FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Division of Water Resource Management

Bureau of Watershed Restoration

SOUTHWEST DISTRICT • MANATEE RIVER BASIN

TMDL Report

Dissolved Oxygen and Nutrient TMDLs for Rattlesnake Slough, WBID 1923

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

STORET Program

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

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http://www.dep.state.fl.us/water/docs/2008_Integrated_Report.pdf

Criteria for Surface Water Quality Classifications

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Basin Status Report for the Manatee River Basin

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

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U.S. Environmental Protection Agency Region 4 Total Maximum Daily Loads in Florida

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Chapter 1: INTRODUCTION

1.1 Purpose of Report

This report presents the Total Maximum Daily Load (TMDL) for dissolved oxygen (DO) and nutrients for Rattlesnake Slough in the Manatee River Planning Unit of the Manatee River Basin. The stream was verified as impaired for both DO and nutrients, and was included on the Verified List of impaired waters for the Manatee River Basin that was adopted by Secretarial Order in May 2009. This TMDL establishes the allowable loadings to Rattlesnake Slough that would restore the waterbody so that it meets its applicable water quality criteria for both DO and nutrients.

1.2 Identification of Waterbody

Rattlesnake Slough is located in the central portion of Manatee County, situated between the City of Bradenton to the northwest and the City of Sarasota to the southwest, along the I-75 corridor (**Figure 1.1)**. Rattlesnake Slough flows primarily in a northeasterly direction into the Braden River and drains an area approximately 3.8 square miles (**Figure 1.2)**. The creek is approximately 3.7 miles long and is a first order stream with a dendritic drainage pattern. This area in Manatee County is experiencing increased development with commercial centers and medium- to high-density housing.

For assessment purposes, the Florida Department of Environmental Protection (Department) has divided the Manatee River Basin into water assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each watershed or stream reach. This TMDL addresses WBID 1923, Rattlesnake Slough, for dissolved oxygen and nutrients.

Rattlesnake Slough is part of the Manatee River Planning Unit. Planning units are groups of smaller watersheds (WBIDs) that are part of a larger basin unit, in this case the Manatee River Basin. The Manatee River Planning Unit consists of 61 WBIDs. **Figure 1.3** shows the locations of these WBIDs and Rattlesnake Slough's location in the 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.

Figure 1.1. Location of the Rattlesnake Slough (WBID 1923) in Manatee County

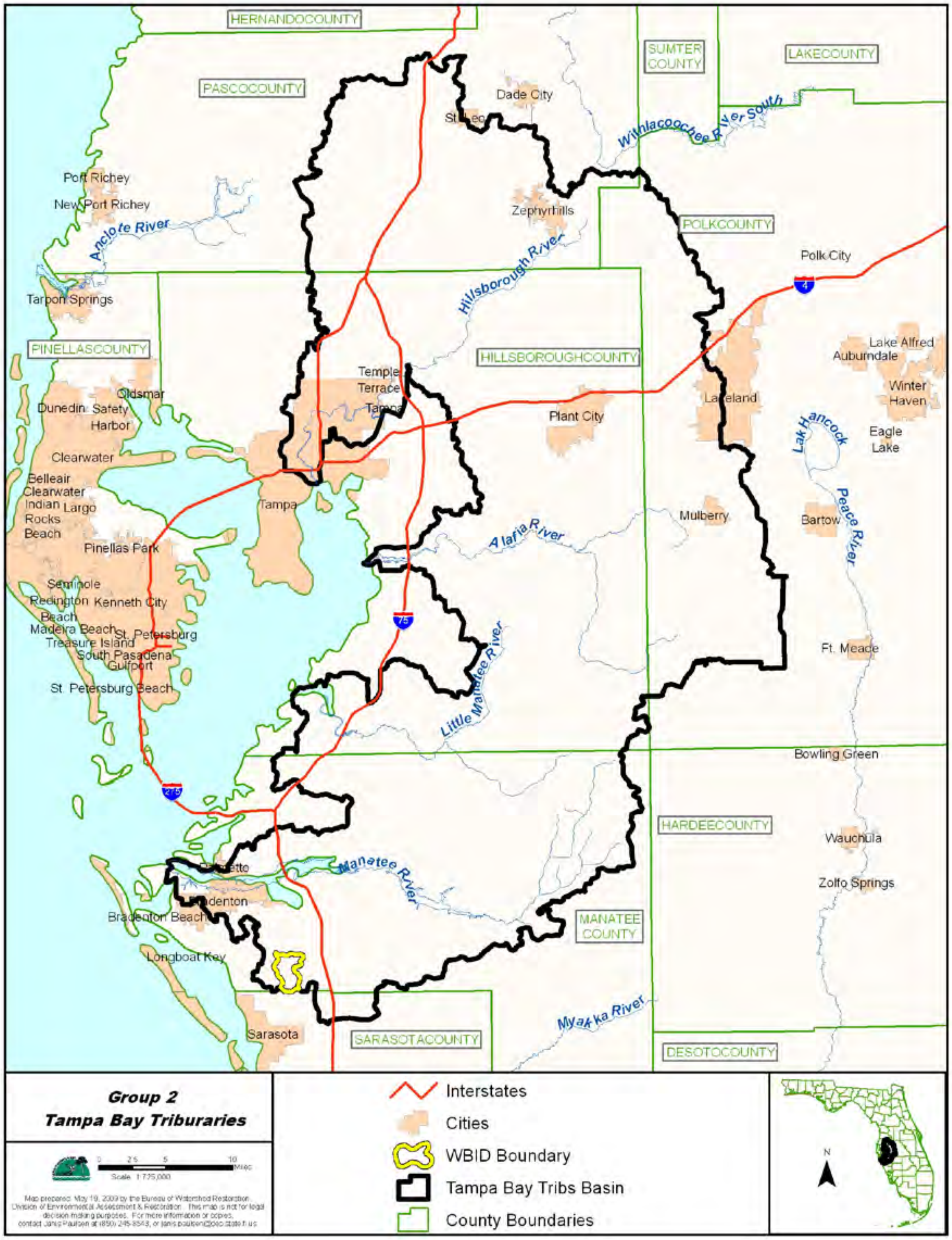


Figure 1.2. Location of the Rattlesnake Slough (WBID 1923) in Manatee County and Major Hydrological Features in the Area

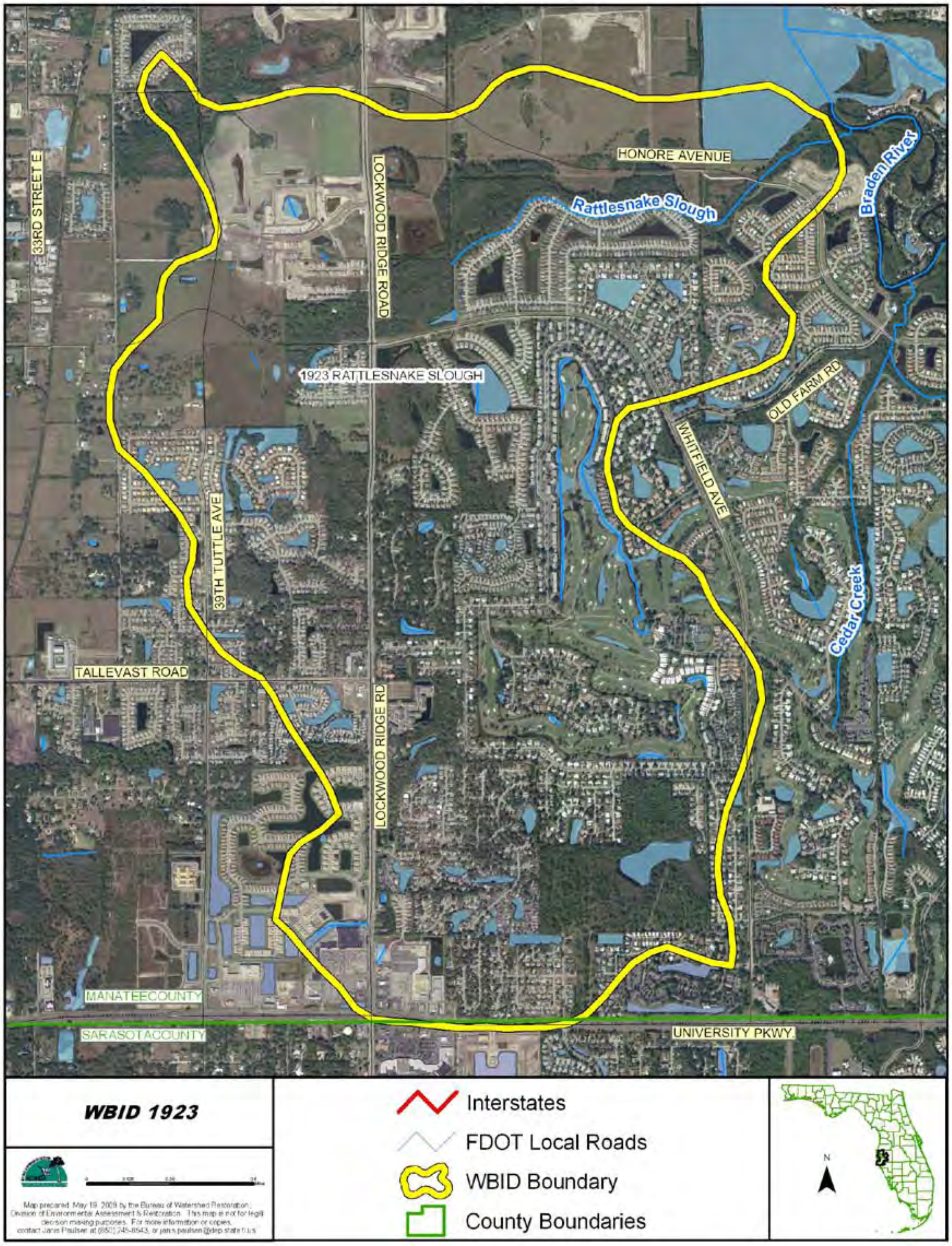
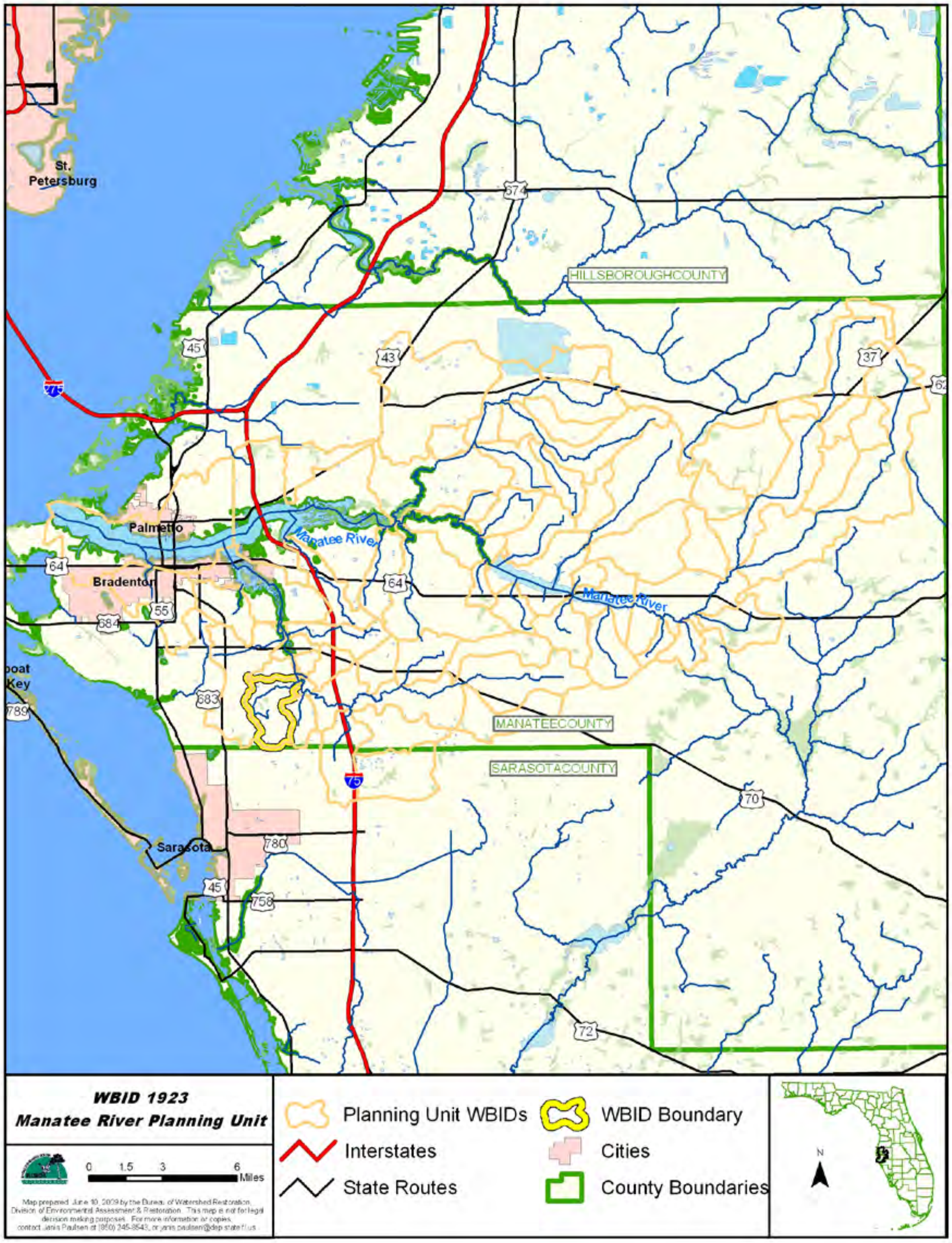


Figure 1.3. WBIDs in the Manatee River Planning Unit



This TMDL Report will be followed by the development and implementation of a restoration plan, designed to reduce the amount of nutrients that caused the verified impairment of Rattlesnake Slough. These activities will depend heavily on the active participation of the Southwest Florida Water Management District (SWFWMD), Manatee 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) lists of surface waters that do not meet applicable water quality standards (impaired waters) and establish a TMDL for each pollutant causing the impairment of listed 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.]); the state's 303(d) list is amended annually to include basin updates.

Florida's 1998 303(d) list included 10 waterbodies in the Manatee River 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 rulemaking 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 modified in 2006 and 2007.

2.2 Information on Verified Impairment

The Department used the IWR to assess water quality impairments in the Rattlesnake Slough watershed and has verified that this waterbody segment is impaired for DO and nutrients based on data in the Department's IWR database. **Tables 2.1** through **2.4** summarize the DO data for the verification period, which for Group 2 waters was January 1, 2001, through June 30, 2008, by overall, month, season, and year, respectively.

There is a 26.6 percent overall exceedance rate for DO in Rattlesnake Slough during the verified period (**Table 2.1**). Exceedances occur in all seasons and in all months except for April and December (**Tables 2.2** and **2.3**). During the verified period, samples ranged from 2.7 to 11.4 milligrams per liter (mg/L).

When aggregating data collected during the verified period (January 2000 – June 2008) by season, the lowest percentage of exceedances occurred in the spring and the highest in summer. Possible relationships between DO and other water quality parameters will be further assessed using the complete historical dataset in Chapter 5.

Table 2.1. Summary of DO Monitoring Data for Rattlesnake Slough (WBID 1923) During the Verified Period (January 1, 2001 – June 30, 2008)

Waterbody (WBID)	Parameter	Dissolved Oxygen
Rattlesnake Slough (1923)	Total number of samples	79
	IWR-required number of exceedances for the Verified List	12
	Number of observed exceedances	21 (26.6%)
	Number of observed nonexceedances	58
	Number of seasons during which samples were collected	4
	Highest observation (mg/L)	11.4
	Lowest observation (mg/L)	2.7
	Median observation (mg/L)	5.4
	Mean observation (mg/L)	5.8
	Median value for 90 BOD observations (mg/L)	2.6
	Median value for 85 TN observations (mg/L)	1.13
	Median value for 85 TP observations (mg/L)	0.38
	Possible causative pollutant by IWR	TP & BOD
	FINAL ASSESSMENT	**Impaired**

Table 2.2. Summary of DO Data by Month for the Verified Period (January 1, 2001 – June 30, 2008)

Month	Number of Samples	Minimum	Maximum	Median	Mean	No of Exceedances	% Exeedance	Mean Precipitation (inches)
January	9	3.9	9.9	6.4	6.7	3	33.3	2.32
February	7	4.5	11.4	7.8	7.6	1	14.3	3.08
March	9	4.9	8.4	5.4	6.0	1	11.1	3.37
April	10	5.5	8.9	6.8	6.9	0	0.0	2.37
May	7	4.5	5.4	4.6	4.8	4	57.1	2.14
June	8	4.5	5.4	4.6	4.8	4	50.0	9.29
July	8	3.0	6.2	5.0	4.7	3	37.5	8.75
August	7	2.7	5.4	5.1	4.5	3	42.9	9.95
September	8	4.2	5.9	5.0	5.0	3	37.5	9.32
October	8	3.9	6.7	5.8	5.6	2	25.0	3.13
November	7	4.8	7.8	6.8	6.4	1	14.3	1.50
December	7	6.0	7.3	6.4	6.6	0	0.0	2.98

Table 2.3. Summary of DO Data by Year for the Verified Period (January 1, 2001 – June 30, 2008)

Season	Number of Samples	Minimum	Maximum	Median	Mean	No of Exceedances	% Exeedance	Mean Precipitation (inches)
Winter	25	3.9	11.4	6.4	6.7	5	20.00	8.10
Spring	25	4.0	8.9	5.4	5.6	8	32.00	13.80
Summe	23	2.7	6.2	5.0	4.8	9	39.13	28.02
Fall	22	2.8	7.8	6.3	6.0	3	13.64	7.61

Table 2.4 Summary of DO Data by Year for the Verified Period (January 1, 2001 – June 30, 2008)

Year	Number of Samples	Minimum	Maximum	Median	Mean	No of Exceedances	% Exeedance	Total Precipitation (inches)
2001	8	3.6	9.2	6.3	6.2	1	12.50%	68.25
2002	10	3.0	8.4	6.7	6.4	1	10.00%	68.27
2003	12	4.5	9.9	5.6	6.3	3	25.00%	61.94
2004	15	3.9	8.1	6.1	5.9	3	20.00%	54.73
2005	13	3.4	11.4	5.4	6.0	4	30.77%	55.21
2006	18	4.8	7.8	5.1	5.5	2	11.11%	60.30
2007	17	2.7	8.0	4.9	5.0	10	58.82%	37.23
2008*	2	4.5	6.4	5.5	5.5	1	50.00%	18.65

*Data only extend through June 30, 2008

Table 2.5 summarizes annual average corrected chlorophyll α (CHLA) concentrations based on the IWR. To determine chlorophyll α exceedances, the historically observed minimum value is calculated using the data from 1990 through 1994. If the annual mean chlorophyll α value during the verified period has increased more than 50 percent over the historical value for two consecutive years, the annual mean concentration is considered an exceedance. The historical minimum value for the Rattlesnake Slough watershed was determined to be 6.54 µg/L. Fifty percent above the minimum value was calculated to be 9.81 µg/L. **Table 2.5** shows the years 2002, 2003, and 2004 were above 9.81 µg/L. The year, 2002, was not assessed as an exceedance since two consecutive years above 9.81 µg/L are required before an annual average concentration for chlorophyll α can be considered. The year, 2003, paired with 2002, caused an exceedance as did the year, 2004, paired with 2003.

Table 2.5 Summary of Annual Average Chlorophyll α for the Verified Period (January 1, 2001 – June 30, 2008)

Year	2002	2003	2004	2005	2006
Mean	16.14	12.02	13.44	6.82	8.47
Exceedance	no	yes	yes	no	no

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)**

Rattlesnake Slough (WBID 1923) is a Class I waterbody, with a designated use of potable water supplies. The Class I water quality criterion applicable to the impairment addressed by this TMDL are for DO and nutrients.

3.2 Applicable Water Quality Standards and Numeric Water Quality Target

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

Dissolved Oxygen Criteria:
Shall not be less than 5.0. 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.

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

62-303.351 Nutrients in Streams.

A stream or stream segment shall be included on the planning list for nutrients if the following biological imbalances are observed:

(1) Algal mats are present in sufficient quantities to pose a nuisance or hinder reproduction of a threatened or endangered species, or

(2) Annual mean chlorophyll α concentrations are greater than 20 ug/l or if data indicate annual mean chlorophyll α 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 α 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 Rattlesnake Slough Watershed

4.2.1 Point Sources

There are no NPDES permitted wastewater facilities discharging directly or indirectly into the watershed.

Municipal Separate Storm Sewer System Permittees

The stormwater collection systems owned and operated by Manatee County and Co-Permittees (FDOT District 1) are covered by a Phase I NPDES municipal separate storm sewer system (MS4) permit (FLS000036). There are no Phase II MS4 permits identified for these waterbodies.

4.2.2 Land Uses and Nonpoint Sources

Nutrient loadings to Rattlesnake Slough are generated from nonpoint sources in the watershed. These potential sources include loadings from surface runoff, ground water inflow, and septic tanks.

Land Uses

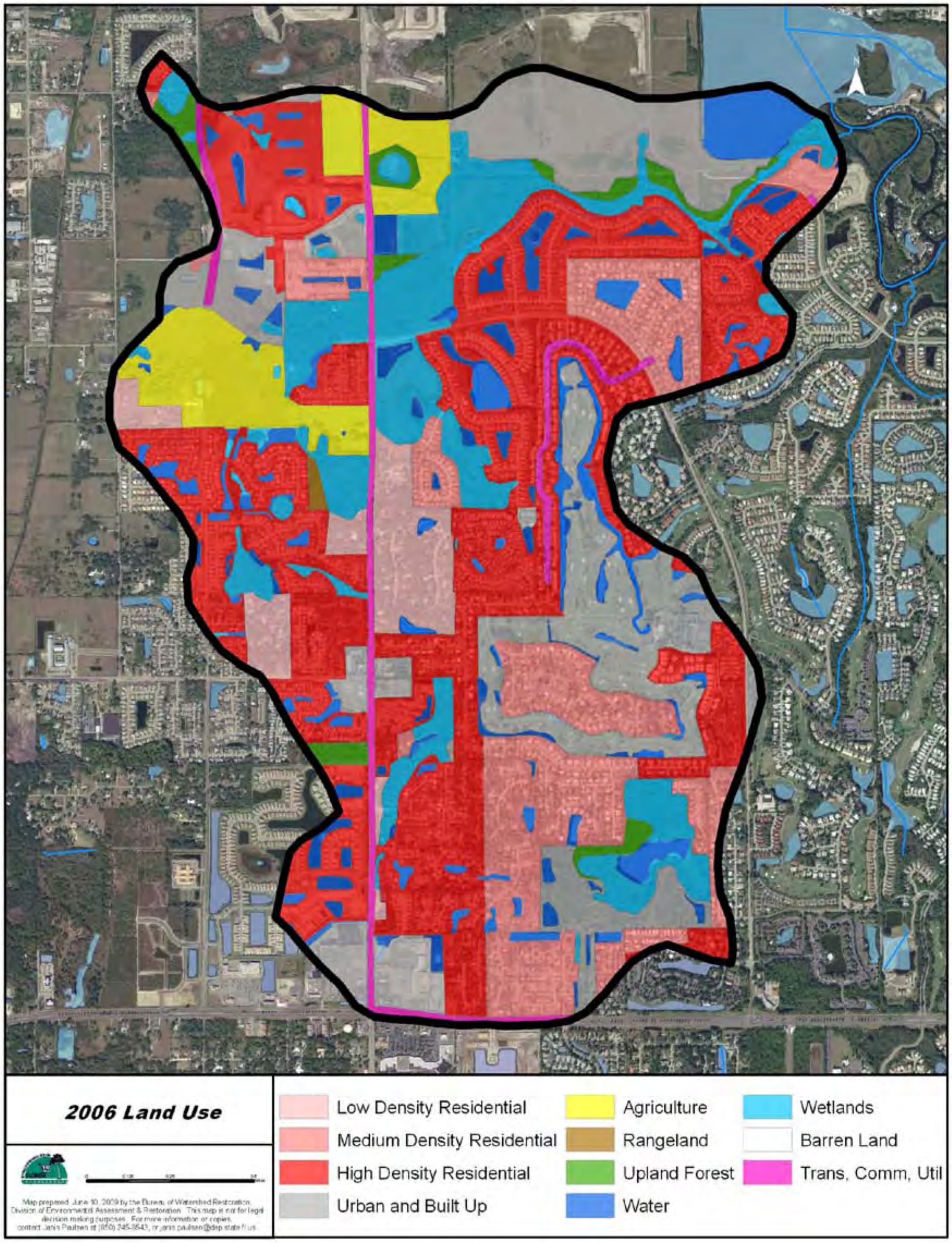
The spatial distribution and acreage of different land use categories were identified using the SWFWMD's year 20064 land use coverage (scale 1:51,000) contained in the Department's geographic information system (GIS) library. Land use categories in the watershed were aggregated using the Level 3 land use codes and tabulated in **Table 4.1**. **Figure 4.1** shows the acreage of the principal land uses in the watershed at the Level 3 land use code.

As shown in **Table 4.1**, the total area of the Rattlesnake Slough watershed (WBID 1923) is about 2,692 acres. The dominant land use category is urban land use (urban and built-up; low-, medium-, and high-density residential; and transportation, communication, and utilities) which accounts for about 71.8 percent of the total basin area. Of the 1,932 acres of urban lands, residential land use occupies about 1,389 acres, or about 51.6 percent of the total basin area. Natural land use areas, which include water/wetlands, upland forest, and barren land, occupy about 601 acres, accounting for about 22.3 percent of the total basin area.

Table 4.1. Classification of Land Use Categories in the Rattlesnake Slough Watershed

Level 4 Land Use Code	Description	Acres	% of Total
1100	Residential, Low Density <Less than two dwelling units per acre>	117.78	4.38
1200	Residential, Medium Density <Two-five dwelling units per acre>	364.62	13.54
1300	Residential, High Density	907.03	33.69
1400	Commercial and Service	55.88	2.08
1700	Institutional	4.60	0.17
1800	Recreational	23.85	0.89
1820	Golf Courses	159.78	5.94
1900	Open Land	230.96	8.58
2100	Cropland and Pastureland	135.00	5.01
2140	Row Crops	18.85	0.70
3200	Shrub and Brushland	3.98	0.15
4200	Upland Hardwood Forests	7.57	0.28
4340	Hardwood - Coniferous Mixed	39.47	1.47
5100	Streams and Waterways	0.07	0.00
5300	Reservoirs	238.57	8.86
6150	Streams and Lake Swamps (Bottomland)	203.09	7.54
6210	Cypress	2.43	0.09
6300	Wetland Forested Mixed	61.52	2.29
6410	Freshwater Marshes	40.00	1.49
6430	Wet Prairies	1.60	0.06
6440	Emergent Aquatic Vegetation	6.80	0.25
6530	Intermittent Ponds	0.08	0.00
7400	Disturbed Land	0.31	0.01
8100	Transportation	68.17	2.53

Figure 4.1. Principal Land Uses in the Rattlesnake Slough Watershed



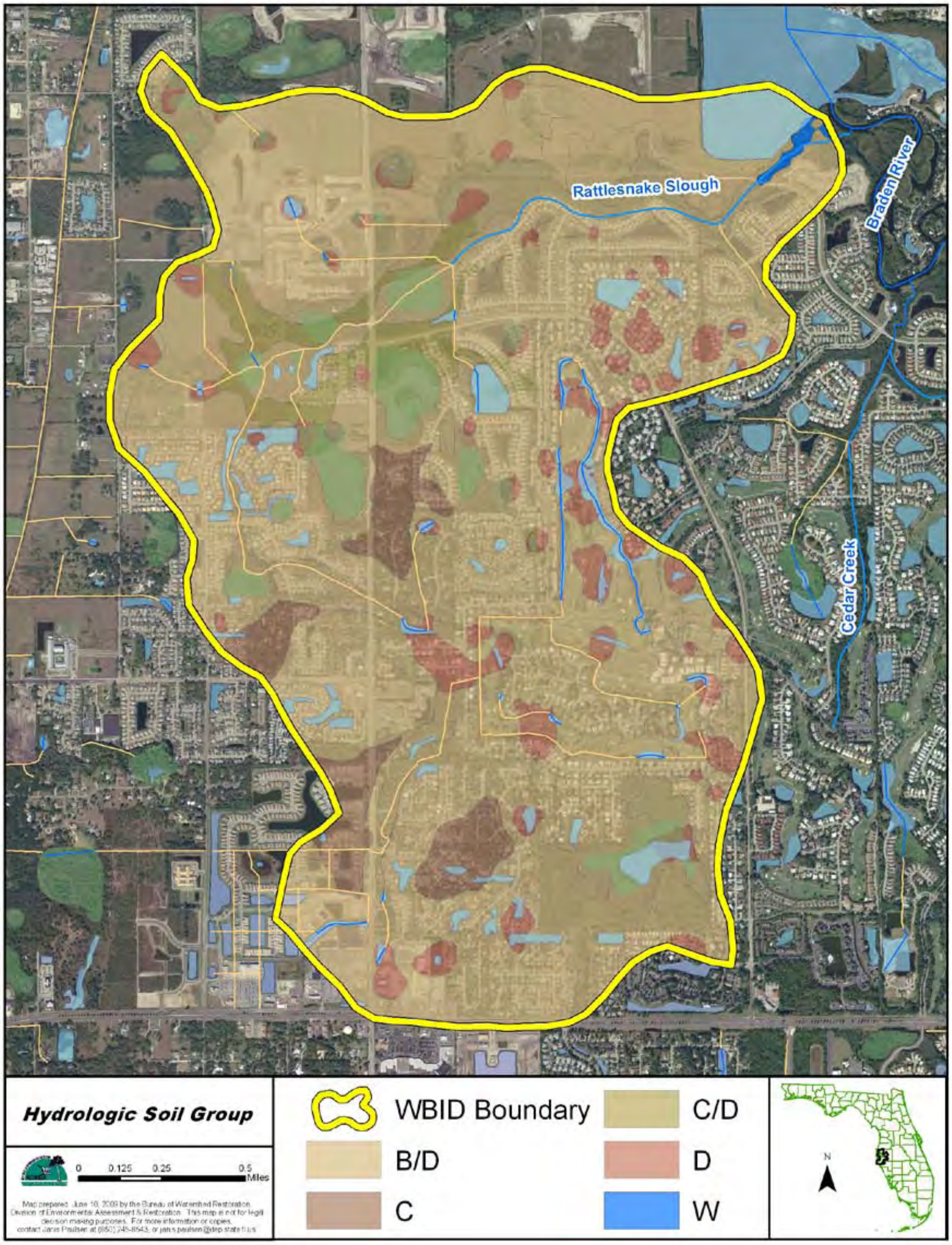
Soil Characteristics

The Soil Survey Geographic Database (SSURGO) in the Department's GIS database from the SWFWMD was accessed to provide coverage of hydrologic soil groups in the Rattlesnake Slough watershed (**Figure 4.2**). **Table 4.2** briefly describes the major hydrology soil classes. Soil group B/D (82.3%) is the predominant soil type interspersed with soil group D (8.4%).

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

Hydrology Class	Description	% of Total
A	High infiltration rates. Soils are deep, well-drained to excessively drained sands and gravels.	Not present
A/D	Drained/undrained hydrology class of soils that can be drained and are classified.	Not present
B	Moderate infiltration rates. Deep and moderately deep, moderately well- and well-drained soils that have moderately coarse textures.	Not present
B/D	Drained/undrained hydrology class of soils that have moderately coarse textures.	82.33
C	Slow infiltration rates. Soils with layers impeding downward movement of water, or soils that have moderately fine or fine textures.	4.89
C/D	Drained/undrained hydrology class of soils that can be drained and classified.	4.16
D	Very slow infiltration rates. Soils are clayey, have a high water table, or are shallow to an impervious layer.	8.38

Figure 4.2. Hydrologic Soil Groups Distribution in the Rattlesnake Slough Watershed



Population

Household size and housing unit information from the 2000 census at the block level was obtained from the U.S Census Bureau. GIS was used to estimate the fraction of each block in the Rattlesnake Slough watershed and then applied to the block information to estimate the population. Based on **Table 4.3**, the population in the watershed is estimated at 4,512, along with 2,056 housing units.

Table 4.3. Estimated Average Household Size in the Rattlesnake Slough Watershed

Tract	Block	Census Block Area	Estimated Block Area in Watershed	Housing Units in Census Block	Housing Units in Watershed	Average Household Size	Population
8.05	3	1139.25	6.90	744	6	2.22	10
8.07	2	1856.78	145.24	692	54	2.65	144
8.08	1	402.04	195.08	819	397	2.38	946
8.08	2	1001.86	499.80	1290	644	1.97	1268
8.09	1	682.40	327.19	1087	521	2.27	1183
8.09	2	380.39	184.44	853	414	2.23	923
8.10	1	2577.73	29.10	1791	20	1.86	38
Estimated Total					**2,056**		**4,512**

Data from U.S. Census Bureau Website, 2000, based Manatee County blocks that are present in the Rattlesnake Slough watershed.
Census Block Area in acres.

Septic Tanks

Based on 2008 Florida Department of Health (FDOH) onsite sewage GIS coverage (http://www.doh.state.fl.us/environment/programs/EhGis/EhGisDownload.htm), and on the 2000 census estimates, it was assumed that the majority of low-density residences in the Rattlesnake Slough watershed are using septic tanks (**Figure 4.3**) estimated to be 78 residences. 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. 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

Other than the estimated 78 residences are currently using septic tank systems, the remaining 1978 medium- and high-density residential units are likely connected to a municipal wastewater facility. An EPA Region 4 memorandum on estimating water quality loadings from MS4 areas (EPA, 2000) suggests that a 5 percent leakage rate from collection systems is realistic. Using the 2000 Census block information, a 5 percent leakage for 70 gallon per person per day discharge, and EPA values for nitrogen and phosphorus concentration in raw sewage yield potential annual loading of nitrogen and phosphorus of 1668 lbs/yr and 695 lbs/yr, respectively (**Table 4.5**).

Table 4.4. Estimated Nitrogen and Phosphorus Annual Loading from Septic Tanks in the Rattlesnake Slough Watershed

Tract	Block	Estimated Number of Households on Septic	Average Household Size	Gallons/Person/Day[1]	TN in Drainfield (mg/L)	TP in Drainfield (mg/L)	Estimated Annual TN Load (lbs/yr)	Estimated Annual TP Load (lbs/yr)
8.07	2	7	2.65	70	36	15	142	59
8.08	1	19	2.38	70	36	15	347	145
8.08	2	50	1.97	70	36	15	756	315
8.09	1	2	2.27	70	36	15	35	15
Estimated Total							**1280**	**534**

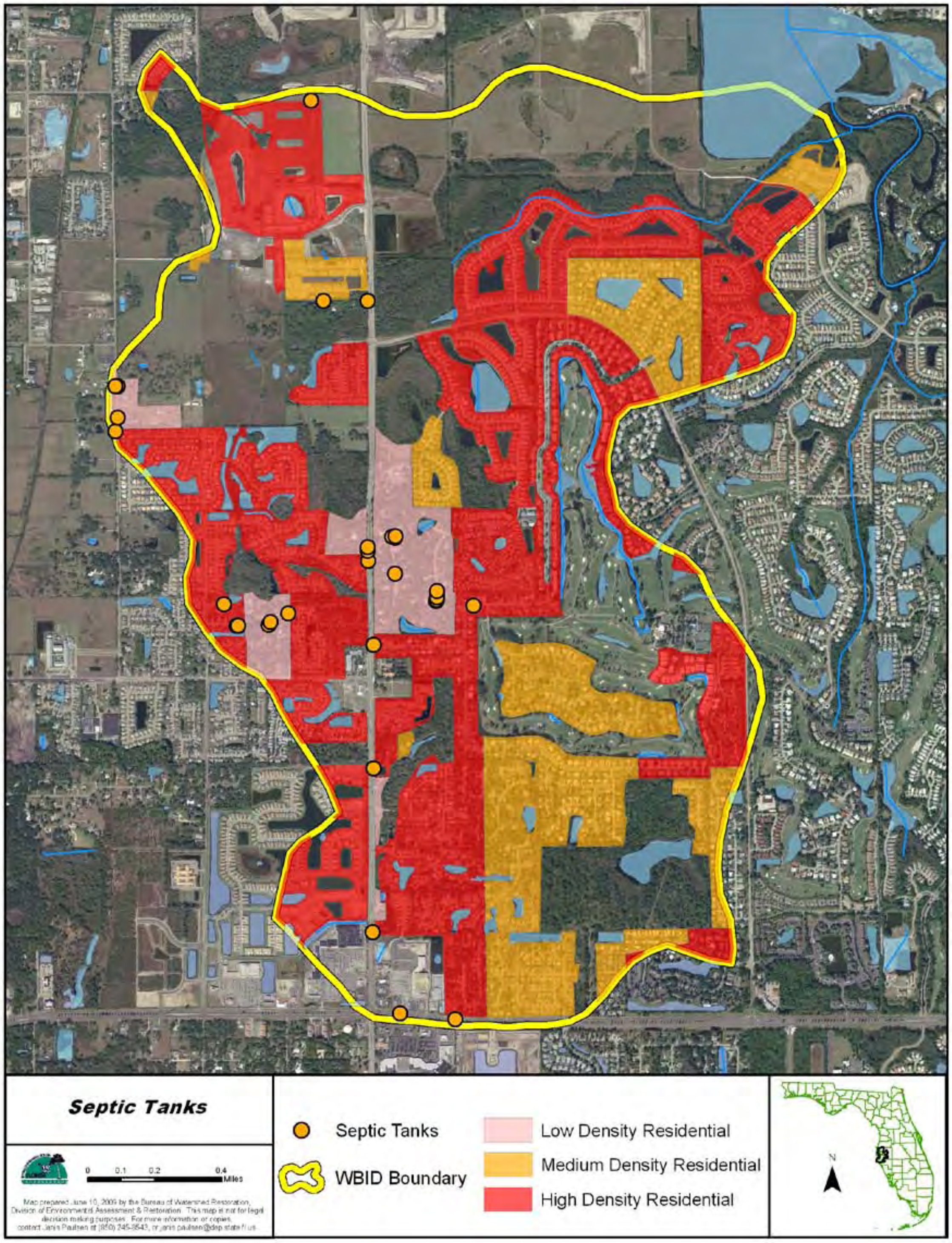
[1]EPA, 1999

Table 4.5. Estimated Nitrogen and Phosphorus Annual Loading from Wastewater Collection Systems in the Rattlesnake Slough Watershed

Tract	Block	Estimated Number of Households on Sewer	Average Household Size	Gallons/Person/Day[1]	TN in Sewage (mg/L)	TP in Sewage (mg/L)	Estimated Annual TN Load (lbs/yr)	Estimated Annual TP Load (lbs/yr)
8.05	3	6	2.22	3.5	36	15	5	2
8.07	2	47	2.65	3.5	36	15	48	20
8.08	1	378	2.38	3.5	36	15	345	144
8.08	2	594	1.97	3.5	36	15	449	187
8.09	1	519	2.27	3.5	36	15	452	188
8.09	2	414	2.23	3.5	36	15	354	148
8.10	1	20	1.86	3.5	36	15	14	6
Estimated Total							**1668**	**695**

[1]EPA, 2002; based on 70 gallons/per person/day with a leakage rate of 5 percent

Figure 4.3. Distribution of Onsite Sewage Disposal Systems (Septic Tanks) in the Rattlesnake Slough Watershed



4.3 Source Summary

4.3.1 Summary of Nutrient Loadings to Rattlesnake Slough from Various Sources

Screening level estimates of annual nitrogen and phosphorus loadings to the watershed were developed based on the 2006 land use and hydrologic soil groups. GIS shapefiles of land use and hydrologic soil groups were used to determine the acreage associated with various Level 2 land uses and soils. Estimates for annual runoff coefficients and event mean concentrations (EMCs) were based on Harper and Baker (2007) and Gao (2006). A screening level estimate of annual runoff was calculated by multiplying the long-term annual average rainfall of 52.4 inches (Bradenton 5ESE, 1965-2008) by the respective runoff coefficient and area. Estimates of annual nitrogen and phosphorus loading were obtained by multiplying the annual runoff by the corresponding EMC. A more detailed loading analysis could be performed based on development of site specific runoff coefficients, EMCs, and knowledge of Best Management Practices (BMPs) that have been implemented in the watershed.

Agriculture

At the level 3 land use category, two agricultural codes were identified in the Rattlesnake Slough watershed. According to Harper et al. (2007), mean stormwater concentrations for total nitrogen and total phosphorus from general agriculture are 2.79 mg/L and 0.431 mg/L respectively. **Table 4.6** summarizes the screening level estimates for nitrogen and phosphorus loads from agricultural sources.

Table 4.6. Estimated Annual Average TN and TP Loads from Agriculture in the Rattlesnake Slough Watershed

Land Use Classification	Soil Group	Acres	Annual Runoff Coefficient	Gross Runoff (AcreFt)	Estimated TN Load (lbs)	Estimated TP Load (lbs)
Cropland and pastureland	B/D	106.08	0.089	41.23	312.78	48.21
	C/D	19.72	0.226	19.46	147.65	22.76
	D	9.19	0.226	9.07	68.81	10.60
Row Crops	B/D	18.85	0.089	7.33	55.58	8.57
SUM		**153.84**		**77.08**	**584.82**	**90.13**

Urban Areas

There are 1,864 acres in the Level 1 category of urban and built-up in the watershed and 68 acres in transportation, communication, and utilities. High-density residential represents approximately 1/3 of the total acreage in the watershed. Medium- and low-density residential represents about 17% of the watershed area or 482 acres. **Table 4.7** summarizes the screening level estimates for nitrogen and phosphorus loads from urban and built-up categories in the watershed.

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

Land Use Classification	Soil Group	Acres	Annual Runoff Coefficient	Gross Runoff (AcreFt)	Estimated TN Load (lbs)	Estimated TP Load (lbs)
Residential, low density - less than 2 dwelling units/acre	B/D	71.6393	0.083	25.96	196.99	30.36
	C	44.56248	0.166	32.30	245.07	37.77
	D	1.57844	0.226	1.56	11.82	1.82
Residential, medium density - 2-5 dwelling units/acre	B/D	313.8011	0.108	147.99	1122.79	173.05
	C	15.52163	0.186	12.61	95.65	14.74
	C/D	0.74338	0.226	0.73	5.57	0.86
	D	33.95793	0.252	37.37	283.51	43.69
	W	0.59552	0.435	1.13	8.58	1.32
Residential, high density - 6 or more dwelling units/acre	B/D	757.4905	0.24	793.85	6022.95	928.27
	C	56.37848	0.289	71.15	539.80	83.19
	C/D	25.36699	0.35	38.77	294.14	45.33
	D	67.76347	0.35	103.57	785.75	121.10
	W	0.03016	0.435	0.06	0.43	0.07
Commercial and services	B/D	46.27001	0.35	70.72	536.52	82.69
	D	9.61245	0.435	18.26	138.53	21.35
Institutional	B/D	4.54	0.241	4.78	36.24	5.59
	C	0.06066	0.289	0.08	0.58	0.09
Recreational	B/D	22.57856	0.089	8.77	66.57	10.26
	D	1.27461	0.226	1.26	9.54	1.47
Golf Courses	B/D	125.90	0.089	48.93	371.22	57.21
	D	33.88	0.226	33.44	253.70	39.10
Open land	B/D	207.2712	0.089	80.55	611.15	94.19
	C/D	13.81034	0.226	13.63	103.40	15.94
	D	9.87458	0.226	9.74	73.93	11.39
Disturbed lands	B/D	0.30832	0.089	0.12	0.91	0.14
Transportation	B/D	57.98639	0.293	74.19	562.88	86.75
	C	4.18662	0.328	6.00	45.49	7.01
	C/D	4.51807	0.375	7.40	56.13	8.65
	D	1.4805	0.375	2.42	18.39	2.83
SUM		**1,932.98**		**1,647.32**	**12,498**	**1926**

Forest/Wetland/Water/Open Lands Areas

Estimates for nitrogen and phosphorus loadings from land uses in the forest, wetland, and water level 2 classifications are summarized in **Table 4.8**. Wetlands and upland forests represented 11.7 and 1.7 percent, respectively of the acreage in the watershed.

Table 4.8. Estimated Forest/Wetland/Water/Open Lands Annual Nitrogen and Phosphorus Loading in the Rattlesnake Slough Watershed

Land Use Classification	Soil Group	Acres	Annual Runoff Coefficient	Gross Runoff (AcreFt)	Estimated TN Load (lbs)	Estimated TP Load (lbs)
Shrub and Brushland	B/D	3.97878	0.089	1.546286534	11.73169113	1.808110103
	C/D	0.0009	0.226	0.00088818	0.00673863	0.00103857
Upland Hardwood Forests	B/D	5.00427	0.089	1.944826131	14.75541497	2.274132056
	C	2.56408	0.166	1.858616123	14.10133879	2.173324616
Hardwood Conifer Mixed	B/D	37.7369	0.089	14.66581724	111.2696995	17.14909347
	C/D	0.00046	0.226	0.000453959	0.003444189	0.000530825
	D	1.72625	0.226	1.703578583	12.92506746	1.992035486
	W	0.00796	0.435	0.01512002	0.11471574	0.017680204
Streams and Waterways	W	0.07096	0.435	0.13478852	1.022641826	0.157611464
Reservoirs	B/D	190.5016	0.435	361.8577132	2745.418027	423.1289432
	C	8.39256	0.435	15.94166772	120.9495897	18.64097619
	C/D	10.85777	0.435	20.62433412	156.4770256	24.11653083
	D	28.47307	0.435	54.08459647	410.3403649	63.24242184
	W	0.34709	0.435	0.659297455	5.002096271	0.7709324
Stream and Lake Swamps (Bottomland)	B/D	161.6749	0.435	307.1014915	2329.982035	359.1011738
	C/D	30.96142	0.435	58.81121729	446.2012836	68.76937346
	D	8.1682	0.435	15.5154959	117.7162199	18.14264321
	W	2.28457	0.435	4.339540715	32.92413806	5.074329521
Cypress	B/D	0.63752	0.435	1.21096924	9.187635526	1.416015511
	D	1.78944	0.435	3.39904128	25.7885596	3.97458087
Wetland Forested Mixed	B/D	53.64396	0.435	101.896702	773.0912797	119.1502689
	C/D	1.05797	0.435	2.009614015	15.24696128	2.34989009
	D	6.81354	0.435	12.94231923	98.1935032	15.13376573
Freshwater Marshes	B/D	26.40661	0.435	50.1593557	380.5595246	58.65254322
	C/D	2.88082	0.435	5.47211759	41.51700994	6.398678951
	D	7.67298	0.435	14.57482551	110.5793444	17.04269466
	W	3.03586	0.435	5.76661607	43.7513728	6.74304312
Wet Prairies	B/D	0.41867	0.435	0.795263665	6.033673242	0.929920966
	C/D	0.74775	0.435	1.420351125	10.77621795	1.660850794
	D	0.43501	0.435	0.826301495	6.269157564	0.966214248
Emergent Aquatic Vegetation	B/D	3.57679	0.435	6.794112605	51.54699911	7.944519576
	C/D	1.28571	0.435	2.442206145	18.52904202	2.855730491
	D	1.9395	0.435	3.68408025	27.95115307	4.307883806
Intermittent Ponds	B/D	0.05153	0.435	0.097881235	0.742625892	0.114454887
	D	0.02664	0.435	0.05060268	0.383923031	0.059170933
SUM		**605.17**		**1,074.35**	**8,151.09**	**1,256.26**

Table 4.9 summarizes the various estimates from various land uses in the watershed. It is important to note that this is not a complete list and represents estimates of potential loadings. In addition, proximity to the waterbody, site specific 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 Rattlesnake Slough. For example, where are the improved pasture and high-density residential areas relative to Rattlesnake Slough, and is there a riparian buffer area between these land uses and the stream? What types of best BMPs, both structural and nonstructural, have been implemented for specific land uses in the watershed that reduce the actual nutrient loads delivered to Rattlesnake Slough? Finally, the age and condition of the septic systems and drainage characteristics in the watershed compared with the county overall 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 Rattlesnake Slough Watershed

Source	Total Nitrogen (lbs/yr)	Total Phosphorus (lbs/yr)
Septic Tanks*	1,280	534
Leaking Collection Systems*	1,668	695
Agriculture	585	90
Urban and Built-up	12,498	1,926
Forest/Wetland/Water/Open Lands	8,151	1,256

*Potential contribution to ground water

Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY

5.1 Determination of Loading Capacity

The TMDL methodology used for Rattlesnake is the load duration curve. Also known as the "Kansas Approach" because it was developed by the state of Kansas, this method has been well documented in the literature, with improved modifications used by EPA Region 4. Basically, the method relates the pollutant concentration to the flow of the stream, in order to establish the existing loading capacity and the allowable pollutant load (TMDL) under a spectrum of flow conditions. It then determines the maximum allowable pollutant load and load reduction requirement based on the analysis of the critical flow conditions. This method requires four steps to develop the TMDL and establish the required load reduction:

1. Develop the flow duration curve,
2. Develop the load duration curve for both the allowable load and existing loading,
3. Define the critical conditions, and
4. Establish the needed load reduction by comparing the existing loading with the allowable load under critical conditions.

5.1.1 Data Used in the Determination of the TMDL

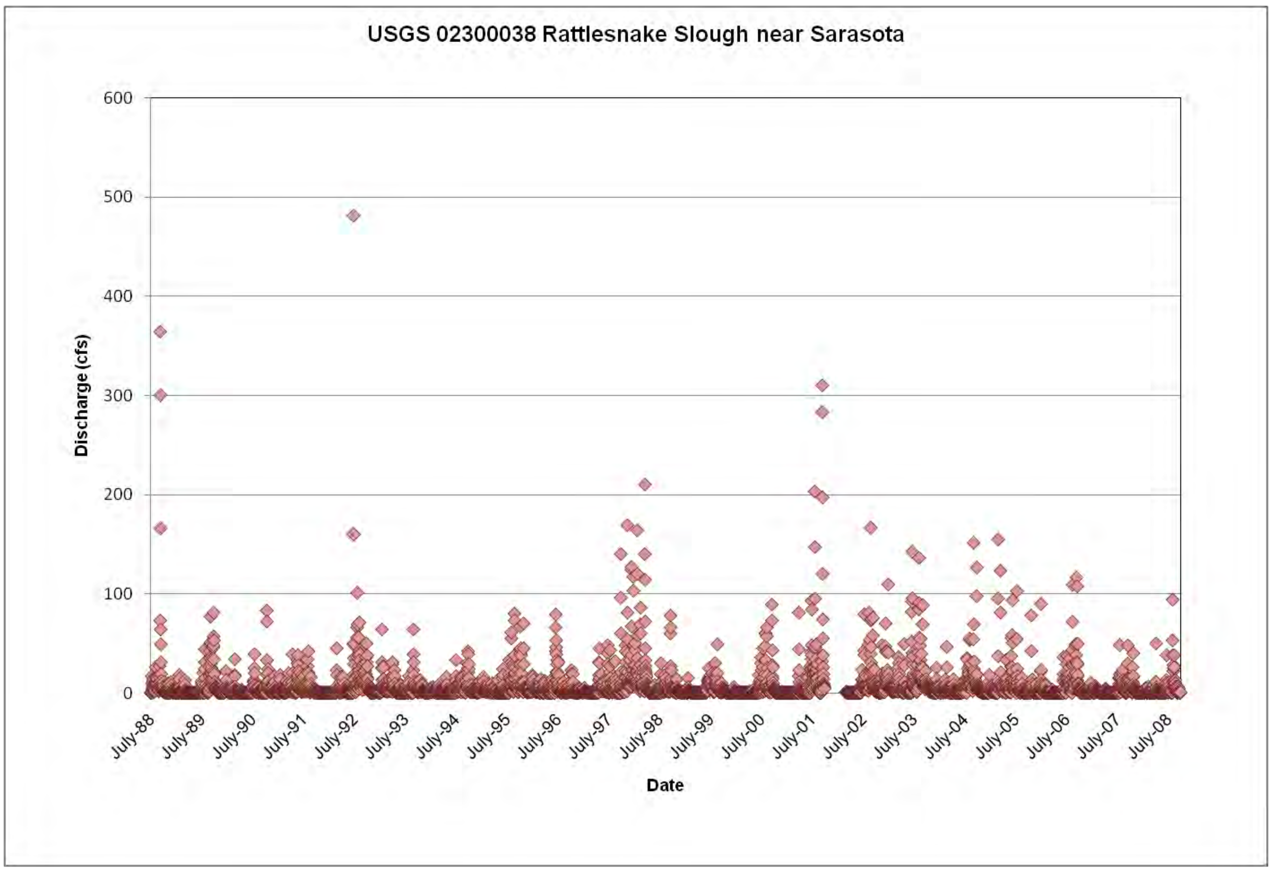
Total nitrogen concentration, total phosphorus, chlorophyll α, DO, BOD and flow measurements were used to estimate both the allowable nutrient loads and existing nutrient loads. A USGS stream flow gaging site on Rattlesnake Slough (02300038) has daily discharge data over the period from July 1, 1988 to September 30, 2008 (**Figure 5.1**). **Table 5.1** provides physical and stream flow statistics for the gage.

Table 5.1. Physical and Statistical Summary for USGS Gaging Site in the Rattlesnake Slough Watershed

USGS Gages 02300038	
Drainage Area (square miles)	3.8
Period of Record	7/1/1988 – 9/30/2008
Mean Basin Elevation (feet)	29
Stream slope (feet/mile)	5.6
Flow Duration	
0.01	67.2
0.05	23
0.1	12
0.2	5.6
0.25	3.8
0.3	2.8

USGS Gages 02300038	
Flow Duration	
0.4	1.65
0.5	1
0.6	0.575
0.7	0.32
0.75	0.2
0.9	0
0.95	0
0.99	0

Figure 5.1 Daily Discharge Recorded at USGS Gage 02300038: Rattlesnake Slough near Sarasota, FL



Three sampling stations on Rattlesnake Slough have historical observations for dissolved oxygen and nutrients (**Figure 5.2**). **Table 5.2** contains summary information on each of the stations. A statistical summary of major water quality parameters from the available data is presented in **Table 5.3**, and **Appendix B** contains historical dissolved oxygen (DO), chlorophyll α (CHLA), total nitrogen (TN), total phosphorus (TP), and 5-day biological oxygen demand (BOD5) available observations from sampling sites in WBID 1923.

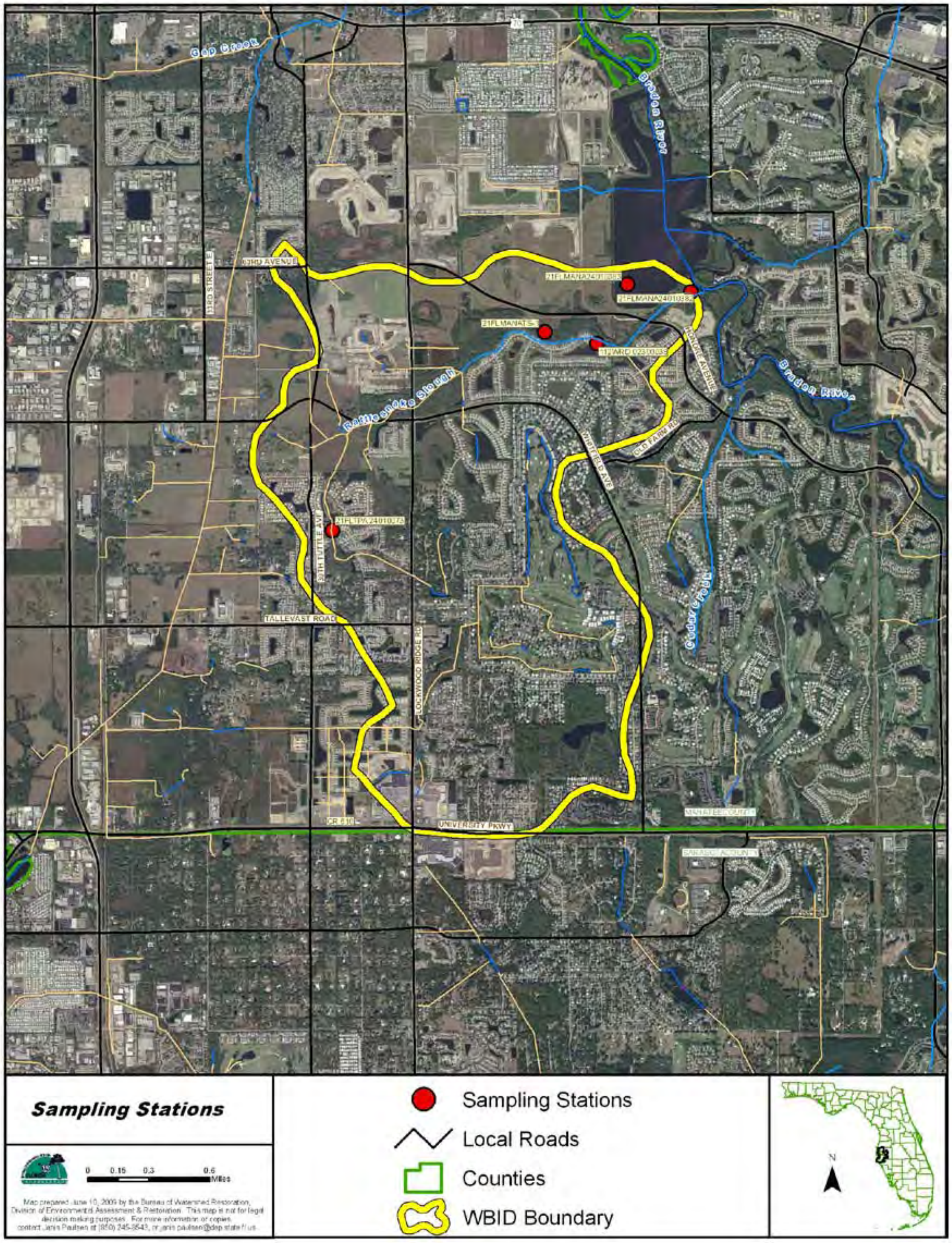
Table 5.2. Sampling Station Summary for the Rattlesnake Slough Watershed

Station	STORET ID	Station Owner	Years With Data	CHLA Samples	DO Samples	TN Samples	TP Samples
Rattlesnake Slough (TS1)	21FLMANATS1	Manatee County	1990-2008	209	245	232	223
Rattlesnake Slough Near Sarasota, FL	112WRD 023000038	USGS	1993-1997	0	5	17	17
TP114 - Rattlesnake Slough	21FLTPA 240100073	FDEP	1998	0	1	0	0

Table 5.3. Summary Statistics for Major Water Quality Parameters Measured in Rattlesnake Slough

Parameter	Sample Number	Minimum	25th Percentile	Median	Mean	75th Percentile	Maximum
BOD5 (mg/L)	132	0.5	2.0	2.4	2.8	3.5	7.7
CHLA (ug/L)	189	1	2.6	5.5	11.3	11.2	234.4
DO (mg/L)	193	2.7	4.4	5.3	5.5	6.6	11.4
TN (mg/L)	192	0.19	0.96	1.17	1.21	1.44	2.56
TP (mg/L)	186	0.07	0.29	0.39	0.43	0.52	2.25

Figure 5.2. Historical Sampling Sites in the Rattlesnake Slough Watershed



Figures 5.3 through **5.6** present the historical observations for DO, CHLA, TN, TP and BOD over time. A linear regression was performed to determine if temporal changes explained the variance in the sample results. The correlation value, R2, was calculated to determine if any variance was temporally dependent for the entire historical period. As the figures show, the R2 values for each parameter ranged from 0.006 to 0.055 with a p = 0.5 indicating the improbability that the sample results are dependent over long periods of time. **Appendix C** contains plots of the same parameters by season, month, and year.

Figure 5.3. Historical DO Observations for Rattlesnake Slough

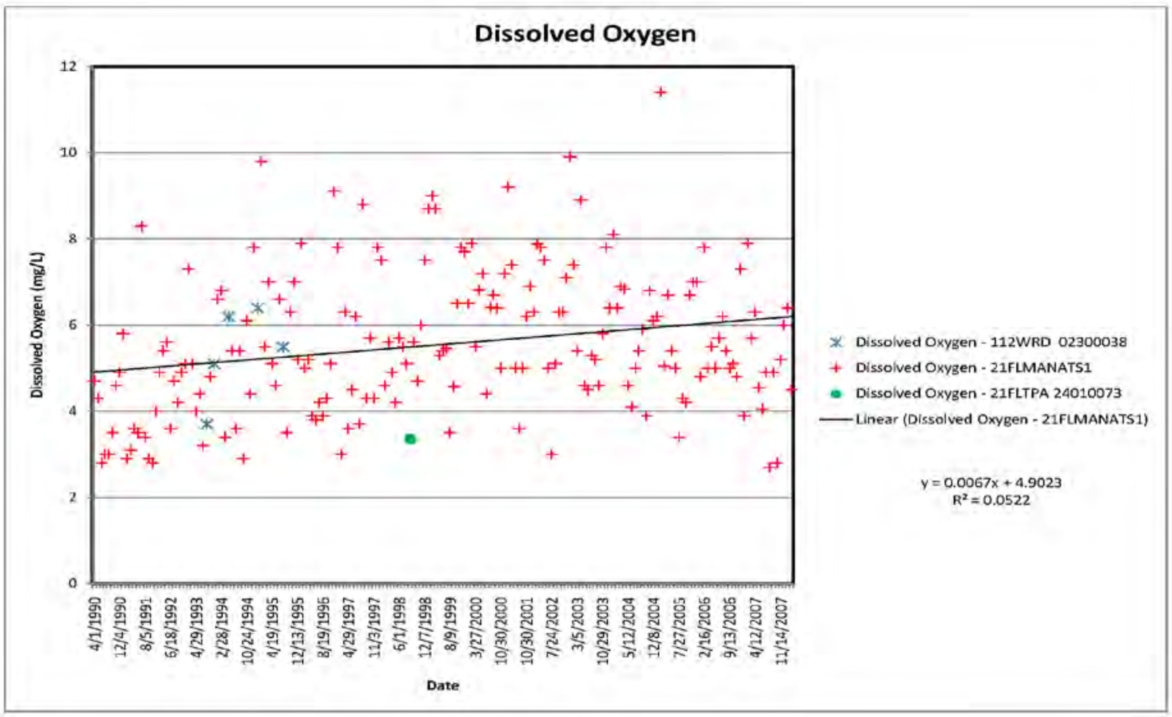


Figure 5.4. Historical CHLA Observations for Rattlesnake Slough

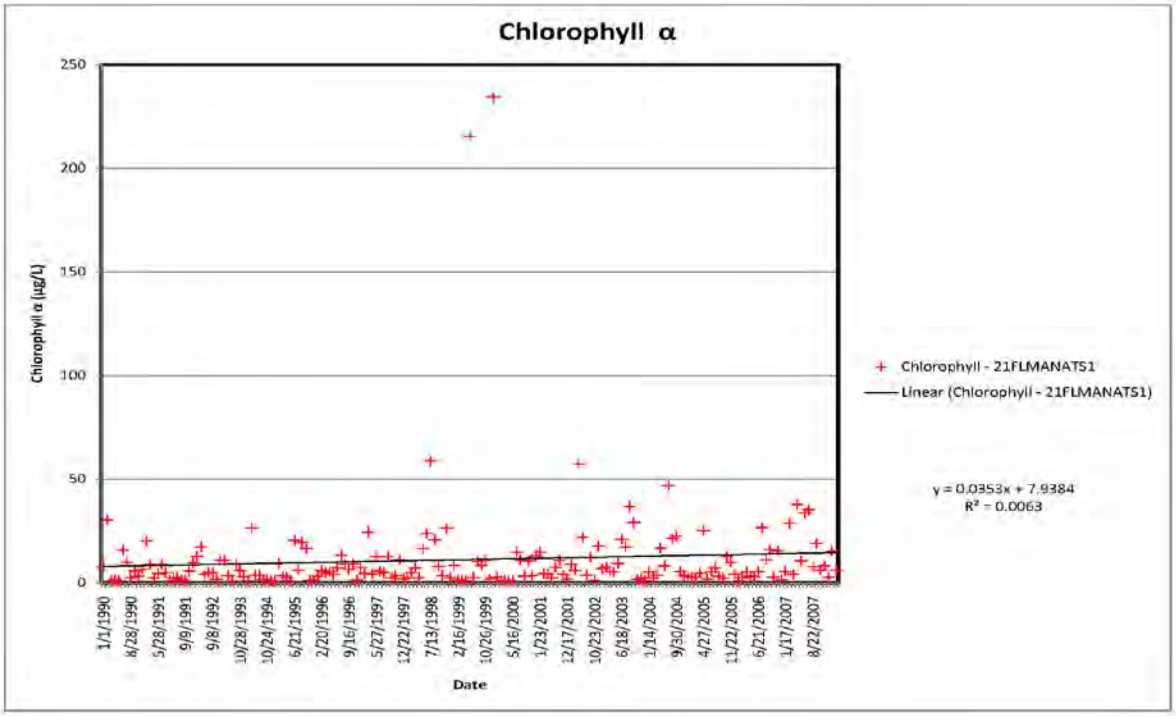


Figure 5.5. Historical TN Observations for Rattlesnake Slough

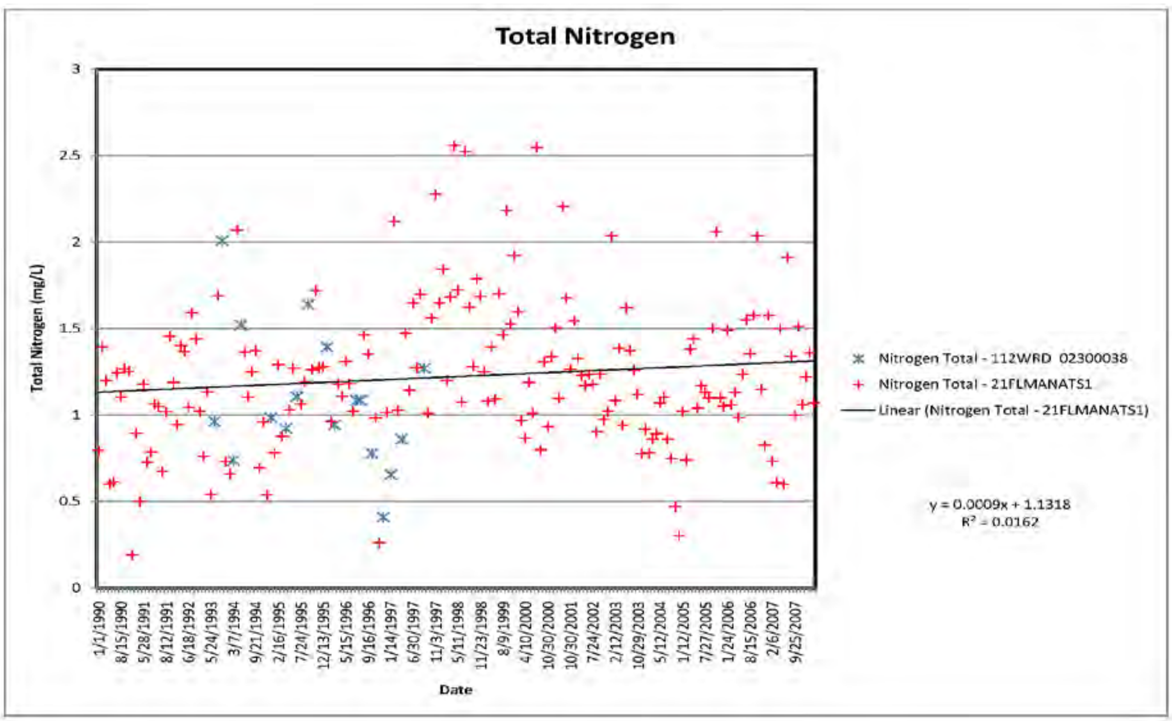


Figure 5.6. Historical TP Observations for Rattlesnake Slough

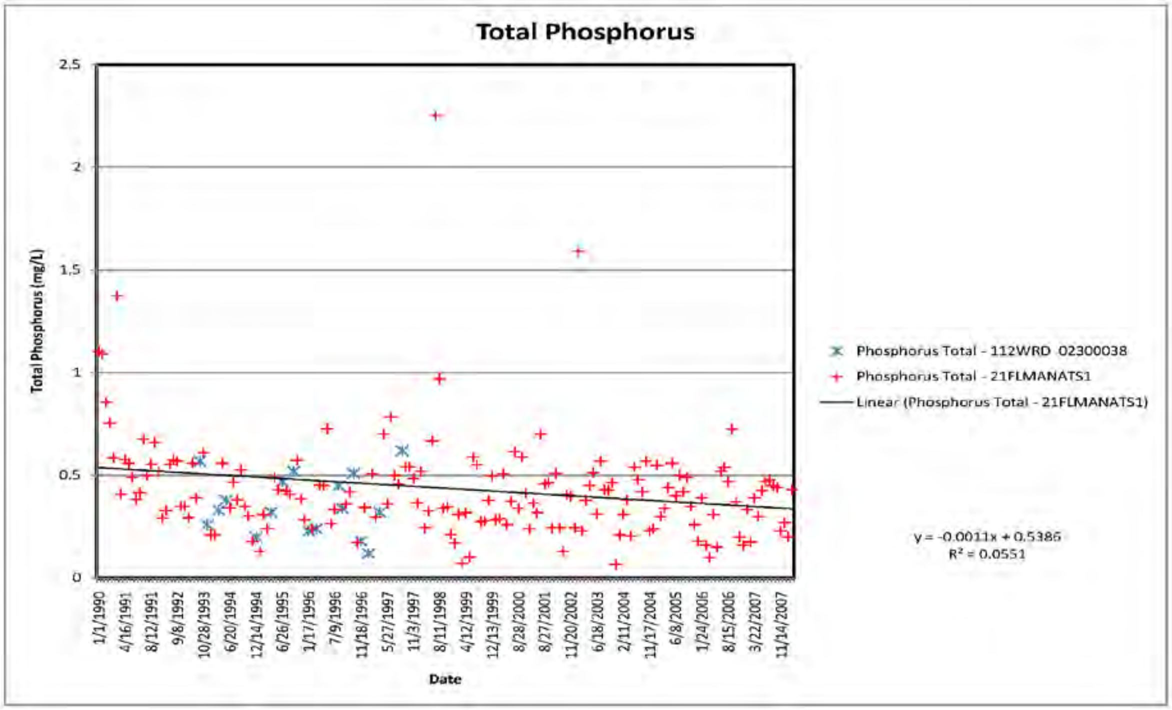
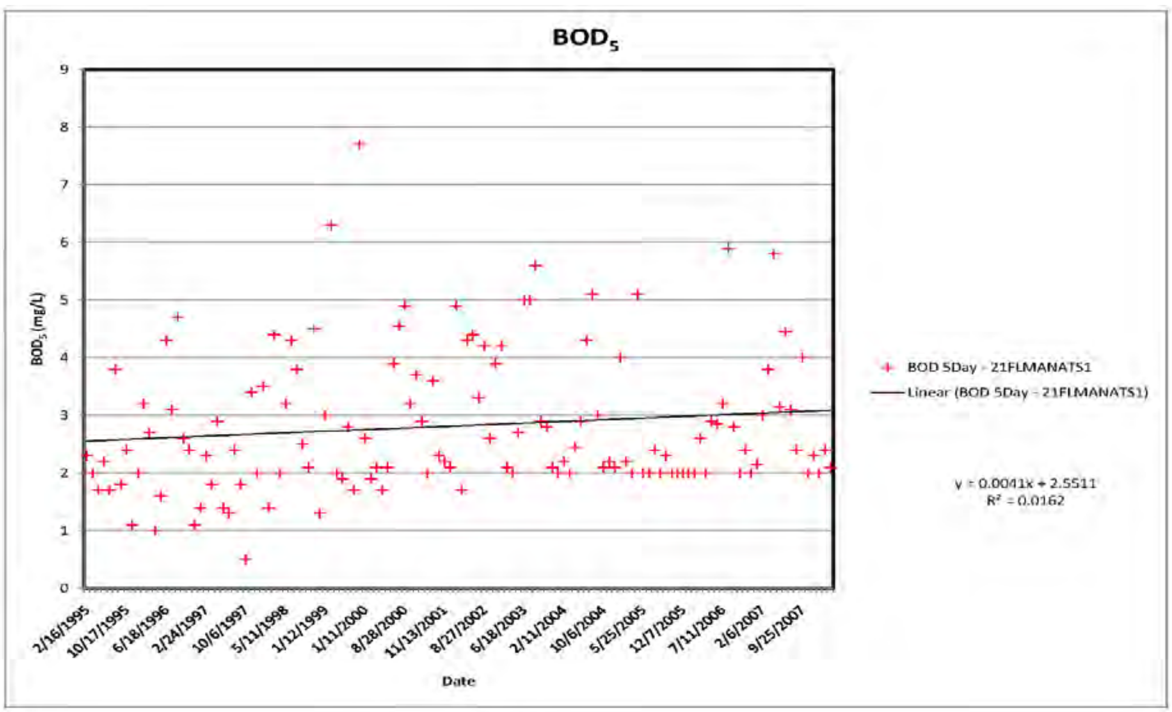


Figure 5.7. Historical BOD5 Observations for Rattlesnake Slough



5.1.2 TMDL Development Process

TMDL Targets for Dissolved Oxygen and Nutrients

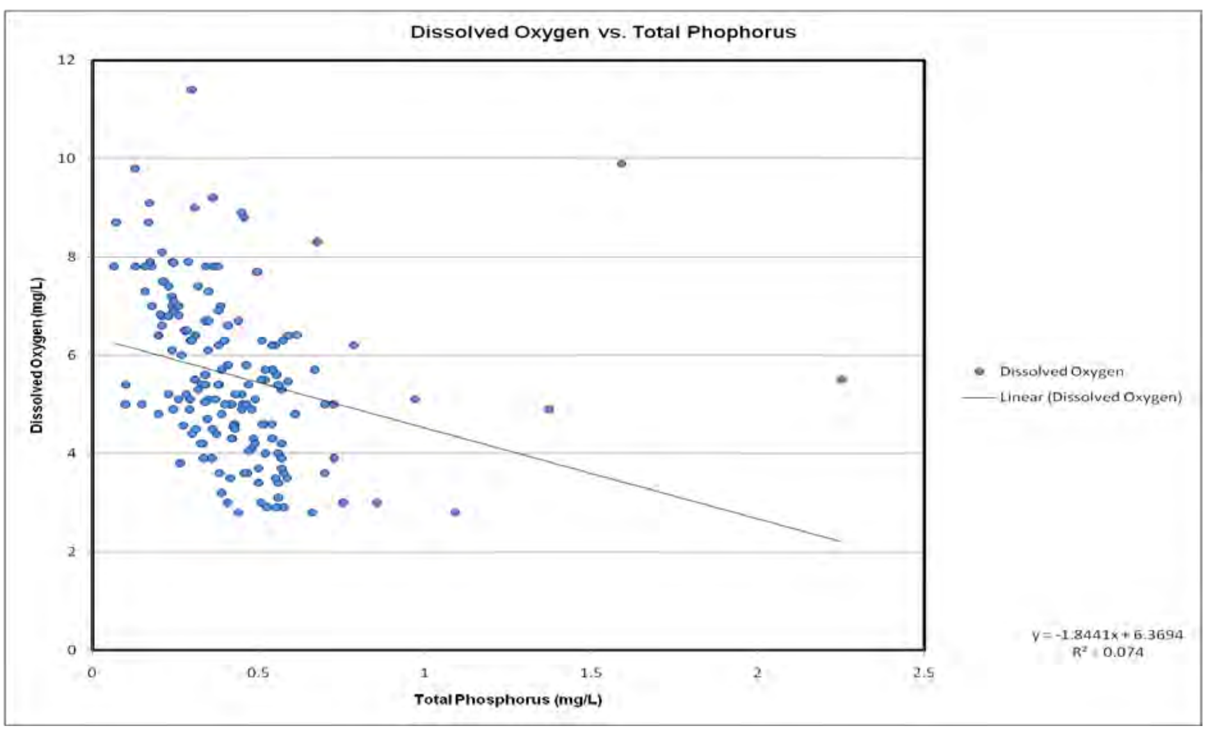
Histograms for DO,CHLA, TN, TP and BOD were charted to determine the general shape of the frequency distribution, symmetry, and modality of the data. With the exception of total nitrogen, most of the parameters did not display normal distribution of data (**Appendix D**). For nonparametric variables, a Spearman correlation matrix was used to assess potential relationships between DO, CHLA, and other water quality parameters (**Appendix E**).

Dissolved Oxygen Pollutants of Concern Target Development

The results of the Spearman test, at an alpha (α) level of 0.05, correlations between DO and TP were determined significant. **Figure 5.8** shows the inverse relationship and the regression equation between DO and TP (equation 1). As discussed in the standards section of the report, Chapter 3, the DO criterion for Class I waters does not allow exceedances below 5.0 mg/L with daily and seasonal fluctuations to be maintained above 5.0 mg/L. The TMDL target for TP was selected as the level predicted to achieve a minimum DO of 5.0 mg/L. Ten percent of the minimum requirement was added in order to add an implicit margin of safety and ensure that both components of the criterion are met. Based on the regression equation, DO concentrations of 5.5 mg/L or greater would be related to TP concentrations less than 0.48 mg/L.

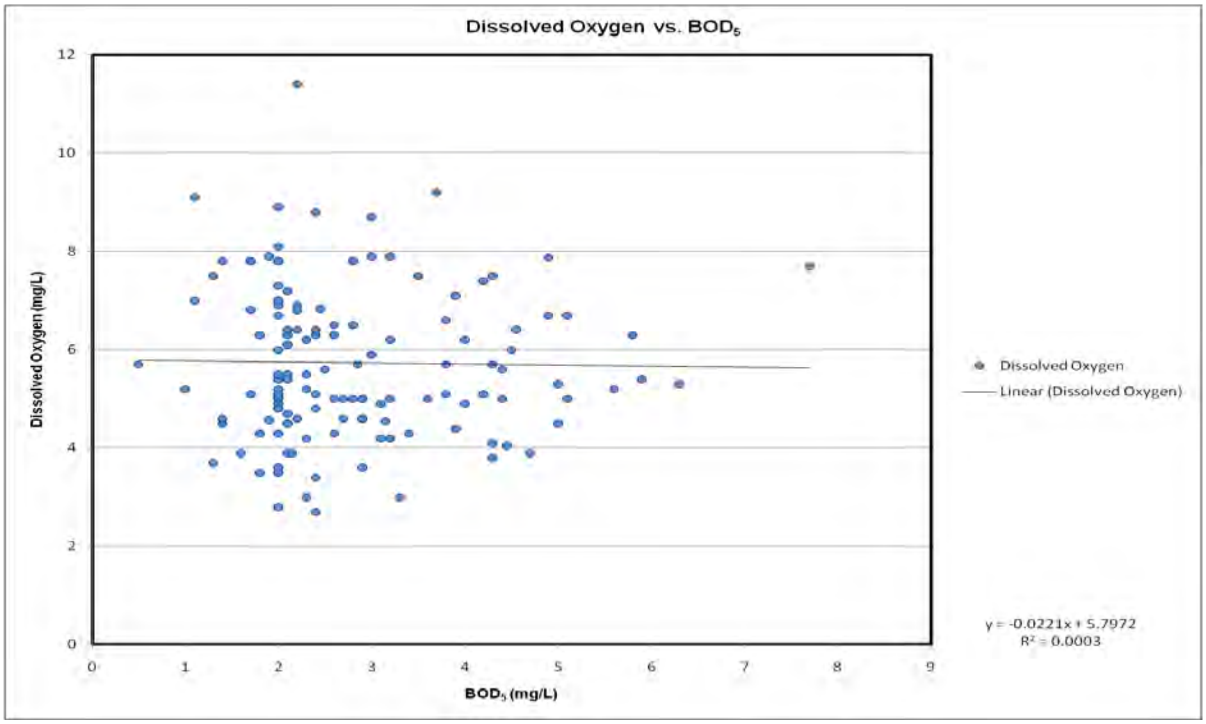
dissolved oxygen (mg/L) = 6.3694 – 1.8441total phosphorus (mg/L) **(1)**

Figure 5.8 Relationship Between DO and TP Observations for Rattlesnake Slough



BOD was also linked as a possible causative pollutant for low DO concentrations. However, the Spearman results did not show any significant correlation between DO and BOD at an alpha (α) of 0.05 (**Appendix E**). **Figure 5.9** shows the relationship between DO and BOD where the correlation (R^2 = 0.0003) was generally absent. However, BOD could be significantly correlated to CHLA. This relationship is further explored below for determining chlorophyll α targets.

Figure 5.9 Relationship Between DO and BOD_5 Observations for Rattlesnake Slough



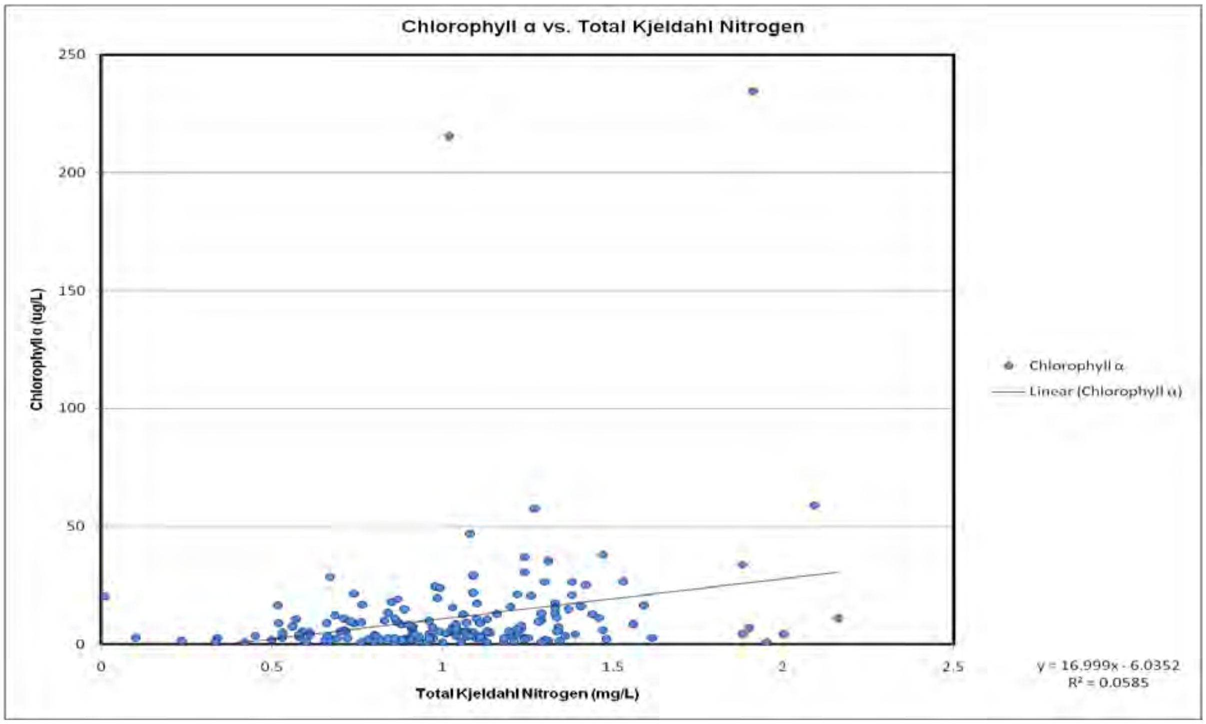
Nutrient Pollutants of Concern Target Development

Chlorophyll α serves as a surrogate for the narrative nutrient criteria where the annual mean concentration for chlorophyll α cannot be above 20 ug/L or have increased more than 50% over historical values for at least two consecutive years for streams. As previously discussed in Chapter 2, Rattlesnake Slough demonstrated several consecutive years where the chlorophyll α values had increased above 50% of the historical value of 6.55 ug/L (**Table 2.5**). As a limiting nutrient, TN had been determined to be a potential causative pollutant for the increased chlorophyll α concentrations. The results from the Spearman correlation test confirmed the association between chlorophyll α and TN at an alpha (α) of 0.5. An even more significant correlation was found between chlorophyll α and total kjeldahl nitrogen (TKN) (**Appendix E**). **Figure 5.10** illustrates the relationship and the regression equation between chlorophyll α and TKN. The TMDL target for TKN was selected as the level predicted to achieve the historical chlorophyll α concentration of 6.55 ug/L. Based on the regression equation (equation 2), to achieve CHLA historical concentrations, TKN concentrations of 0.72 mg/L or less are needed. TKN represents approximately 84% of the TN concentrations in 96% of the total observations. Consequently, any reductions required for TKN will also result in reductions for TN. To meet historical chlorophyll α concentrations of 6.55 ug/L or less, the calculated TN concentrations would be 0.86 mg/L or less (equation 3).

chlorophyll α (ug/L) = 16.999total kjeldahl nitrogen (mg/L) - 6.0352 **(2)**

total nitrogen (mg/L) = total kjeldahl nitrogen (mg/L) / 0.84 **(3)**

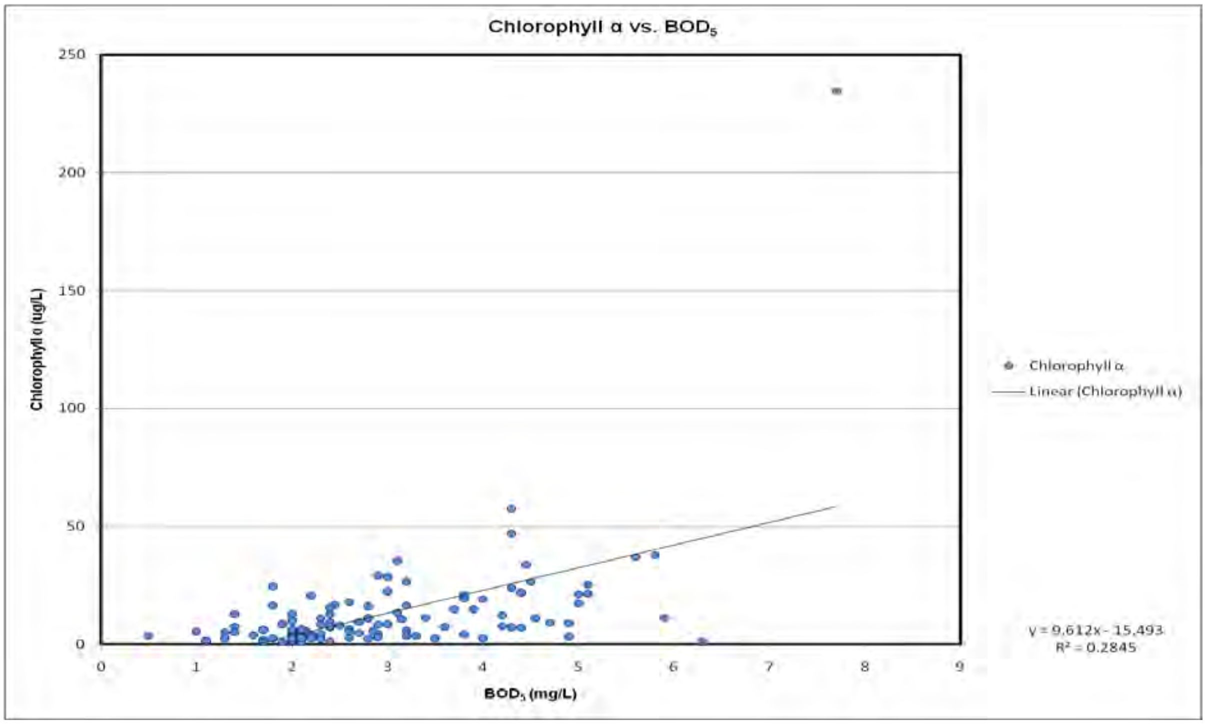
Figure 5.10 Relationship Between Chlorophyll α and TKN Observations for Rattlesnake Slough



As mentioned above, when the Spearman correlation test was performed BOD demonstrated a significant correlation to chlorophyll α (**Appendix E**). **Figure 5.11** illustrates the relationship and the regression equation between chlorophyll α and BOD. Based on the regression equation (equation 4), chlorophyll α concentrations of 6.55 ug/L or less would be related to BOD concentrations less than 2.40 mg/L. Although, the TMDL considered BOD reductions necessary to achieve a DO concentration of 5.0 mg/L or greater, no compelling relationship could be established. However, when BOD levels are high, there is a probability the increased oxygen demand will have a negative influential affect on DO concentrations. Reductions in BOD to lower CHLA concentrations could also potentially increase DO levels.

chlorophyll α (ug/L) = 9.612(5-day biological oxygen demand (mg/L)) – 15.493 **(4)**

Figure 5.11 Relationship Between Chlorophyll α and BOD_5 Observations for Rattlesnake Slough



TMDL Objectives

Table 5.4 summarizes the dissolved oxygen and nutrient targets for the Rattlesnake Slough watershed.

Table 5.4. Proposed Target Concentrations for the Pollutants of Concern for Rattlesnake Slough Watershed

Impaired Parameter	Pollutant of Concern	Proposed Targets
Dissolved Oxygen	TP	0.48 mg/L
Chlorophyll α	TN	0.84 mg/L
	BOD	2.40 mg/L

Develop the Flow Duration Curve

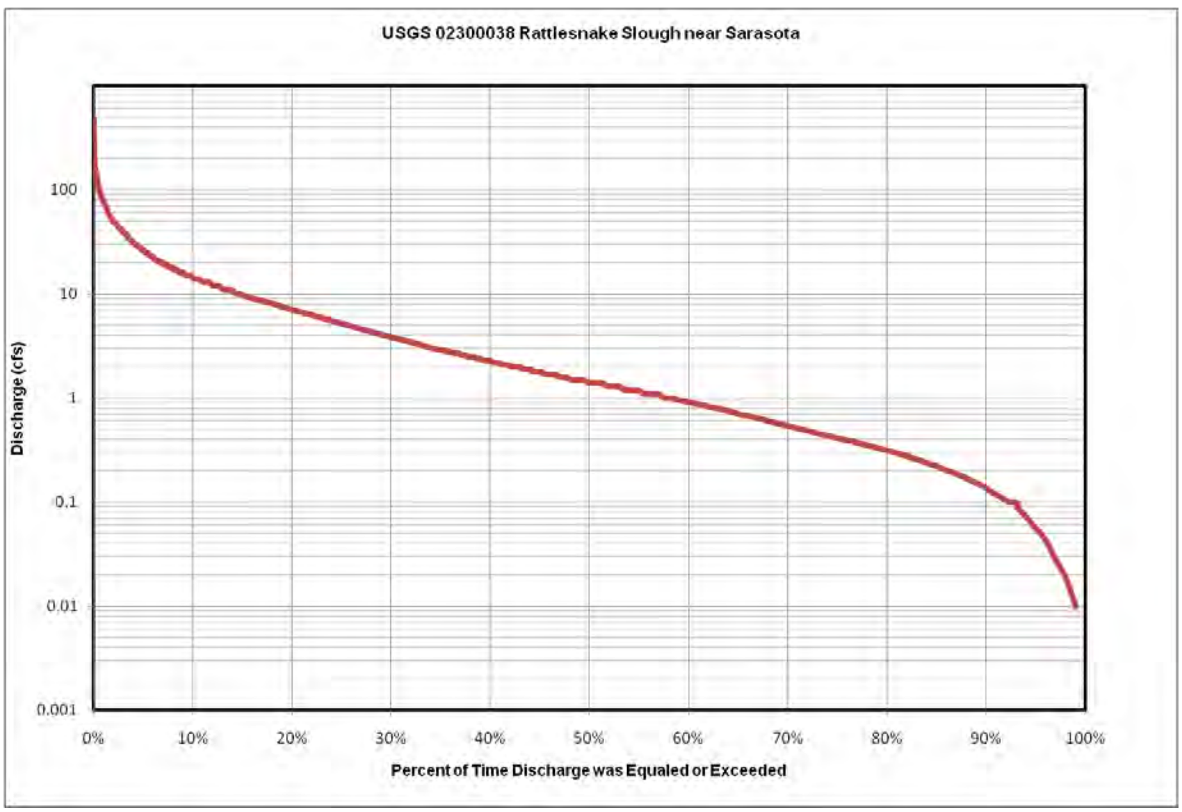
The load duration was chosen for TMDL development for several reasons. The calculated loads do not require any assumptions regarding loading rates, stream hydrology, land use conditions, or soil types. All available flow and water quality data are used providing an insight into critical conditions. The method also accurately identifies the allowable and existing loads at the point in the stream where sufficient data were collected.

The first step in the development of load duration curves is to create *flow duration curves.* This is a cumulative frequency curve of daily mean flows without regard to chronology of occurrence

(Leopold, 1994). The flow duration curve includes all flows observed at the gage for the applicable period of record; flow rates are typically sorted from the highest value to the lowest. For each flow value the curve displays the corresponding percent of time that flow value is met or exceeded–the flow duration interval (FDI). Extremely high flows are rarely exceeded and have low FDI values; very low flows are often exceeded and have high FDI values.

The range of flows from the USGS flow gage was divided into "flow zones." The concept of zones is adopted from Dr. Bruce Cleland (Cleland, August 15, 2002). The purpose of the zones is to demarcate hydrologic conditions between drought and peak flood into flow ranges such as low, dry, average, moist, and high. Expressing the flows in terms of frequency of recurrence (duration) allows a linkage of exceedances of the criterion to specific flow intervals and durations. Following Dr. Cleland's approach (Cleland, September 2003), the Department selected the following flow zones: "High" (0 – 10), "Moist"(11 – 40), "Mid-Range" (41 – 60), "Dry" (61 – 90), and "Low" (91 – 100). **Figure 5.12** shows the flow duration curve for USGS Gage 02300038 (located approximately 0.5 mile upstream from the mouth of the slough). The period of record used for the flow duration analysis for gage 02300038 is July 1, 1988 to September 30, 2008.

Figure 5.12 Flow Duration Curve for USGS Gage 02300038, Rattlesnake Slough near Sarasota, FL



Develop the Load Duration Curves for Both the Allowable Load and Existing Loading Capacity

A load duration limit curve can be created from a flow duration curve by multiplying the flow values by the applicable water quality criterion or target and a conversion factor (equation 5). The independent x-axis remains as the FDI, and the dependent y-axis depicts the load at that point in the watershed rather than the flow. The limit curve or target line therefore represents the allowable load (or the TMDL) at each flow condition.

allowable load = (observed flow) x (conversion factor) x (state criteria or target) ***(5)***

existing loading = (observed flow) x (conversion factor) x (measured concentration) ***(6)***

The load duration curve for the Rattlesnake Slough is shown in **Figure 5.13**, using a target of 0.48 mg/L total phosphorus. **Figure 5.13** also displays the observed loads, which are calculated by multiplying the sampled total phosphorus concentration by the daily mean flow (equation 6). Points plotting above the curve represent exceedances of the target and are therefore unallowable loads. Those plotting below the curve represent compliance with the target and allowable daily loads. **Figure 5.14** depicts the load duration curve for total nitrogen using a target of 0.84 mg/L and the BOD load duration curve using a target of 2.40 mg/L is shown in **Figure 5.15**.

As shown in **Figures 5.13 -5.15**, exceedances for TP, TN, and BOD criteria in the Rattlesnake Slough occur across the entire span of the flow record. The nature of the impairment can be inferred based on when the loads occur (Cleland, 2003). In general, exceedances on the right side of the curve typically occur during low-flow events, which implies a contribution from either point sources or base flow, which could come from the load from failed septic tanks and sewer line leakage that interact with surface water. The exceedances that appear on the left side of the curve usually represent loading from stormwater-related sources.

Figure 5.13 Load Duration Curve for Total Phosphorus in Rattlesnake Slough, WBID 1923

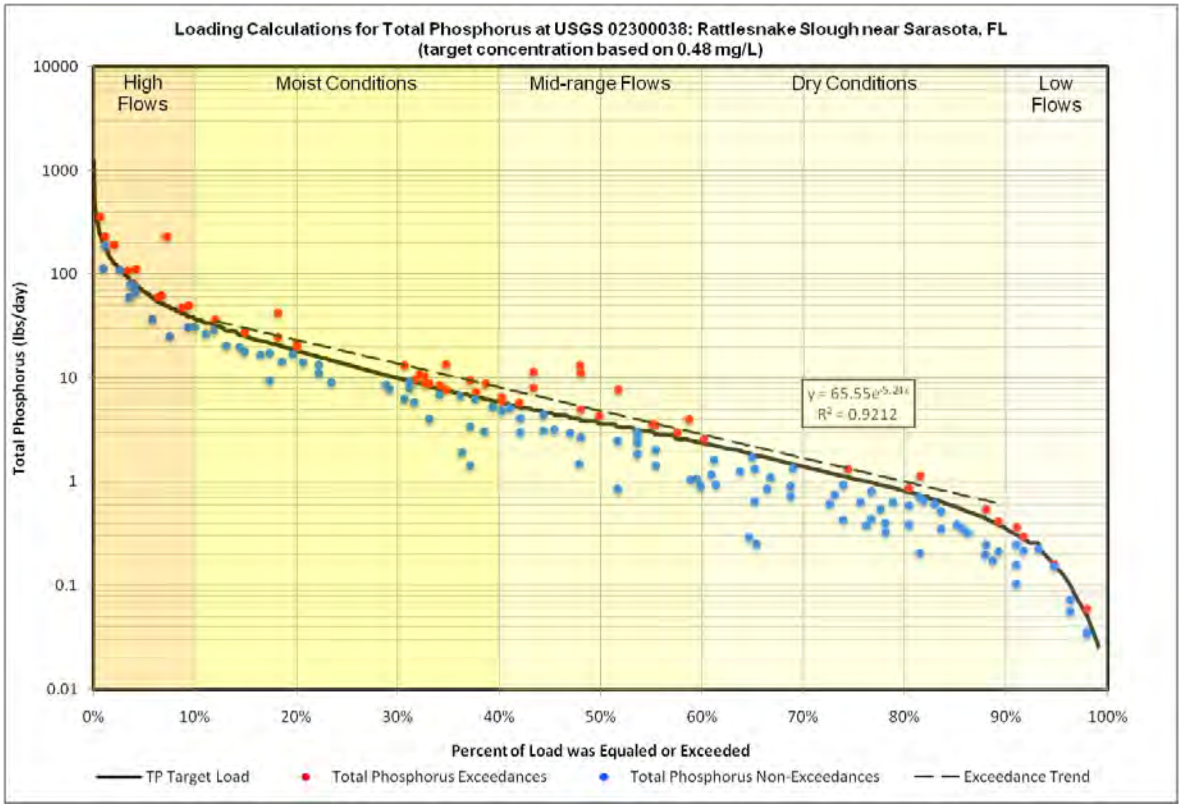


Figure 5.14 Load Duration Curve for Total Nitrogen in Rattlesnake Slough, WBID 1923

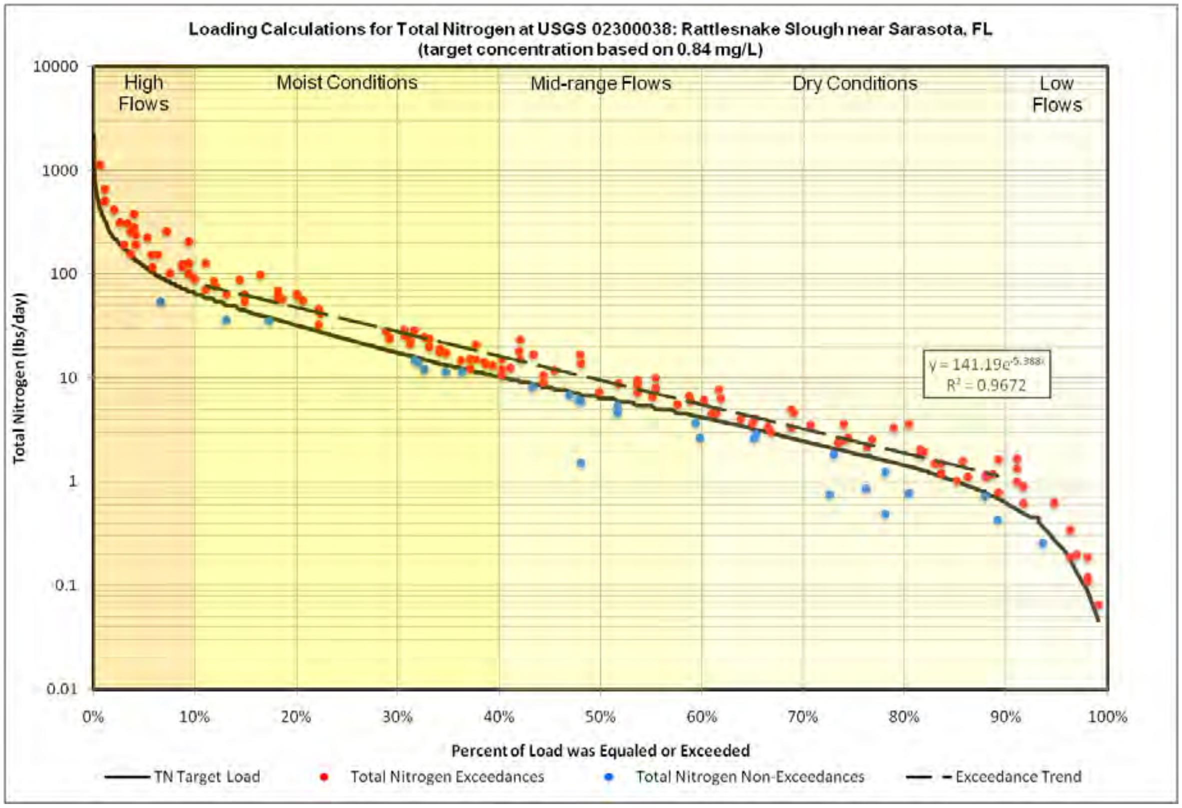
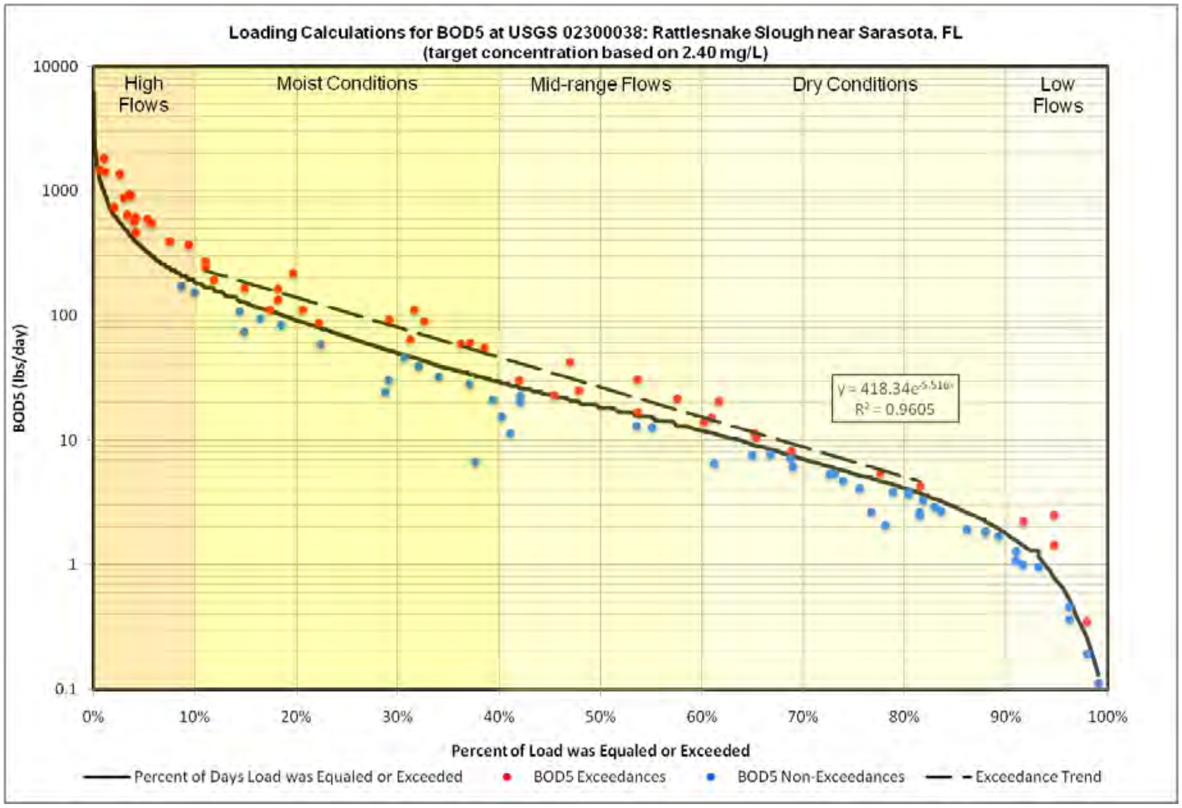


Figure 5.15 Load Duration Curve for BOD_5 in Rattlesnake Slough, WBID 1923



Define the Critical Condition

The critical condition for nutrient loadings in a given watershed depends on many factors, including the presence of point sources and the land use pattern in the watershed. Typically, the critical condition for nonpoint sources is an extended dry period followed by a rainfall runoff event. During the wet weather period, rainfall washes off nutrients that have built up on the land surface under dry conditions, resulting in the wet weather exceedances. However, significant nonpoint source contributions can also appear under dry conditions without any major surface runoff event. This usually happens when nonpoint sources contaminate the surficial aquifer, and nutrients are brought into the receiving waters through base flow. In addition, wildlife having direct access to the receiving water can contribute to the exceedance during dry weather. The critical condition for point source loading typically occurs during periods of low stream flow, when dilution is minimized.

Loads that plot above the curve during flow duration intervals of 85 to 99 (low flow conditions) are likely indicative of constant discharge sources such as wastewater treatment plants, irrigation return flows, or dry weather flows. Those plotting above the curve between flow duration intervals of 10 to 70 reflect wet weather contributions associated with sheet and rill erosion, wash off processes, and, potentially, stream bank erosion. Those loads plotting above the curve at flow duration intervals greater than 99 or less than 10 percent reflect extreme hydrologic conditions of drought or flood, respectively.

For the Rattlesnake Slough watershed because TP, TN, and BOD exceedances occur throughout the flow record, no critical flow condition was defined for this TMDL. The Department used the flow records and water quality data available between the 10^{th} to 90^{th} percentile flow duration intervals for the TMDL analysis. Flow conditions that were exceeded less than 10 percent of the time were not used because they represent abnormally high-flow events, and flow conditions occurring greater than 90 percent of the time were not used because they are extreme low-flow events.

Establish the Needed Load Reduction by Comparing the Existing Load with the Allowable Load under the Critical Condition

In **Figures 5.13 – 5.15**, points plotting above the load duration curves represent exceedances of the proposed target for TP, TN, and BOD respectively and are therefore unallowable loads. The percent reduction required to achieve the target load was determined by first establishing a trend line for the loads that exceeded the allowable loading. Loadings between the 10^{th} to 90^{th} percentiles were used for the trend line analysis. Exceedances occurring during abnormally high-flow events (10% of the time or less) or low-flow events (90% or greater) were not used in the analysis. Several types of trend lines were examined, and the exponential function was found to have the highest correlation coefficient (R^2) or "goodness of fit". The R^2 indicates how closely the estimated values for the trend line correspond to actual data. A trend line is most reliable when its R^2 value is near 1.00. Therefore, the exponential function was used to predict the existing loads at every 5^{th} percentile flow interval between the 10^{th} and 90^{th} percentile. The following is the exponential equation developed to predict the total phosphorus existing loading:

$$\textit{total phosphorus} = 65.55e^{-5.24x} \qquad (7)$$

Where:

X is the flow duration interval between the 10^{th} and 90^{th} percentile.

Similar equations were also developed to predict the total nitrogen and BOD_5 existing loadings. Equation 8 calculates the existing loadings for total nitrogen:

$$\textit{total nitrogen} = 141.19e^{-5.388x} \qquad (8)$$

Where:

X is the flow duration interval between the 10^{th} and 90^{th} percentile.

Equation 9 predicts the existing loadings for BOD_5:

$$BOD_5 = 418.24e^{-5.516x} \qquad (9)$$

Where:

X is the flow duration interval between the 10^{th} and 90^{th} percentile.

For comparative purposes, the allowable loadings were calculated as the product of the water quality target and the flow corresponding to a given flow duration interval between the 10^{th} and 90^{th} percentile (in increments of 5 percent).

A percent reduction was calculated for each interval between the 10^{th} and 90^{th} percentile flow intervals using the following equation:

$$\textit{load reduction} = (\textit{existing loading} - \textit{allowable loading}) * 100 / \textit{existing loading} \qquad (10)$$

The final percent reduction needed was the median of all the percent reductions calculated at the various recurrence intervals between the 10^{th} and 90^{th} percentile. **Table 5.5, Table 5.6, and Table 5.7** show the calculations of the TMDL and percent reductions for total phosphorus, total nitrogen and BOD, respectively, in Rattlesnake Slough.

Table 5.5 Calculations for Total Phosphorus Reductions for the Dissolved Oxygen TMDL for Rattlesnake Slough

Flow Interval	Flow (cfs)	AllowableTP Loading (lbs/day)	Existing TP Loading (lbs/day)	% Reduction
10%	14.21	36.78	38.82	5.23%
15%	9.80	25.37	29.87	15.05%
20%	7.03	18.19	22.98	20.86%
25%	5.20	13.46	17.69	23.88%
30%	3.85	9.96	13.61	26.84%
35%	2.90	7.51	10.47	28.31%
40%	2.29	5.94	8.06	26.31%
45%	1.80	4.66	6.20	24.85%
50%	1.40	3.62	4.77	24.05%
55%	1.19	3.08	3.67	16.10%
60%	0.92	2.38	2.83	15.71%
65%	0.71	1.84	2.17	15.47%
70%	0.55	1.42	1.67	14.90%
75%	0.42	1.09	1.29	15.55%
80%	0.32	0.83	0.99	16.39%
85%	0.23	0.60	0.76	21.90%
90%	0.14	0.36	0.59	38.22%
Median				**20.86%**

Table 5.6 Calculations for Total Nitrogen Reductions for the Nutrients TMDL for Rattlesnake Slough

Flow Interval	Flow (cfs)	Allowable TN Loading (lbs/day)	Existing TN Loading (lbs/day)	% Reduction
10%	14.21	64.37	82.38	21.86%
15%	9.80	44.40	62.92	29.44%
20%	7.03	31.83	48.06	33.77%
25%	5.20	23.56	36.71	35.83%
30%	3.85	17.42	28.04	37.86%
35%	2.90	13.14	21.42	38.66%
40%	2.29	10.39	16.36	36.48%
45%	1.80	8.15	12.50	34.75%

Flow Interval	Flow (cfs)	Allowable TN Loading (lbs/day)	Existing TN Loading (lbs/day)	% Reduction
50%	1.40	6.34	9.55	33.56%
55%	1.19	5.39	7.29	26.06%
60%	0.92	4.17	5.57	25.16%
65%	0.71	3.22	4.25	24.39%
70%	0.55	2.49	3.25	23.32%
75%	0.42	1.90	2.48	23.34%
80%	0.32	1.45	1.90	23.53%
85%	0.23	1.04	1.45	28.05%
90%	0.14	0.63	1.11	42.66%
Median				**29.44%**

Table 5.7 Calculations for BOD_5 Reductions for the Nutrients TMDL for Rattlesnake Slough

Flow Interval	Flow (cfs)	Allowable BOD_5 Loading (lbs/day)	Existing BOD_5 Loading (lbs/day)	% Reduction
10%	14.208	183.91	240.98	23.68%
15%	9.8	126.85	182.89	30.64%
20%	7.026	90.95	138.81	34.48%
25%	5.2	67.31	105.35	36.11%
30%	3.846	49.78	79.96	37.74%
35%	2.9	37.54	60.68	38.14%
40%	2.294	29.69	46.06	35.53%
45%	1.8	23.30	34.96	33.35%
50%	1.4	18.12	26.53	31.69%
55%	1.19	15.40	20.14	23.50%
60%	0.92	11.91	15.28	22.08%
65%	0.71	9.19	11.60	20.76%
70%	0.55	7.12	8.80	19.13%
75%	0.42	5.44	6.68	18.63%
80%	0.32	4.14	5.07	18.31%
85%	0.23	2.98	3.85	22.64%
90%	0.14	1.81	2.92	37.96%
Median				**30.64%**

5.1.3 Critical Conditions/Seasonality

A nonparametric test (Kruskal-Wallis) was applied to the DO, CHLA, TN, TP, and BOD5 datasets to determine whether there were significant difference among seasons and months. Kruskal-Wallis tests the medians between groups and then calculates if there is any significant difference between the groups (chi-square). If a chi-square value calculated is greater than the expected value, then there are significant differences between the medians (**Appendix F**). All the parameters with the exception of total nitrogen showed notable differences among seasons and months. Total nitrogen did not show any meaningful differences between seasons or months; however, TN did show annual median differences where chi-square was greater than expected.

For the Rattlesnake Slough watershed rainfall data (**Appendix G**) were used to compare with the measured DO and CHLA data. Measurements were sorted by month and season to determine whether there was a temporal pattern of exceedances. Daily rainfall data from Bradenton 5ESE were also obtained and included in the analysis. **Table 5.8**, **Figures 5.16a** and **5.16b** presents summary statistics by month and season, for dissolved oxygen measurements. The chlorophyll α summary statistics are shown in **Table 5.9**, **Figures 5.17a** and **5.17b**.

Table 5.8 Summary Statistics of Dissolved Oxygen Data for Rattlesnake Slough, WBID 1923, by Month and Season

Month	Number of Observations	Minimum	Maximum	Median	Mean	Number of Exceedances	% Exceedance of TP	Average Monthly Rainfall (in)
January	18	3.90	9.90	7.05	7.09	3	16.7%	2.74
February	19	3.00	11.40	6.80	6.52	6	31.6%	2.51
March	21	3.40	8.70	5.60	5.93	2	9.5%	3.42
April	24	2.90	8.90	5.40	5.67	7	29.2%	1.76
May	16	3.10	7.20	4.50	4.60	12	75.0%	2.70
June	22	3.60	6.20	4.80	4.88	11	50.0%	8.10
July	23	2.80	8.57	4.30	4.72	13	56.5%	8.83
August	24	2.70	8.80	4.90	4.85	12	50.0%	9.47
September	25	2.80	6.40	4.30	4.52	16	64.0%	7.41
October	20	2.80	6.70	5.40	5.41	5	25.0%	2.92
November	19	4.30	9.10	6.80	6.35	5	26.3%	1.99
December	20	4.90	7.80	7.05	6.73	1	5.0%	2.29
Season	**Number of Observations**	**Minimum**	**Maximum**	**Median**	**Mean**	**Number of Exceedances**	**% Exceedance of TP**	**Average Monthly Rainfall (in)**
Winter	58	3.00	11.4	6.35	6.48	8	13.8%	8.67
Spring	62	2.90	8.9	5.00	5.11	23	37.1%	12.48
Summer	72	2.70	8.8	4.435	4.69	35	48.6%	25.72
Fall	59	2.80	9.1	6.30	6.16	10	16.9%	7.10

Figure5.16a Monthly Dissolved Oxygen Exceedances and Rainfall for Rattlesnake Slough

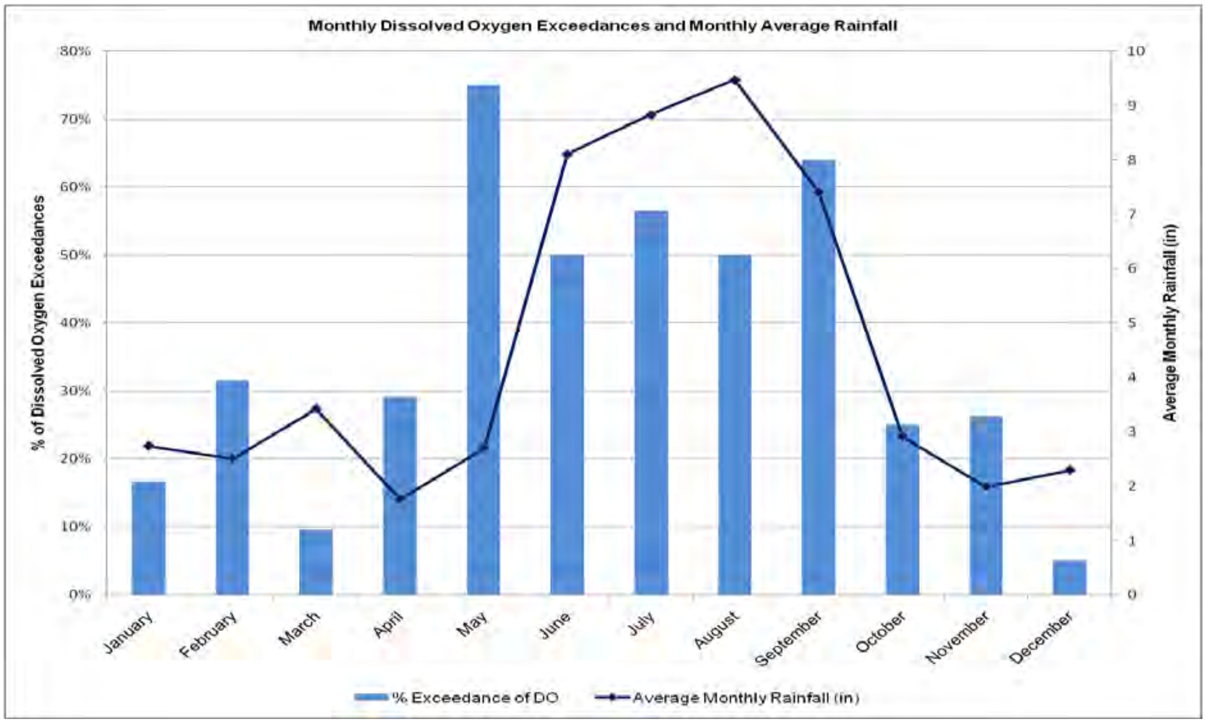


Figure5.16b Seasonal Dissolved Oxygen Exceedances and Rainfall for Rattlesnake Slough

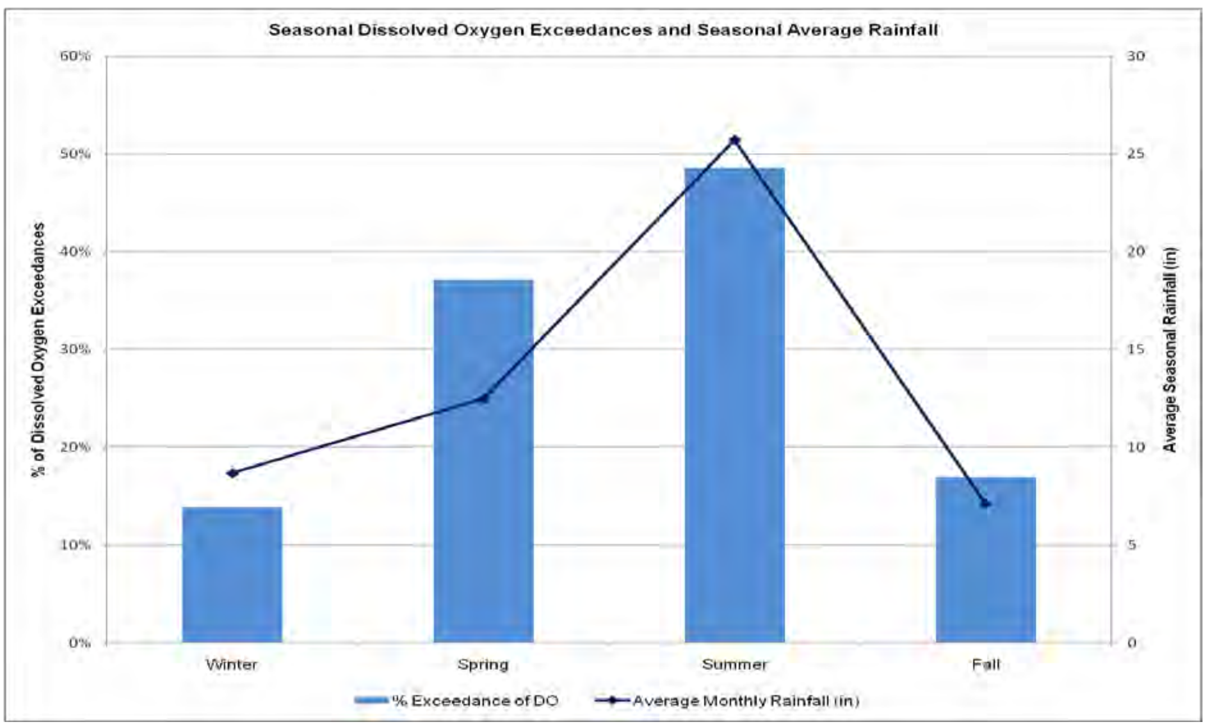


Table 5.9 Summary Statistics of Chlorophyll α Data for Rattlesnake Slough, WBID 1923, by Month and Season

Month	Number of Observations	Minimum	Maximum	Median	Mean	Number of Exceedances	% Exceedance of CHLA	Average Monthly Rainfall (in)
January	16	1.00	15.40	6.25	6.81	8	50.0%	2.74
February	16	1.00	30.50	4.67	8.95	5	31.3%	2.51
March	18	1.00	24.51	4.73	5.65	4	22.2%	3.42
April	19	1.00	57.40	4.40	12.78	7	36.8%	1.76
May	13	1.00	16.49	6.60	7.25	7	53.8%	2.70
June	18	4.08	215.40	17.68	28.09	12	66.7%	8.10
July	21	1.00	58.80	10.80	15.60	11	52.4%	8.83
August	20	1.40	36.90	9.60	10.32	11	55.0%	9.47
September	19	1.00	29.20	8.00	10.07	10	52.6%	7.41
October	18	1.30	12.80	3.50	4.91	4	22.2%	2.92
November	16	1.00	26.40	7.30	8.48	8	50.0%	1.99
December	15	1.00	234.40	2.60	19.81	4	26.7%	2.29
Season	**Number of Observations**	**Minimum**	**Maximum**	**Median**	**Mean**	**Number of Exceedances**	**% Exceedance of CHLA**	**Average Monthly Rainfall (in)**
Winter	50	1.00	30.5	5.15	7.08	17	34.0%	8.67
Spring	50	1.00	215.4	6.92	16.85	26	52.0%	12.48
Summer	60	1.00	58.8	8.2	12.09	32	53.3%	25.72
Fall	49	1.00	234.4	3.50	10.64	16	32.7%	7.10

Figure5.17a Monthly Chlorophyll α Exceedances and Rainfall for Rattlesnake Slough

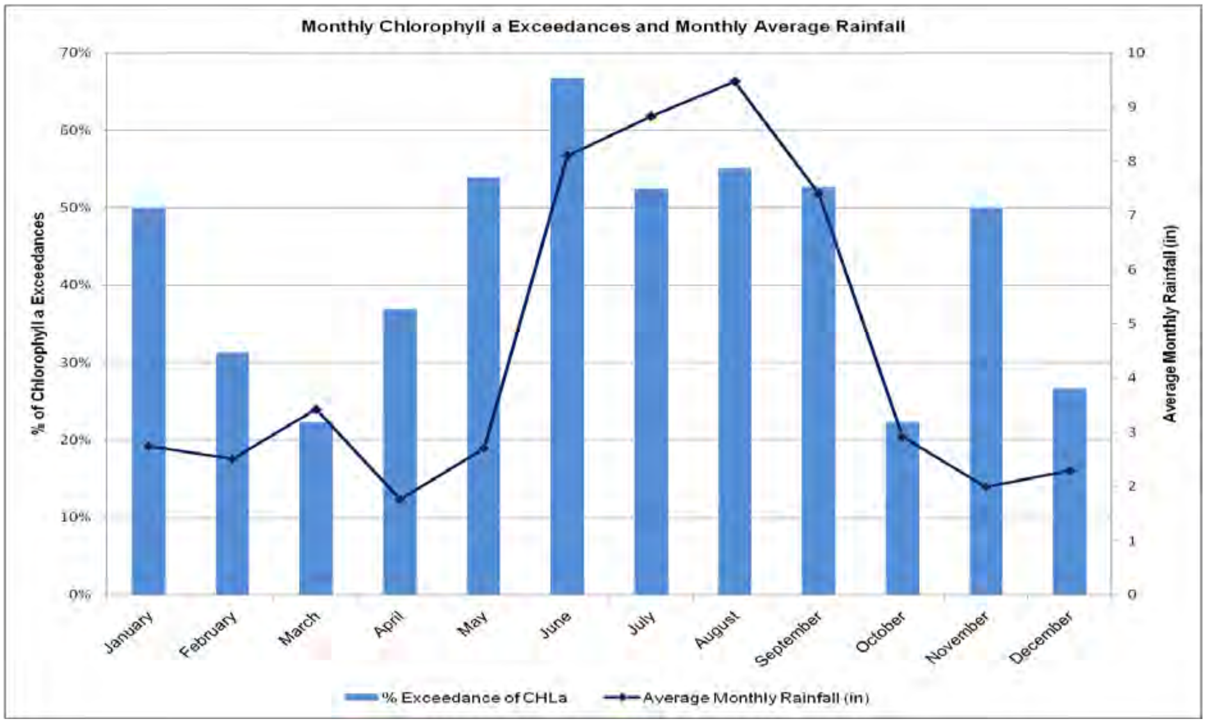
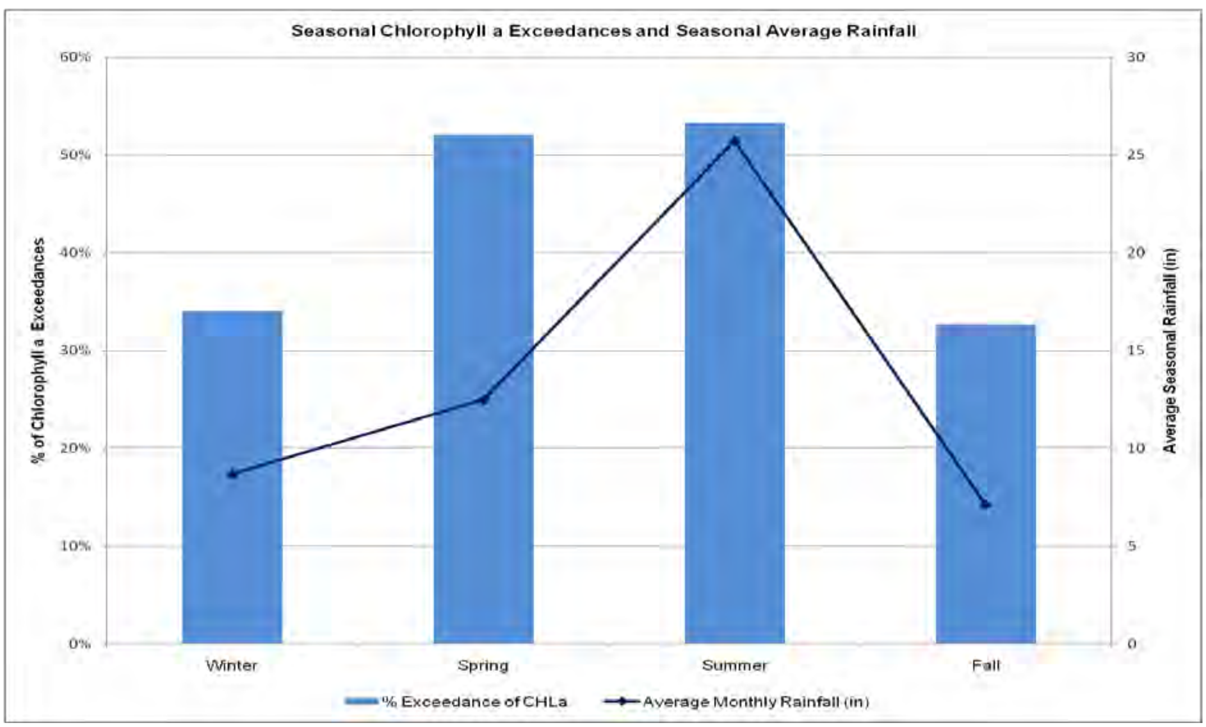


Figure5.17b Seasonal Chlorophyll α Exceedances and Rainfall for Rattlesnake Slough



The data for Rattlesnake Slough reflected a temporal pattern of critical seasonal increase. For dissolved oxygen, during the wet season months beginning in May to September exceedances were observed with increase rainfall mean, also on a seasonal approach there were a direct correlation with rainfall and % exceedances. The chlorophyll α data showed similar patterns of seasonality. However, the data also indicated an increase in exceedances during the dry season of the year for the cooler months of January and November.

A major advantage of flow duration curves is the ability to consider the general hydrologic condition of the watershed. However, they provide limited information regarding the magnitude or nature of the various sources. In the instance of chlorophyll α, a Spearman matrix correlation showed a stronger correlation between a 7-day and 14-day moving average with rainfall (**Appendix H**), suggesting other mechanisms such as the transport of nutrients from runoff. Higher exceedances during drier, cooler months indicate rainfall may not be the only means of pollutant transport in the watershed. Chlorophyll α monthly exceedances rates were 22% or higher. As a result, the loading reductions for the TMDL were calculated for the entire year.

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:

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

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

$$\textbf{TMDL} \cong \sum \textbf{WLAs}_{\textbf{wastewater}} + \sum \textbf{WLAs}_{\textbf{NPDES Stormwater}} + \sum \textbf{LAs} + \textbf{MOS}$$

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 Rattlesnake Slough are expressed in terms of a percent reduction in total phosphorus, total nitrogen, and 5-day biological oxygen demand to meet both the DO and nutrient criteria (**Table 6.1**).

Table 6.1. TMDL Components for Rattlesnake Slough

WBID	Parameter	TMDL (mg/L)	WLA		LA (% Reduction)[1]	MOS
			Wastewater (mg/L)	NPDES Stormwater (% Reduction)[1]		
1923	TP	0.48	N/A	21%	21%	Implicit
1923	TN	0.84	NA	30%	30%	Implicit
1923	BOD_5	2.40	NA	31%	31%	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 total phosphorus reduction of 21%, a total nitrogen reduction of 30%, and a BOD_5 reduction of 31% 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 Rattlesnake Slough watershed; however, any future discharge permits issued in the watershed will also be required to meet the state's Class I criterion for DO and contain appropriate discharge limitations on phosphorus, nitrogen, and BOD_5that will comply with the TMDL.

6.3.2 NPDES Stormwater Discharges

The WLA for stormwater discharges with an MS4 permit would responsible for a reduction in current anthropogenic TP, TN, and BOD loadings of 21%, 30% and 31%, respectively. 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 applying a ten percent increase above minimum criterion of 5.0 mg/L for dissolved oxygen and by applying the historically observed value of 6.54 ug/L for chlorophyll α.

Chapter 7: TMDL IMPLEMENTATION

TMDL Implementation

Following the adoption of this TMDL by rule, the Department will determine the best course of action regarding its implementation. Depending upon the pollutant(s) causing the waterbody impairment and the significance of the waterbody, the Department will select the best course of action leading to the development of a plan to restore the waterbody. Often this will be accomplished cooperatively with stakeholders by creating a Basin Management Action Plan, referred to as the BMAP. Basin Management Action Plans are the primary mechanism through which TMDLs are implemented in Florida [see Subsection 403.067(7) F.S.]. A single BMAP may provide the conceptual plan for the restoration of one or many impaired waterbodies.

If the Department determines a BMAP is needed to support the implementation of this TMDL, a BMAP will be developed through a transparent stakeholder-driven process intended to result in a plan that is cost-effective, technically feasible, and meets the restoration needs of the applicable waterbodies. Once adopted by order of the Department Secretary, BMAPs are enforceable through wastewater and municipal stormwater permits for point sources and through BMP implementation for nonpoint sources. Among other components, BMAPs typically include:

- Water quality goals (based directly on the TMDL);
- Refined source identification;
- Load reduction requirements for stakeholders (quantitative detailed allocations, if technically feasible);
- 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;
- Implementation funding mechanisms;
- An evaluation of future increases in pollutant loading due to population growth;
- Implementation milestones, project tracking, water quality monitoring, and adaptive management procedures; and
- Stakeholder statements of commitment (typically a local government resolution).

BMAPs are updated through annual meetings and may be officially revised every five years. Completed BMAPs in the state have improved communication and cooperation among local stakeholders and state agencies, improved internal communication within local governments, applied high-quality science and local information in managing water resources, clarified obligations of wastewater point source, MS4 and non-MS4 stakeholders in TMDL implementation, enhanced transparency in DEP decision-making, and built strong relationships between DEP and local stakeholders that have benefited other program areas.

However, in some basins, and for some parameters, particularly those with fecal coliform impairments, the development of a BMAP using the process described above will not be the most efficient way to restore a waterbody, such that it meets its' designated uses. Why? Because fecal coliform impairments result from the cumulative effects of a multitude of potential sources, both natural and anthropogenic. Addressing these problems requires good old fashioned detective work that is best done by those in the area. There are a multitude of assessment tools that are available to assist local governments and interested stakeholders in this detective work. The tools range from the simple – such as Walk the WBIDs and GIS mapping - to the complex such as Bacteria Source Tracking. Department staff will provide technical assistance, guidance, and oversight of local efforts to identify and minimize fecal coliform sources of pollution. Based on work in the Lower St Johns River tributaries and the Hillsborough River basin, the Department and local stakeholders have developed a logical process and tools to serve as a foundation for this detective work. In the near future, the Department will be releasing these tools to assist local stakeholders with the development of local implementation plans to address fecal coliform impairments. In such cases, the Department will rely on these local initiatives as a more cost-effective and simplified approach to identify the actions needed to put in place a roadmap for restoration activities, while still meeting the requirements of Chapter 403.067(7), F.S.

References

Cleland, B. August 15, 2002. *TMDL Development from the Bottom Up – Part II: Using Load Duration Curves to Connect the Pieces*. Washington, D.C.: America's Clean Water Foundation.

Cleland, B. September 2003. *TMDL Development from the Bottom Up – Part III: Duration Curves and Wet-Weather Assessments.* Washington, D.C.: America's Clean Water Foundation.

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.

———. 2003. *Basin Status Report: Tampa Bay Basin.* Tallahassee, Florida: Bureau of Watershed Management.

Florida Department of Health Website. 2008. Available: http://www.doh.state.fl.us/environment/OSTDS/statistics/ostdsstatistics.htm.

Gao, Xueqing. 2006 *Nutrient and Unionized Ammonia TMDLs for Lake Jesup WBIDs 2981 and 2981A*. FDEP, Tallahassee, Florida. Bureau of Watershed Management Available: http://www.dep.state.fl.us/water/tmdl/docs/tmdls/final/gp2/lake-jessup-nutr_ammonia-tmdl.pdf

Harper, H.H., and D.M. Baker. 2007. *Evaluation of current stormwater design criteria within the state of Florida.* Orlando, Florida: Environmental Research & Design, Inc.

Leopold, L.B. 1994. *A View of the River.* Harvard University Press. Cambridge, MA.

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.

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

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, CHLA, BOD_5, TN, and TP Observations in Rattlesnake Slough, 1992–2008

Date	Station	BOD_5 (mg/L)	Chlorophyll α (ug/L)	Dissolved Oxygen (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
1/1/1990	21FLMANATS1		7.56		0.795	1.103
2/1/1990	21FLMANATS1		30.5		1.392	
3/20/1990	21FLMANATS1		1		1.2	
4/1/1990	21FLMANATS1		1.77	4.7	0.6	
7/10/1990	21FLMANATS1		1	4.3	0.612	
7/24/1990	21FLMANATS1		15.83	2.8	1.244	1.091
8/15/1990	21FLMANATS1		10	3	1.106	0.856
8/28/1990	21FLMANATS1		2.4	3	1.269	0.754
9/11/1990	21FLMANATS1		5.59	3.5	1.254	0.586
10/16/1990	21FLMANATS1		3.1			
11/6/1990	21FLMANATS1		6.4	4.6		
12/4/1990	21FLMANATS1		20.3	4.9	0.19	1.373
1/22/1991	21FLMANATS1		8.8	5.8	0.895	0.408
4/16/1991	21FLMANATS1		2.5	2.9	0.499	0.576
5/28/1991	21FLMANATS1		4.5	3.1	1.178	0.559
6/11/1991	21FLMANATS1		9		0.728	0.491
6/24/1991	21FLMANATS1		5	3.6	0.786	0.383
7/8/1991	21FLMANATS1		1	3.5	1.064	0.416
7/29/1991	21FLMANATS1		2.3	8.3	1.048	0.676
8/5/1991	21FLMANATS1		2.7	3.4	0.675	0.5
8/12/1991	21FLMANATS1		1.4	2.9	1.018	0.555
9/9/1991	21FLMANATS1		1	2.8	1.454	0.661
9/23/1991	21FLMANATS1		5.7	4	1.187	0.521
2/25/1992	21FLMANATS1		9.6	4.9	0.945	0.293
3/24/1992	21FLMANATS1		12.86	5.4	1.4	0.33
4/13/1992	21FLMANATS1		17.29	5.6	1.367	0.554
6/18/1992	21FLMANATS1		4.08	3.6	1.044	0.576
8/31/1992	21FLMANATS1		5	4.7	1.59	
9/8/1992	21FLMANATS1		4.83	4.2	1.44	0.57
10/26/1992	21FLMANATS1		1.73	4.9	1.02	
11/2/1992	21FLMANATS1		11	5.1		0.35
12/14/1992	21FLMANATS1		10.82	7.3	0.76	0.35
1/20/1993	21FLMANATS1		3.47	5.1		0.295
4/29/1993	21FLMANATS1		1	4	1.134	0.56
5/24/1993	21FLMANATS1		8.86	4.4	0.54	
7/20/1993	21FLMANATS1			3.2		0.39
9/29/1993	112WRD 02300038			3.7	0.9635	0.57
10/28/1993	21FLMANATS1		5.89	4.8	1.69	0.61
12/7/1993	112WRD 02300038			5.1	2.009	0.26
1/12/1994	21FLMANATS1			6.6	0.73	0.21

Date	Station	BOD_5 (mg/L)	Chlorophyll α (ug/L)	Dissolved Oxygen (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
2/28/1994	21FLMANATS1		3.05	6.8	0.66	0.21
3/7/1994	112WRD 02300038				0.738	0.33
3/21/1994	21FLMANATS1		1	3.4	2.07	0.56
6/17/1994	112WRD 02300038			6.2	1.52	0.38
6/20/1994	21FLMANATS1		26.45	5.4	1.363	0.341
7/18/1994	21FLMANATS1		3.71	3.6	1.105	0.467
8/9/1994	21FLMANATS1		3.71	5.4	1.25	0.38
9/21/1994	21FLMANATS1		1.49	2.9	1.371	0.527
10/24/1994	21FLMANATS1		1.72	6.1	0.694	0.349
11/11/1994	21FLMANATS1		1	4.4	0.96	0.301
12/7/1994	21FLMANATS1		1	7.8	0.537	0.179
12/14/1994	112WRD 02300038			6.4	0.984	0.2
1/11/1995	21FLMANATS1		9.58	9.8	0.78	0.13
2/16/1995	21FLMANATS1	2.3	3.4	5.5	1.29	0.31
3/22/1995	21FLMANATS1	2	2.48	7	0.875	0.24
4/10/1995	112WRD 02300038				0.9225	0.32
4/19/1995	21FLMANATS1	1.7	1	5.1	1.03	0.49
6/21/1995	21FLMANATS1	2.2	20.56	4.6	1.27	0.43
6/26/1995	112WRD 02300038				1.107	0.47
7/24/1995	21FLMANATS1	1.7	6.16		1.062	0.424
8/23/1995	21FLMANATS1	3.8	19.5	6.6	1.193	0.408
9/4/1995	112WRD 02300038			5.5	1.64	0.52
9/13/1995	21FLMANATS1	1.8	16.47	3.5	1.263	
10/17/1995	21FLMANATS1	2.4	1.31	6.3	1.718	0.573
11/7/1995	21FLMANATS1	1.1	1.6	7	1.274	0.387
12/13/1995	21FLMANATS1	2	3.17	5.2	1.279	0.284
1/17/1996	112WRD 02300038				1.394	0.23
2/20/1996	21FLMANATS1	3.2	5.95	7.9	0.962	0.242
2/21/1996	112WRD 02300038				0.943	0.24
3/18/1996	21FLMANATS1	2.7	4.76	5	1.18	0.452
4/10/1996	21FLMANATS1	1	5.38	5.2	1.108	0.45
5/15/1996	21FLMANATS1	1.6	3.94	3.9	1.31	0.727
6/18/1996	21FLMANATS1	4.3	7.23	3.8	1.182	0.264
7/9/1996	21FLMANATS1	3.1	13.37	4.2	1.021	0.334
7/15/1996	112WRD 02300038				1.0865	0.45
8/13/1996	112WRD 02300038				1.0865	0.34
8/19/1996	21FLMANATS1	4.7	9.2	3.9	1.464	0.36
9/16/1996	21FLMANATS1	2.6	6.52	4.3	1.352	0.421
10/3/1996	112WRD 02300038				0.779	0.51
10/28/1996	21FLMANATS1	2.4	9.22	5.1	0.982	
11/12/1996	21FLMANATS1	1.1	1.49	9.1	0.261	0.172
11/18/1996	112WRD 02300038				0.41	0.18
12/16/1996	21FLMANATS1	1.4	7.43	7.8	1.016	0.343

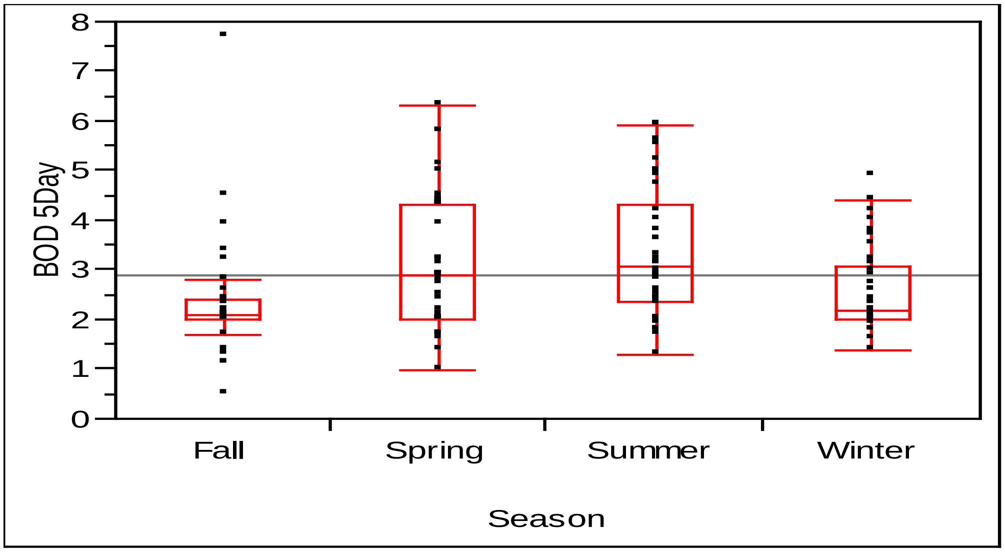
Date	Station	BOD_5 (mg/L)	Chlorophyll α (ug/L)	Dissolved Oxygen (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
1/14/1997	112WRD 02300038				0.656	0.12
2/24/1997	21FLMANATS1	2.3	4.34	3	2.12	0.508
3/24/1997	21FLMANATS1	1.8	24.51	6.3	1.026	0.297
3/26/1997	112WRD 02300038				0.861	0.32
4/29/1997	21FLMANATS1	2.9	4.31	3.6	1.473	0.7
5/27/1997	21FLMANATS1	1.4	12.7	4.5	1.143	0.362
6/30/1997	21FLMANATS1		5.64	6.2	1.648	0.785
7/21/1997	21FLMANATS1	1.3	4.96	3.7	1.274	0.5
8/11/1997	21FLMANATS1	2.4	12.7	8.8	1.699	0.458
8/20/1997	112WRD 02300038				1.271	0.62
9/22/1997	21FLMANATS1	1.8	2.51	4.3	1.009	0.542
10/6/1997	21FLMANATS1	0.5	3.56	5.7	1.56	0.542
11/3/1997	21FLMANATS1	3.4	11.21	4.3	2.275	0.485
12/22/1997	21FLMANATS1	2	2	7.8	1.647	0.365
1/12/1998	21FLMANATS1	3.5	2.58	7.5	1.842	
2/23/1998	21FLMANATS1	1.4	5	4.6	1.2	0.519
3/9/1998	21FLMANATS1	4.4	7.16	5.6	1.682	
4/27/1998	21FLMANATS1	2	2.51	4.9	2.557	0.244
5/11/1998	21FLMANATS1	3.2	16.49	4.2	1.721	0.326
6/1/1998	21FLMANATS1	4.3	23.77	5.7	1.076	0.669
7/13/1998	21FLMANATS1		58.8	5.5	2.522	2.25
8/11/1998	21FLMANATS1	3.8	20.8	5.1	1.625	0.97
8/19/1998	21FLTPA 24010073			3.36		
9/14/1998	21FLMANATS1	2.5	8	5.6	1.281	0.34
10/27/1998	21FLMANATS1	2.1	3.5	4.7	1.787	0.346
11/23/1998	21FLMANATS1	4.5	26.4	6	1.687	
12/7/1998	21FLMANATS1	1.3	2.5	7.5	1.251	0.214
1/12/1999	21FLMANATS1	3	8.4	8.7	1.08	0.17
2/16/1999	21FLMANATS1		1.6	9	1.393	0.309
3/9/1999	21FLMANATS1		1.1	8.7		0.073
4/12/1999	21FLMANATS1	6.3	1.1	5.3		0.318
6/7/1999	21FLMANATS1		215.4	5.4	1.092	0.102
7/26/1999	21FLMANATS1		2.5	5.46	1.701	0.588
8/9/1999	21FLMANATS1	2	10.3	3.5	1.464	0.551
9/20/1999	21FLMANATS1	1.9	8.4	4.57	2.182	0.275
10/26/1999	21FLMANATS1	2.8	11	6.5		0.279
11/29/1999	21FLMANATS1	1.7	1.9	7.8	1.526	0.378
12/13/1999	21FLMANATS1	7.7	234.4	7.7	1.922	0.497
1/11/2000	21FLMANATS1	2.6	2.7	6.5	1.598	0.285
2/14/2000	21FLMANATS1	1.9	1	7.9		0.29
3/27/2000	21FLMANATS1	2.1	1.3	5.5	0.967	0.508
4/10/2000	21FLMANATS1	1.7	1	6.81	0.866	0.261
5/16/2000	21FLMANATS1	2.1	1	7.2	1.189	

Date	Station	BOD_5 (mg/L)	Chlorophyll α (ug/L)	Dissolved Oxygen (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
6/26/2000	21FLMANATS1	3.9	14.8	4.4	1.011	0.374
7/17/2000	21FLMANATS1	4.55	11	6.41	2.547	0.6155
8/28/2000	21FLMANATS1	4.9	3.2	6.7	0.798	0.34
9/18/2000	21FLMANATS1		10.6	6.4	1.307	0.59
10/30/2000	21FLMANATS1	3.2	3.5	5	0.933	0.414
11/27/2000	21FLMANATS1		13.1	7.2	1.336	0.239
1/23/2001	21FLMANATS1	3.7	14.8	9.2	1.504	0.363
4/23/2001	21FLMANATS1		4.4	7.4	1.097	0.318
7/24/2001	21FLMANATS1	2.9	4.3	5	2.204	0.699
8/27/2001	21FLMANATS1	2	2.5	3.6		0.458
9/18/2001	21FLMANATS1	3.6	7.3	5	1.677	0.465
10/30/2001	21FLMANATS1	2.3	10.9	6.2	1.266	
11/13/2001	21FLMANATS1	2.2	4.1	6.9	1.545	0.245
12/17/2001	21FLMANATS1	2.1	2	6.3	1.328	0.51
1/28/2002	21FLMANATS1	4.9	8.8	7.88	1.229	0.246
3/12/2002	21FLMANATS1	1.7	6	7.8	1.1695	0.1308
4/29/2002	21FLMANATS1	4.3	57.4	7.5		
6/26/2002	21FLMANATS1	4.4	21.9	5	1.234	
7/24/2002	21FLMANATS1	3.3	3.6	3	1.178	0.407
8/27/2002	21FLMANATS1	4.2	12.2	5.1	0.902	
10/23/2002	21FLMANATS1		1.3	6.3	1.239	
11/20/2002	21FLMANATS1	2.6	17.9	6.3	0.973	0.398
12/11/2002	21FLMANATS1	3.9		7.1	1.02	0.246
1/29/2003	21FLMANATS1		6.9	9.9	2.035	1.59
2/12/2003	21FLMANATS1	4.2	7.6	7.4	1.084	0.231
3/5/2003	21FLMANATS1	2.1	5.5	5.4	1.385	0.379
4/16/2003	21FLMANATS1	2	5.3	8.9	0.941	0.45
5/7/2003	21FLMANATS1	2.7	9.4	4.6	1.621	0.512
6/18/2003	21FLMANATS1	5	21.1	4.5		0.312
7/9/2003	21FLMANATS1	5	17.3	5.3	1.373	0.57
8/6/2003	21FLMANATS1	5.6	36.9	5.2		0.431
9/3/2003	21FLMANATS1	2.9	29.2	4.6	1.26	0.428
10/29/2003	21FLMANATS1		1.7	5.8	1.119	0.464
11/24/2003	21FLMANATS1	2.8	2.4	7.8	0.775	0.067
12/10/2003	21FLMANATS1	2.1	1	6.4	0.918	
1/14/2004	21FLMANATS1	2	5.3	8.1	0.78	0.21
2/11/2004	21FLMANATS1	2.2	2.5	6.4	0.86	0.31
3/31/2004	21FLMANATS1	2	3.8	6.9	0.89	0.38
4/14/2004	21FLMANATS1	2.45	16.8	6.833333333		0.205
5/12/2004	21FLMANATS1	2.9	8.2	4.6	1.07	0.54
6/16/2004	21FLMANATS1	4.3	46.9	4.1	1.106	0.48
7/21/2004	21FLMANATS1	5.1	21.4	5	0.86	0.42
9/2/2004	21FLMANATS1			5.4		

Date	Station	BOD_5 (mg/L)	Chlorophyll α (ug/L)	Dissolved Oxygen (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
9/30/2004	21FLMANATS1	3	22.5	5.9		
10/6/2004	21FLMANATS1	2.1	5.4	3.9	0.75	0.57
11/17/2004	21FLMANATS1	2.2	3.6	6.8	0.47	0.23
12/8/2004	21FLMANATS1	2.1	2.9	6.1	0.3	0.24
1/12/2005	21FLMANATS1	4	2.6	6.2	1.02	0.55
2/9/2005	21FLMANATS1	2.2	2.6	11.4	0.74	0.3
3/24/2005	21FLMANATS1	2	4.8	5.05	1.38	0.34
4/27/2005	21FLMANATS1	5.1	25.2	6.7	1.44	0.44
5/25/2005	21FLMANATS1	2	2	5.4	1.04	0.56
6/8/2005	21FLMANATS1	2	5.3	5	1.17	0.4
7/27/2005	21FLMANATS1	2.4	7.2	3.4	1.13	0.5
8/24/2005	21FLMANATS1	2	3.1	4.3	1.1	0.42
9/22/2005	21FLMANATS1	2.3	2.3	4.2	1.5	0.49
10/27/2005	21FLMANATS1	2	12.8	6.7	2.06	0.35
11/22/2005	21FLMANATS1	2	9.9	7	1.1	0.26
12/7/2005	21FLMANATS1	2	4.1	7	1.05	0.18
1/24/2006	21FLMANATS1	2	1	4.8	1.49	0.39
2/16/2006	21FLMANATS1	2	2.5	7.8		0.16
3/22/2006	21FLMANATS1	2.6	5.3	5	1.06	0.1
4/12/2006	21FLMANATS1	2	3.3	5.5	1.13	0.31
5/11/2006	21FLMANATS1	2.9	3	5	0.985	0.15
6/21/2006	21FLMANATS1	2.85	5.5	5.7	1.235	0.52
7/11/2006	21FLMANATS1	3.2	26.6	6.2	1.55	0.54
8/15/2006	21FLMANATS1	5.9	11.1	5.4	1.355	0.47
9/13/2006	21FLMANATS1	2.8	16	5	1.575	0.725
10/19/2006	21FLMANATS1	2	2.75	5.1	2.035	0.37
11/1/2006	21FLMANATS1	2.4	15.5	4.8	1.15	0.2
12/13/2006	21FLMANATS1	2	1.45	7.3	0.825	0.16
1/17/2007	21FLMANATS1	2.15	5.5	3.9	1.575	0.335
2/6/2007	21FLMANATS1	3	28.65	7.9	0.735	0.175
3/22/2007	21FLMANATS1	3.8	4.1	5.7	0.61	0.39
4/12/2007	21FLMANATS1	5.8	37.85	6.3	1.5	0.3
5/3/2007	21FLMANATS1	3.15	10.6	4.55	0.6	0.425
6/6/2007	21FLMANATS1	4.45	33.75	4.05	1.91	0.47
7/25/2007	21FLMANATS1	3.1	35.3	4.9	1.34	0.48
8/22/2007	21FLMANATS1	2.4	7.7	2.7		
9/25/2007	21FLMANATS1	4	19	4.9	1	0.45
10/17/2007	21FLMANATS1	2	6.3	2.8	1.51	0.44
11/14/2007	21FLMANATS1	2.3	8.2	5.2	1.06	0.23
12/5/2007	21FLMANATS1	2	2.6	6	1.22	0.27
1/16/2008	21FLMANATS1	2.4	15.4	6.4	1.36	0.2
2/7/2008	21FLMANATS1	2.1	6.3	4.5	1.07	0.43

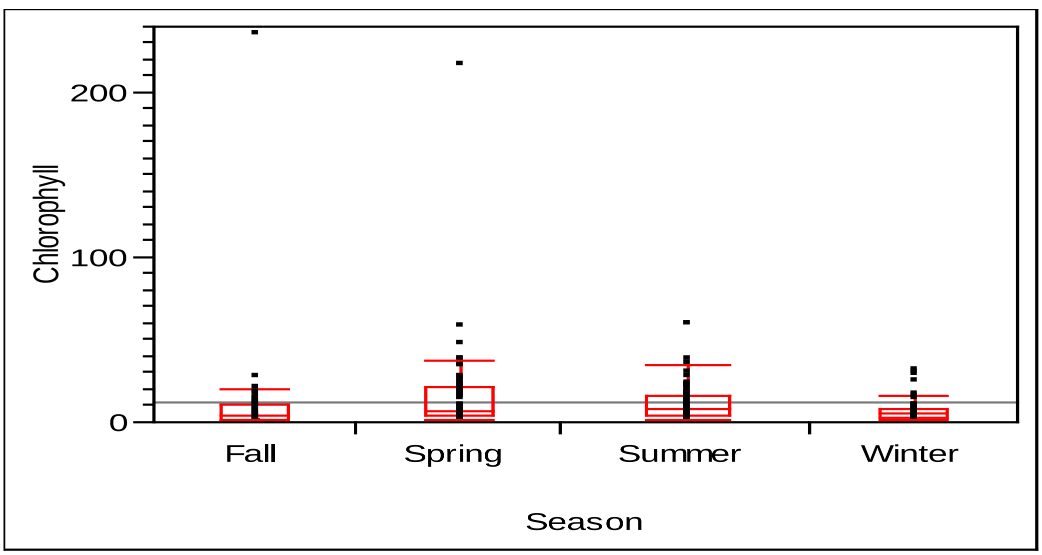
Appendix C: Chart of BOD_5, CHLA, DO, TN, and TP Observations by Season, Month, and Year in Rattlesnake Slough

Seasonal Charts



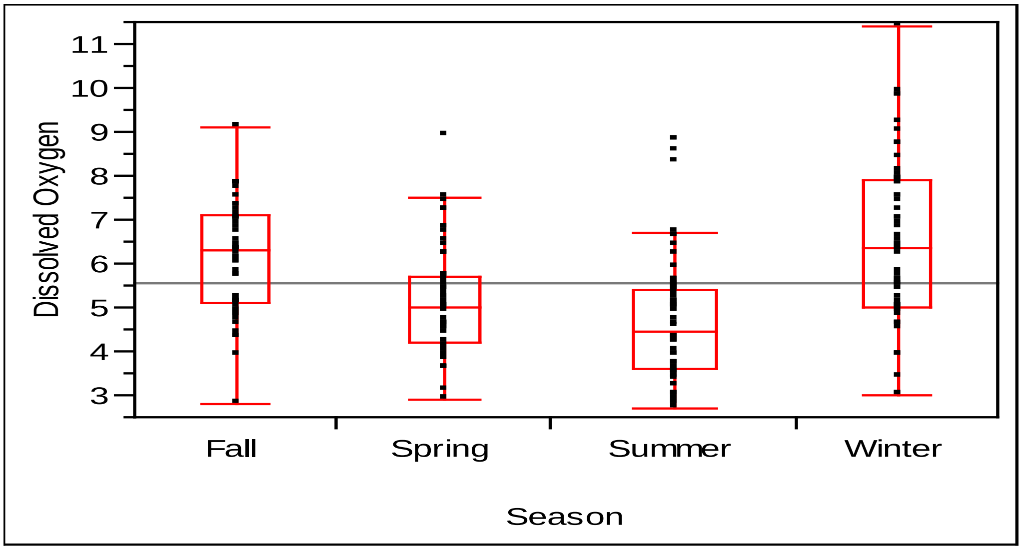
BOD_5 Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Fall	0.5	1.26	2	2.1	2.4	3.5	7.7
Spring	1	1.68	2	2.9	4.3	5.24	6.3
Summer	1.3	1.8	2.375	3.05	4.325	5.51	5.9
Winter	1.4	1.8	2	2.2	3.05	4.04	4.9



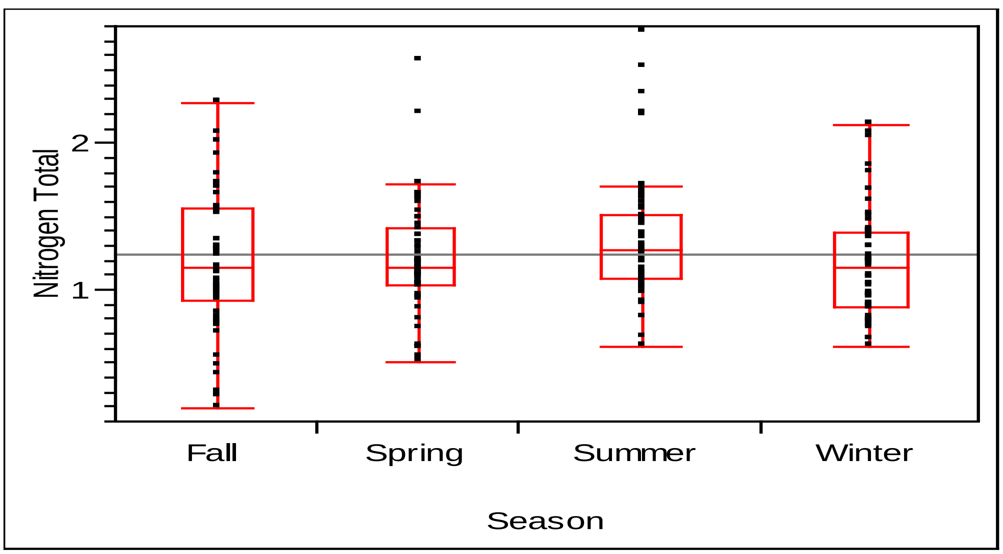
Chorophyll a Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Fall	1	1.31	1.815	3.5	10.36	15.5	234.4
Spring	1	1.167	3.78	6.915	20.695	37.41	215.4
Summer	1	2.3	3.6275	8.2	16.3775	26.19	58.8
Winter	1	1.12	2.6	5.15	8.5	15.34	30.5



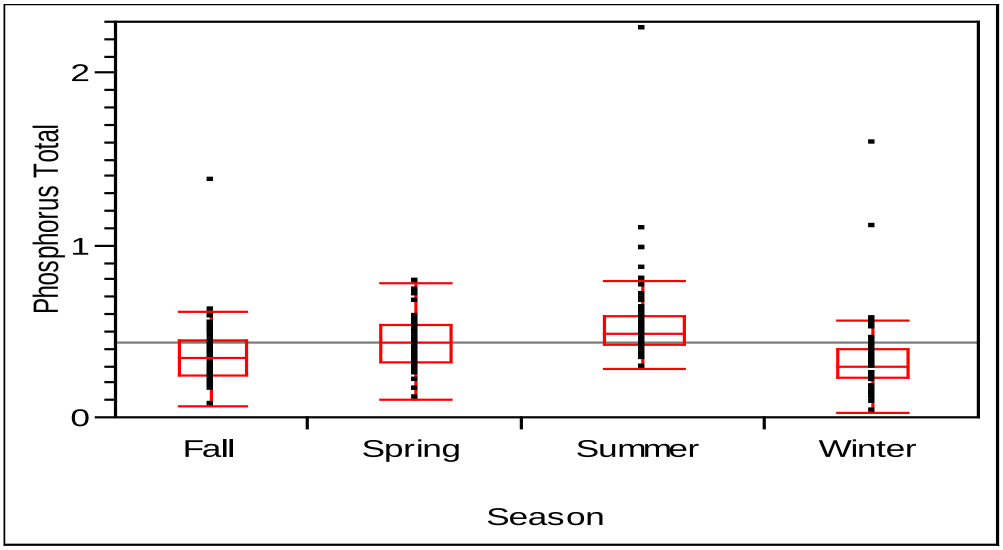
Dissolved Oxygen Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Fall	2.8	4.6	5.1	6.3	7.1	7.8	9.1
Spring	2.9	3.66	4.2	5	5.7	6.807	8.9
Summer	2.7	3	3.6	4.435	5.4	6.54	8.8
Winter	3	4.44	5	6.35	7.885	9.02	11.4



Total Nitrogen Quantiles

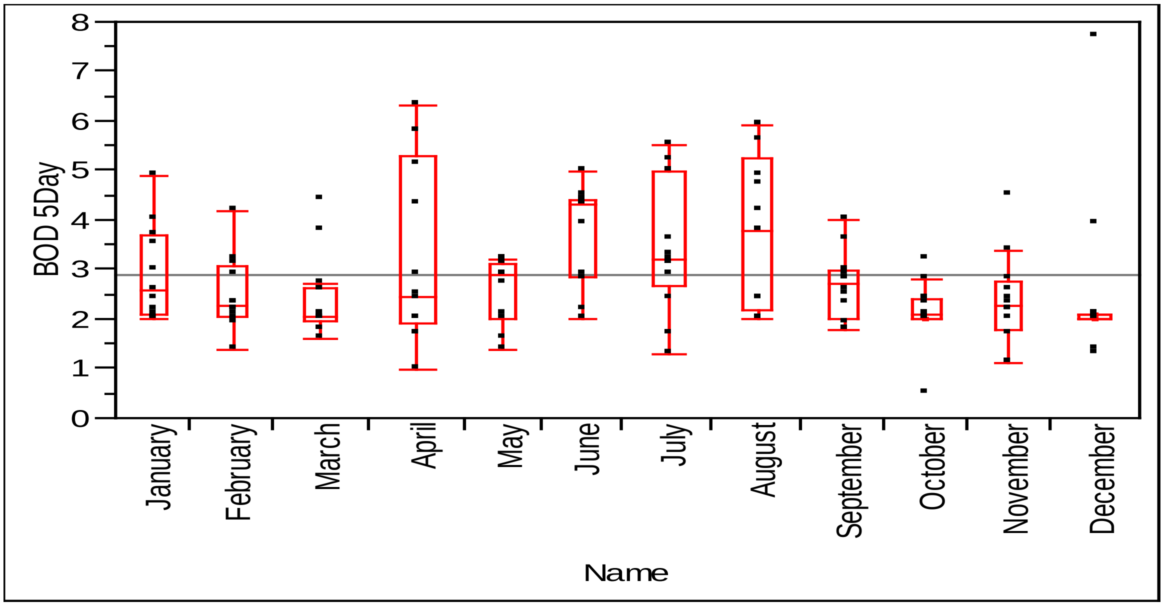
Level	Minimum	10%	25%	Median	75%	90%	Maximum
Fall	0.19	0.47	0.918	1.15	1.56	2.009	2.275
Spring	0.499	0.7162	1.03	1.143	1.4175	1.6553	2.557
Summer	0.612	0.96715	1.080875	1.2725	1.51	1.7008	2.756
Winter	0.61	0.7386	0.875	1.1545	1.39325	1.8294	2.12



Total Phosphorus Quantiles

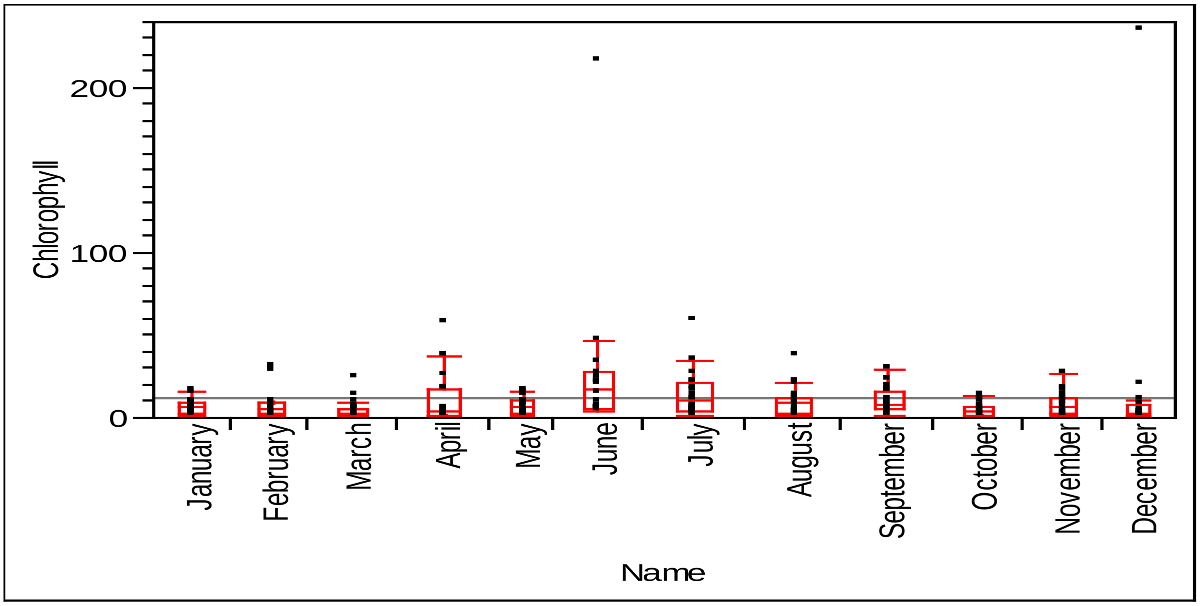
Level	Minimum	10%	25%	Median	75%	90%	Maximum
Fall	48.8636	51.67744	53.4345	60	80.66665	86.83328	87.5
Spring	34.5238	39.31645	44.14718	51.99345	58.20603	70.614	73.0769
Summer	35.3658	36.379	40.7437	50.90305	67.22968	86.27046	105.063
Winter	32.6087	36.7439	54.96855	61.3636	75.0958	86.12632	98

Monthly Charts



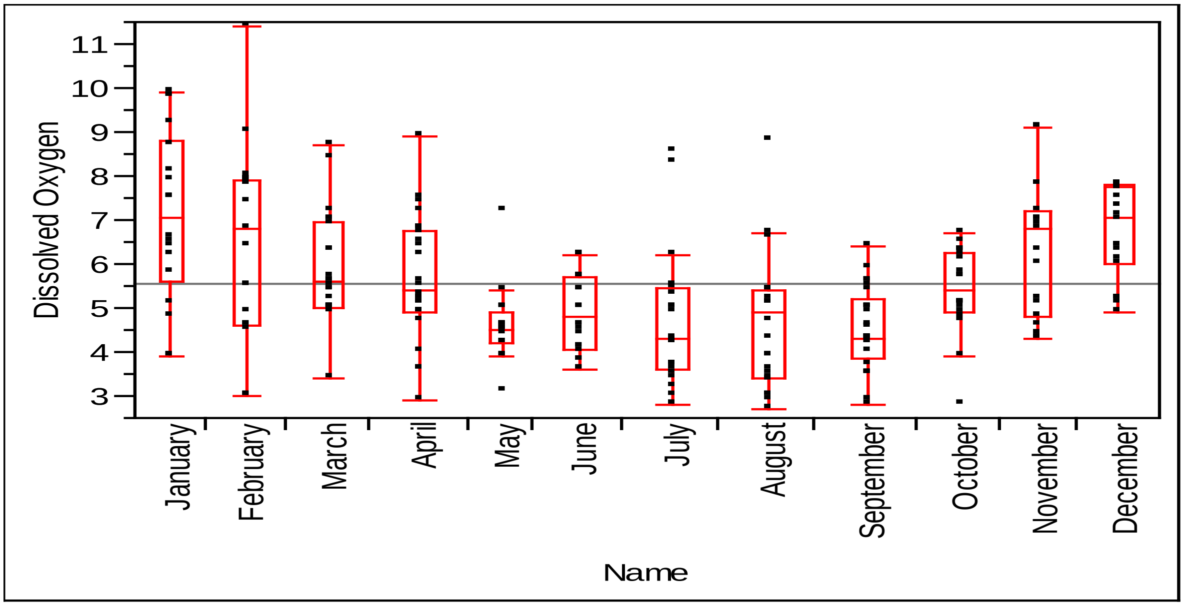
BOD_5 Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
January	2	2	2.1	2.6	3.7	4.72	4.9
February	1.4	1.55	2.025	2.25	3.05	3.9	4.2
March	1.6	1.7	1.95	2.05	2.625	4.1	4.4
April	1	1.35	1.925	2.45	5.275	6.05	6.3
May	1.4	1.44	2	2.9	3.1	3.2	3.2
June	2	2.06	2.825	4.3	4.4	4.85	5
July	1.3	1.46	2.65	3.2	5	5.38	5.5
August	2	2	2.2	3.8	5.25	5.9	5.9
September	1.8	1.8	2	2.7	2.975	3.88	4
October	0.5	0.95	2	2.1	2.4	3.08	3.2
November	1.1	1.1	1.775	2.25	2.75	4.17	4.5
December	1.3	1.34	2	2	2.1	6.18	7.7



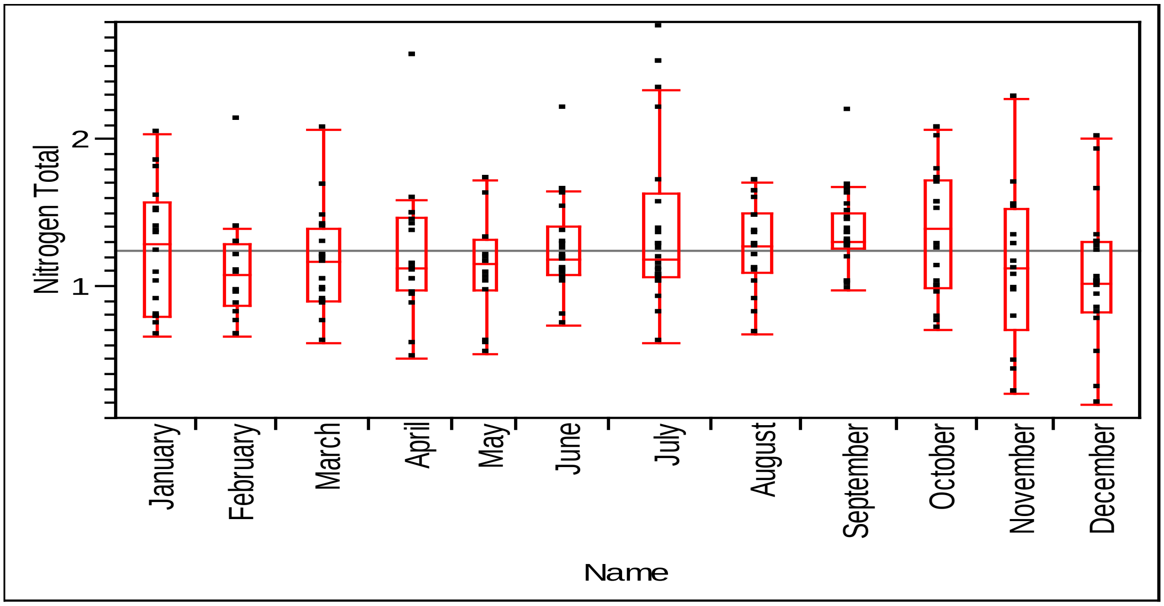
Chlorophyll α Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
January	1	2.106	2.8925	6.25	8.8	14.98	15.4
February	1	1.42	2.525	4.67	9.1	29.59	30.5
March	1	1	2.185	4.73	5.915	14.025	24.51
April	1	1	1.77	4.4	17.29	37.9	57.4
May	1	1.4	3	6.6	11.05	15.734	16.49
June	4.08	4.908	5.5	17.68	28.2375	63.75	215.4
July	1	1.26	3.655	10.8	21.4	54.1	58.8
August	1.4	2.41	3.125	9.6	12.575	20.8	36.9
September	1	1.49	4.83	8	16.1	22.5	29.2
October	1.3	1.309	1.7275	3.5	7.03	11.18	12.8
November	1	1.343	2.025	7.3	12.6275	20.45	26.4
December	1	1	1.5	2.6	7.43	105.94	234.4



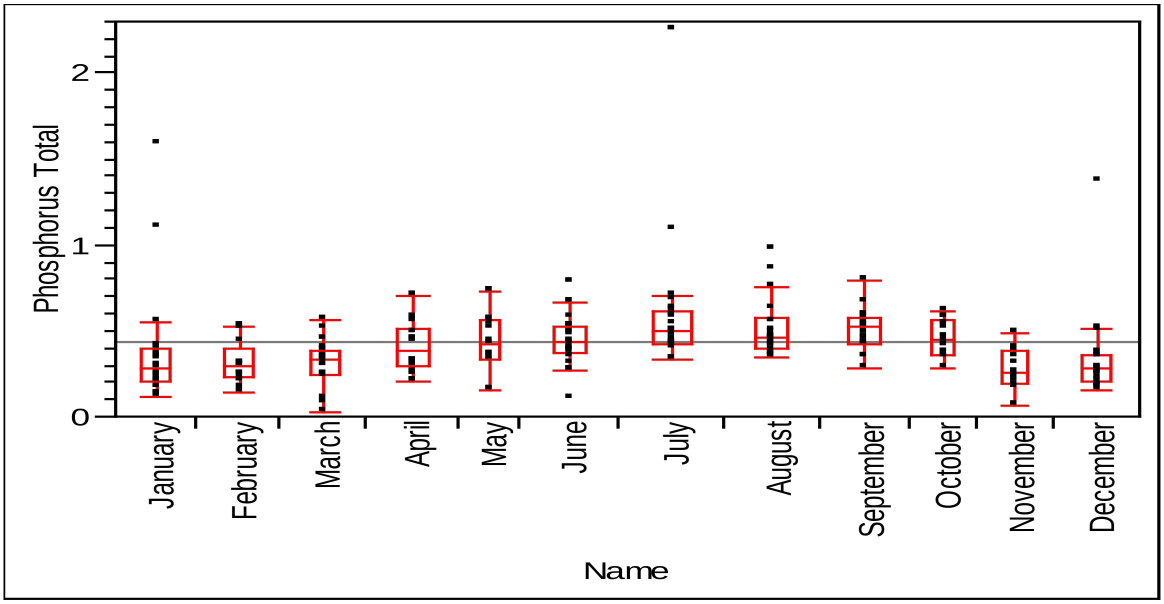
Dissolved Oxygen Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
January	3.9	3.9	5.625	7.05	8.825	9.81	9.9
February	3	3	4.6	6.8	7.9	9	11.4
March	3.4	4.92	5	5.6	6.95	8.16	8.7
April	2.9	3.6	4.9	5.4	6.775	7.45	8.9
May	3.1	3.66	4.2	4.5	4.9	5.94	7.2
June	3.6	3.66	4.075	4.8	5.7	6.2	6.2
July	2.8	3.08	3.6	4.3	5.46	7.46	8.57
August	2.7	2.95	3.425	4.9	5.4	7.75	8.8
September	2.8	3.26	3.85	4.3	5.2	5.72	6.4
October	2.8	3.98	4.925	5.4	6.275	6.48	6.7
November	4.3	4.3	4.8	6.8	7.2	9.1	9.1
December	4.9	5.11	6.025	7.05	7.775	7.8	7.8



Total Nitrogen Quantiles

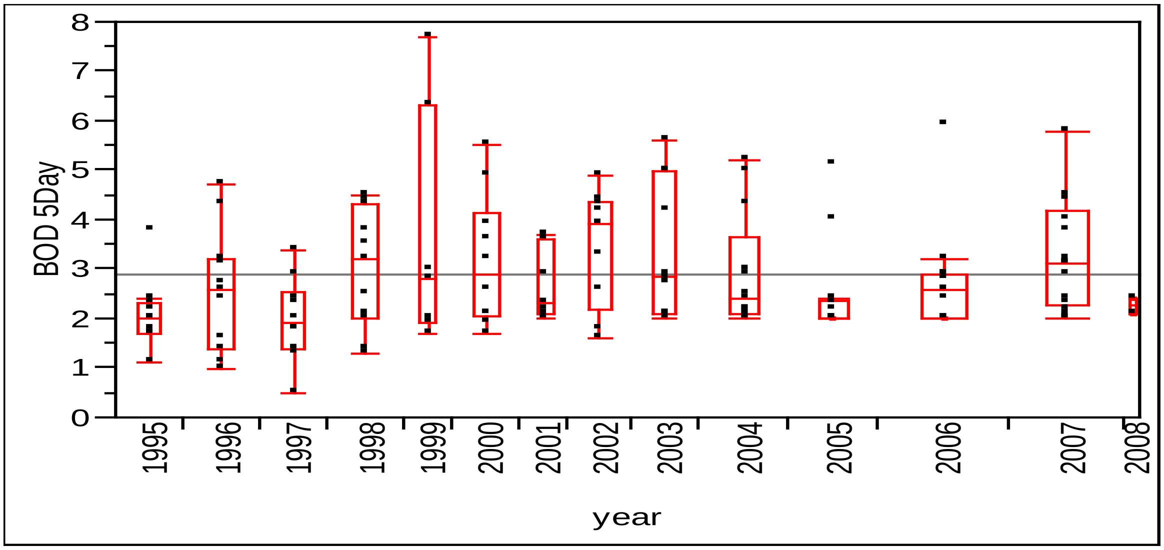
Level	Minimum	10%	25%	Median	75%	90%	Maximum
January	0.656	0.735	0.78375	1.2895	1.5745	1.842	2.035
February	0.66	0.66	0.86	1.07	1.29	2.12	2.12
March	0.61	0.7872	0.89	1.16	1.385	1.682	2.07
April	0.499	0.6266	0.96325	1.119	1.46475	2.4603	2.557
May	0.54	0.575	0.9725	1.143	1.31	1.721	1.721
June	0.728	0.8535	1.076	1.182	1.40225	1.648	2.2
July	0.612	0.87	1.055	1.178	1.6255	2.522	2.756
August	0.675	0.8292	1.096625	1.27	1.4955	1.6768	1.699
September	0.9635	1.0036	1.254	1.307	1.5	1.6622	2.182
October	0.694	0.7529	0.982	1.388	1.718	2.055	2.06
November	0.261	0.261	0.69875	1.125	1.53075	2.275	2.275
December	0.19	0.3474	0.825	1.02	1.3035	1.867	2.009



Total Phosphorus Quantiles

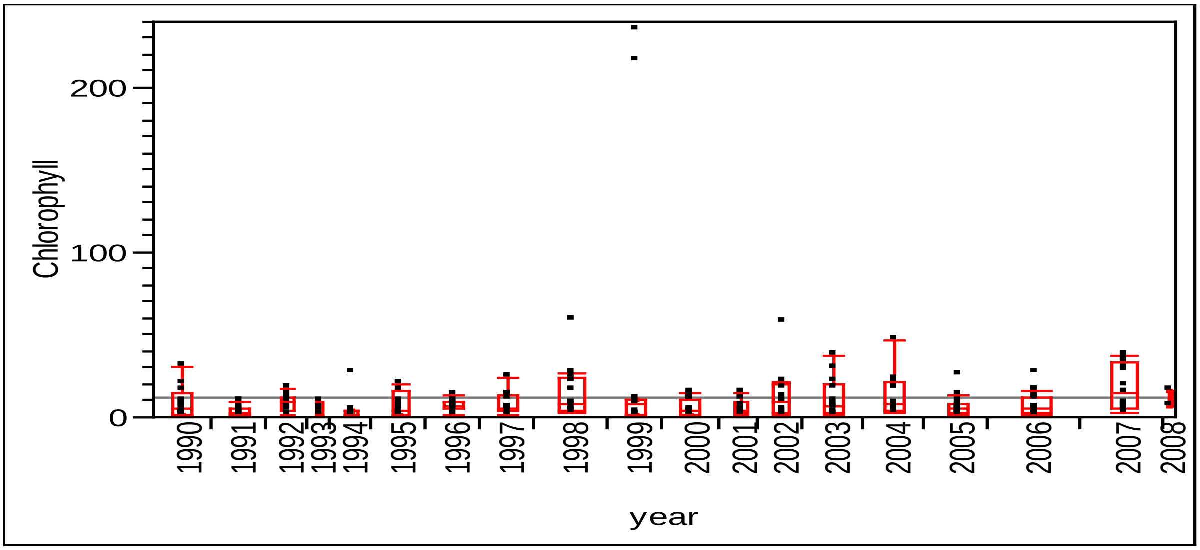
Level	Minimum	10%	25%	Median	75%	90%	Maximum
January	0.12	0.13	0.2	0.285	0.39	1.103	1.59
February	0.14	0.165	0.23325	0.2965	0.4	0.5179	0.519
March	0.0276	0.0757	0.24	0.33	0.3875	0.5024	0.56
April	0.2	0.2202	0.29025	0.38	0.506	0.6628	0.7
May	0.15	0.15	0.326	0.425	0.55925	0.727	0.727
June	0.102	0.264	0.374	0.43	0.52	0.7386	0.785
July	0.334	0.3676	0.42	0.5	0.6155	1.5546	2.25
August	0.34	0.346	0.401	0.458	0.57125	0.9358	0.97
September	0.275	0.34	0.4245	0.521	0.578	0.6608	0.79
October	0.279	0.3259	0.355	0.452	0.563	0.5841	0.61
November	0.067	0.1615	0.195	0.2525	0.387	0.485	0.485
December	0.15	0.1709	0.2035	0.277	0.36125	0.5087	1.373

Yearly Charts



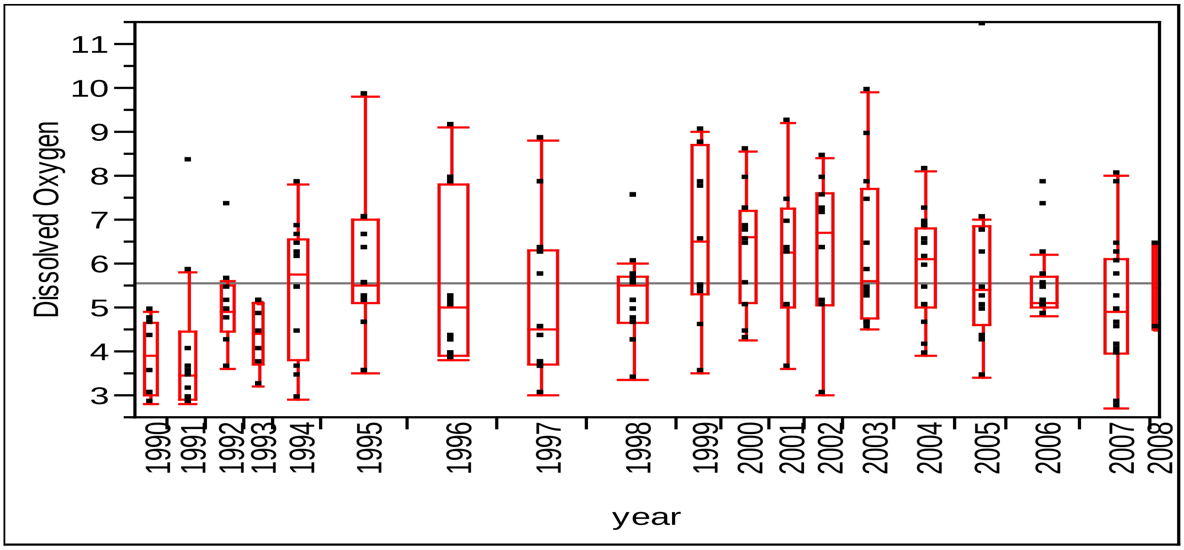
BOD$_5$ Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
1995	1.1	1.16	1.7	2	2.325	3.66	3.8
1996	1	1.02	1.4	2.6	3.2	4.62	4.7
1997	0.5	0.58	1.375	1.9	2.525	3.35	3.4
1998	1.3	1.32	2	3.2	4.3	4.48	4.5
1999	1.7	1.7	1.9	2.8	6.3	7.7	7.7
2000	1.7	1.72	2.05	2.9	4.15	5.44	5.5
2001	2	2	2.1	2.3	3.6	3.7	3.7
2002	1.6	1.6	2.2	3.9	4.35	4.9	4.9
2003	2	2.01	2.1	2.85	5	5.54	5.6
2004	2	2	2.1	2.4	3.65	5.12	5.2
2005	2	2	2	2	2.35	4.66	5.1
2006	2	2	2	2.6	2.9	5.9	5.9
2007	2	2	2.25	3.1	4.2	5.8	5.8
2008	2.1	2.1	2.1	2.25	2.4	2.4	2.4



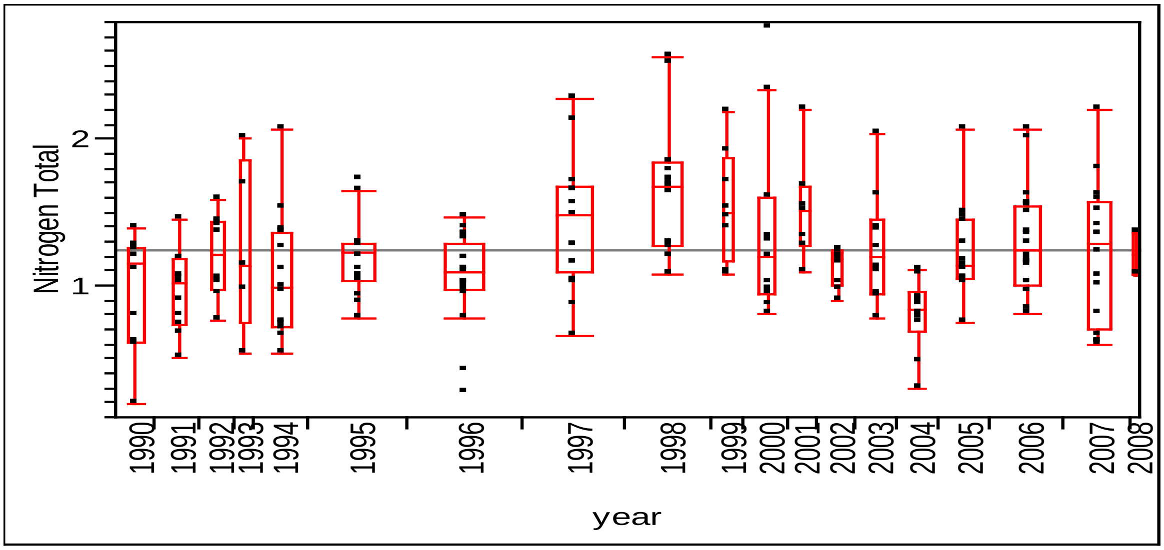
Chlorophyll α Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
1990	1	1	1.9275	5.995	14.3725	27.44	30.5
1991	1	1	1.4	2.7	5.7	8.96	9
1992	1.73	1.73	4.455	9.6	11.93	17.29	17.29
1993	1	1	1.6175	4.68	8.1175	8.86	8.86
1994	1	1	1	1.72	3.71	26.45	26.45
1995	1	1.062	1.6	3.4	16.47	20.348	20.56
1996	1.49	1.98	4.76	6.52	9.2	12.54	13.37
1997	2	2.102	3.56	4.96	12.7	22.148	24.51
1998	2.5	2.506	3.5	8	23.77	58.8	58.8
1999	1.1	1.1	1.6	8.4	11	230.6	234.4
2000	1	1	1.075	3.35	11.1	14.29	14.8
2001	2	2	2.9	4.35	10	14.8	14.8
2002	1.3	1.3	3.15	9.3	19.9	57.4	57.4
2003	1	1.21	3.125	7.25	20.15	34.59	36.9
2004	2.5	2.66	3.7	8.2	21.4	37.14	46.9
2005	2	2.12	2.6	4.7	8.55	20.24	25.2
2006	1	1.4	2.7	5.3	11.4	16.1	26.6
2007	2.6	3.8	5.95	14.6	33.75	37.82	37.9
2008	6.3	6.3	6.3	10.85	15.4	15.4	15.4



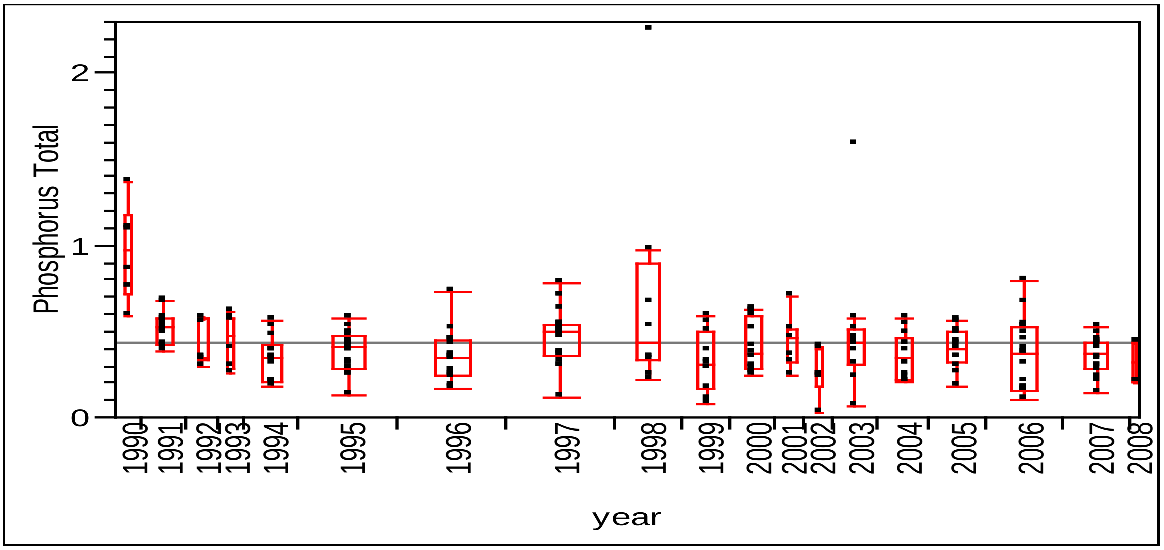
Dissolved Oxygen Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
1990	2.8	2.8	3	3.9	4.675	4.9	4.9
1991	2.8	2.81	2.9	3.45	4.45	8.05	8.3
1992	3.6	3.6	4.45	4.9	5.5	7.3	7.3
1993	3.2	3.2	3.7	4.4	5.1	5.1	5.1
1994	2.9	3.05	3.8	5.75	6.55	7.5	7.8
1995	3.5	3.72	5.1	5.5	7	9.24	9.8
1996	3.8	3.83	3.9	5	7.8	8.74	9.1
1997	3	3.18	3.7	4.5	6.3	8.5	8.8
1998	3.36	4.2	4.675	5.5	5.7	7.5	7.5
1999	3.5	3.714	5.3	6.5	8.7	8.94	9
2000	4.25	4.295	5.125	6.6	7.2	8.369	8.57
2001	3.6	3.6	5	6.25	7.275	9.2	9.2
2002	3	3.2	5.075	6.7	7.595	8.348	8.4
2003	4.5	4.53	4.75	5.6	7.7	9.6	9.9
2004	3.9	4.02	5	6.1	6.8	7.56	8.1
2005	3.4	3.72	4.6	5.4	6.85	9.64	11.4
2006	4.8	4.8	5	5.1	5.7	7.35	7.8
2007	2.7	2.78	3.95	4.9	6.1	7.84	8
2008	4.5	4.5	4.5	5.45	6.4	6.4	6.4



Total Nitrogen Quantiles

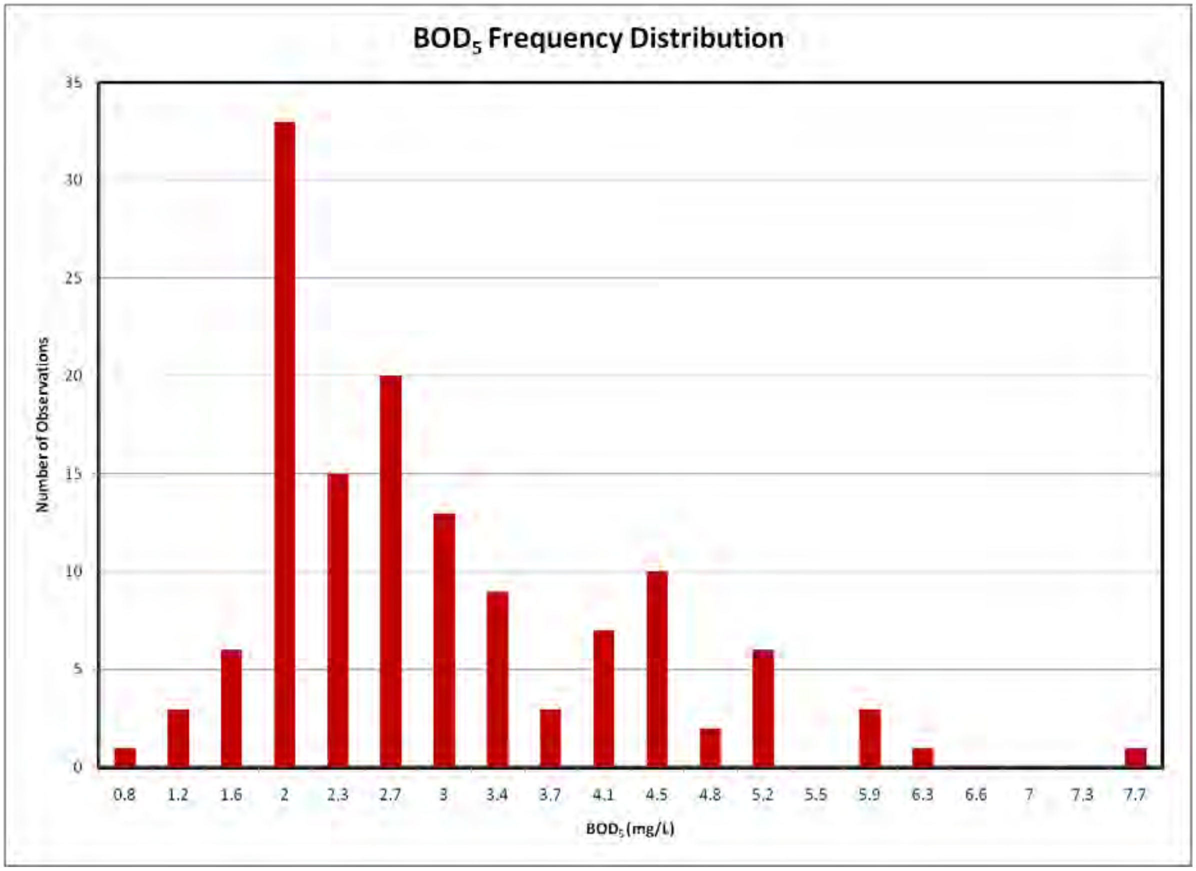
Level	Minimum	10%	25%	Median	75%	90%	Maximum
1990	0.19	0.231	0.609	1.153	1.25775	1.3797	1.392
1991	0.499	0.5342	0.728	1.018	1.178	1.4006	1.454
1992	0.76	0.76	0.96375	1.2055	1.43	1.59	1.59
1993	0.54	0.54	0.75175	1.134	1.8495	2.009	2.009
1994	0.537	0.5862	0.712	0.984	1.367	1.85	2.07
1995	0.78	0.8275	1.03	1.228	1.279	1.679	1.718
1996	0.261	0.3951	0.967	1.0865	1.278	1.401	1.464
1997	0.656	0.9498	1.0845	1.473	1.6735	2.182	2.275
1998	1.076	1.1008	1.266	1.682	1.842	2.55	2.557
1999	1.08	1.08	1.16725	1.495	1.86675	2.182	2.182
2000	0.798	0.8116	0.933	1.189	1.598	2.6724	2.756
2001	1.097	1.097	1.266	1.504	1.677	2.204	2.204
2002	0.902	0.902	0.9965	1.178	1.2315	1.239	1.239
2003	0.775	0.7893	0.93525	1.1895	1.444	1.9936	2.035
2004	0.3	0.317	0.68	0.835	0.95	1.1024	1.106
2005	0.74	0.852	1.045	1.13	1.455	1.836	2.06
2006	0.81	0.837	0.9975	1.235	1.5425	2.015	2.06
2007	0.59	0.604	0.6975	1.28	1.57	1.92	2.2
2008	1.07	1.07	1.07	1.215	1.36	1.36	1.36



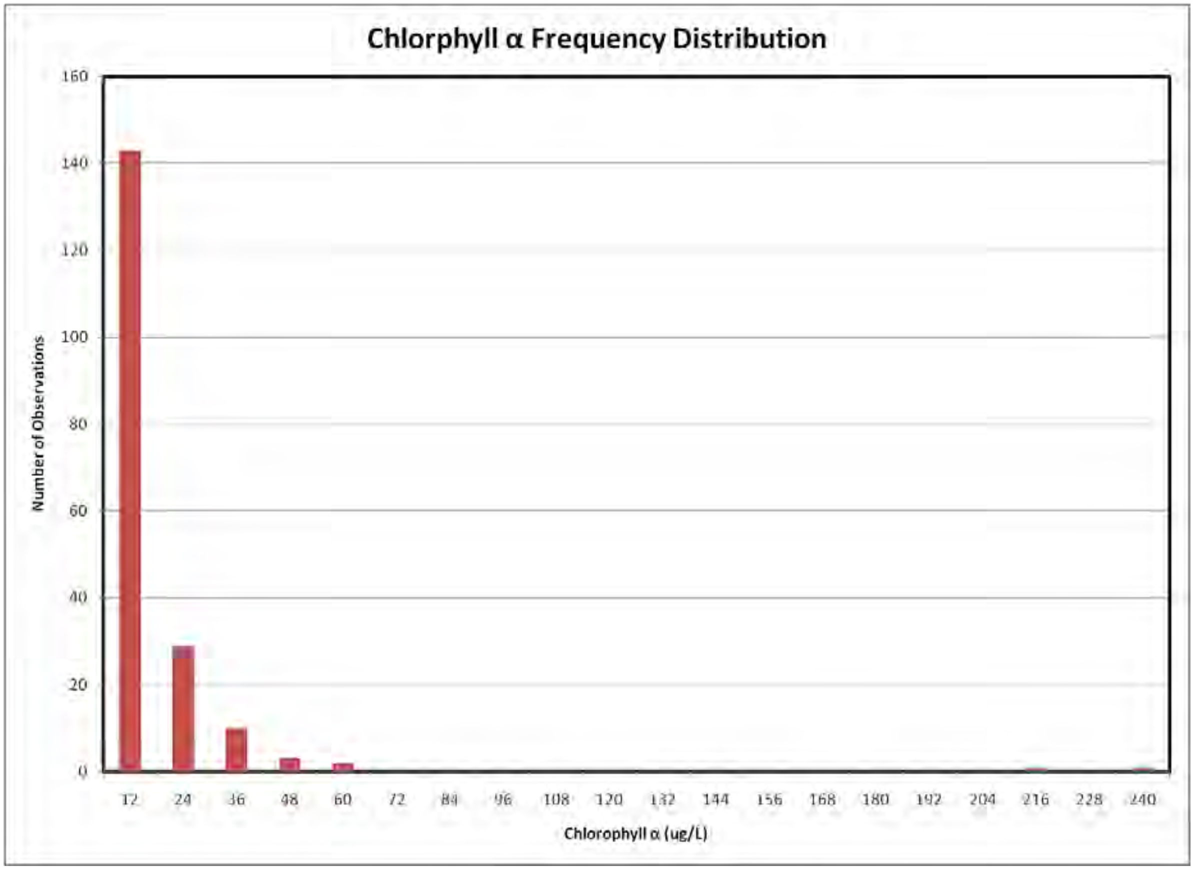
Total Phosphorus Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
1990	0.586	0.586	0.712	0.9735	1.1705	1.373	1.373
1991	0.383	0.388	0.416	0.521	0.576	0.673	0.676
1992	0.293	0.293	0.33	0.35	0.57	0.576	0.576
1993	0.26	0.26	0.28625	0.475	0.58	0.61	0.61
1994	0.179	0.1874	0.21	0.341	0.4235	0.5468	0.56
1995	0.13	0.174	0.284	0.408	0.47	0.5518	0.573
1996	0.172	0.1776	0.242	0.343	0.45	0.5751	0.727
1997	0.12	0.297	0.3635	0.5	0.542	0.734	0.785
1998	0.214	0.235	0.326	0.4325	0.89475	2.25	2.25
1999	0.073	0.0788	0.17	0.309	0.497	0.5806	0.588
2000	0.239	0.2434	0.285	0.374	0.59	0.6194	0.622
2001	0.245	0.245	0.318	0.458	0.51	0.699	0.699
2002	0.0276	0.0276	0.1824	0.246	0.40025	0.407	0.407
2003	0.067	0.0998	0.312	0.431	0.512	1.386	1.59
2004	0.2	0.203	0.215	0.345	0.465	0.561	0.57
2005	0.18	0.212	0.32	0.4	0.495	0.556	0.56
2006	0.1	0.145	0.1575	0.37	0.52	0.673	0.79
2007	0.14	0.189	0.2775	0.365	0.4375	0.492	0.52
2008	0.2	0.2	0.2	0.315	0.43	0.43	0.43

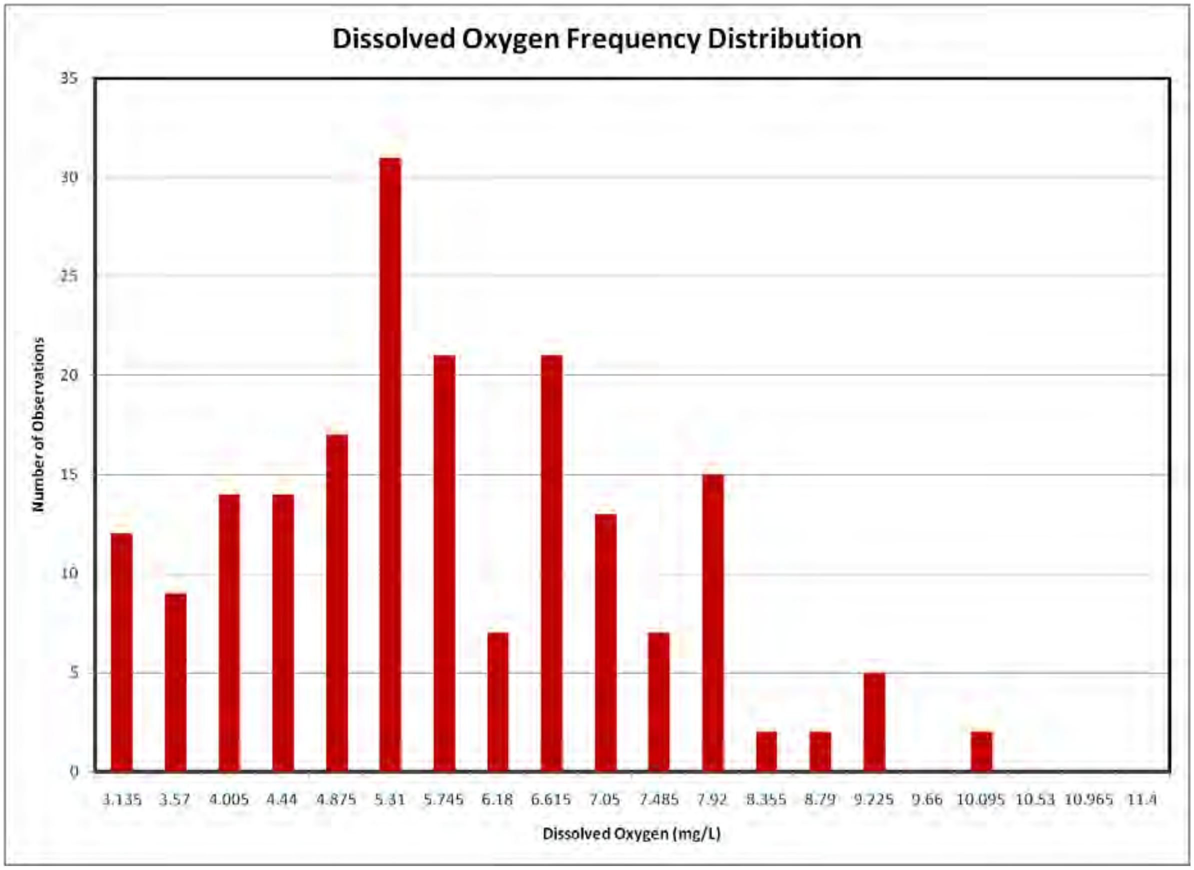
Appendix D: Histograms of BOD_5, CHLA, DO, TN, and TP Observations in Rattlesnake Slough



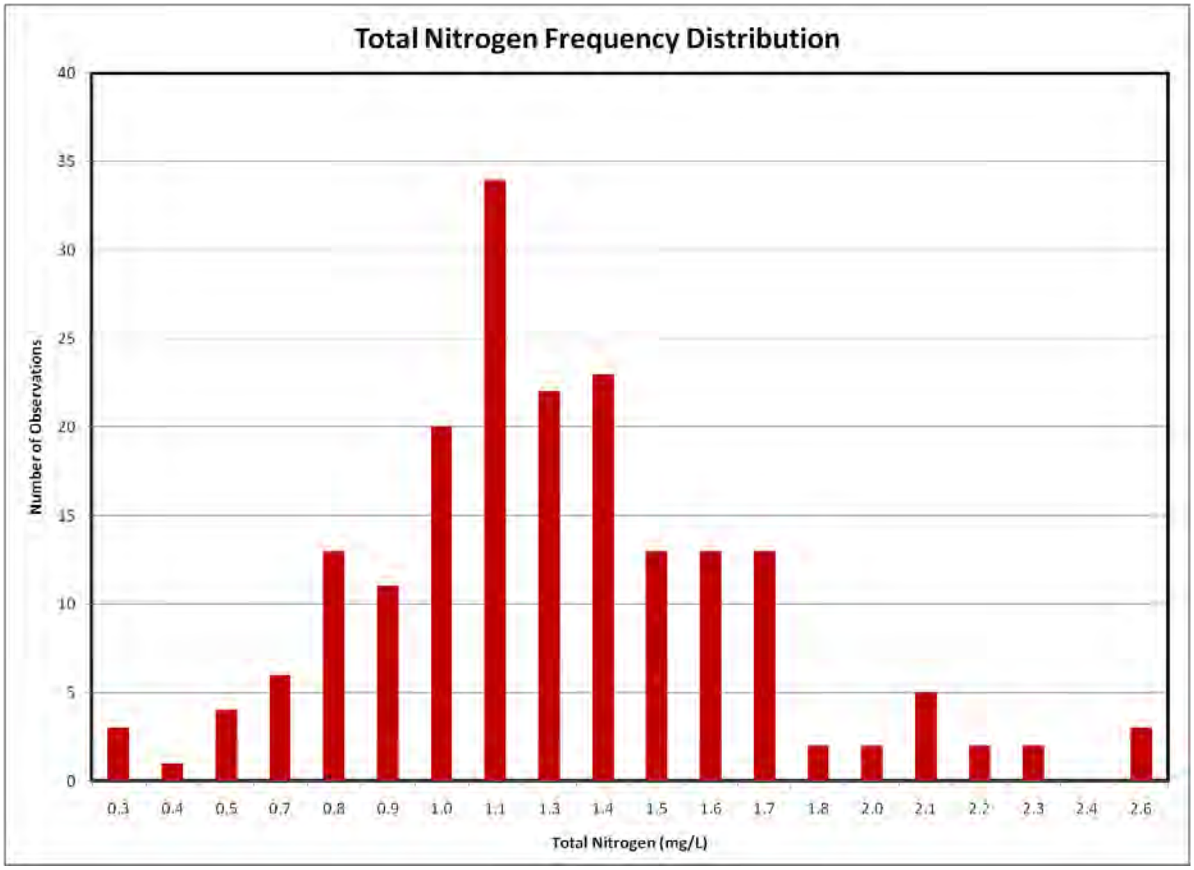
BOD_5	
Mean	2.821588
Standard Error	0.105375
Median	2.4
Mode	2
Standard Deviation	1.215238
Sample Variance	1.476804
Kurtosis	1.557872
Skewness	1.191337
Range	7.2
Minimum	0.5
Maximum	7.7
Sum	375.2711
Count	133
Confidence Level(95.0%)	0.208441



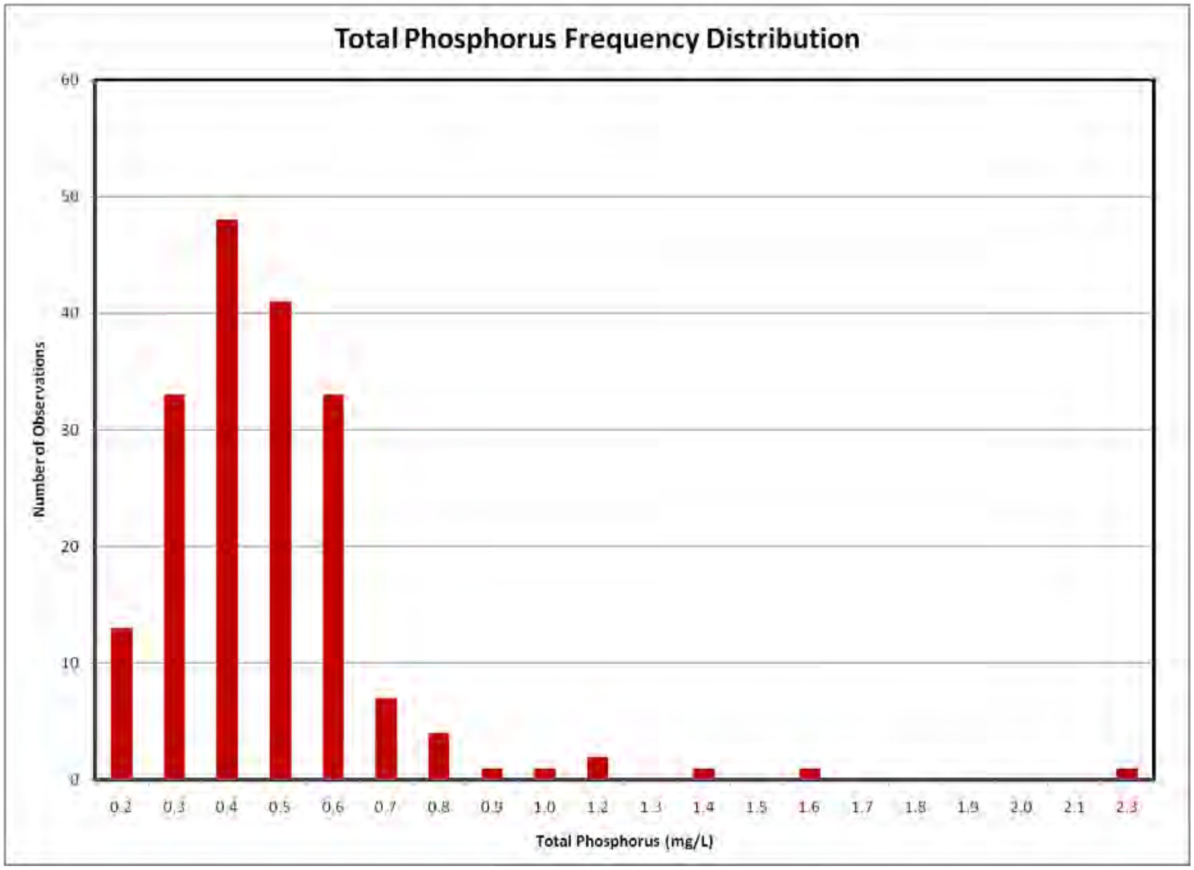
Chlorophyll α	
Mean	13.23226
Standard Error	2.459518
Median	6
Mode	2.5
Standard Deviation	28.36455
Sample Variance	804.5477
Kurtosis	46.83774
Skewness	6.502626
Range	233.4
Minimum	1
Maximum	234.4
Sum	1759.89
Count	133
Confidence Level(95.0%)	4.86517



Dissolved Oxygen	
Mean	5.82701
Standard Error	0.136831
Median	5.5
Mode	5
Standard Deviation	1.595704
Sample Variance	2.546272
Kurtosis	0.284878
Skewness	0.564492
Range	8.7
Minimum	2.7
Maximum	11.4
Sum	792.4733
Count	136
Confidence Level(95.0%)	0.270609



Total Nitrogen	
Mean	1.26805
Standard Error	0.03751
Median	1.189
Mode	1.0865
Standard Deviation	0.429319
Sample Variance	0.184314
Kurtosis	0.975012
Skewness	0.678593
Range	2.296
Minimum	0.261
Maximum	2.557
Sum	166.1145
Count	131
Confidence Level(95.0%)	0.074209



Total Phosphorus	
Mean	0.40491
Standard Error	0.021946
Median	0.376
Mode	0.45
Standard Deviation	0.250223
Sample Variance	0.062612
Kurtosis	25.59711
Skewness	4.012854
Range	2.183
Minimum	0.067
Maximum	2.25
Sum	52.6383
Count	130
Confidence Level(95.0%)	0.043421

Appendix E: Spearman Correlation Matrix Analysis for Water Quality Parameters in Rattlesnake Slough

Nonparametric: Spearman's ρ

Variable	by Variable	Spearman ρ	Prob>|ρ|	Plot
Chlorophyll	BOD 5Day	0.6255	<.0001	
Dissolved Oxygen	BOD 5Day	-0.0557	0.5025	
Dissolved Oxygen	Chlorophyll	-0.0080	0.9108	
Nitrate Nitrite	BOD 5Day	-0.2323	0.0058	
Nitrate Nitrite	Chlorophyll	-0.0946	0.1860	
Nitrate Nitrite	Dissolved Oxygen	-0.1138	0.0818	
Nitrogen Ammonia	BOD 5Day	-0.1724	0.0472	
Nitrogen Ammonia	Chlorophyll	0.0362	0.6101	
Nitrogen Ammonia	Dissolved Oxygen	-0.0308	0.6420	
Nitrogen Ammonia	Nitrate Nitrite	0.0913	0.1596	
Nitrogen Kjeldahl	BOD 5Day	0.2472	0.0029	
Nitrogen Kjeldahl	Chlorophyll	0.2914	<.0001	
Nitrogen Kjeldahl	Dissolved Oxygen	-0.1393	0.0310	
Nitrogen Kjeldahl	Nitrate Nitrite	0.1030	0.1062	
Nitrogen Kjeldahl	Nitrogen Ammonia	0.1604	0.0124	
Nitrogen Organic	BOD 5Day	.	.	
Nitrogen Organic	Chlorophyll	.	.	
Nitrogen Organic	Dissolved Oxygen	-0.3000	0.6238	
Nitrogen Organic	Nitrate Nitrite	0.0604	0.8178	
Nitrogen Organic	Nitrogen Ammonia	0.4232	0.0905	
Nitrogen Organic	Nitrogen Kjeldahl	0.9865	<.0001	
Nitrogen Total	BOD 5Day	0.1046	0.2254	
Nitrogen Total	Chlorophyll	0.2026	0.0049	
Nitrogen Total	Dissolved Oxygen	-0.1300	0.0489	
Nitrogen Total	Nitrate Nitrite	0.4687	<.0001	
Nitrogen Total	Nitrogen Ammonia	0.1675	0.0101	
Nitrogen Total	Nitrogen Kjeldahl	0.8886	<.0001	
Nitrogen Total	Nitrogen Organic	0.8196	<.0001	
Phosphorus Total	BOD 5Day	0.1667	0.0533	
Phosphorus Total	Chlorophyll	0.1095	0.1378	
Phosphorus Total	Dissolved Oxygen	-0.4598	<.0001	
Phosphorus Total	Nitrate Nitrite	0.2757	<.0001	
Phosphorus Total	Nitrogen Ammonia	-0.0284	0.6702	
Phosphorus Total	Nitrogen Kjeldahl	0.3368	<.0001	
Phosphorus Total	Nitrogen Organic	0.5840	0.0138	
Phosphorus Total	Nitrogen Total	0.3478	<.0001	

Appendix F: Kurskal-Wallis Analysis of BOD_5, CHLA, DO, TN, and TP Observations

Seasonal Analysis

BOD_5

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
Fall	37	2023.50	54.6892	-3.310
Spring	37	3177.50	85.8784	1.772
Summer	38	3477.00	91.5000	2.737
Winter	37	2497.00	67.4865	-1.223

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
17.3305	3	0.0006

Chlorophyll α

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
Fall	49	4145.50	84.602	-2.698
Spring	50	5963.50	119.270	1.912
Summer	60	7206.00	120.100	2.290
Winter	50	4630.00	92.600	-1.661

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
14.2057	3	0.0026

Dissolved Oxygen

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
Fall	59	9354.00	158.542	3.937
Spring	62	6623.00	106.823	-2.397
Summer	72	6129.50	85.132	-5.657
Winter	58	9519.50	164.129	4.562

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
55.0336	3	<.0001

Total Nitrogen

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
Fall	59	7023.50	119.042	-0.726
Spring	58	7052.00	121.586	-0.411
Summer	70	10051.0	143.586	2.545
Winter	62	6998.50	112.879	-1.528

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
6.9514	3	0.0735

Total Phosphorus

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
Fall	54	5108.50	94.602	-3.113
Spring	59	7767.50	131.653	1.420
Summer	68	11313.5	166.375	6.436
Winter	59	4730.50	80.178	-5.136

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
58.6364	3	<.0001

Monthly Analysis

BOD_5

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
January	11	919.000	83.545	0.681
February	12	796.000	66.333	-0.724
March	14	782.000	55.857	-1.746
April	14	1080.50	77.179	0.196
May	11	790.000	71.818	-0.251
June	12	1307.00	108.917	2.845
July	13	1280.50	98.500	2.058
August	13	1311.50	100.885	2.267
September	12	885.000	73.750	-0.101
October	12	650.000	54.167	-1.746
November	12	727.000	60.583	-1.207
December	13	646.500	49.731	-2.213

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
28.4885	11	0.0027

Chlorophyll α

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
January	16	1632.50	102.031	-0.202
February	16	1542.00	96.375	-0.592
March	18	1455.50	80.861	-1.770
April	19	1902.00	100.105	-0.368
May	13	1327.00	102.077	-0.178
June	18	2734.50	151.917	3.442
July	21	2615.50	124.548	1.560
August	20	2346.50	117.325	0.957
September	19	2244.00	118.105	0.989
October	18	1414.50	78.583	-1.937
November	16	1655.50	103.469	-0.103
December	15	1075.50	71.700	-2.212

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
26.1382	11	0.0062

Dissolved Oxygen

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
January	18	3296.00	183.111	3.464
February	19	3080.50	162.132	2.256
March	21	3143.00	149.667	1.560
April	24	3269.50	136.229	0.725
May	16	1222.50	76.406	-2.823
June	22	2131.00	96.864	-1.970
July	23	1952.00	84.870	-2.850
August	24	2246.50	93.604	-2.298
September	25	1931.00	77.240	-3.539
October	20	2565.50	128.275	0.145
November	19	3070.50	161.605	2.223
December	20	3718.00	185.900	3.846

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
71.2560	11	<.0001

Total Nitrogen

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
January	20	2513.00	125.650	0.040
February	19	1930.50	101.605	-1.472
March	23	2555.00	111.087	-0.971
April	20	2449.50	122.475	-0.162
May	16	1763.50	110.219	-0.847
June	22	2839.00	129.045	0.274
July	25	3427.50	137.100	0.884
August	22	3092.00	140.545	1.059
September	23	3531.50	153.543	1.993
October	20	2882.00	144.100	1.235
November	18	2008.50	111.583	-0.819
December	21	2133.00	101.571	-1.556

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
13.2287	11	0.2786

Total Phosphorus

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
January	19	1495.50	78.711	-2.733
February	20	1550.50	77.525	-2.890
March	20	1684.50	84.225	-2.439
April	22	2592.00	117.818	-0.189
May	14	1878.00	134.143	0.756
June	23	3297.50	143.370	1.660
July	25	4254.50	170.180	3.779
August	22	3503.50	159.250	2.745
September	21	3555.50	169.310	3.371
October	16	2385.50	149.094	1.704
November	18	1226.50	68.139	-3.325
December	20	1496.50	74.825	-3.072

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
74.7301	11	<.0001

Yearly Analysis

BOD_5

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
1995	10	433.000	43.3000	-2.409
1996	11	732.000	66.5455	-0.674
1997	10	428.000	42.8000	-2.447
1998	11	903.000	82.0909	0.564
1999	7	553.000	79.0000	0.247
2000	10	837.500	83.7500	0.662
2001	7	536.500	76.6429	0.099
2002	9	854.000	94.8889	1.427
2003	10	949.000	94.9000	1.511
2004	13	1044.50	80.3462	0.466
2005	13	736.500	56.6538	-1.606
2006	19	1423.50	74.9211	-0.006
2007	17	1619.50	95.2647	2.060
2008	2	125.000	62.5000	-0.405

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
22.8079	13	0.0440

Chlorophyll α

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
1990	12	1171.50	97.625	-0.433
1991	11	719.500	65.409	-2.229
1992	9	1058.50	117.611	0.637
1993	4	317.500	79.375	-0.852
1994	9	471.000	52.333	-2.668
1995	11	999.000	90.818	-0.797
1996	11	1185.50	107.773	0.154
1997	11	1166.50	106.045	0.056
1998	15	1994.50	132.967	1.857
1999	11	1102.50	100.227	-0.266
2000	12	993.000	82.750	-1.310
2001	8	753.000	94.125	-0.516
2002	9	1135.00	126.111	1.068
2003	12	1405.50	117.125	0.713
2004	13	1676.50	128.962	1.473
2005	13	1188.50	91.423	-0.834
2006	19	1782.00	93.789	-0.846
2007	17	2548.00	149.882	3.191
2008	2	277.500	138.750	0.787

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
33.5441	18	0.0143

Dissolved Oxygen

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
1990	8	347.000	43.375	-3.270
1991	10	531.000	53.100	-3.239
1992	9	946.000	105.111	-0.877
1993	7	464.000	66.286	-2.205
1994	12	1507.50	125.625	-0.016
1995	21	3141.00	149.571	1.553
1996	22	2517.00	114.409	-0.783
1997	22	2432.00	110.545	-1.044
1998	22	2760.00	125.455	-0.035
1999	11	1847.50	167.955	1.959
2000	12	2009.50	167.458	2.026
2001	8	1234.50	154.313	1.119
2002	10	1678.50	167.850	1.859
2003	12	1878.00	156.500	1.490
2004	15	2225.50	148.367	1.229
2005	13	1785.50	137.346	0.577
2006	18	2330.50	129.472	0.209
2007	17	1741.50	102.441	-1.384
2008	2	249.500	124.750	-0.020

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
47.5499	18	0.0002

Total Nitrogen

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
1990	10	885.500	88.550	-1.631
1991	11	785.500	71.409	-2.522
1992	8	966.000	120.750	-0.167
1993	5	626.000	125.200	0.003
1994	13	1215.50	93.500	-1.618
1995	24	2876.00	119.833	-0.368
1996	28	2702.00	96.500	-2.221
1997	25	4027.00	161.080	2.639
1998	21	4071.00	193.857	4.577
1999	8	1437.00	179.625	2.178
2000	11	1391.00	126.455	0.066
2001	7	1247.00	178.143	1.978
2002	9	936.000	104.000	-0.889
2003	10	1252.00	125.200	0.007
2004	10	417.000	41.700	-3.731
2005	13	1635.50	125.808	0.040
2006	18	2452.50	136.250	0.686
2007	16	1943.50	121.469	-0.201
2008	2	259.000	129.500	0.084

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
64.1883	18	<.0001

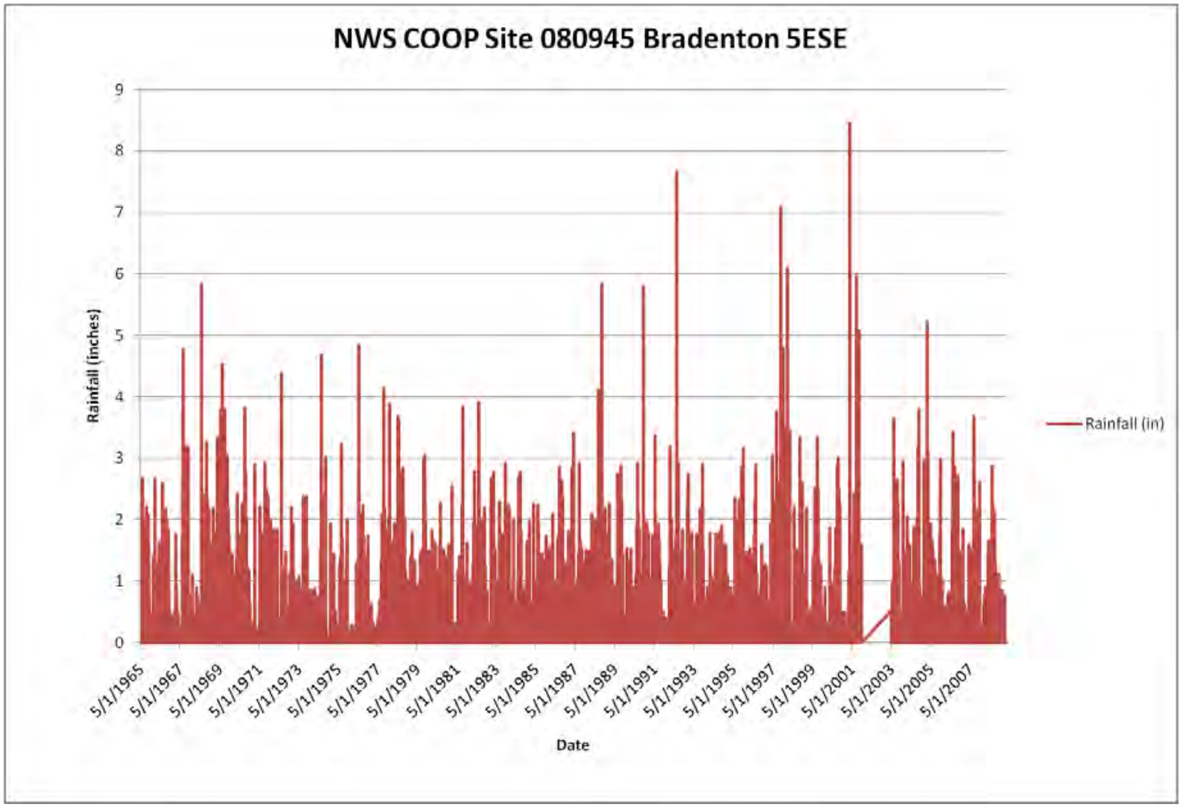
Total Phosphorus
Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
1990	6	1379.00	229.833	3.904
1991	11	1944.00	176.727	2.748
1992	7	948.000	135.429	0.575
1993	6	849.000	141.500	0.747
1994	13	1204.50	92.654	-1.485
1995	23	2552.00	110.957	-0.692
1996	26	2603.00	100.115	-1.584
1997	25	3851.50	154.060	2.552
1998	16	2295.00	143.438	1.366
1999	11	962.000	87.455	-1.614
2000	11	1347.00	122.455	0.093
2001	7	938.000	134.000	0.519
2002	6	373.000	62.167	-2.081
2003	11	1429.00	129.909	0.458
2004	12	1148.00	95.667	-1.269
2005	13	1539.50	118.423	-0.109
2006	18	1814.00	100.778	-1.251
2007	16	1580.50	98.781	-1.293
2008	2	163.000	81.500	-0.793

1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
47.7296	18	0.0002

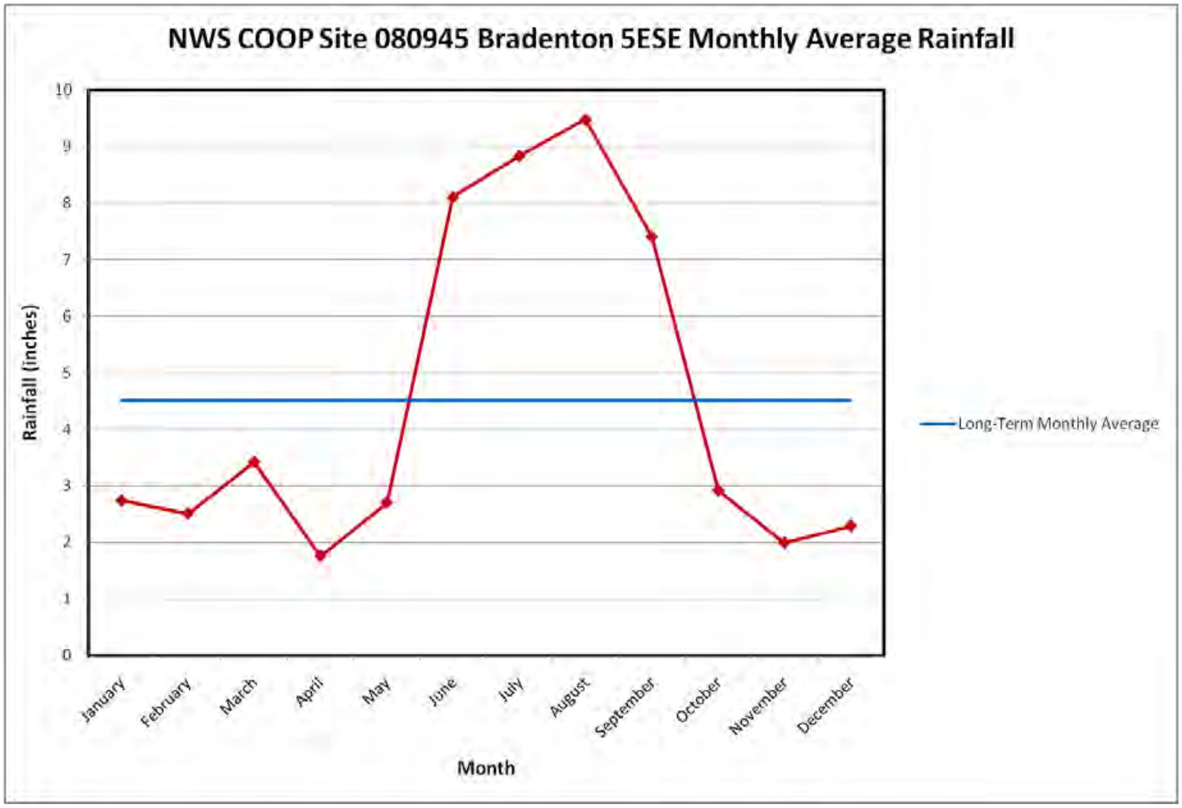
Appendix G: Daily, Monthly, and Annual precipitation at Bradenton 5ESE, 1965-2009

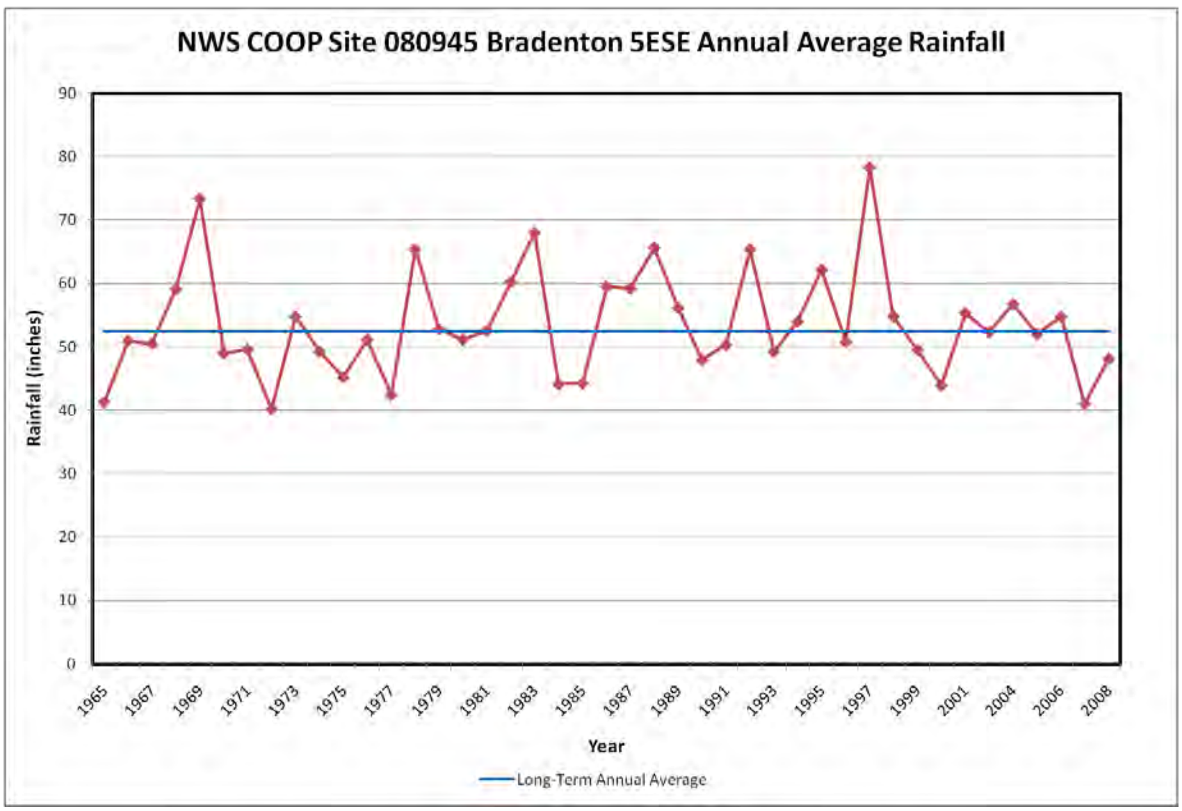


Monthly and Annual Precipitation at Bradenton 5ESE, 1965-2009

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1965					0.21	9.85	11.37	6.15	9.3	1.68	0.86	1.89	41.31
1966	6.43	1.65	0.96	2.79	2.57	9.43	7.23	10.68	6.48	1.54	0.43	0.8	50.99
1967	1.48	3.99	0.53	0	0.28	10.45	6.11	13.52	10.17	1.16	0.81	2.03	50.53
1968		1.6	1.56	0.06	3.85	16.46	12.74	8.68	5.98	5.03	2.24	0.91	59.11
1969	3.29	1.61	8.43	0.9	7.52	9.76	9.75	11.21	8.92	5.23	1.15	5.62	73.39
1970	2.22	2.33	7.29	0.12	4.29	4.96	2.39	11.7	8.04	3.61	1.41	0.66	49.02
1971	0.28	5.02	0.8	0.21	2.87	3.15	7.19	11.97	8.88	4.77	2.47	2	49.61
1972	1.96	5.35	3.71	0.18	0.81	6.83	4.51	7.43	1.96	1.36	3.58	2.55	40.23
1973	6.35	2.42	1.73	2.99	0.98	1.18	12.08	10.81	10.39	1.65	1.4	2.79	54.77
1974	0	1.54	0.78	0.79	1.07	17.33	8.48	10.29	4.5	0.06	0.21	4.23	49.28
1975	0.95	2.66	0.74	0.5	1.93	8.71	7.4	5.7	7.44	8.5	0.17	0.54	45.24
1976	0.55	0.29	0.22	1.55	7.64	9.29	8.23	10.01	7.27	1.6	2.86	1.64	51.15
1977	2.12	1.14	0.52	0.55	1	3.28	9.26	8.53	5.57	1.21	2.61	6.71	42.5
1978	3.38	4.29	3.08	0.19	9.34	8.94	13.87	8.61	7.81	3.07	0.21	2.61	65.4
1979	5.92	1.07	1.83	0.4	4.29	4.7	5.96	10.4	14.5	0.53	0.58	2.63	52.81
1980	3.73	2.59	2.1	3.7	4.1	3.11	10.26	10.23	5.23	2.06	3.58	0.5	51.19

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1981	0.95	3.27	0.91	0.03	1.67	7.19	3.51	24.42	5.01	0.67	2.61	2.36	52.6
1982	1.23	2.79	7.42	2.32	1.13	9.79	7.36	9.35	11.88	4.96	1.19	0.86	60.28
1983	2.34	10.16	8.63	2.42	1.17	6.84	7.43	7.01	6.45	4.91	4.43	6.23	68.02
1984	1.45	2.27	3.65	2.15	2.38	5.46	16.28	3.96	2.33	0.45	3.49	0.24	44.11
1985	3.31	1.04	2.87	2.82	1.34	6.93	6.63	8.04	4.99	2.25	2.6	1.44	44.26
1986	3.06	1.93	4.07	0.93	1.93	10.82	11.18	10.44	6.07	3.36	2.95	2.78	59.52
1987	3.69	2.62	11.1	0.23	2.87	6.18	14.25	4.45	6.55	2.89	3.64	0.75	59.22
1988	3.13	2.34	5.27	0.77	2.55	2.8	12.94	13.63	15.57	0.58	5.15	0.92	65.65
1989	2.66	0.13	2.97	1.38	2.44	9.06	9.82	7.99	13.4	1.26	0.59	4.47	56.17
1990	0.29	4.07	1.09	1.33	1.91	8.7	8.55	6.6	3.39	7.11	2.85	2.05	47.94
1991	3.79	1.2	3.96	4.57	9.39	4.15	10.61	8.18	2.74	1.21	0.06	0.44	50.3
1992	0.98	7.13	4.05	2.93	0.15	22.34	7.07	10.22	3.91	3.19	1.81	1.59	65.37
1993	9.03	2.03	2.16	3.73	1.53	3.66	6.94	7.33	4.08	7.09	0.68	0.99	49.25
1994	3.51	0.75	2.8	2.57	0.18	10.8	8.14	9.45	7.24	3.53	1.65	3.39	54.01
1995	3.09	2.22	2.57	3.41	1.48	8.93	10.67	11.3	8.25	5.12	3.97	1.16	62.17
1996	3.95	1	5.5	1.58	9.52	11.75	3.7	3.2	3.2	4.94	0.65	1.82	50.81
1997	1.92	1.21	4.5	8.78	3.27	7.22	8.77	7.6	11.1	2.62	9.4	11.94	78.33
1998	10.26	5.91	8.16	0.1	3.41	0.64	4.92	5.64	11.1	0.97	2.7	1.03	54.84
1999	3.69	0.5	0.97	0.55	2.05	7.89	6.48	17.63	4.25	2.95	0.69	1.91	49.56
2000	0.64	0.4	2.5	1.21	0.99	4.55	8.85	11.71	10.42	0.23	1.63	0.83	43.96
2001	0.11	0	10.35	0.5	1.72	9.79	15.93	4.74	9.47	2.75			55.36
2003					2.78	16.1	5.43	15.37	7.96	0.88	0.71	3.09	52.32
2004	2.13	4.4	0.5	2.81	0.53	6.81	8.5	12.73	12.04	1.64	1.54	3.13	56.76
2005	1.45	5.3	5.22	3.87	2.71	10.33	7.99	3.57	1.73	6.96	2.27	0.63	52.03
2006	0.32	1.81	0.78	0.89	1.77	8.53	11.97	9.75	14.23	1.48	1.02	2.22	54.77
2007	2.31	1.22	0.48	2.81	0.5	3.58	9.28	7.13	7.28	5.94	0.05	0.47	41.05
2008	2.54	1.47	3.56	2.49	2.09	10.17	9.85	10.03	1.42	2.37	0.79	1.37	48.15
2009	1.74	0.65											2.39
Max Value	10.26	10.16	11.1	8.78	9.52	22.34	16.28	24.42	15.57	8.5	9.4	11.94	78.33
Min Value	0	0	0.22	0	0.15	0.64	2.39	3.2	1.42	0.06	0.05	0.24	2.39
Mean	2.74	2.51	3.42	1.76	2.70	8.10	8.83	9.47	7.41	2.92	1.99	2.29	52.40
Median	2.31	1.98	2.8	1.33	1.93	8.53	8.5	9.45	7.27	2.37	1.585	1.855	51.61


NWS COOP Site 080945 Bradenton 5ESE Monthly Average Rainfall
Rainfall (inches)
0
1
2
3
4
5
6
7
8
9
10
January
February
March
April
May
June
July
August
September
October
November
December
Month
Long-Term Monthly Average


NWS COOP Site 080945 Bradenton 5ESE Annual Average Rainfall
Rainfall (inches)
0
10
20
30
40
50
60
70
80
90
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2004
2006
2008
Year
Long-Term Annual Average

Appendix H: Spearman Correlation Matrix Analysis for Water Quality Parameters, Stream Flow and Rainfall in Rattlesnake Slough

Nonparametric: Spearman's ρ

Variable	by Variable	Spearman ρ	Prob>|ρ|	Plot
26252 Pearce Drain 7-day Moving Average	26252 Pearce Drain_Rainfall (in)	0.4839	<.0001	
26253 Pearce Drain 14-day Moving Average	26252 Pearce Drain_Rainfall (in)	0.3877	<.0001	
26253 Pearce Drain 14-day Moving Average	26252 Pearce Drain 7-day Moving Average	0.7797	0.0000	
Discharge (cfs)	26252 Pearce Drain_Rainfall (in)	0.3783	<.0001	
Discharge (cfs)	26252 Pearce Drain 7-day Moving Average	0.7228	0.0000	
Discharge (cfs)	26253 Pearce Drain 14-day Moving Average	0.7643	0.0000	
Chlorophyll	26252 Pearce Drain_Rainfall (in)	0.1171	0.2664	
Chlorophyll	26252 Pearce Drain 7-day Moving Average	0.5244	<.0001	
Chlorophyll	26253 Pearce Drain 14-day Moving Average	0.4773	<.0001	
Chlorophyll	Discharge (cfs)	0.3640	<.0001	
Dissolved Oxygen	26252 Pearce Drain_Rainfall (in)	-0.0996	0.3396	
Dissolved Oxygen	26252 Pearce Drain 7-day Moving Average	-0.1949	0.0598	
Dissolved Oxygen	26253 Pearce Drain 14-day Moving Average	-0.2487	0.0156	
Dissolved Oxygen	Discharge (cfs)	-0.0621	0.3308	
Dissolved Oxygen	Chlorophyll	-0.0080	0.9108	

Appendix I: Public Comments and FDEP Responses

The below comments were received by email from Mr. Robert C. Brown of the Manatee County Natural Resources Department on July 20, 2009

Comment 1.
The calculation methodology for both the fecal coliform and dissolved oxygen TMDLs utilizes the median of only the target load or concentration exceedances to determine a percentage reduction needed for the TMDL. The load reduction requirement is then assigned to *all* flow into the waterbody, including the significant amount of flow that is well within acceptable ranges.

Manatee County recommends the TMDL calculation methodology be modified to either 1) include a determination of the percentage of flow requiring the specified load reduction, or 2) utilize all data (both above and below the criterion) to determine the percentage reduction on all flow necessary to achieve the water quality criteria.

FDEP response: For clarification, the target load is determined for all flow data available. The allowable loads calculated are then plotted against the target load to determine when exceedances occur. The percent reduction is the relationship between the exceedance load trend and the target load. The percent reductions are calculated from a trend line throughout the entire flow interval regime, which displays the best fit and central tendency of all the exceedances loads. Instead of corresponding to a specific flow interval, the percent reduction median represents a probability distribution of the exceedances load population separating half of the higher values and from half of lesser values. It is “a middle of the road” estimation for the all exceedance loads calculated for all possible flows. The corresponding percentage of flow is only associated with the *one* point where the median occurs.

Since DO exceedances occurred both above and below the target loads or target concentrations for nutrients and BOD_5, the exceedance load calculations were used to determine the percent reductions in order to provide an implicit, conservative, protective margin of safety. The percent reductions are provided as an initial proposal to be utilized during the Basin Management Action Plan and to assist with wasteload allocations between the stakeholders and collaborative parties. Reasonable assurance, meeting the water quality criteria, may be obtainable by applying both the target concentrations and target loads, where utilizing both may provide more management opportunities.

Comment 2.
The draft TMDLs for both Nonsense Creek (WBID 1913) and Braden River (WBID 1914) do not acknowledge the Tara, Lakewood Ranch, and University Place Community Development Districts (CDDs) that lie within these watersheds (see Figure 1). These CDDs are responsible for discharges from their stormwater collection systems under a Phase II MS4 permit.

FDEP Response: Currently the Lakewood Ranch Community Development District is a regulated Phase II MS4 under the permit, FLR04E107. The Tara and University Place CDDs are presently not designated as a regulated Phase II MS4s. A petition may be submitted to the Department requesting designation as regulated Phase II MS4s under the NPDES stormwater program. See Chapter 62-624, F.A.C. describing the petition and designation requirements.

Comment 4.
Rattlesnake Slough (WBID 1923), Cedar Creek (WBID 1926), Nonsense Creek (WBID 1913) and Braden River (WBID 1914) lie within the Evers Reservoir Watershed Overlay District, and Gilly Creek (WBID 1840) lies within the Lake Manatee Watershed Overlay District. Section 604 of the Manatee County Land Development Code imposes restrictions and requirements designed to be protective of water quality in these potable-source watersheds. Stormwater systems within the overlay districts must meet Outstanding Florida Waters (OFW) design criteria, and septic tank locations are subject to additional setback criteria.

FDEP response: The Department values the expressed efforts by Manatee County to prevent the lowering of existing water quality criteria for the watersheds within the overlay districts. One of the purposes of the TMDL is to provide supportive measures, which will ensure protection for Florida's waters for generations to come. FDEP encourages these efforts to be presented by Manatee County during the Basin Management Action Plan (BMAP) development phase of the TMDL process.

Comment 6.
As reported in the draft TMDLs, average dissolved oxygen (DO) concentrations in the Rattlesnake Slough (WBID 1923) and Nonsense Creek (1913) watersheds for the 7.5 year verified period were 5.5 mg/L and 5.6 mg/L, respectfully. Data from the county's sampling stations in these watersheds indicate that average annual DO values have been generally increasing since 1990 (Figure 3). These data suggest that a DO TMDL for these subwatersheds may not be necessary.

FDEP response: While the data do suggest a DO TMDL may not be warranted for either watershed, the methodology for determining if a watershed is impaired for dissolved oxygen is outlined in Chapter 62-303, F. A. C. Both waters are on the list of water segments submitted to EPA in 1998 and had sufficient quality and quantity of data to be assessed. Each were placed on the planning list to be assessed and then re-evaluated using the data from January 1, 2001 to June 30, 2008. The watersheds were then verified as impaired for DO when 10% or more of the samples did not meet the DO criterion with a 90% confidence level using a binomial distribution. As outlined in Chapter 2 of the TMDLs, 12 exceedances are required, by rule, to be considered verified impaired for DO. Rattlesnake Slough (WBID 1923) had 21 exceedances and Nonsense Creek (WBID 1913) had 14 exceedances. The initial assessment by the Impaired Waters Rule (IWR) suggested the possible causative pollutants to be nutrients (total nitrogen and/or total phosphorus) and BOD_5 as a result of urbanization and related anthropogenic activities.

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