	0.22
VEMDSC02	10/4/1993	5.28	76.8	5.5	1.198	0.17
VEMDSC01	10/4/1993	5.87	88.5	5.2	1.632	0.12
VEMDSC04	11/1/1993	1.33	16.4	0.4	0.857	0.16
VEMDSC05	11/1/1993	4.54	46.5	0.3	1.342	0.23
VEMDSC02	11/1/1993	6.22	73.7	8.6	1.333	0.13
VEMDSC01	11/1/1993	6.54	85.4	3.7	1.206	0.09
VEMDSC04	12/6/1993	1.34	15.8	12.7	0.936	0.13
VEMDSC05	12/6/1993	1.59	18.5	0.5	0.805	0.15
VEMDSC02	12/6/1993	6.05	73.7	7.9	1.161	0.1
VEMDSC01	12/6/1993	6.53	83.7	1.9	1.411	0.07
VEMDSC04	1/3/1994	3.66	36.6	2.12	1.269	0.3
VEMDSC05	1/3/1994	5.565	57.3711	2.54	1.3375	0.375
VEMDSC01	1/3/1994	7.52	77.5257	2.08	1.281	0.07
VEMDSC02	1/3/1994	8.28	85.3608	26.38	1.002	0.1
VEMDSC04	2/7/1994	5.41	54.1	1	1.76	0.15
VEMDSC05	2/7/1994	5.61	57.835	1	1.672	0.13
VEMDSC02	2/7/1994	6.27	66.70205	2.36	1.836	0.14
VEMDSC01	2/7/1994	7.35	77.3684	3.05	1.845	0.11
VEMDSC01	3/7/1994			3.33	1.628	0.08

Station	Sample Date	DO (mg/L)	DOSAT (%)	Corr Chla (µg/L)	TN (mg/L)	TP (mg/L)
VEMDSC02	3/7/1994			2.345	1.677	0.12
VEMDSC04	3/7/1994			1	1.675	0.09
VEMDSC05	3/7/1994			1	1.763	0.06
VEMDSC05	4/4/1994	3.02	32.5	0.5	1.048	0.17
VEMDSC04	4/4/1994	4.56	52.8	5.4	1.346	0.22
VEMDSC02	4/4/1994	5.62	72.6	2.3	1.883	0.12
VEMDSC01	4/4/1994	5.96	78.4	2	2.071	0.11
VEMDSC01	5/2/1994			3.19	1.483	0.17
VEMDSC02	5/2/1994			8.73	1.0705	0.245
VEMDSC04	5/2/1994			21.3	1.019	0.27
VEMDSC05	5/2/1994			23.91	1.005	0.36
VEMDSC04	6/6/1994	1.1	13.924	6.32	0.841	0.38
VEMDSC05	6/6/1994	2.68	31.5294	1.85	1.41	0.28
VEMDSC02	6/6/1994	5.05	66.44735	10.455	1.982	0.205
VEMDSC01	6/6/1994	5.99	78.8158	7.35	1.481	0.15
VEMDSC04	7/6/1994	3.4	40.4762	5.92	1.914	0.17
VEMDSC05	7/6/1994	4.3	51.1904	1	2.172	0.16
VEMDSC02	7/6/1994	4.42	56.6666	9.86	1.578	0.23
VEMDSC01	7/6/1994	4.91	62.9487	5.9	1.439	0.15
VEMDSC01	8/1/1994			10.39		
VEMDSC02	8/1/1994			44.785	1.7185	0.265
VEMDSC04	8/1/1994			1	2.294	0.61
VEMDSC05	8/1/1994			1	2.349	0.53
VEMDSC04	9/6/1994	3.44	40.9523	1	2.04	0.22
VEMDSC05	9/6/1994	4.26	50.1176	1.24	1.94	0.19
VEMDSC02	9/6/1994	4.37	53.9506	3.49	0.952	0.15
VEMDSC01	9/6/1994	5.49	69.4936	5.19	0.478	0.09
VEMDSC04	10/3/1994	4.25	50.5952	1	2.717	0.19
VEMDSC05	10/3/1994	4.715	56.1309	1	2.4305	0.22
VEMDSC02	10/3/1994	5.31	64.7561	3.61	1.526	0.29
VEMDSC01	10/3/1994	5.61	68.4146	3.45	1.643	0.16
VEMDSC04	11/1/1994	4.285	49.2528	1.765	1.746	0.625
VEMDSC02	11/1/1994	4.55	54.1666	1.77	1.226	0.25
VEMDSC05	11/1/1994	4.92	56.5517	1.01	3.648	0.42
VEMDSC01	11/1/1994	5.19	61.7857	2.87	0.944	0.19
VEMDSC04	12/5/1994	3.87	43	1.78	0.872	0.17
VEMDSC05	12/5/1994	4.55	50.5555	1	1.145	0.15
VEMDSC02	12/5/1994	5.22	60	1.37	1.163	0.14
VEMDSC01	12/5/1994	6.29	72.2988	5.68	0.949	0.11
VEMDSC04	1/9/1995	6.24	60	1	1.448	0.2
VEMDSC05	1/9/1995	6.79	64.0566	1	1.519	0.07

Station	Sample Date	DO (mg/L)	DOSAT (%)	Corr Chla (μg/L)	TN (mg/L)	TP (mg/L)
VEMDSC02	1/9/1995	6.59	64.6078	1.15	1.054	0.14
VEMDSC01	1/9/1995	7.6	73.0769	3.79	0.801	0.12
VEMDSC04	2/6/1995	2.98	29.8	1	1.071	0.08
VEMDSC05	2/6/1995	5.65	54.3269	1	0.918	0.07
VEMDSC01	2/6/1995	7.9	73.1481	1.73	0.542	0.08
VEMDSC02	2/6/1995	8.14	76.7924	3.63	0.848	0.09
VEMDSC05	3/6/1995	3.21	34.1489	3.475	1.016	0.12
VEMDSC04	3/6/1995	3.9	41.4893	13.19	0.851	0.13
VEMDSC01	3/6/1995	5.9	64.1304	2.43	0.555	0.1
VEMDSC02	3/6/1995	6.5	72.2222	5.43	0.626	0.07
VEMDSC05	4/3/1995	3.71	38.2474	1	1.239	0.12
VEMDSC04	4/3/1995	4.05	42.6315	4.77	0.949	0.16
VEMDSC01	4/3/1995	6.2	65.9574	1.85	0.397	0.11
VEMDSC02	4/3/1995	6.075	66.03255	3.435	0.584	0.11
VEMDSC04	5/1/1995	2.1	25.6097	20.08	0.572	0.34
VEMDSC05	5/1/1995	2.8	32.1839	8.05	0.872	0.13
VEMDSC01	5/1/1995	4.72	57.5609	3.21	0.576	0.23
VEMDSC02	5/1/1995	5.24	64.6913	5.16	0.422	0.22
VEMDSC04	6/5/1995	1.45	15.2791	9.06	1.1025	0.275
VEMDSC05	6/5/1995	4.7	55.9523	3.76	0.93	0.26
VEMDSC02	6/5/1995	5.5	69.6203	10.38	1.048	0.2
VEMDSC01	6/5/1995	6.4	79.0123	6.59	0.56	0.32
VEMDSC04	7/10/1995	2.17	27.8205	23.32	1.1755	0.32
VEMDSC05	7/10/1995	3.12	39.4936	41.42		
VEMDSC01	7/10/1995	4.88	62.5641	3.58	0.068	0.16
VEMDSC02	7/10/1995	4.97	65.3947	5.96	0.096	0.2
VEMDSC04	8/7/1995	3.23	39.8765	1	1.782	0.14
VEMDSC05	8/7/1995	3.94	48.0488	1	1.922	0.2
VEMDSC02	8/7/1995	4.3	56.5789	26.41	1.939	0.24
VEMDSC01	8/7/1995	4.31	57.4666	5.78	1.229	0.25
VEMDSC01	9/5/1995			3.87	1.334	0.2
VEMDSC02	9/5/1995			1	1.507	0.22
VEMDSC04	9/5/1995			1	1.6725	0.255
VEMDSC05	9/5/1995			1.77	1.862	0.2
VEMDSC04	10/2/1995	3.8	46.9135		1.457	0.17
VEMDSC02	10/2/1995	4.3	54.4303		1.429	0.23
VEMDSC05	10/2/1995	4.6	56.7901		1.585	0.14
VEMDSC01	10/2/1995	5.1	64.5569		1.368	0.19
VEMDSC04	11/6/1995	3.32	37.7272	1.01	1.38	0.08
VEMDSC05	11/6/1995	4.15	46.1111	1.64	1.39	0.05
VEMDSC02	11/6/1995	6.03	69.3103	3.2	0.862	0.25

Station	Sample Date	DO (mg/L)	DOSAT (%)	Corr Chla (μg/L)	TN (mg/L)	TP (mg/L)
VEMDSC01	11/6/1995	6.42	75.5294	4.57	0.595	0.3
VEMDSC04	12/4/1995	2.75	29.2553	3.12	0.764	0.14
VEMDSC01	12/4/1995	7.17	81.4772	2.85	0.714	0.16
VEMDSC02	12/4/1995			1	0.908	0.16
VEMDSC04	1/8/1996	7.67	69.45945	1	1.201	0.07
VEMDSC05	1/8/1996	7.99	70.7079	1	1.174	0.07
VEMDSC02	1/8/1996	8.36	73.9823	2.72	1.128	0.08
VEMDSC01	1/8/1996	8.76	81.1111	8.3	0.683	0.15
VEMDSC04	2/5/1996	5.85	55.1886	1	1.491	0.24
VEMDSC05	2/5/1996	6.8	61.2612	1	1.326	0.11
VEMDSC02	2/5/1996	8.155	73.46845	2.31	0.824	0.14
VEMDSC01	2/5/1996	8.44	76.036	2.42	0.622	0.11
VEMDSC05	3/4/1996	4.97	49.1784	1.365	1.32	0.15
VEMDSC04	3/4/1996	5.54	55.4	2.99	2.22	0.41
VEMDSC02	3/4/1996	7.1	74.7368	1.85	0.645	0.14
VEMDSC01	3/4/1996	7.55	79.4736	1.81	0.483	0.2
VEMDSC05	4/1/1996	5.325	57.8804	1.76	1.007	0.165
VEMDSC02	4/1/1996	5.37	58.3695	1.54	0.986	0.24
VEMDSC04	4/1/1996	5.59	60.7608	1.07	1.01	0.22
VEMDSC01	4/1/1996	6.07	68.9772	2.12	0.522	0.34
VEMDSC05	5/6/1996	4.02	46.2069	10.33	1.026	0.12
VEMDSC04	5/6/1996	5.035	61.4024	74.98	1.139	0.175
VEMDSC01	5/6/1996	5.33	65	2.19	0.355	0.13
VEMDSC02	5/6/1996	5.86	75.1282	3.52	0.482	0.1
VEMDSC05	6/3/1996	1.8	20.9317	232.985	0.413	0.08
VEMDSC04	6/3/1996	4.46	54.3902	12.4	0.476	0.1
VEMDSC02	6/3/1996	5.17	63.0488	3.37	0.309	0.33
VEMDSC01	6/3/1996	5.41	64.4047	2.49	0.322	0.23
VEMDSC02	7/8/1996	3.89	48.0247	6.89	1.328	0.4
VEMDSC01	7/8/1996	3.92	48.395	1.67	0.94	0.2
VEMDSC04	7/8/1996	4.59	54.6428	2.19	1.352	0.34
VEMDSC05	7/8/1996	5.04	59.99995	1.705	1.4835	0.235
VEMDSC01	8/5/1996			3.8	0.477	0.16
VEMDSC02	8/5/1996			2.62	0.529	0.13
VEMDSC04	8/5/1996			61.13	0.612	0.17
VEMDSC05	8/5/1996			21.2	0.794	0.125
VEMDSC04	9/3/1996	0.52	6.58228	31.15	0.661	0.26
VEMDSC05	9/3/1996	1.9	22.619	4.35	0.858	0.15
VEMDSC01	9/3/1996	4.94	65	4.97	0.62	0.17
VEMDSC02	9/3/1996	5.06	66.5789	7.9	0.603	0.13
VEMDSC02	10/7/1996	4.96	58.3529	2.26	0.977	0.29

Station	Sample Date	DO (mg/L)	DOSAT (%)	Corr Chla (μg/L)	TN (mg/L)	TP (mg/L)
VEMDSC01	10/7/1996	5.03	59.1764	2.56	0.641	0.23
VEMDSC04	10/7/1996	5.33	61.2643	1.95	1.276	0.53
VEMDSC05	10/7/1996	5.77	66.3218	1.09	1.319	0.43
VEMDSC04	11/4/1996	2.79	31.7045	1	0.949	0.12
VEMDSC05	11/4/1996	3.59	39.0217	1	1.044	0.08
VEMDSC02	11/4/1996	6.43	73.0681	2.38	0.874	0.12
VEMDSC01	11/4/1996	6.82	75.7777	2.55	0.665	0.13
VEMDSC05	12/2/1996	2.75	29.2553	1	0.475	0.11
VEMDSC04	12/2/1996	3.05	33.1521	1.99	0.58	0.11
VEMDSC02	12/2/1996	7.23	80.3333	5.42	0.601	0.12
VEMDSC01	12/2/1996	7.69	83.5869	14.35	0.43	0.1
VEMDSC04	1/6/1997	0.69	7.66666	1.14	0.59	0.12
VEMDSC05	1/6/1997	2.72	28.9361	1	0.425	0.2
VEMDSC02	1/6/1997	5.51	61.2222	4.14	0.357	0.12
VEMDSC01	1/6/1997	7.07	78.5555	2.82	0.298	0.22
VEMDSC05	2/3/1997	0.295	3.138295	1.035	0.597	0.095
VEMDSC04	2/3/1997	0.32	3.40425	1.54	0.876	0.2
VEMDSC02	2/3/1997	7.56	79.5789	3.24	0.588	0.1
VEMDSC01	2/3/1997	9.99	105.158	1.26	0.416	0.1
VEMDSC05	3/3/1997	0.57	6.47727	11.11	0.648	0.11
VEMDSC04	3/3/1997	0.7	8.04597	3.06		
VEMDSC02	3/3/1997	6.66	79.2857	5.23	0.488	0.12
VEMDSC01	3/3/1997	7.45	87.647	3.96	0.454	0.17
VEMDSC05	4/7/1997	0.72	8.47059	22.18	0.583	0.2
VEMDSC02	4/7/1997	5.075	58.3333	3.16	0.502	0.17
VEMDSC04	4/7/1997	5.12	60.2353	10.94	0.703	0.17
VEMDSC01	4/7/1997	7.32	84.1379	1.97	0.411	0.12
VEMDSC01	5/5/1997			4.34	0.467	0.12
VEMDSC02	5/5/1997			4.01	0.5035	0.115
VEMDSC04	5/5/1997			3.61	0.466	0.14
VEMDSC05	5/5/1997			8.08	0.459	0.14
VEMDSC05	6/2/1997	0.61	7.17647	1.44	0.664	0.17
VEMDSC04	6/2/1997	4.77	56.1176		0.628	0.19
VEMDSC02	6/2/1997	4.805	58.59755	5.525	0.5415	0.135
VEMDSC01	6/2/1997	5.88	71.7073	3.86	0.47	0.12
VEMDSC04	7/7/1997	1.43	17.6543	1	0.77	0.21
VEMDSC05	7/7/1997	2.42	28.4706	1	1.685	0.35
VEMDSC01	7/7/1997	5.04	66.3158	1.84	0.644	0.12
VEMDSC02	7/7/1997	5.065	66.6447	2.2	0.621	0.145
VEMDSC05	8/4/1997	3.65	43.4523	1	1.586	0.21
VEMDSC01	8/4/1997			6.62	0.714	0.13

Station	Sample Date	DO (mg/L)	DOSAT (%)	Corr Chla (µg/L)	TN (mg/L)	TP (mg/L)
VEMDSC02	8/4/1997			10.19	0.713	0.145
VEMDSC04	8/4/1997			3.84	1.312	0.21
VEMDSC04	9/8/1997	3.24	38.1176	1	1.238	0.22
VEMDSC02	9/8/1997	3.59	43.7805	6.02	1.169	0.21
VEMDSC05	9/8/1997	3.89	45.7647	1	1.249	0.18
VEMDSC01	9/8/1997			4.42	0.764	0.13
VEMDSC04	10/6/1997	0.24	2.92683	9.29	0.919	0.19
VEMDSC05	10/6/1997	3.12	35.862	1	0.891	0.09
VEMDSC02	10/6/1997	5.875	71.6463	3.57	0.758	0.1
VEMDSC01	10/6/1997	6.1	75.3086	3.07	0.571	0.04
VEMDSC04	11/3/1997	4.69	52.1111	1	1.485	0.44
VEMDSC05	11/3/1997	5.44	57.8723	1	1.156	0.27
VEMDSC02	11/3/1997	5.57	64.0229	1.96	1.254	0.26
VEMDSC01	11/3/1997	7.54	88.7058	3.32	0.716	0.15
VEMDSC04	12/1/1997	3.18	33.8298	17.29	0.823	0.14
VEMDSC05	12/1/1997	3.63	38.617	1	0.847	0.14
VEMDSC02	12/1/1997	6.81	72.4468	1	0.797	0.1
VEMDSC01	12/1/1997	7.08	76.9565	1.29	0.55	0.09
VEMDSC04	1/5/1998	6.48	66.8041	1	1.057	0.12
VEMDSC05	1/5/1998	6.85	70.6185	1	1.107	0.1
VEMDSC02	1/5/1998	6.89	72.5263	1.01	1.091	0.11
VEMDSC01	1/5/1998	7.67	81.5957	2.29	1.1	0.12
VEMDSC04	2/2/1998	6.42	62.9411	1	1.103	0.15
VEMDSC05	2/2/1998	6.57	64.4117	1	1.096	0.11
VEMDSC02	2/2/1998	7.625	76.25	1.005	0.7125	0.07
VEMDSC01	2/2/1998	7.79	77.9	1	0.489	0.05
VEMDSC02	3/2/1998	6.09	64.1052	1	0.885	0.17
VEMDSC04	3/2/1998	6.3	64.9484	1	1.079	0.2
VEMDSC05	3/2/1998	6.79	70	1	1.122	0.16
VEMDSC01	3/2/1998	7.06	74.3158	1		0.07
VEMDSC05	4/6/1998	4.4	46.8085	1	1.034	0.07
VEMDSC04	4/6/1998	4.3	47.7777	3.58	0.901	0.08
VEMDSC02	4/6/1998	4.4	48.8889	3	0.6	0.13
VEMDSC01	4/6/1998	7	79.5455	2.44	0.418	0.1
VEMDSC01	5/4/1998			2.63	0.563	0.1
VEMDSC02	5/4/1998			3.45		0.11
VEMDSC04	5/4/1998				0.551	0.1
VEMDSC05	5/4/1998			5.52	0.692	0.19
VEMDSC04	6/1/1998	1.57	20.1282	9.46	0.502	0.17
VEMDSC05	6/1/1998	2.22	27.4074	8.02	0.794	0.51
VEMDSC02	6/1/1998	5.36	70.5263	3.81	0.517	0.15

Station	Sample Date	DO (mg/L)	DOSAT (%)	Corr Chla (µg/L)	TN (mg/L)	TP (mg/L)
VEMDSC01	6/1/1998	5.95	78.2894	4.6	0.461	0.13
VEMDSC05	7/6/1998	0.15	1.97368	8.41	1.128	0.64
VEMDSC04	7/6/1998	0.85	11.3333	11.58		0.43
VEMDSC02	7/6/1998	4.7	62.6666	5.66	0.521	0.18
VEMDSC01	7/6/1998	5.505	73.4	3.82	0.4845	0.175
VEMDSC04	8/3/1998	0.07	0.933333	48.48	1.468	0.51
VEMDSC05	8/3/1998	1.52	18.5366	1.7	1.459	0.44
VEMDSC02	8/3/1998	4.61	60.6579	6.89	0.562	0.19
VEMDSC01	8/3/1998	6.07	79.8684	4.24	0.3368	0.14
VEMDSC04	9/8/1998	2.39	29.1463	8.09	1.2764	0.35
VEMDSC05	9/8/1998	2.84	34.6341	1	1.3095	0.24
VEMDSC02	9/8/1998	4.745	60.83335	5.04	0.595	0.165
VEMDSC01	9/8/1998	5.16	63.7037	4.13	0.2286	0.08
VEMDSC04	10/5/1998	4.02	49.0244	1.27		
VEMDSC05	10/5/1998	4.27	52.0731	1		
VEMDSC02	10/5/1998	4.3	54.4303	4.15		
VEMDSC01	10/5/1998	4.9	62.8205	4.45		
VEMDSC01	10/6/1998					0.11
VEMDSC02	10/6/1998					0.18
VEMDSC04	10/6/1998					0.24
VEMDSC05	10/6/1998					0.23
VEMDSC04	11/2/1998	3.68	40.8889	4.89	1.102	0.17
VEMDSC05	11/2/1998	3.97	44.1111	1	1.335	0.17
VEMDSC02	11/2/1998	5.01	59.6428	2.89	0.723	0.09
VEMDSC01	11/2/1998	5.63	67.0238	4.33	0.53	0.09
VEMDSC05	12/2/1998	0.35	3.88889	1.3	0.827	0.18
VEMDSC04	12/2/1998	3.68	40.8889	263.06	0.723	0.14
VEMDSC02	12/2/1998	6.6	75.862	3.73	0.368	0.12
VEMDSC01	12/2/1998	6.55	77.0588	3.92	0.304	0.1
VEMDVC-074	1/4/1999	3.57	37.90316	1	0.527	0.14
VEMDVC-073	1/4/1999	3.26	39.8186	2.285	0.462	0.11
VEMDVC-072	1/4/1999	6.64	87.66389	1.28	0.306	0.1
VEMDVC-071	1/4/1999	7.27	93.1	3.2	0.487	0.01
VEMDVC-074	2/1/1999	3.05	35.83873	1.11	0.813	0.18
VEMDVC-073	2/1/1999	4.18	51.94915	2.88	0.675	0.13
VEMDVC-071	2/1/1999	5.63	74.6	2.2	0.253	0.1
VEMDVC-072	2/1/1999	5.71	83.02783		0.229	0.17
VEMDVC-074	3/1/1999	1.83	22.47503	1	0.657	0.14
VEMDVC-073	3/1/1999	6.03	72.57485	6.04	0.704	0.12
VEMDVC-071	3/1/1999	8.31	102.7	1.1	0.242	0.12
VEMDVC-072	3/1/1999	8.31	113.2818	1.73	0.256	0.4

Station	Sample Date	DO (mg/L)	DOSAT (%)	Corr Chla (μg/L)	TN (mg/L)	TP (mg/L)
VEMDVC-072	4/5/1999	5.27	84.6	2.76	0.447	0.1
VEMDVC-071	4/5/1999	6.35	94.3	3.3	0.274	0.09
VEMDVC-073	4/5/1999			5	0.425	0.12
VEMDVC-074	4/5/1999			3.8	0.82	0.24
VEMDVC-074	5/3/1999	1.27	17.32478	1	0.847	0.3
VEMDVC-073	5/3/1999	1.79	24.83932	3.87	0.658	0.21
VEMDVC-071	5/3/1999	6.48	89.5	2.6	0.338	0.19
VEMDVC-072	5/3/1999	6.4	94.93836	2.86	0.372	0.19
VEMDVC-073	6/7/1999	0.95	14.84744	12.2	0.749	0.3
VEMDVC-074	6/7/1999	1.55	22.03065	13.2	0.632	0.29
VEMDVC-072	6/7/1999	4.96	82.10178	6.7	0.594	0.17
VEMDVC-071	6/7/1999	5.6	85.6	5.7	0.486	0.14
VEMDVC-074	7/7/1999	4.04	54.28378	1.7	1.546	0.15
VEMDVC-073	7/7/1999	4.1	56.66585	8.6	1.716	0.18
VEMDVC-071	7/7/1999	5.24	83	10.1	0.917	0.19
VEMDVC-072	7/7/1999	6.03	93.70771	63	1.26	0.21
VEMDVC-073	8/2/1999	0.22	3.198505	5.8	1.137	0.43
VEMDVC-072	8/2/1999	4.07	70.23625	3.53	0.579	0.18
VEMDVC-071	8/2/1999	5.39	85.8	6.6	0.416	0.14
VEMDVC-074	9/7/1999	0.28	4.2	1.3	0.848	0.25
VEMDVC-073	9/7/1999	1.5	22.4	3.2	0.851	0.15
VEMDVC-072	9/7/1999	4.4	74.1	7.6	0.455	0.15
VEMDVC-071	9/7/1999	5.11	81.1	5.5	0.417	0.16
VEMDVC-072	10/4/1999	3.34	45.5	1.4	1.643	0.28
VEMDVC-073	10/4/1999	3.5	47.1	1.11	1.973	0.32
VEMDVC-071	10/4/1999	4.11	54.0	1.8	1.507	0.2
VEMDVC-074	10/4/1999					
VEMDVC-074	11/1/1999	4.14	52.5	1	1.427	0.13
VEMDVC-073	11/1/1999	4.34	55.3	1	1.387	0.15
VEMDVC-072	11/1/1999	4.46	59.2	2.5	1.283	0.19
VEMDVC-071	11/1/1999	5.64	73.9	2.5	1.283	0.19
VEMDVC-074	12/6/1999	3.51	40.9	1	0.88	0.11
VEMDVC-073	12/6/1999	4.37	50.0	2.7	0.91	0.15
VEMDVC-072	12/6/1999	6.74	91.0	1.2	0.54	0.1
VEMDVC-071	12/6/1999	7.39	94.5	1.4	0.534	0.08
VEMDVC-073	1/3/2000	2.43	28.3	1	0.81	0.09
VEMDVC-074	1/3/2000	2.89	34.4	1	0.83	0.09
VEMDVC-072	1/3/2000	6.95	91.3	2.55	0.64	0.09
VEMDVC-071	1/3/2000	8.14	104.3	1.66	0.397	0.07
VEMDVC-073	4/3/2000	4.13	51.7	3.27	1.08	0.22
VEMDVC-074	4/3/2000	4.3	53.7	1.55	1.01	0.19

Station	Sample Date	DO (mg/L)	DOSAT (%)	Corr Chla (µg/L)	TN (mg/L)	TP (mg/L)
VEMDVC-072	4/3/2000	6.07	81.9	4.88	0.93	0.25
VEMDVC-071	4/3/2000	7.72	102.1	7.51	0.553	0.2
VEMDVC-074	7/10/2000	0.79	11.3	14.76	0.76	0.24
VEMDVC-073	7/10/2000	2.74	39.8	4.43	0.66	0.24
VEMDVC-072	7/10/2000	4.79	79.4	2.56	0.518	0.14
VEMDVC-073	10/2/2000	2.77	36.2	4.06	1.07	0.2
VEMDVC-074	10/2/2000	3.54	46.0	1.06	1.09	0.16
VEMDVC-072	10/2/2000	4.49	66.2	4.72	0.76	0.14
VEMDVC-074	2/5/2001	0.01	0.1	1	0.73	0.41
VEMDVC-073	2/5/2001	0.04	0.5	23.36	1.01	0.25
VEMDVC-072	2/5/2001	6.85	88.9	2.05	0.46	0.08
VEMDVC-071	2/5/2001	8.97	111.1	0.86	0.281	0.07
VEMDVC-071	5/7/2001	0.53	7.9	3.44	0.271	0.12
VEMDVC-074	5/7/2001	0.91	12.2	20.67	0.72	0.16
VEMDVC-073	5/7/2001	4.92	67.3	7.5	0.59	0.16
VEMDVC-072	5/7/2001	5.19	83.0	3.85	0.36	0.12
VEMDVC-072	8/6/2001	3.81	51.9	7.52	1.63	0.22
VEMDVC-073	8/6/2001	4.46	59.6	1	1.77	0.31
VEMDVC-074	8/6/2001	4.76	63.1	1.55	2	0.31
VEMDVC-071	8/6/2001	4.34	63.6	5.8	0.938	0.22
VEMDVC-073	11/5/2001	4.94	62.1	1	1.36	0.04
VEMDVC-074	11/5/2001	5.25	65.7	1	1.33	0.05
VEMDVC-072	11/5/2001	6.23	88.6	1	0.85	0.07
VEMDVC-071	11/5/2001	7.19	103.2	1.69	0.303	0.19
VEMDVC-072	3/4/2002	7.24	86.6	1		
VEMDVC-071	3/4/2002	7.02	86.8	0.8	0.363	0.06
VEMDVC-072	6/3/2002	4.69	80.2	6.1		
VEMDVC-071	6/3/2002	5.35	86.1	4.4	0.468	0.15
VEMDVC-071	9/9/2002	5.75	89.9			0.2
VEMDVC-072	12/2/2002	7.22	94.6			
VEMDVC-071	12/2/2002	7.73	99.2	1.9		0.027
VEMDVC-074	2/3/2003	5.13	55.6		0.913	0.08
VEMDVC-073	2/3/2003	5.57	59.9		0.821	0.09
VEMDVC-071	2/3/2003	8.48	103.9	2.58	0.316	0.1
VEMDVC-072	2/3/2003	8.5	108.0		0.536	0.08
WPB 20010738	3/12/2003	5.88	72.0	1	1.158	0.133
WPB 20010737	3/12/2003	7.505	95.2	33.39722	1.222	0.148
VEMDVC-074	5/5/2003	2.54	33.0		1.024	0.15
VEMDVC-073	5/5/2003	3.45	46.2		0.914	0.15
VEMDVC-072	5/5/2003	5.73	90.5		0.582	0.16
VEMDVC-071	5/5/2003			2.72	0.356	0.18

Station	Sample Date	DO (mg/L)	DOSAT (%)	Corr Chla (µg/L)	TN (mg/L)	TP (mg/L)
WPB 20010738	6/4/2003	2.53	38.2	8.99	0.573	0.1
WPB 20010737	6/4/2003	7.1	95.8	13.92	1.125	0.093
VEMDVC-072	8/4/2003	4.01	58.0			
VEMDVC-073	8/4/2003	4.31	58.1			
VEMDVC-071	8/4/2003	4.32	61.9	2.69	0.923	0.19
VEMDVC-074	8/4/2003	4.74	63.8			
WPB 20010738	8/13/2003	4.86	66.2	1.89	1.262	0.236
WPB 20010737	8/13/2003	6.925	99.9	24.53	1.069	0.089
WPB 20010738	8/26/2003	2.8	38.1	11.71	1.685	0.325
WPB 20010737	8/26/2003	6.93	103.5	7.18	0.9	0.059
WPB 20010738	9/15/2003	3.23	43.0	1.41	1.081	0.122
WPB 20010737	9/15/2003	6.69	96.4	19.19	0.934	0.076
WPB 20010738	10/9/2003	5.28	68.6	1	1.188	0.195
WPB 20010737	10/9/2003	6.17	84.3	16.14	1.085	0.091
VEMDVC-074	11/3/2003	2.64	34.0			
VEMDVC-073	11/3/2003	3.27	42.6			
VEMDVC-072	11/3/2003	5.83	88.3			
VEMDVC-071	11/3/2003	6.87	102.1	3.34		0.08
VEMDVC-074	3/1/2004	6.29	69.7	1.12		
VEMDVC-073	3/1/2004	6.4	71.2	1		
VEMDVC-072	3/1/2004	7.32	88.1	1.95		
VEMDVC-071	3/1/2004	9.2	107.3	1.64		
VEMDVC-073	6/7/2004	3.08	42.7			
VEMDVC-071	6/7/2004	5.53	83.3			
VEMDVC-072	6/7/2004	5.58	88.2			
VEMDVC-073	10/11/2004	3.1	40.9			
VEMDVC-074	10/11/2004	3.42	45.0			
VEMDVC-072	10/11/2004	4.95	69.4			
VEMDVC-074	12/6/2004	4.21	48.7			
VEMDVC-073	12/6/2004	4.74	55.2			
VEMDVC-071	12/6/2004	6.87	91.4			
VEMDVC-072	12/6/2004	9.2	120.9			
VEMDVC-074	2/7/2005	5.95	67.3			
VEMDVC-073	2/7/2005	7.09	83.0			
VEMDVC-071	2/7/2005	8.52	107.1	2.16	0.345	0.07
VEMDVC-072	2/7/2005	8.51	115.6			
CEN 27010197	2/9/2005	5.07	65.6	2.88	0.761	0.081
CEN 27010195	2/9/2005	5.65	74.1	3.96	0.729	0.08
CEN 27010196	2/9/2005	5.73	74.5	4.54	0.743	0.077
CEN 27010194	2/9/2005	6.05	79.5	1.43	0.648	0.07
CEN 27010193	2/9/2005	6.15	81.2	3.18	0.646	0.0585

Station	Sample Date	DO (mg/L)	DOSAT (%)	Corr Chla (μg/L)	TN (mg/L)	TP (mg/L)
CEN 27010194	4/5/2005	5.6		1	1.207	0.092
CEN 27010194	4/18/2005	6.38	83.6			
CEN 27010196	4/18/2005	6.42	84.1			
CEN 27010197	4/18/2005	6.46	84.3			
CEN 27010195	4/18/2005	6.44	84.5			
CEN 27010193	4/18/2005	6.5	85.4			
VEMDVC-074	5/2/2005	4.25	53.2			
VEMDVC-073	5/2/2005	5.16	65.9			
VEMDVC-071	5/2/2005	7.18	99.5	7.14	0.473	0.13
VEMDVC-072	5/2/2005	7.09	100.3			
CEN 27010193	6/13/2005	3.68		3.475	1.381	0.315
CEN 27010194	6/13/2005	3.7		4.04	1.228	0.29
CEN 27010195	6/13/2005	3.72		3.98	1.229	0.27
CEN 27010196	6/13/2005	3.76				
CEN 27010197	6/13/2005	3.7				
CEN 27010197	6/29/2005	4.38	61.5			
VEMDVC-072	8/8/2005	4.19	60.3	4.21		
VEMDVC-073	8/8/2005	5.01	67.5	2.29		
VEMDVC-074	8/8/2005	5.34	71.8	1.43		
VEMDVC-071	8/8/2005	4.92	73.5	1.79		
CEN 27010193	8/8/2005	4.34		2.37	1.438	0.35
CEN 27010194	8/8/2005	4.31		3.42	1.237	0.36
CEN 27010195	8/8/2005	4.21		3.42	1.236	0.31
CEN 27010196	8/8/2005	4.29				
CEN 27010197	8/8/2005	4.18				
VEMDVC-074	11/7/2005	6.42	78.8			
VEMDVC-073	11/7/2005	6.43	80.7			
VEMDVC-072	11/7/2005	7.13	97.6			
VEMDVC-071	11/7/2005	7.4	100.8	3.87		0.09
CEN 27010193	12/12/2005	6.05	69.1	2.55		0.13
CEN 27010196	12/12/2005	6.17	69.2			
CEN 27010194	12/12/2005	6.04	69.3	2.71		0.14
CEN 27010195	12/12/2005	6.42	72.8	2.63		0.1
CEN 27010197	12/12/2005	6.54	72.8			
VEMDVC-073	1/9/2006	5.34	56.7	2.45		
VEMDVC-072	1/9/2006	7.52	90.2	1.58		
VEMDVC-071	1/9/2006	8.72	102.1	1.04	0.223	0
VEMDVC-073	4/3/2006	5.97	77.8			
VEMDVC-071	4/3/2006	6.48	85.9	1.03	0.27	0.22
VEMDVC-071	7/10/2006			2.07		
VEMDVC-072	7/10/2006			5.29		

Station	Sample Date	DO (mg/L)	DOSAT (%)	Corr Chla (μg/L)	TN (mg/L)	TP (mg/L)
VEMDVC-073	7/10/2006			17.88		0.03
VEMDVC-073	10/3/2006	2.79	36	13.29		0.21
VEMDVC-073	10/3/2006	2.79	39.5	13.29		
VEMDVC-072	10/3/2006	5.99	88.5	6.72		0.12
VEMDVC-072	10/3/2006	5.99	96.8	6.72		
VEMDVC-071	10/3/2006	6.35	97.3	7.01		0.09

Appendix C: Kruskal–Wallis Analysis of DO, DOSAT, Corrected Chla, TN, and TP Observations versus Season in Spruce Creek

Kruskal-Wallis One-Way Analysis of Variance for 492 cases
Dependent variable is DO
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	133	33366.000
SPRING	122	28163.500
SUMMER	113	18079.000
WINTER	124	41669.500

Kruskal-Wallis Test Statistic = 92.632
Probability is 0.000 assuming Chi-square distribution with 3 df

Kruskal-Wallis One-Way Analysis of Variance for 481 cases
Dependent variable is DOSAT
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	133	32272.500
SPRING	116	28035.500
SUMMER	108	20317.500
WINTER	124	35295.500

Kruskal-Wallis Test Statistic = 27.874
Probability is 0.000 assuming Chi-square distribution with 3 df

Kruskal-Wallis One-Way Analysis of Variance for 459 cases
Dependent variable is CHLAC
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	110	21742.500
SPRING	107	31267.500
SUMMER	125	34480.000
WINTER	117	18080.000

Kruskal-Wallis Test Statistic = 83.378
Probability is 0.000 assuming Chi-square distribution with 3 df

Kruskal-Wallis One-Way Analysis of Variance for 435 cases
Dependent variable is TN
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	97	23811.000
SPRING	111	18692.500
SUMMER	112	29324.000
WINTER	115	23002.500

Kruskal-Wallis Test Statistic = 37.870
Probability is 0.000 assuming Chi-square distribution with 3 df

Kruskal-Wallis One-Way Analysis of Variance for 459 cases
Dependent variable is TP
Grouping variable is SEASON$

Group	Count	Rank Sum
FALL	111	24608.500
SPRING	118	29985.500
SUMMER	113	33349.000
WINTER	117	17627.000

Kruskal-Wallis Test Statistic = 73.545
Probability is 0.000 assuming Chi-square distribution with 3 df

Appendix D: Kruskal–Wallis Analysis of DO, DOSAT, Corrected Chla, TN, and TP Observations versus Month in Spruce Creek

Kruskal-Wallis One-Way Analysis of Variance for 492 cases
Dependent variable is DO
Grouping variable is MONTH

Group	Count	Rank Sum
1	39	12790.500
2	49	16398.500
3	36	12480.500
4	43	12387.000
5	33	7512.500
6	46	8264.000
7	37	5457.000
8	42	7277.500
9	34	5344.500
10	44	9041.000
11	44	11385.000
12	45	12940.000

Kruskal-Wallis Test Statistic = 114.195
Probability is 0.000 assuming Chi-square distribution with 11 df

Kruskal-Wallis One-Way Analysis of Variance for 481 cases
Dependent variable is DOSAT
Grouping variable is MONTH

Group	Count	Rank Sum
1	39	10571.500
2	49	13963.500
3	36	10760.500
4	42	11531.000
5	33	7864.500
6	41	8640.000
7	37	6333.500
8	37	7832.000
9	34	6152.000
10	44	9542.000
11	44	11036.500
12	45	11694.000

Kruskal-Wallis Test Statistic = 37.086
Probability is 0.000 assuming Chi-square distribution with 11 df

Kruskal-Wallis One-Way Analysis of Variance for 459 cases
Dependent variable is CHLAC
Grouping variable is MONTH

Group	Count	Rank Sum
1	35	5485.500
2	42	6308.500
3	40	6286.000
4	34	7477.000
5	34	10673.500
6	39	13117.000
7	40	12218.500
8	47	13079.500
9	38	9182.000
10	37	8333.000
11	38	6000.000
12	35	7409.500

Kruskal-Wallis Test Statistic = 108.868
Probability is 0.000 assuming Chi-square distribution with 11 df

Kruskal-Wallis One-Way Analysis of Variance for 435 cases
Dependent variable is TN
Grouping variable is MONTH

Group	Count	Rank Sum
1	37	6797.000
2	45	8781.000
3	33	7424.500
4	35	6221.500
5	39	5920.500
6	37	6550.500
7	33	8281.500
8	41	11510.500
9	38	9532.000
10	31	9297.500
11	35	9272.000
12	31	5241.500

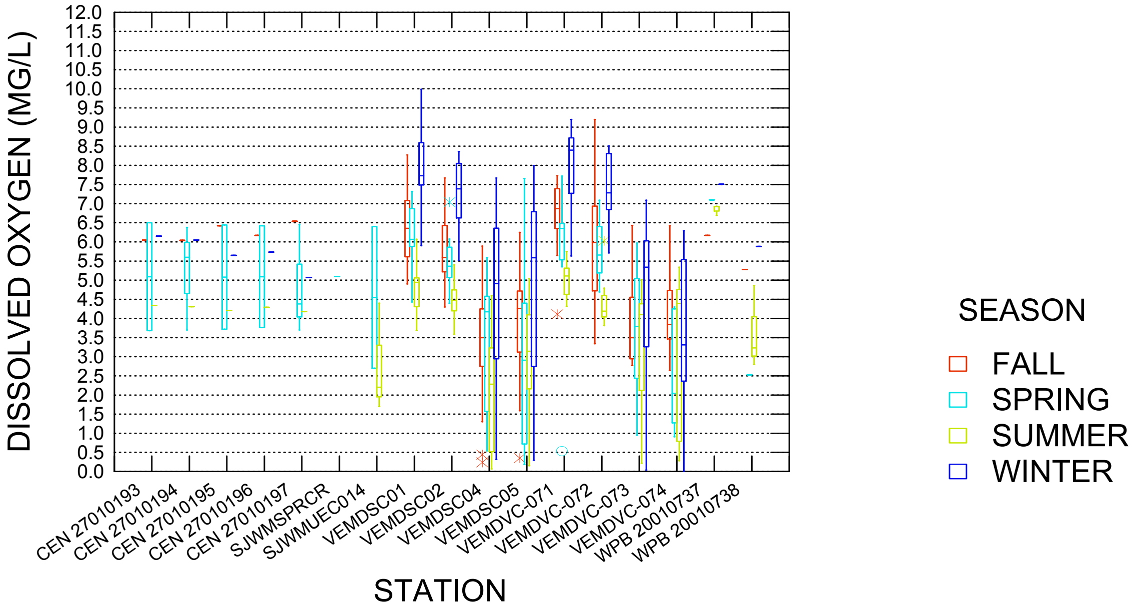
Kruskal-Wallis Test Statistic = 60.474
Probability is 0.000 assuming Chi-square distribution with 11 df

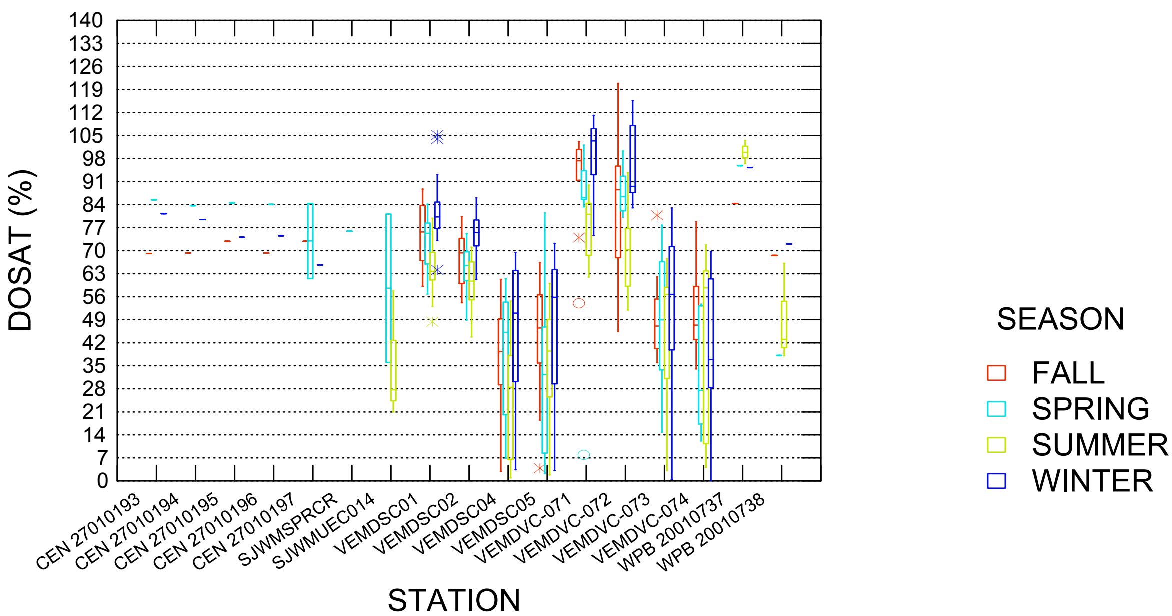
Kruskal-Wallis One-Way Analysis of Variance for 459 cases
Dependent variable is TP
Grouping variable is MONTH

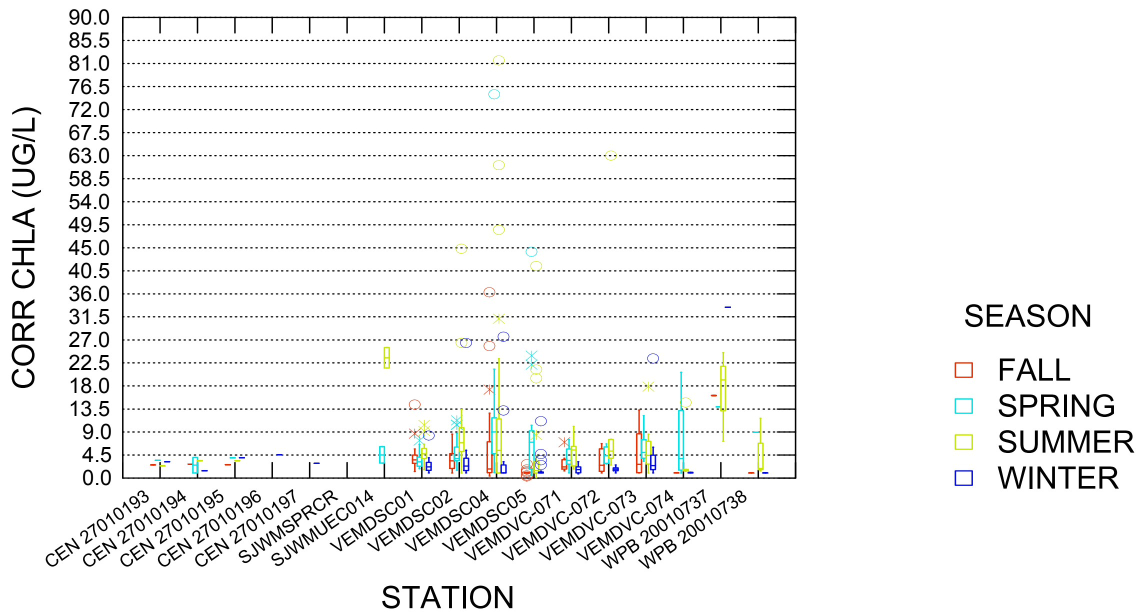
Group	Count	Rank Sum
1	37	5820.500
2	46	5747.500
3	34	6059.000
4	38	8386.000
5	42	10459.000
6	38	11140.500
7	34	10831.000
8	41	13389.000
9	38	9129.000
10	38	11002.500
11	38	8048.500
12	35	5557.500

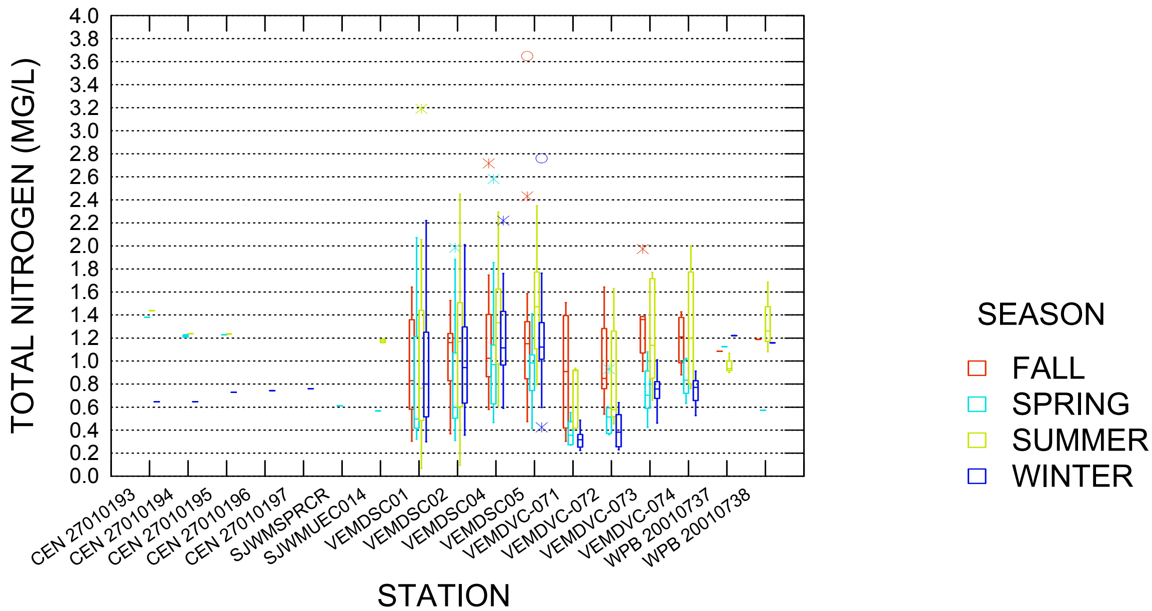
Kruskal-Wallis Test Statistic = 110.555
Probability is 0.000 assuming Chi-square distribution with 11 df

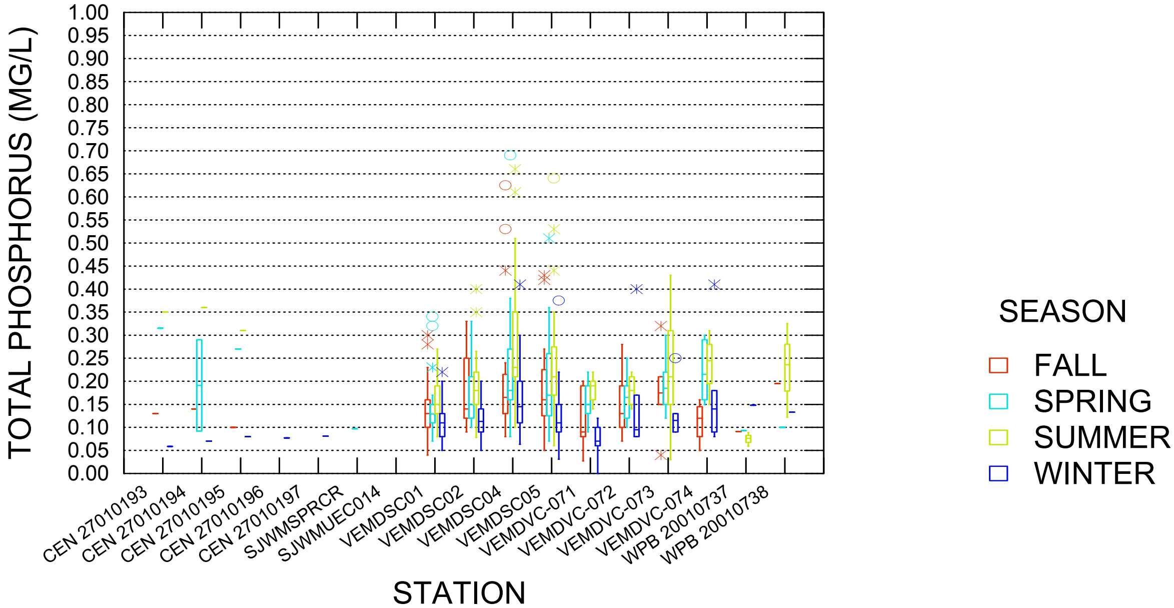
Appendix E: Chart of DO, DOSAT, Corrected Chla, TN, and TP Observations by Season, Station, and Year in Spruce Creek

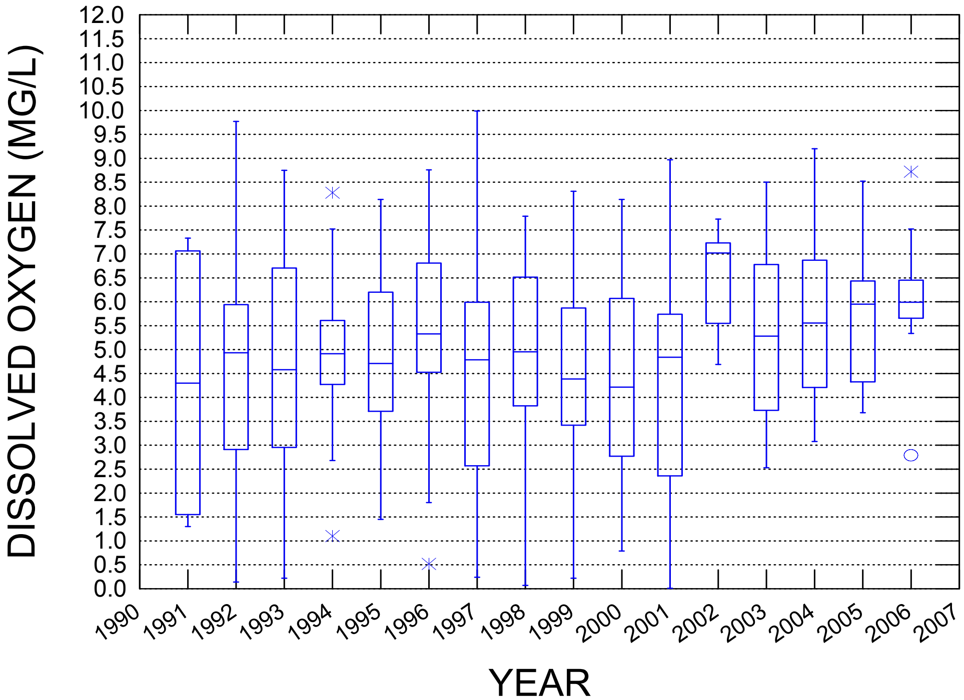


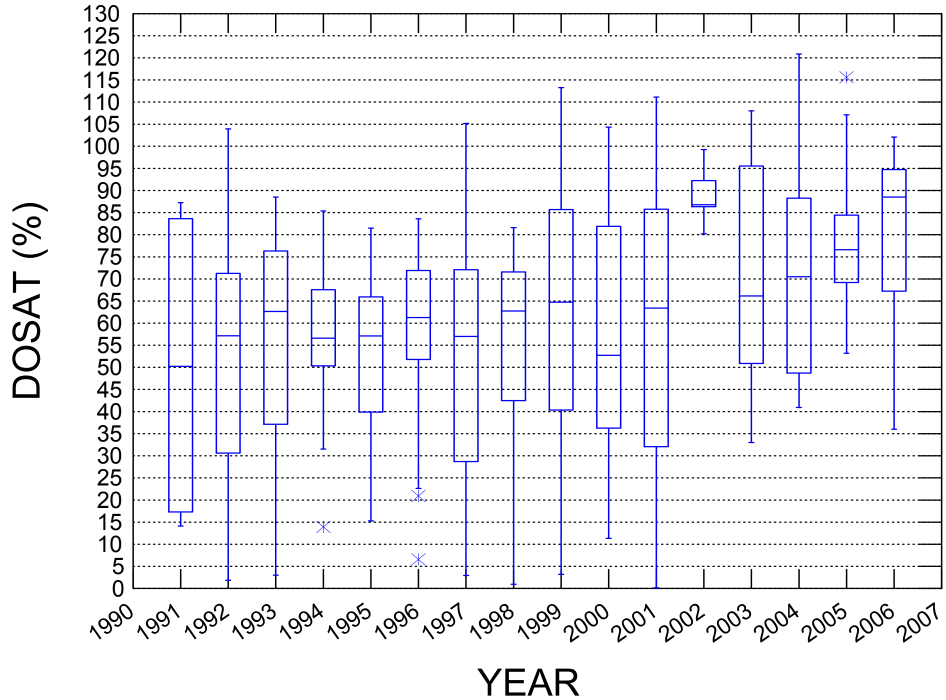


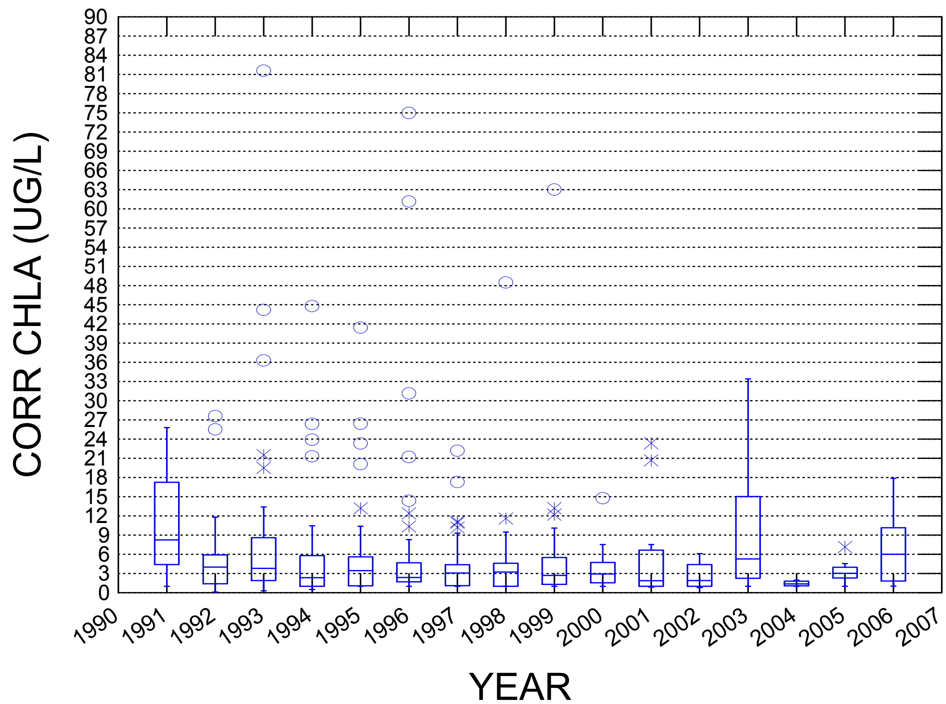

CORR CHLA (UG/L)
90.0
85.5
81.0
76.5
72.0
67.5
63.0
58.5
54.0
49.5
45.0
40.5
36.0
31.5
27.0
22.5
18.0
13.5
9.0
4.5
0.0
CEN 27010193
CEN 27010194
CEN 27010195
CEN 27010196
CEN 27010197
SJWMSPRCR
SJWMUEC014
VEMDSC01
VEMDSC02
VEMDSC04
VEMDSC05
VEMDVC-071
VEMDVC-072
VEMDVC-073
VEMDVC-074
WPB 20010737
WPB 20010738
STATION
SEASON
FALL
SPRING
SUMMER
WINTER

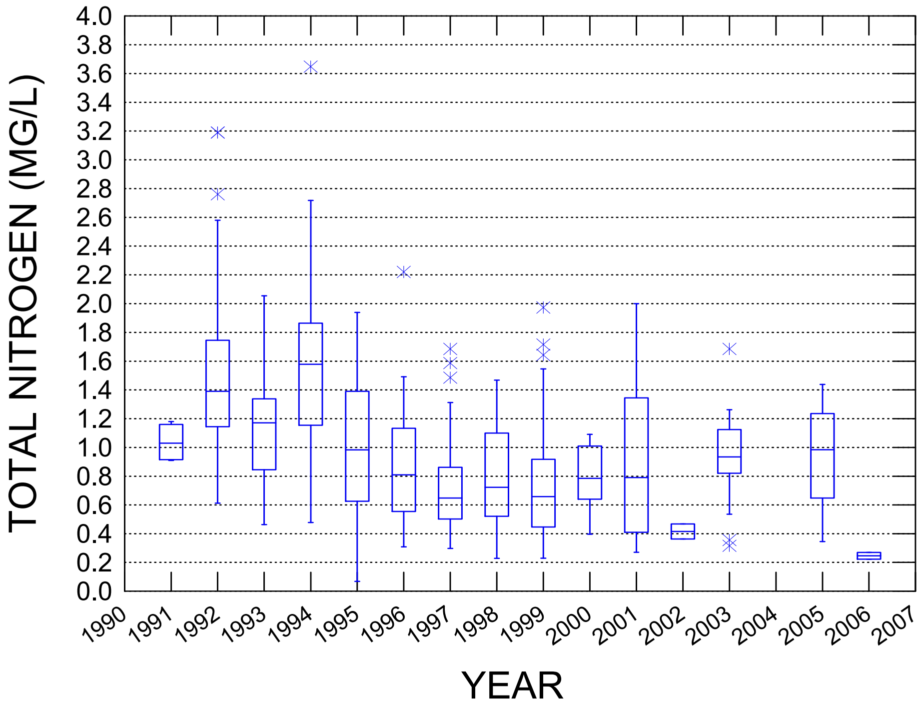

TOTAL NITROGEN (MG/L)
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
CEN 27010193
CEN 27010194
CEN 27010195
CEN 27010196
CEN 27010197
SJWMSPRCR
SJWMUEC014
VEMDSC01
VEMDSC02
VEMDSC04
VEMDSC05
VEMDVC-071
VEMDVC-072
VEMDVC-073
VEMDVC-074
WPB 20010737
WPB 20010738
STATION
SEASON
FALL
SPRING
SUMMER
WINTER

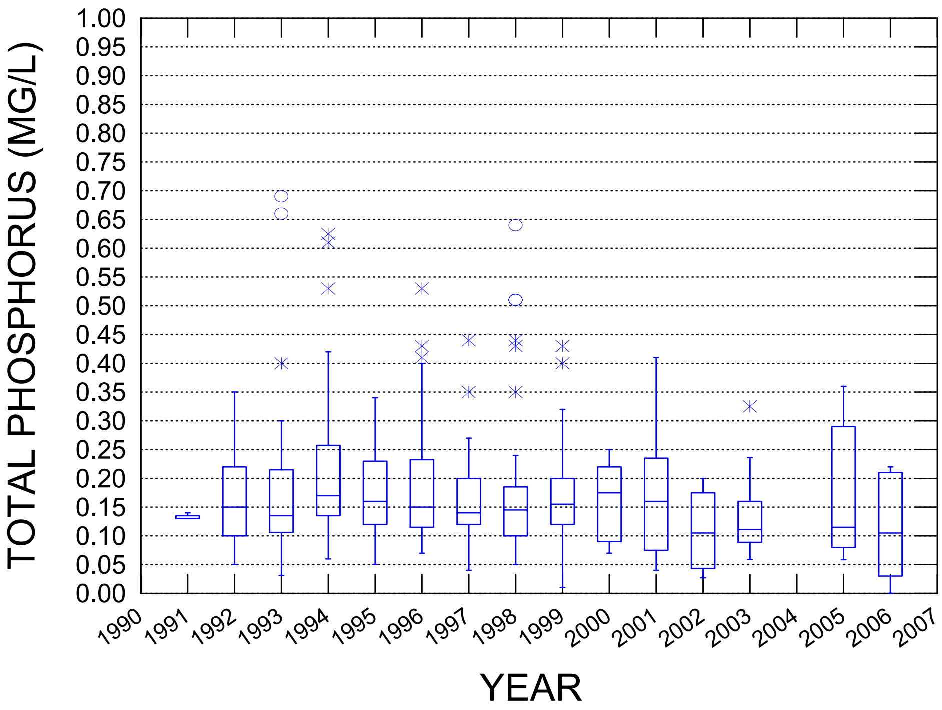

TOTAL PHOSPHORUS (MG/L)
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
CEN 27010193
CEN 27010194
CEN 27010195
CEN 27010196
CEN 27010197
SJWMSPRCR
SJWMUEC014
VEMDSC01
VEMDSC02
VEMDSC04
VEMDSC05
VEMDVC-071
VEMDVC-072
VEMDVC-073
VEMDVC-074
WPB 20010737
WPB 20010738
STATION
SEASON
FALL
SPRING
SUMMER
WINTER

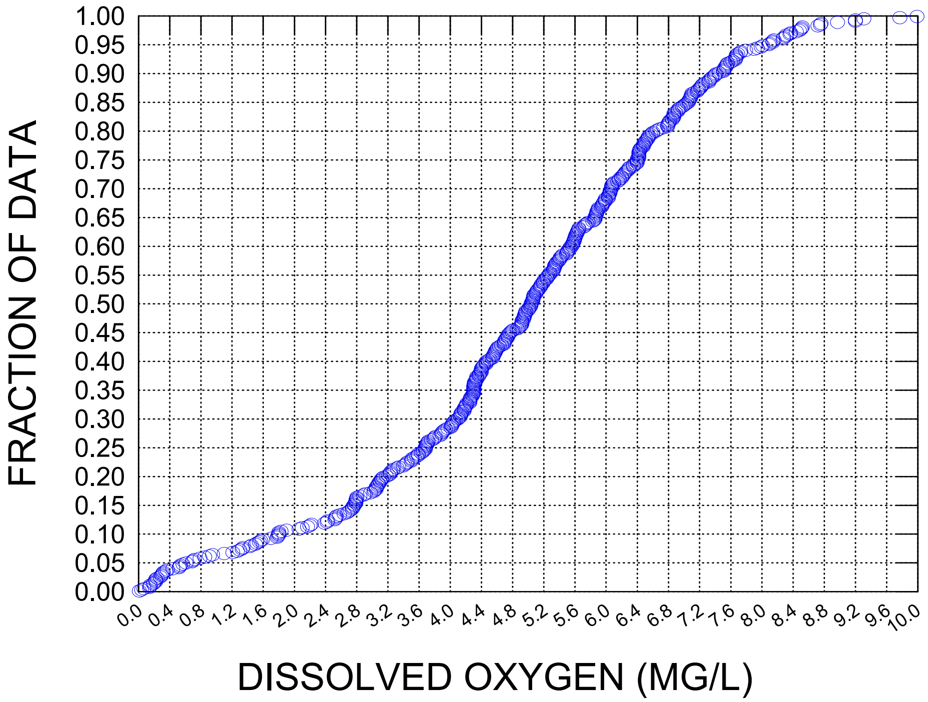

DISSOLVED OXYGEN (MG/L)
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
YEAR

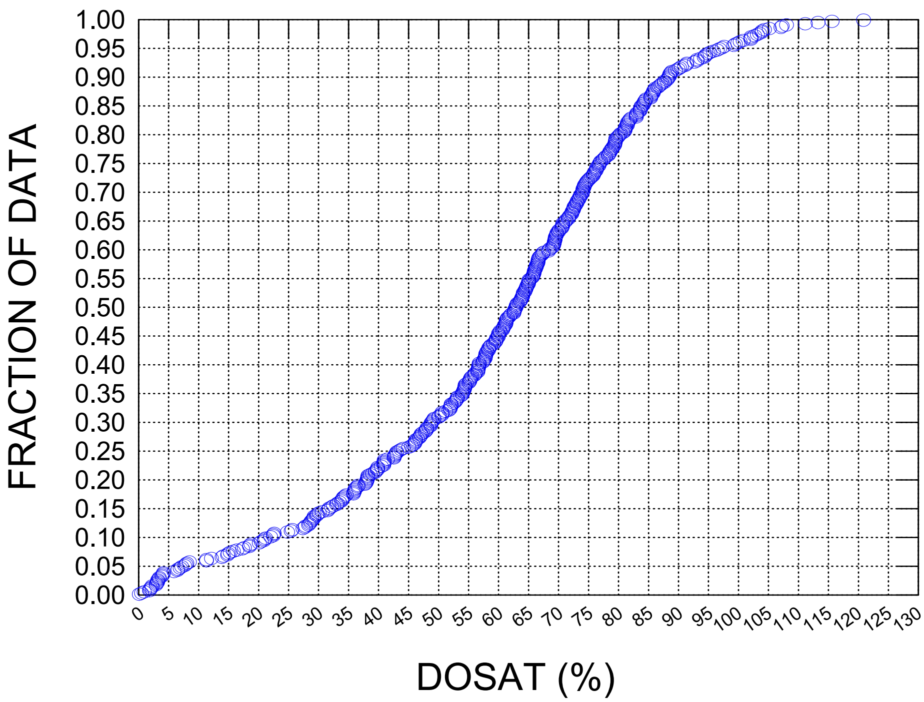

DOSAT (%)
YEAR

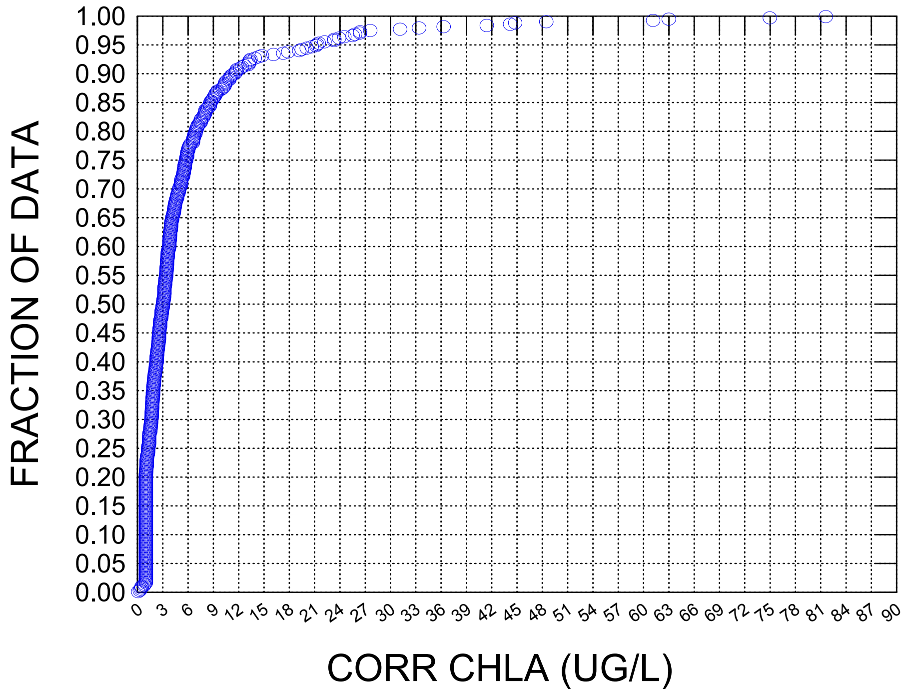

CORR CHLA (UG/L)
YEAR

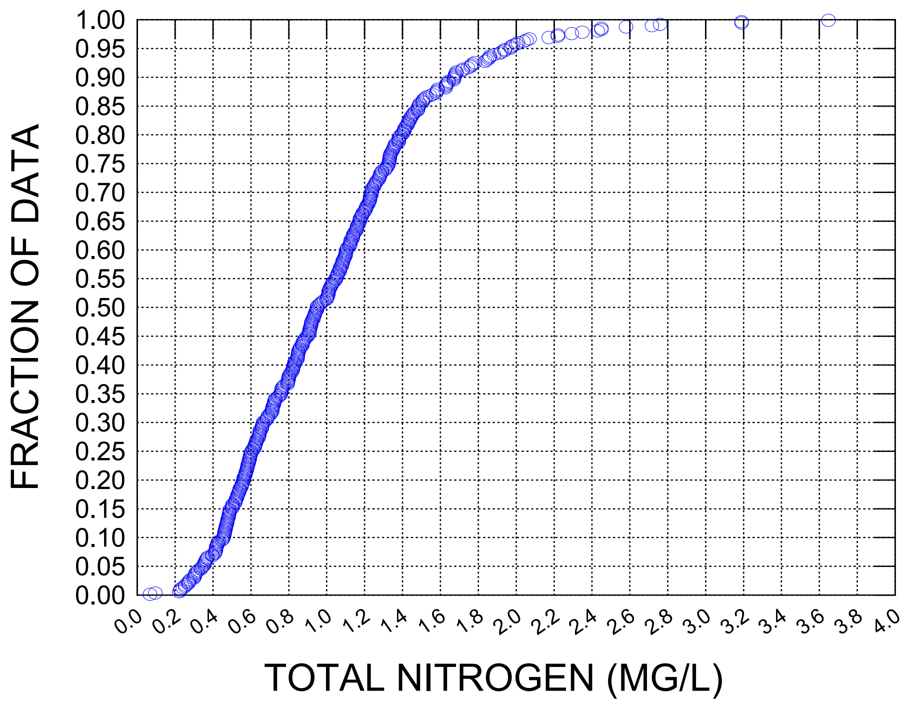

TOTAL NITROGEN (MG/L)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
4.0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
YEAR

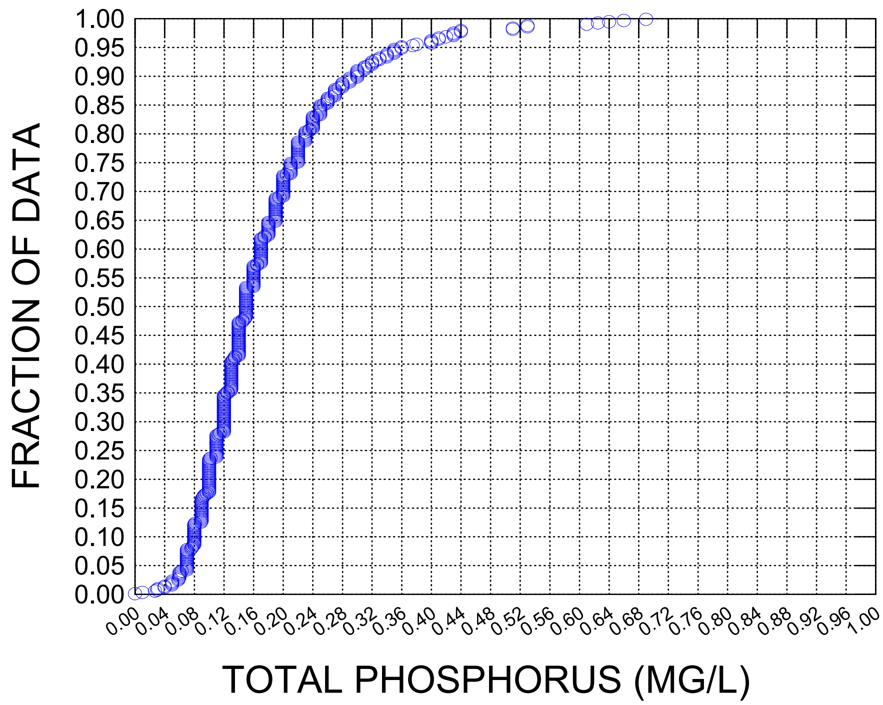

TOTAL PHOSPHORUS (MG/L)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
0.55
0.60
0.65
0.70
0.75
0.80
0.85
0.90
0.95
1.00
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
YEAR

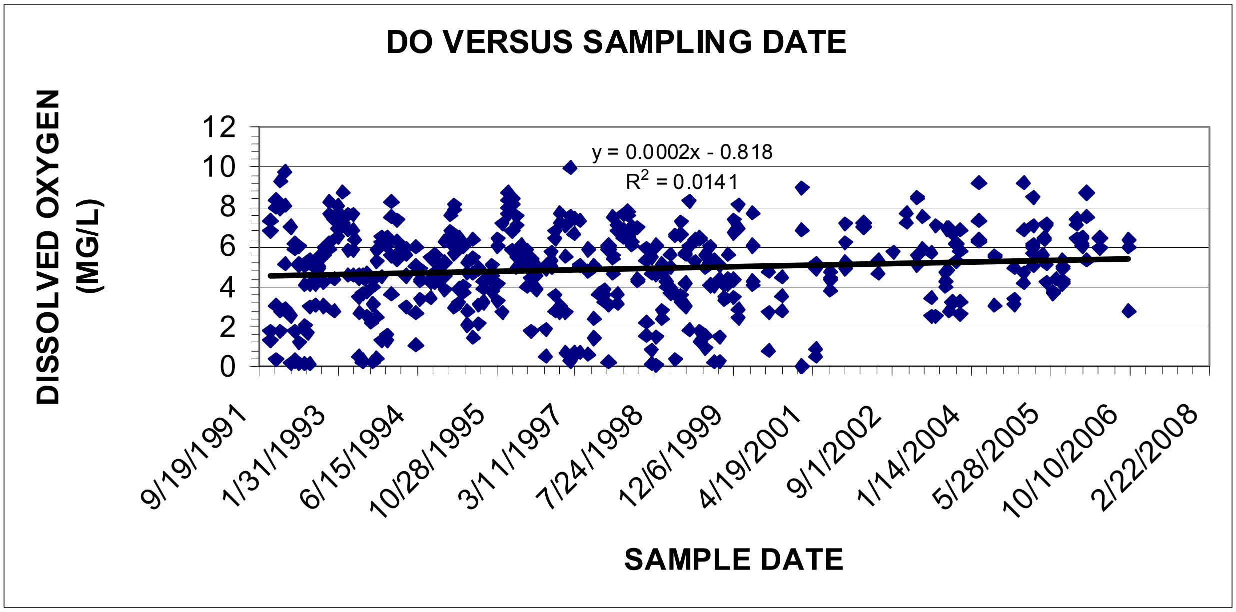

FRACTION OF DATA
DISSOLVED OXYGEN (MG/L)

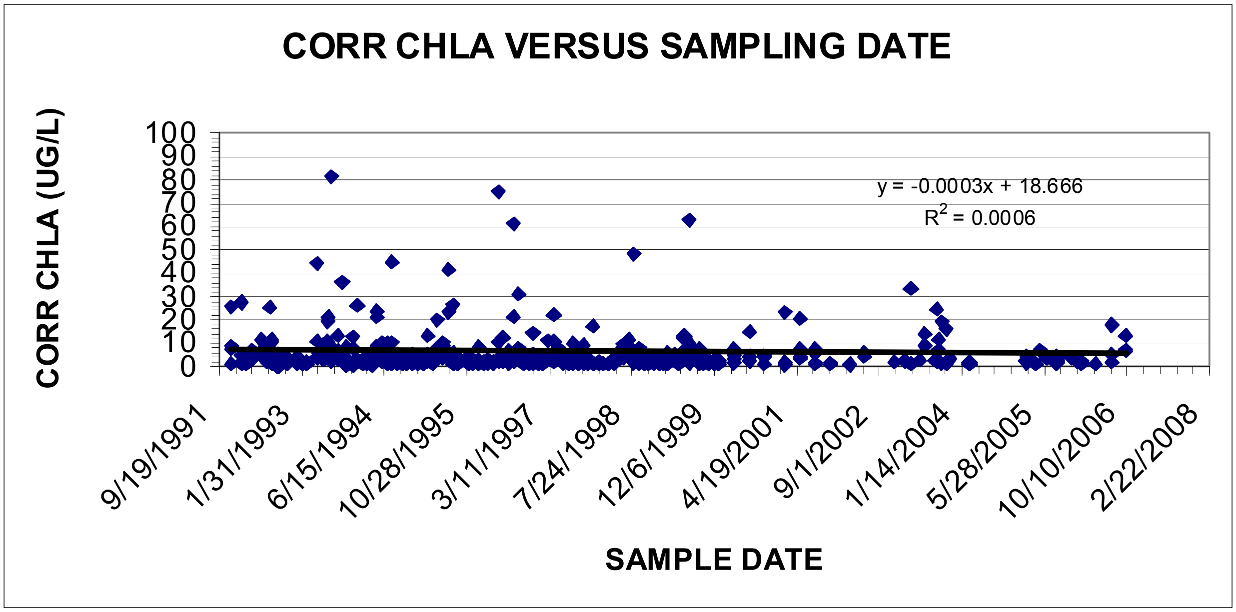

FRACTION OF DATA
DOSAT (%)

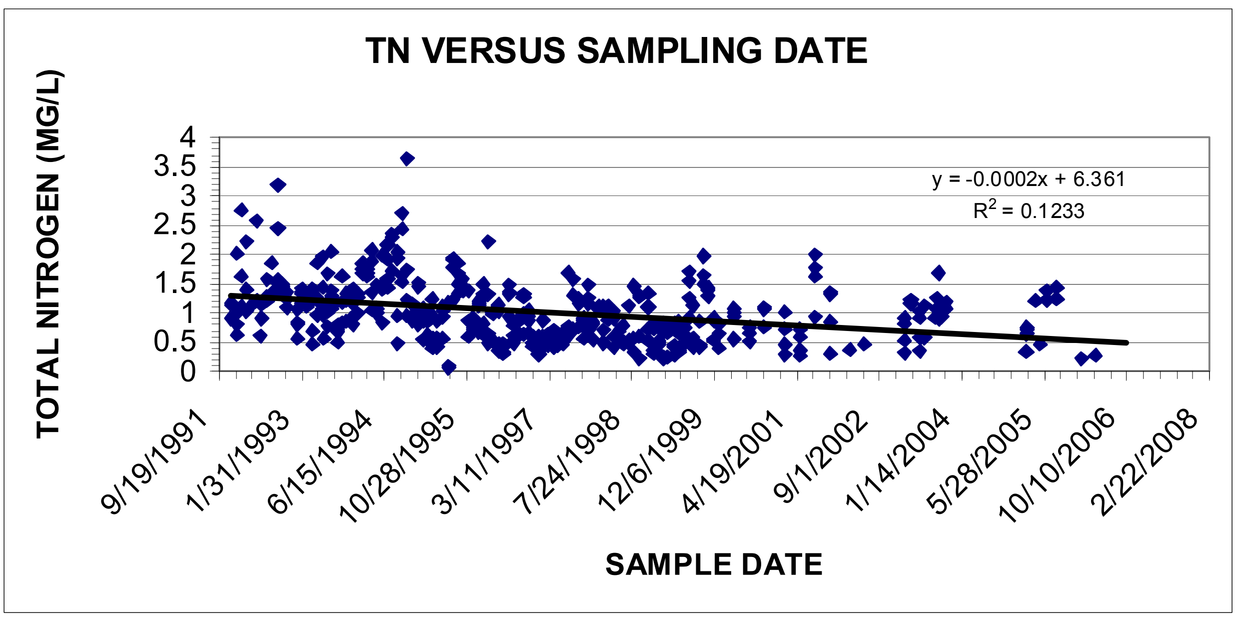

FRACTION OF DATA
CORR CHLA (UG/L)

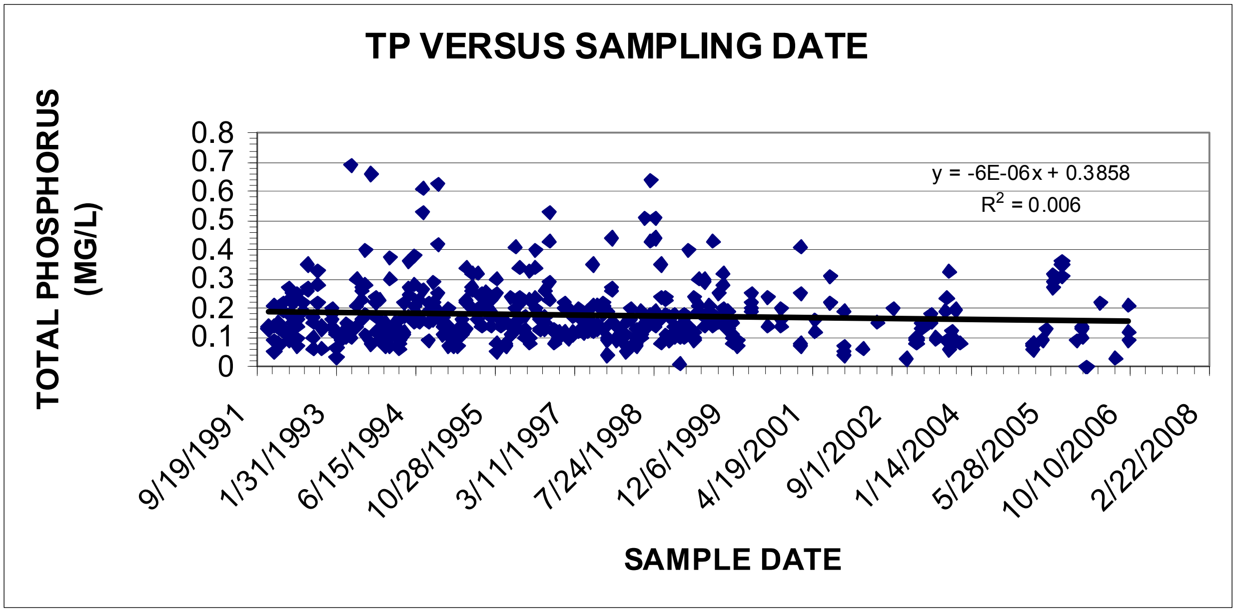

FRACTION OF DATA
TOTAL NITROGEN (MG/L)


FRACTION OF DATA
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.00 0.04 0.08 0.12 0.16 0.20 0.24 0.28 0.32 0.36 0.40 0.44 0.48 0.52 0.56 0.60 0.64 0.68 0.72 0.76 0.80 0.84 0.88 0.92 0.96 1.00
TOTAL PHOSPHORUS (MG/L)


DO VERSUS SAMPLING DATE
DISSOLVED OXYGEN (MG/L)
12
10
8
6
4
2
0
y = 0.0002x - 0.818
R2 = 0.0141
9/19/1991
1/31/1993
6/15/1994
10/28/1995
3/11/1997
7/24/1998
12/6/1999
4/19/2001
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
SAMPLE DATE

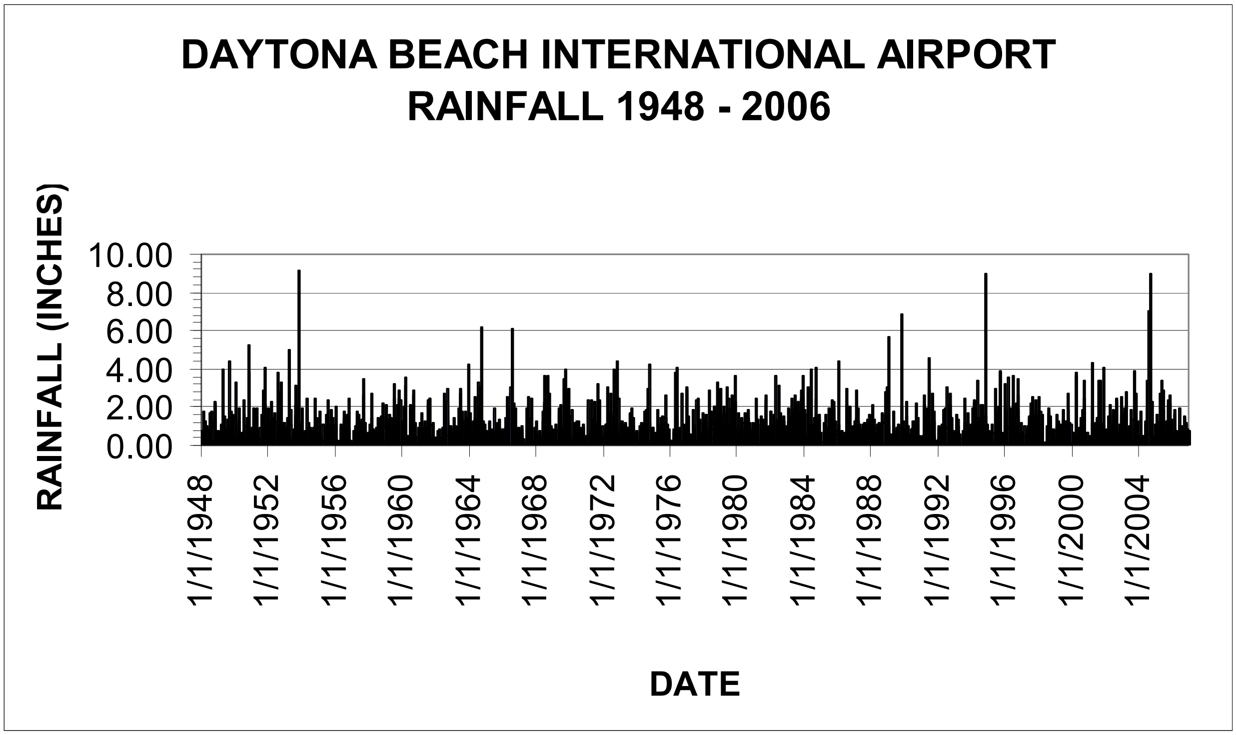

CORR CHLA VERSUS SAMPLING DATE
CORR CHLA (UG/L)
100
90
80
70
60
50
40
30
20
10
0
y = -0.0003x + 18.666
R^2 = 0.0006
9/19/1991
1/31/1993
6/15/1994
10/28/1995
3/11/1997
7/24/1998
12/6/1999
4/19/2001
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
SAMPLE DATE


TN VERSUS SAMPLING DATE
TOTAL NITROGEN (MG/L)
4
3.5
3
2.5
2
1.5
1
0.5
0
y = -0.0002x + 6.361
R^2 = 0.1233
9/19/1991
1/31/1993
6/15/1994
10/28/1995
3/11/1997
7/24/1998
12/6/1999
4/19/2001
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
SAMPLE DATE



STORET ID	Station
21FLVEMDSC01	Spruce Creek Center Bridge on U.S. Hwy 1
21FLVEMDSC02	Spruce Creek West of SSC Railroad
21FLVEMDSC04	Spruce Creek West of Airport Rd
21FLVEMDSC05	Spruce Creek at Dock at Gamble Place
21FLSJWMSPRCR	Spruce Creek 100 M Upstream from ICWW
21FLSJWMUEC014	Spruce Creek at Airport Rd
21FLVEMDVC-071	Spruce Creek, from W Side of Center Bridge on U.S. 1
21FLVEMDVC-072	Spruce Creek, from Dock at Riverwood, W. of SCL Railroad
21FLVEMDVC-073	Spruce Creek, from W. Side of Moody Bridge on Airport Rd
21FLVEMDVC-074	Spruce Creek, from Dock at Gamble Place
21FLWPB 20010737	Spruce Creek @ Cypress Head Development
21FLWPB 20010738	Spruce Creek @ Airport Rd
21FLCEN 27010193	Spruce Creek @ 675M Upstream of RR Bridge
21FLCEN 27010194	Spruce Creek @ 0.68 Miles Upstream of RR Bridge
21FLCEN 27010195	Spruce Creek @ 0.87 Miles Upstream of RR Bridge
21FLCEN 27010196	Spruce Creek @ 1.07 Miles Upstream of RR Bridge
21FLCEN 27010197	Spruce Creek @ 1.3 Miles Upstream of RR Bridge

Appendix F: Chart of Rainfall for Daytona International Airport, 1948–2006



Appendix G: Spearman Correlation Matrix Analysis for Water Quality Parameters in Spruce Creek

Spearman correlation matrix

	DATE2	TIME	DEPTH	DO	DOSAT
DATE2	1.000				
TIME	0.284	1.000			
DEPTH	-0.036	-0.049	1.000		
DO	0.087	0.419	-0.157	1.000	
DOSAT	0.257	0.501	-0.257	0.918	1.000
CHLA	0.066	0.186	-0.074	-0.097	0.076
CHLAC	-0.044	0.099	-0.076	-0.152	0.001
TN	-0.401	-0.266	-0.060	-0.184	-0.253
TP	-0.065	-0.280	0.061	-0.478	-0.440
COLOR	-0.016	-0.272	0.119	-0.244	-0.373
TEMP	0.053	-0.015	-0.016	-0.412	-0.145
NH4	-0.366	-0.361	0.239	-0.422	-0.538
NO3O2	-0.087	-0.128	0.114	-0.142	-0.276
SECCHI	-0.025	0.160	0.149	0.094	0.114
TKN	-0.430	-0.274	-0.059	-0.188	-0.251
BOD	-0.175	-0.113	-0.242	-0.847	0.200
TSS	-0.050	0.358	-0.116	0.321	0.476
ORTHOP	-0.135	-0.404	-0.005	-0.523	-0.547
TURBIDITY	0.128	0.076	-0.071	0.069	0.163
SALINITY	0.019	0.384	-0.143	0.368	0.528
FLOWCFS	0.020	-0.012	-0.029	0.131	0.037
FLOW3DAYAVE	0.045	-0.017	-0.012	0.125	0.038
PRECIP	-0.030	-0.046	0.086	-0.089	-0.069
RAINDAY3	0.065	-0.057	-0.003	-0.089	-0.080

	CHLA	CHLAC	TN	TP	COLOR
CHLA	1.000				
CHLAC	0.950	1.000			
TN	-0.272	-0.170	1.000		
TP	0.073	0.176	0.263	1.000	
COLOR	-0.437	-0.391	0.594	0.194	1.000
TEMP	0.564	0.532	0.048	0.401	-0.138
NH4	0.471	0.006	0.322	0.219	0.001
NO3O2	-0.285	-0.266	0.326	0.063	0.517
SECCHI	0.268	0.239	-0.539	-0.112	-0.670
TKN	-0.241	-0.124	0.992	0.263	0.524
BOD	.	0.300	0.644	0.483	.
TSS	0.475	0.390	-0.278	-0.053	-0.610
ORTHOP	-0.083	-0.003	0.456	0.675	0.534
TURBIDITY	0.137	0.086	0.085	0.222	-0.040
SALINITY	0.439	0.360	-0.557	-0.225	-0.844
FLOWCFS	-0.431	-0.395	0.447	0.088	0.644
FLOW3DAYAVE	-0.431	-0.385	0.442	0.092	0.642
PRECIP	0.103	0.053	-0.008	0.162	0.045
RAINDAY3	-0.073	-0.099	0.082	0.266	0.194

Spearman correlation matrix (continued)

	TEMP	NH4	NO3O2	SECCHI	TKN
TEMP	1.000				
NH4	-0.033	1.000			
NO3O2	-0.287	0.528	1.000		
SECCHI	0.021	-0.245	-0.267	1.000	
TKN	0.080	0.258	0.232	-0.514	1.000
BOD	0.671	-0.004	-0.088	-0.574	0.869
TSS	0.328	-0.160	-0.371	0.258	-0.206
ORTHOP	0.309	0.179	0.307	-0.346	0.405
TURBIDITY	0.198	0.047	0.019	-0.222	0.108
SALINITY	0.199	-0.438	-0.493	0.536	-0.482
FLOWCFS	-0.118	-0.062	0.349	-0.559	0.379
FLOW3DAYAVE	-0.097	-0.058	0.330	-0.534	0.378
PRECIP	0.150	0.054	-0.009	-0.059	-0.010
RAINDAY3	0.104	-0.153	0.068	-0.256	0.069

	BOD	TSS	ORTHOP	TURBIDITY	SALINITY
BOD	1.000				
TSS	.	1.000			
ORTHOP	.	-0.340	1.000		
TURBIDITY	.	0.492	0.097	1.000	
SALINITY	0.763	0.726	-0.523	0.129	1.000
FLOWCFS	0.541	-0.215	0.325	0.105	-0.441
FLOW3DAYAVE	0.483	-0.232	0.314	0.072	-0.451
PRECIP	-0.242	0.123	0.134	0.073	-0.025
RAINDAY3	0.582	0.019	0.349	0.166	-0.143

	FLOWCFS	FLOW3DAYAVE	PRECIP	RAINDAY3
FLOWCFS	1.000			
FLOW3DAYAVE	0.969	1.000		
PRECIP	0.079	0.017	1.000	
RAINDAY3	0.408	0.342	0.507	1.000

Pair-wise frequency table

	DATE2	TIME	DEPTH	DO	DOSAT
DATE2	538				
TIME	534	534			
DEPTH	528	528	528		
DO	492	492	486	492	
DOSAT	481	481	475	481	481
CHLA	300	300	296	264	264
CHLAC	459	459	455	421	414
TN	435	435	431	401	394
TP	459	455	454	419	412
COLOR	490	490	484	449	449
TEMP	498	498	492	492	481
NH4	68	68	66	68	61
NO3O2	481	481	477	442	435
SECCHI	463	463	458	423	412
TKN	464	460	455	425	418
BOD	27	27	27	27	16
TSS	439	435	430	399	399
ORTHOP	399	399	399	362	362
TURBIDITY	453	449	443	413	413
SALINITY	449	449	449	444	444
FLOWCFS	538	534	528	492	481
FLOW3DAYAVE	538	534	528	492	481
PRECIP	538	534	528	492	481
RAINDAY3	538	534	528	492	481

	CHLA	CHLAC	TN	TP	COLOR
CHLA	300				
CHLAC	299	459			
TN	265	410	435		
TP	273	428	430	459	
COLOR	294	437	421	436	490
TEMP	267	424	401	420	454
NH4	13	55	56	60	51
NO3O2	289	435	435	434	459
SECCHI	287	401	381	391	426
TKN	274	432	435	457	442
BOD	0	15	12	15	0
TSS	264	407	410	429	432
ORTHOP	266	356	348	360	393
TURBIDITY	277	421	423	442	446
SALINITY	244	388	360	382	417
FLOWCFS	300	459	435	459	490
FLOW3DAYAVE	300	459	435	459	490
PRECIP	300	459	435	459	490
RAINDAY3	300	459	435	459	490

Pair-wise frequency table (continued)

	TEMP	NH4	NO3O2	SECCHI	TKN
TEMP	498				
NH4	68	68			
NO3O2	445	61	481		
SECCHI	429	25	426	463	
TKN	425	63	438	394	464
BOD	27	15	12	25	15
TSS	399	36	416	383	436
ORTHOP	365	36	386	351	362
TURBIDITY	413	48	429	384	449
SALINITY	449	41	404	399	382
FLOWCFS	498	68	481	463	464
FLOW3DAYAVE	498	68	481	463	464
PRECIP	498	68	481	463	464
RAINDAY3	498	68	481	463	464

	BOD	TSS	ORTHOP	TURBIDITY	SALINITY
BOD	27				
TSS	0	439			
ORTHOP	0	363	399		
TURBIDITY	0	439	364	453	
SALINITY	16	375	346	376	449
FLOWCFS	27	439	399	453	449
FLOW3DAYAVE	27	439	399	453	449
PRECIP	27	439	399	453	449
RAINDAY3	27	439	399	453	449

	FLOWCFS	FLOW3DAYAVE	PRECIP	RAINDAY3
FLOWCFS	538			
FLOW3DAYAVE	538	538		
PRECIP	538	538	538	
RAINDAY3	538	538	538	538

Appendix H: Linear Regression Analysis of DO and Corrected Chla Observations versus Nutrients and BOD in Spruce Creek

Dep Var: DO N: 419 Multiple R: 0.422 Squared multiple R: 0.178

Adjusted squared multiple R: 0.177 Standard error of estimate: 1.909

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	6.389	0.188	0.000	.	34.027	0.000
TP	-8.941	0.939	-0.422	1.000	-9.518	0.000

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	330.273	1	330.273	90.600	0.000
Residual	1520.124	417	3.645		

*** WARNING ***
Case 75 has large leverage (Leverage = 0.067)
Case 95 has large leverage (Leverage = 0.060)
Case 141 has large leverage (Leverage = 0.049)
Case 151 has large leverage (Leverage = 0.052)
Case 326 has large leverage (Leverage = 0.055)

Durbin-Watson D Statistic 1.581
First Order Autocorrelation 0.204

Dep Var: DO N: 401 Multiple R: 0.109 Squared multiple R: 0.012

Adjusted squared multiple R: 0.009 Standard error of estimate: 2.090

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	5.220	0.230	0.000	.	22.674	0.000
TN	-0.438	0.201	-0.109	1.000	-2.180	0.030

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	20.764	1	20.764	4.754	0.030
Residual	1742.565	399	4.367		

*** WARNING ***
Case 45 has large leverage (Leverage = 0.046)
Case 46 has large leverage (Leverage = 0.046)
Case 153 has large leverage (Leverage = 0.066)

Durbin-Watson D Statistic 1.465
First Order Autocorrelation 0.263

Dep Var: DO N: 421 Multiple R: 0.145 Squared multiple R: 0.021

Adjusted squared multiple R: 0.019 Standard error of estimate: 2.089

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	4.917	0.108	0.000	.	45.608	0.000
CHLAC	-0.016	0.005	-0.145	1.000	-3.001	0.003

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	39.303	1	39.303	9.006	0.003
Residual	1828.584	419	4.364		

*** WARNING ***
Case 226 has large leverage (Leverage = 0.348)
Case 351 has large leverage (Leverage = 0.446)

Durbin-Watson D Statistic 1.452
First Order Autocorrelation 0.270

Dep Var: DO N: 68 Multiple R: 0.547 Squared multiple R: 0.299

Adjusted squared multiple R: 0.289 Standard error of estimate: 1.509

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	5.658	0.284	0.000	.	19.898	0.000
NH4	-18.990	3.578	-0.547	1.000	-5.307	0.000

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	64.109	1	64.109	28.168	0.000
Residual	150.211	66	2.276		

*** WARNING ***
Case 17 has large leverage (Leverage = 0.176)
Case 456 has large leverage (Leverage = 0.177)

Durbin-Watson D Statistic 1.560
First Order Autocorrelation 0.146

Dep Var: DO1 N: 27 Multiple R: 0.828 Squared multiple R: 0.685

Adjusted squared multiple R: 0.672 Standard error of estimate: 0.632

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	6.938	0.258	0.000	.	26.842	0.000
BOD	-0.892	0.121	-0.828	1.000	-7.371	0.000

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	21.692	1	21.692	54.327	0.000
Residual	9.982	25	0.399		

*** WARNING ***
Case 466 is an outlier (Studentized Residual = -4.093)

Durbin-Watson D Statistic 1.624
First Order Autocorrelation 0.165

Dep Var: DO N: 442 Multiple R: 0.086 Squared multiple R: 0.007

Adjusted squared multiple R: 0.005 Standard error of estimate: 2.086

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	5.014	0.150	0.000	.	33.524	0.000
NO3O2	-2.801	1.555	-0.086	1.000	-1.801	0.072

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	14.112	1	14.112	3.244	0.072
Residual	1913.820	440	4.350		

*** WARNING ***
Case 215 has large leverage (Leverage = 0.129)
Case 279 has large leverage (Leverage = 0.084)

Durbin-Watson D Statistic 1.368
First Order Autocorrelation 0.313

Dep Var: CHLAC N: 428 Multiple R: 0.036 Squared multiple R: 0.001

Adjusted squared multiple R: 0.000 Standard error of estimate: 18.871

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	5.560	1.808	0.000	.	3.076	0.002
TP	6.556	8.877	0.036	1.000	0.738	0.461

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	194.209	1	194.209	0.545	0.461
Residual	151699.350	426	356.102		

*** WARNING ***
Case 75 has large leverage (Leverage = 0.061)
Case 90 is an outlier (Studentized Residual = 3.985)
Case 95 has large leverage (Leverage = 0.054)
Case 141 has large leverage (Leverage = 0.044)
Case 151 has large leverage (Leverage = 0.047)
Case 226 is an outlier (Studentized Residual = 14.825)
Case 326 has large leverage (Leverage = 0.050)
Case 351 is an outlier (Studentized Residual = 18.093)

Durbin-Watson D Statistic 1.975
First Order Autocorrelation 0.011

Dep Var: CHLAC N: 435 Multiple R: 0.052 Squared multiple R: 0.003

Adjusted squared multiple R: 0.000 Standard error of estimate: 18.724

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	7.624	1.336	0.000	.	5.705	0.000
NO3O2	-15.558	14.431	-0.052	1.000	-1.078	0.282

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	407.482	1	407.482	1.162	0.282
Residual	151797.347	433	350.571		

*** WARNING ***
Case 90 is an outlier (Studentized Residual = 4.032)
Case 215 has large leverage (Leverage = 0.140)
Case 226 is an outlier (Studentized Residual = 14.834)
Case 279 has large leverage (Leverage = 0.091)
Case 351 is an outlier (Studentized Residual = 18.322)

Durbin-Watson D Statistic 1.967
First Order Autocorrelation 0.015

Dep Var: CHLAC N: 55 Multiple R: 0.014 Squared multiple R: 0.000

Adjusted squared multiple R: 0.000 Standard error of estimate: 7.675

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	6.460	1.527	0.000	.	4.231	0.000
NH4	1.925	19.297	0.014	1.000	0.100	0.921

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.586	1	0.586	0.010	0.921
Residual	3122.352	53	58.912		

*** WARNING ***
Case 17 has large leverage (Leverage = 0.205)
Case 443 is an outlier (Studentized Residual = 4.014)
Case 456 has large leverage (Leverage = 0.206)

Durbin-Watson D Statistic 2.040
First Order Autocorrelation -0.083

Dep Var: CHLAC N: 428 Multiple R: 0.036 Squared multiple R: 0.001

Adjusted squared multiple R: 0.000 Standard error of estimate: 18.871

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	5.560	1.808	0.000	.	3.076	0.002
TP	6.556	8.877	0.036	1.000	0.738	0.461

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	194.209	1	194.209	0.545	0.461
Residual	151699.350	426	356.102		

*** WARNING ***
Case 75 has large leverage (Leverage = 0.061)
Case 90 is an outlier (Studentized Residual = 3.985)
Case 95 has large leverage (Leverage = 0.054)
Case 141 has large leverage (Leverage = 0.044)
Case 151 has large leverage (Leverage = 0.047)
Case 226 is an outlier (Studentized Residual = 14.825)
Case 326 has large leverage (Leverage = 0.050)
Case 351 is an outlier (Studentized Residual = 18.093)

Durbin-Watson D Statistic 1.975
First Order Autocorrelation 0.011

Appendix I: Monthly and Annual Precipitation at Daytona International Airport, 1948–2006

Year(s)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Totals
1948	4.52	1.22	5.13	2.37	0.49	2.4	10.43	7.33	9.82	8.29	1.07	1.93	55
1949	0.37	1.95	2.01	7.12	1.4	4.24	5.97	11.5	6.26	3.65	1.86	3.93	50.22
1950	0.15	0.59	3.53	2.79	2.13	6.45	5.56	3.88	5.86	13	0.74	2.54	47.22
1951	0.77	2.46	1.18	3.28	2.53	2.66	3.8	4.19	14	8.54	3.15	2.88	49.46
1952	0.66	6.76	3.01	1.66	4.39	1.35	1.25	9.02	11.9	5.41	1.96	0.71	48.1
1953	1.75	3.35	7.75	4.97	1.46	1.37	8.67	19.9	10	12.9	2.3	4.85	79.29
1954	0.37	0.86	2.33	6.29	3.21	2.35	3.5	3.04	1.88	4.91	3.98	1.24	33.96
1955	2.47	1.43	1.84	1.78	1.55	7.76	5.67	2.64	6.66	3.17	2.61	1.22	38.8
1956	2.55	0.9	0.25	2.42	2.48a	7.41	3.01	4.06	1.94	5.82	0.46	0.06	31.36
1957	0.97	1.62	3.13	1.73	5.65	4.23	10.53	4.01	10.7	1.8	0.82	1.34	46.48
1958	3.94	4.73	5.52	2.24	2.27	6.06	1.96	4	2.19	8.52	1.77	1.95	45.15
1959	4.53	2.13	7.7	3.17	2.4	8.13	5.68	3.6	5.26	7.12	4.26	2.26	56.24
1960	1.16	9.13	7.52	0.76	0.62	10.8	8.7	6.84	11	0.97	0.53	1.24	59.18
1961	1.96	3.7	1.17	2.16	2.39	6.81	5.16	7.68	3.2	2.25	2.85	0.73	40.06
1962	0.9	0.82	1.82	0.78	0.16	7.96	10.04	8.5	8.84	3.57	2.49	0.71	46.59
1963	2.91	5.83	1.46	1.4	6.82	7.42	6.89	2.01	5.43	2.71	7.98	2.17	53.03
1964	5.29	2.65	4.84	3.61	2.58	4.73	7.67	10.8	11.4	3.54	3.13	2.52	62.76
1965	2.22	3	3.05	1	0.08	9	3.72	2.97	4.33	3.65	0.97	2.14	36.13
1966	2.89	5.58	0.36	2.56	6.77	15.2	7.09	7.93	4.49	4.6	1.19	1.6	60.25
1967	1.26	3.98	0.31	0	0.73	7.51	9.04	3.02	5.56	0.19	0	2.98	34.58
1968	0.42	1.73	1.79	0.4	4.79	14.4	6.25	11.1	6.07	7.44	2.43	1.38	58.17
1969	1.53	2.03	2.74	0.12	6.47	2.47	2.61	9.4	8.89	6.97	1.96	5.03	50.22
1970	3.94	3.79	3.59	2.08	1.68	2.62	3.65	3.61	3.54	3.87	0.31	0.72	33.4
1971	0.61	5.48	2	2.57	3.12	4.73	3.2	3.97	7.2	9.53	1.33	2.49	46.23
1972	2.37	3.97	6.66	1.41	4.02	7.06	3.22	8.29	0.42	3.08	10.96	2.48	53.94
1973	4.66	2.02	2.63	3.09	2.41	4.32	4.69	7.58	5.14	4.4	0.75	2.54	44.23
1974	0.3	1.1	3.19	0.44	2.66	8.65	6.31	9.96	10.5	1.42	0.48	2.2	47.21
1975	1.66	2.27	1.52	2.96	2.99	9	6.89	3.16	6.61	5.84	1.46	0.83	45.19
1976	0.6	0.7	2.03	4.27	12.33	11.1	1.07	3.8	5.1	1.9	3.38	6	52.32
1977	4.69	2.45	1.43	0.41	4.61	1.15	2.23	7.91	6.55	1.46	3.04	4.74	40.67
1978	2.89	5.98	2.31	3.3	0.56	7.48	5.53	7.99	4.63	8.31	0.07	4.89	53.94
1979	7.1	1.94	4.08	3.96	6.13	3.03	11.69	5.24	15.2	2.13	7.96	0.56	69.02
1980	3.75	0.76	2.41	2.54	3.62	5.57	5.82	4.13	1.83	2.42	3.12	1.39	37.36
1981	0.32	5.54	3	0.29	1.74	1.03	4.69	7.19	7.59	1.08	2.57	4.64	39.68
1982	2.46	2.08	5.81	6.04	4.68	8.29	5.31	3.21	4.96	3.23	1.58	2.53	50.18
1983	2.51	5.96	7.71	6.17	3.86	6.37	1.92	6.82	8.57	10.1	2.01	12	73.99
1984	1.46	3.44	1.31	5.29	6.04	2.84	6.77	4.02	10.7	1.09	3.52	0.2	46.71
1985	0.79	0.58	1.49	3.14	3.42	6.81	2.16	9.83	10.6	4.08	0.41	2.05	45.38
1986	7.16	1.28	1.85	0.44	0.99	3.5	14.43	3.47	3.58	3.47	5.08	2.76	48.01
1987	2.21	6.64	7.94	0.28	2.65	3.81	2.78	4.89	5.63	2.77	5.87	0.25	45.72

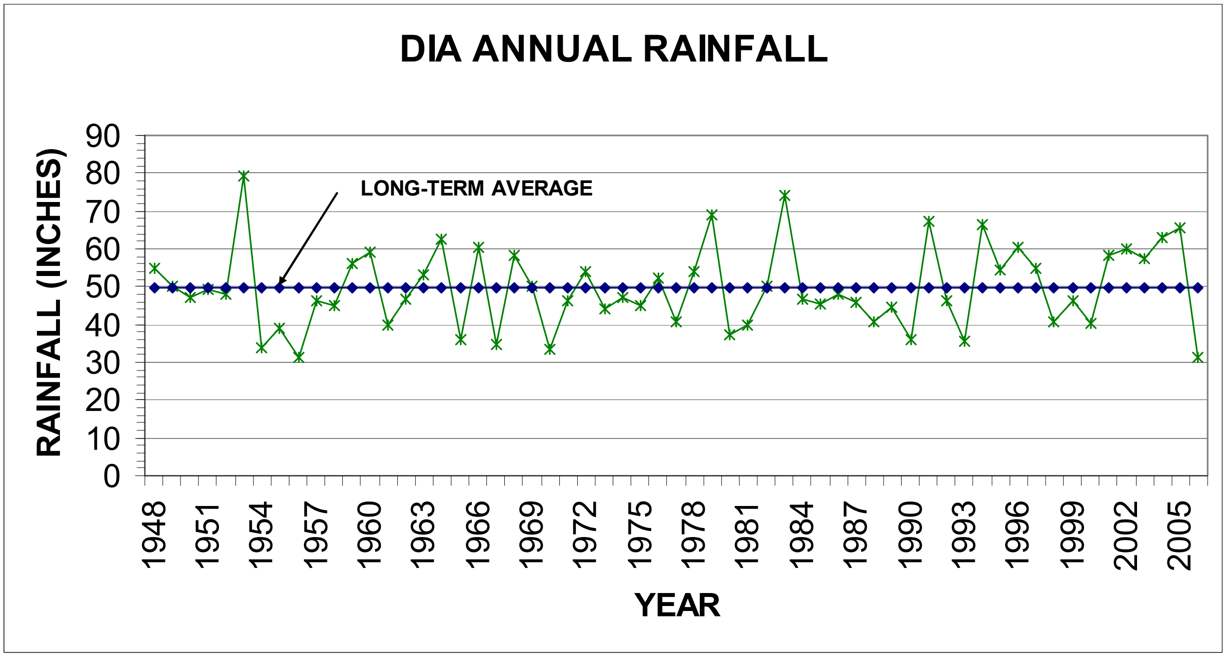
Year(s)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Totals
1988	5.36	1.72	4.57	1.68	1.78	2.39	2.94	4.79	6.81	1.24	6.7	0.93	40.91
1989	6.82	0.64	2.01	2.92	2.02	1.84	2.44	4.47	5.04	11.6	0.88	3.93	44.65
1990	1.42	5.61	1.94	1.48	1.45	2.71	5.85	7	1.61	5.88	0.83	0.34	36.12
1991	2.25	1.65	8.11	5.57	6.79	12.7	11.97	7.6	5.52	2.94	0.61	1.51	67.19
1992	2.42	1.71	2.28	2.81	3.13	10.6	0.16	8.86	6.57	5.21	2.15	0.47	46.41
1993	4.29	3.02	5.56	0.33	0.65	2.19	5.05	2.66	2.74	5.53	1.83	1.86	35.71
1994	5.6	2.66	3.44	5.05	3.09	6.54	6.91	7.08	5.93	4.72	12.91	2.71	66.64
1995	1.53	1.39	2.01	1.34	1.26	6.61	6.59	10.7	14.1	3.99	1.44	3.44	54.44
1996	5.53	1.32	12.15	2.22	2.28	11.4	1.9	5.7	3.92	11.2	0.96	2.01	60.49
1997	2.03	0.46	2.3	3.3	3.77	6.38	7.69	7.91	4.78	5.29	3.02	7.76	54.69
1998	4.33	7.25	3.97	0.14	0.16	0.83	5.63	7.56	5.79	1.84	1.66	1.35	40.51
1999	4.88	1.81	1.01	1.48	1.47	8.54	4.03	3.58	7.05	7.84	3.12	1.56	46.37
2000	1.8	0.65	8.48	1.15	0.32	3.08	5.09	3.17	13.6	0.93	1.14	0.8	40.16
2001	0.88	0.38	9.98	0.28	1.77	5.26	9.55	3.57	16.1	3.22	6.92	0.35	58.27
2002	2.01	2.76	1.51	2.53	1.66	12.3	7.35	11.6	3.86	2.94	1.85	9.61	59.94
2003	0.51	5.17	10.57	0.81	0.96	7.05	7.3	6.55	4.15	7.95	4.75	1.53	57.3
2004	1.25	4.47	1.1	1.19	0.49	5.2	10.34	18	16.5	1.34	0.93	2.24	62.97
2005	2.6	1.25	5.51	3.17	7.97	13.7	2.73	4.29	7.35	13.5	1.87	1.85	65.77
2006	0.24	4.33	0.08	1.11	0.78	5.72	4.48	4.81	2.97	2.53	1.1	3.21	31.36

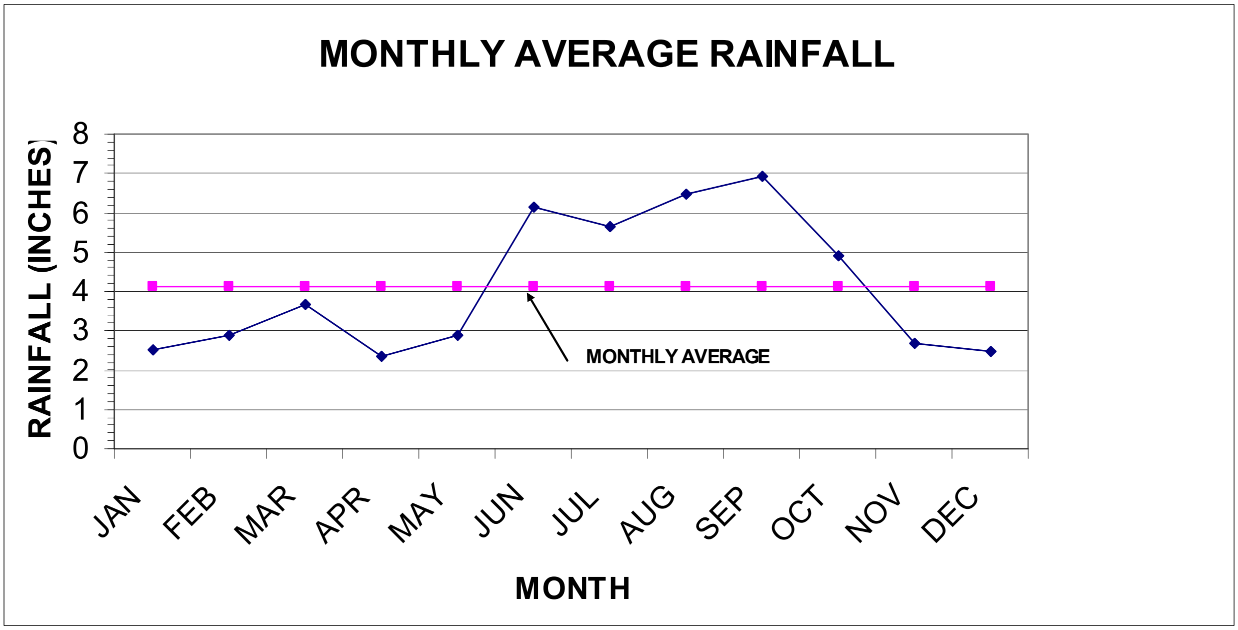
Max value	**7.16**	**9.13**	**12.15**	**7.12**	**12.33**	**15.2**	**14.43**	**19.9**	**16.5**	**13.5**	**12.91**	**12**	**79.29**
Min value	**0.15**	**0.38**	**0.08**	**0**	**0.08**	**0.83**	**0.16**	**2.01**	**0.42**	**0.19**	**0**	**0.06**	**31.36**
Mean	**2.52**	**2.89**	**3.66**	**2.37**	**2.89**	**6.15**	**5.65**	**6.48**	**6.92**	**4.9**	**2.66**	**2.48**	**49.58**
Median	**2.21**	**2.13**	**2.63**	**2.22**	**2.4**	**6.37**	**5.56**	**5.7**	**5.93**	**3.87**	**1.87**	**2.01**	**47.22**
# years	**59**	**59**	**59**	**59**	**59**	**59**	**59**	**59**	**59**	**59**	**59**	**59**	**59**

FLAGS: a = 1, b = 2, c = 3, …, or z = 26 or more missing days

Rainfall is in inches, and represents data from Daytona Beach International Airport.

Appendix J: Annual and Monthly Average Precipitation at Daytona International Airport





Appendix K: Response to Comments Following the January 15, 2008 Public Meeting

BCI engineers & scientists

January 25, 2008

Mr. Jan Mandrup-Poulsen, Environmental Administrator
Watershed Assessment Section
Florida Department of Environmental Protection
Mail Station 3555
2600 Blair Stone Road
Tallahassee, FL 32399-2400

RE: Public Comment for Proposed Total Maximum Daily Loads (TMDLs) in Spruce Creek for Fecal Coliform (WBID 2674) and Nutrients and Dissolved Oxygen (WBID 2674A), Volusia County, Florida

Dear Mr. Mandrup-Poulsen:

The following comments were prepared by BCI Engineers & Scientists, Inc. (BCI) on behalf of Volusia County.

Proposed TMDL for Fecal Coliforms in Spruce Creek (WBID 2674):

1. It has been brought to the attention of FDEP that the Volusia County Environmental Health Laboratory data collected for fecal coliform was not included in the data used to develop the TMDL. After review, it is noted that the samples taken were not within WBID 2674.

   Although the data meets the criteria of the Impaired Waters Rule (IWR) for exceedances, the data set used is limited. Additional sampling should be done to support TMDL development and BMAP implementation.

2. Figure 4.2 Principal Land Uses in the Spruce Creek Watershed does not appear to accurately illustrate the current conditions. Please explain how the land use maps are used in the establishment of the TMDL in regards to percent reduction and allocation requirements. Updated information should be obtained and used in TMDL development and BMAP implementation.

Proposed TMDL for Nutrients and Dissolved Oxygen (WBID 2674A):

1. It has been brought to the attention of FDEP that the Volusia County Environmental Health Laboratory data collected for DO & Nutrients was not included in the data used to develop the TMDL. It is our understanding that FDEP is reviewing this information to determine if it will affect the listing of the waterbody and the TMDL development. Therefore, the TMDL should not be adopted until the information has been reviewed and incorporated into the TMDL if applicable.

2. Figure 4.2 Principal Land Uses in the Spruce Creek Watershed does not appear to accurately illustrate the current conditions. Please explain how the land use maps are used in the establishment of the TMDL in regards to percent reduction and allocation

requirements. Updated information should be obtained and used in TMDL development and BMAP implementation.

3. The relationship between DO and phosphorus concentrations is indirect and should be tested and confirmed. The correlation of DO and BOD is stronger and may suggest a different focus for eliminating the DO impairment.

On behalf of Volusia County, BCI would like to request an extension of the commenting period based on the information provided above. Therefore, allowing Volusia County and FDEP to review and evaluate the additional data to determine if it will have an affect on the TMDL.

Please contact myself or Gene Medley at (561) 741-8838 if you have any questions or would like to discuss any of the information.

Sincerely,

Carolyn Farmer
Environmental Scientist

CF/mp

cc: Jennifer Gihring, FDEP
Wayne Magley, FDEP
John Gamble, Volusia County

Response to comments on the TMDL for Nutrients and Dissolved Oxygen: WBID 2674A

Comment 1. Following the January 15, 2008 public workshop, Ms. Kelly Young of the Volusia County Environmental Health Laboratory provided a spreadsheet of water quality data collected in this WBID. The Department had not assigned station VEMDVC – 071 to this WBID so information contained in Florida STORET from this station was not used in the original assessment or draft TMDL. With the exception of this station, data collected by the County that was part of Legacy STORET or Florida STORET was used. Data from this station along with some additional data that were not previously entered into STORET were incorporated into the present TMDL. As a result, the percent reduction in total phosphorus from anthropogenic sources changed from 32 to 27.

Comment 2. Principal land uses illustrated in **Figure 4.3** and summarized in **Table 4.1** were based on the 2004 land use coverages provided to the Department from the St. Johns Water Management District and represent the most current coverage made available to the Department. The land use figure and table were presented to illustrate the general features of the watershed and were not used in the establishment of the TMDL. The percent reduction calculations were based upon water quality measurements taken at ambient stations located along Spruce Creek. Section 4.3 of the document identified **Potential** sources that might contribute nutrients and BOD to Spruce Creek. Acreage information from the land use summary was used to obtain estimates of potential nutrient contributions from these activities. As part of the BMAP process, updated and more detailed land use information could assist in further refining pollutant sources and cost effective measures to reduce these pollutants.

Comment 3. We agree that the linear regression between phosphorus and DO may reflect an indirect relationship, however, it does not mean that the TMDL should be delayed. Monitoring should be a component of the basin management action plan (BMAP), particularly as part of a more detailed source identification element and assessment of cost effective strategies to reduce nutrients and BOD contributions from anthropogenic activities in the watershed. This would provide an opportunity to test and confirm the relationship between DO and phosphorus concentrations and the system response to reductions in these pollutants as best management practices are implemented.

Florida Department of Environmental Protection
Division of Water Resource Management
Bureau of Watershed Management
2600 Blair Stone Road, Mail Station 3565
Tallahassee, Florida 32399-2400
www.dep.state.fl.us/water/