TMDL Report

Nutrient TMDL for Winter Haven Northern Chain of Lakes, Lake Haines and Lake Smart

(WBIDs 1488C, 1488A)

U.S. Environmental Protection Agency
Region 4

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EPA United States Environmental Protection Agency

Region 4 serving the southeast

In compliance with the provisions of the Federal Clean Water Act, 33 U.S.C §1251 et. seq., as amended by the Water Quality Act of 1987, P.L. 400-4, the U.S Environmental Protection Agency is hereby establishing the Total Maximum Daily Load (TMDL) for nutrients in the Peace River Basin (WBIDs 1488A and 1488C). Subsequent actions must be consistent with this TMDL.

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James D. Giattina, Director
Water Management Division

Date

Acknowledgments

EPA would like to acknowledge that the Florida Department of Environmental Protection (FDEP) helped prepare the contents of this report. However, the total maximum daily loads (TMDLs) contained herein were developed by EPA. Many of the text and figures may not read as though EPA is the primary author for this reason, but EPA is officially establishing the TMDL for nutrients for the lakes in **Table 2.1**. EPA is establishing this TMDL in order to meet consent decree requirements pursuant to the Consent Decree entered in the case of Florida Wildlife Federation, et al. v. Carol Browner, et al., Case No. 98-356-CIV-Stafford.

This report was developed with significant contributions from staff in the Florida Department of Environmental Protection's (Department) Watershed Assessment Section. EPA also recognizes the primary source of information utilized in developing these TMDLs is the Southwest Florida Water Management District's Winter Haven Chain of Lakes Pollutant Load Reduction Goal Study (PLRG) by McCary, J.P., and M.A. Ross.

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Florida Department of Environmental Protection, Bureau of Watershed Management TMDL Program

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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

2002 305(b) Report

http://www.dep.state.fl.us/water/docs/2002_305b.pdf

Criteria for Surface Water Quality Classifications

http://www.dep.state.fl.us/legal/rules/shared/62-302t.pdf

Basin Status Report for the Tampa Bay Basin

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

Water Quality Assessment Report for the Tampa Bay Basin

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Allocation Technical Advisory Committee (ATAC) Report

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

http://www.epa.gov/region4/water/tmdl/florida/

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1: INTRODUCTION

1.1 Purpose of Report

This report presents the Total Maximum Daily Load (TMDL) for total phosphorus to address the nutrient impairment for the Winter Haven Chain of Lakes, which are located in the Upper Peace River Planning Unit and part of the larger Sarasota Bay, Peace River, and Myakka River Basin Group. A number of the lakes in the watershed were verified as impaired for nutrients, using the methodology described in the Identification of Impaired Surface Waters Rule (IWR), Chapter 62-303, Florida Administrative Code (F.A.C.). Ten lakes were included on the 1998 303(d) list as impaired for nutrients. Sixteen lakes were included on the FDEP Verified List of impaired waters for the Sarasota Bay, Peace River, and Myakka River Basin Group that was adopted by Secretarial Order in June 2005. This TMDL report establishes the allowable loadings to the watershed that would restore two of the ten lakes on the 1998 303 (d) list so that they meet the applicable water quality standards for nutrients. These two lakes are Lakes Haines and Smart. The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards, based on the relationship between pollution sources and ambient water quality conditions.

The Winter Haven Chain of Lakes is one of the ten priority Surface Water Improvement and Management (SWIM) waterbodies designated by the Southwest Florida Water Management District. For SWIM waterbodies, State of Florida water policy requires the Water Management Districts to set and adopt Pollutant Load Reduction Goals (PLRGs) for pollutants of concern. In the Water Resource Implementation Rule (Chapter 62-40, F.A.C.), PLRGs are defined as estimated numeric reductions in pollutant loadings needed to preserve or restore designated uses of receiving bodies of water and maintain water quality consistent with applicable state standards. In 2005, the District developed a revised PLRG for phosphorus to address lake eutrophication throughout the watershed (McCary and Ross, 2005), and this PLRG serves as the basis for the nutrient TMDL.

1.2 Identification of Waterbody

The Winter Haven Chain of Lakes watershed is located in north-central Polk County within and around the City of Winter Haven **(see Figure 1.1).** The Winter Haven Chain of Lakes system is generally divided into the Northern Chain consisting of 5 lakes and the Southern Chain consisting of 16 lakes **(see Figure 1.2)**. The watershed draining to the lakes is almost 32 square miles and almost half of this area is comprised of water and wetlands. The Northern Chain Lakes includes Conine, Rochelle, Haines, Smart and Fannie. The Southern Chain Lakes consists of Winterset, Eloise, Summit, Lulu, Roy, Shipp, May, Howard, Cannon, Blue, Mirror, Spring, Idylwild, Jessie, Mariana, and Hartridge. Lakes Blue and Mariana are only connected to the other lakes in the Southern Chain when seasonal high waters exceed various threshold levels.

In the Northern Chain, water levels in lakes Haines, Rochelle, Conine and Smart fluctuate at the same level since they are interconnected via man-made canals. The Structure P-6, between Lakes Smart and Fannie, controls these lake levels. Lake Fannie is downstream of Structure P-

6 and its elevation is controlled by Structure P-7. When water passes through Structure P-7, it eventually flows into the Peace Creek Drainage Canal. At high water levels, water from the Southern Chain can enter the Northern Chain via a weir structure that allows flow from the east side of Lake Hartridge to the west side of Lake Conine.

In the Southern Chain, water levels are related via a series of interconnecting canals. As mentioned above, Lakes Blue and Mariana are connected to the other lakes only during wet periods. The Southern Chain discharges from a structure on the southern side of Lake Lulu, which controls water levels of all the lakes in the Southern Chain (except Blue and Mariana). Discharge from this structure can be controlled to regulate lake levels in the Southern Chain. Flows out of Lake Lulu enter the Wahneta Farms Drainage Canal that eventually flows into the Peace Creek Drainage Canal at an area just north of Lake Garfield.

For assessment purposes, the Florida Department of Environmental Protection (Department) has divided the Upper Peace River Planning Unit into water assessment polygons with a unique **w**ater**b**ody **id**entification (WBID) number for each waterbody or water segment. The Winter Haven Chain of Lakes watershed includes the 21 lake WBIDs in the Northern and Southern Chain. The sixteen lake segments placed on the verified list for nutrient impairment is the primary subject of this TMDL. **Figure 1.2** shows the watershed, as well as the locations of the water quality monitoring stations and control structures discussed in this report.

1.3 Background

EPA is developing this TMDL in order to meet consent decree requirements pursuant to the Consent Decree entered in the case of Florida Wildlife Federation, et al. v. Carol Browner, et al., Case No. 98-356-CIV-Stafford.

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 not meeting their water quality standards. TMDLs provide important water quality restoration goals that will guide restoration activities.

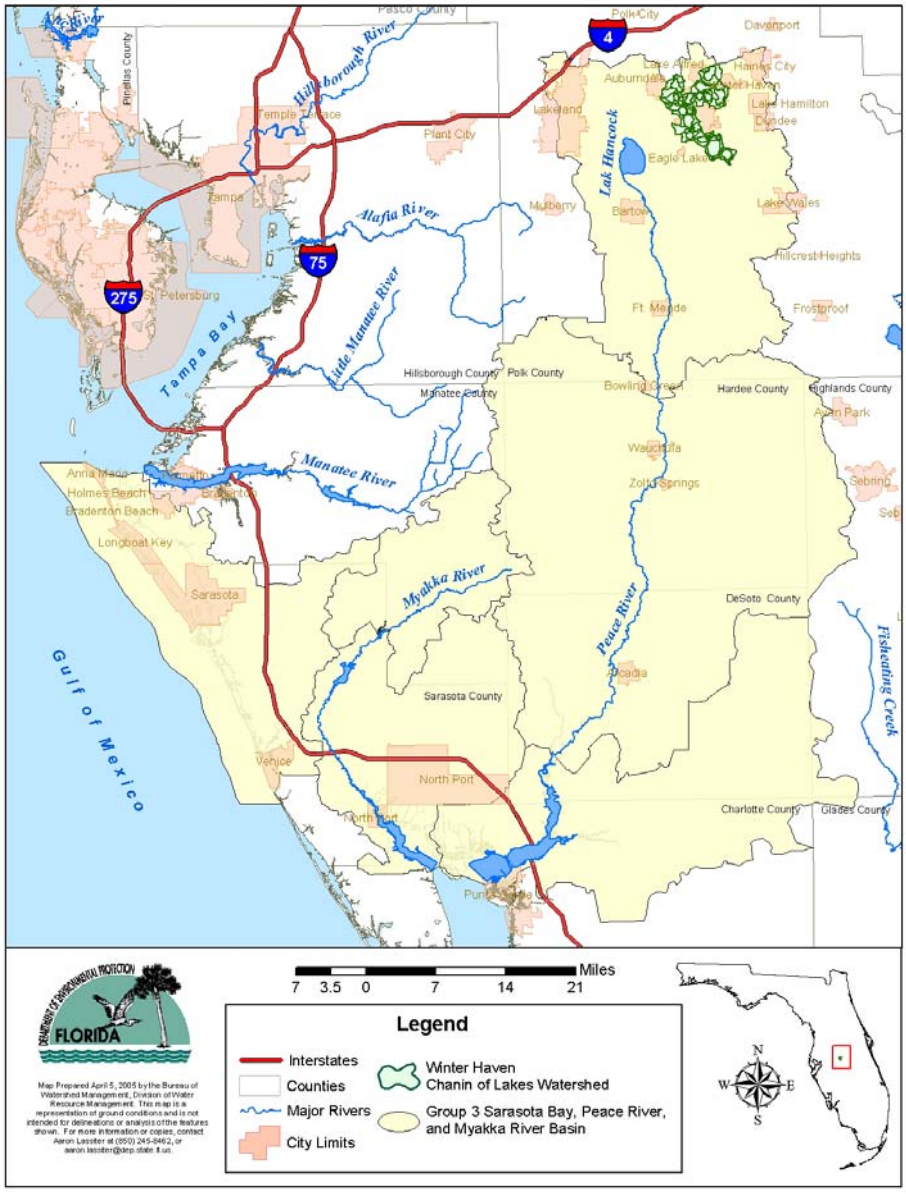

Figure 1.1: Location of the Winter Haven Chain of Lakes Water Segments, and Major Geopolitical Features in the Sarasota Bay, Peace River, and Myakka River Basin Group

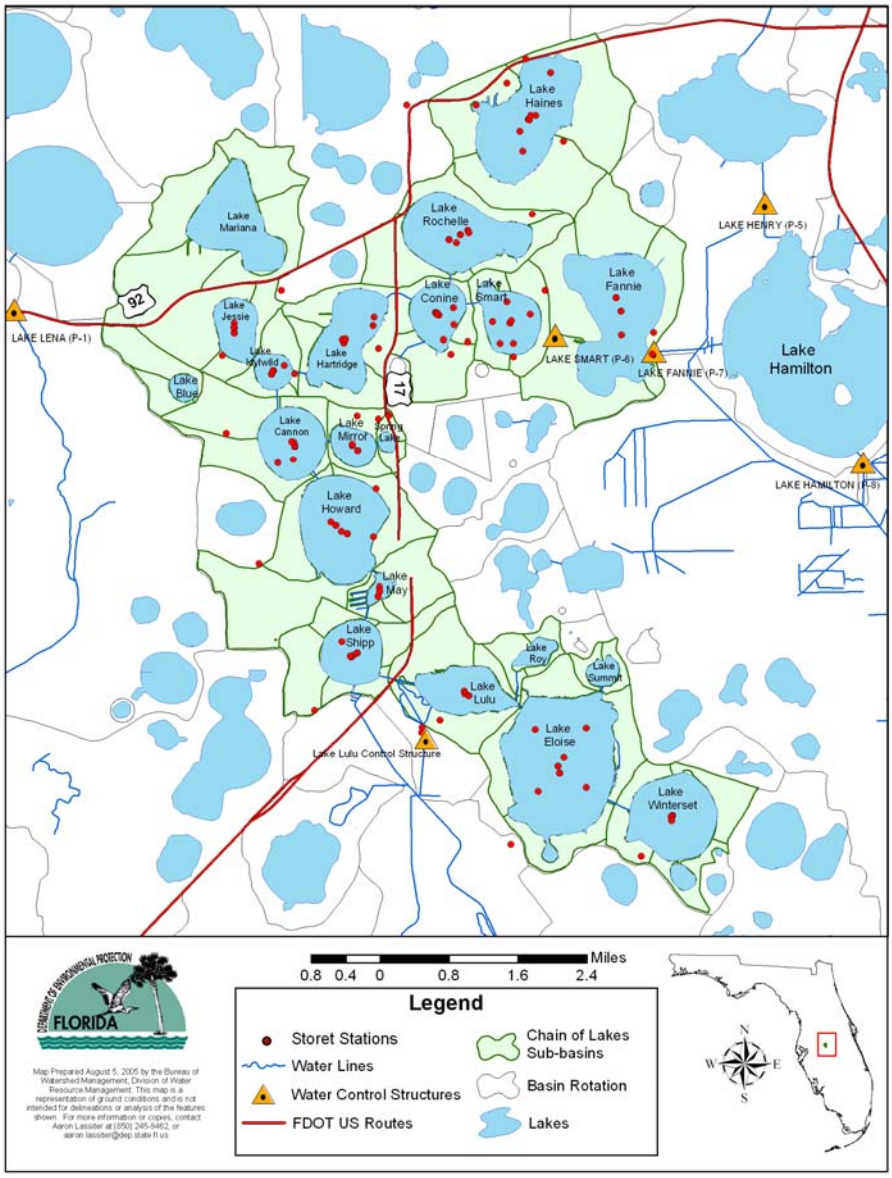

Figure 1.2: Winter Haven Chain of Lakes Water Segments, and Monitoring Locations

2: DESCRIPTION OF WATER QUALITY PROBLEM

2.1 Statutory Requirements and Rulemaking History

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

Florida's 1998 303(d) list included 84 waterbodies in the Sarasota Bay, Peace River, and Myakka River Basin Group. However, the FWRA (Section 403.067, F.S.) stated that all previous Florida 303(d) lists were for planning purposes only and directed the Department to develop, and adopt by rule, a new science-based methodology to identify impaired waters. After a long rule-making process, the Environmental Regulation Commission adopted the new methodology as Chapter 62-303, F.A.C. (Identification of Impaired Surface Waters Rule, or IWR), in April 2001. The list of waters for which impairments have been verified using the methodology in the IWR is referred to as the Verified List.

2.2 Information on Verified Impairment

The FDEP used the IWR to assess water quality in the Winter Haven Chain of Lakes and verified the impairments for nutrients shown in **Table 2.1. Table 2.2** summarizes the nutrient assessment results for the lakes placed on the verified list using data collected during the verification period (January 1997 to June 2004) and planning period (January 1992 to December 2001). The Trophic State Index (TSI), a calculation based on nutrient and chlorophyll a concentrations, is the primary means of assessing nutrient impairment in lakes. The IWR listing methodology has two TSI thresholds that are applied depending on the annual mean color in lake water. Lakes or lake segments are placed on the verified list if the annual mean TSI in any one year exceeds 60 when the mean annual color is greater than 40 platinum cobalt units (PCU) or if the TSI exceeds 40 when the mean annual color is less than or equal to 40 PCU. The majority of the sixteen impaired lakes were placed on the verified list because at least one annual mean TSI exceeded 40, during the verification period, when the annual mean color was less than or equal to 40 PCU **(see Table 2.2)**. However, as explained in Chapter 3, the TSI threshold of 60 is used as the target in the PLRG Study, based on paleolimnological research performed on lakes in the Winter Haven Chain.

Most of the lake data used in the assessment were collected by the Polk County Natural Resources Division, Florida Lake Watch, and the Southwest Florida Water Management District. **Appendix B** presents graphs of the individual chlorophyll a, total nitrogen, and total phosphorus results for each of the 10 lakes with a high priority for TMDL development.

As part of the listing process, the Department attempts to identify the limiting nutrient or nutrients for the impaired waterbody. The limiting nutrient, generally nitrogen or phosphorus, is defined as the nutrient that limits plant growth when it is not available in sufficient quantities. A

limiting nutrient is a chemical that is necessary for plant growth, but available in quantities smaller than those needed for algae, represented by chlorophyll *a*, and macrophytes to grow. Once the limiting nutrient in a waterbody is exhausted, algae stop growing. If more of the limiting nutrient is added, larger algal populations will result until nutrients or other environmental factors again limit their growth.

In Florida waterbodies, nitrogen and phosphorus are most often the limiting nutrients. Determining the limiting nutrient in a waterbody can be accomplished by calculating the ratio of nitrogen to phosphorus in the waterbody. Water column ratios of total nitrogen (TN) to total phosphorus (TP) of less than 10 indicate nitrogen limitation, TN to TP ratios between 10 and 30 indicate co-limitation by nitrogen and phosphorus, and TN to TP ratios greater than 30 indicate phosphorus limitation. Based on the data collected during the verified period, the Winter Haven Chain of Lakes median TN to TP ratios indicate that the lakes are either phosphorus limited or co-limited **(Table 2.2)**. Of the lakes on the verified list, Lakes Mirror, Howard, Shipp, Winterset, and Eloise in the Southern Chain are phosphorus limited and the rest of the lakes are co-limited.

In addition to causing excessive growth of algae, nutrient enrichment of a waterbody can lead to widely varying dissolved oxygen levels and low DO concentrations in bottom waters. Algal populations produce oxygen as a result of photosynthesis during daylight hours and consume oxygen due to respiration at night and at water depths where light does not penetrate. Additionally, a portion of the dead algal population will become part of the organic material that will be broken down by microbes and in the process will consume DO in the water column and sediments.

Table 2.1: Impaired Lakes in the Winter Haven Chain of Lakes

WBID	Water Segment Name	Parameter Causing Impairment	Priority for TMDL Development	Projected Year for TMDL Development
1488C	Lake Haines	Nutrients (TSI)	High	2004
1488A	Lake Smart	Nutrients (TSI)	High	2004

Table 2.2: Summary of Nutrient Assessment Results for the Impaired Winter Haven Chain of Lakes

WBID	Water Segment Name	Chain	Impaired Waters Rule Assessment Status	TMDL Year	TN/TP Ratio Median	Annual Average TSI[a]												Average TSI 1992 to 2003
						1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	
1521H	LAKE CANNON	Southern	Impaired Nutrients (TSI)	2004	22.0	63.0	62.2	59.5	66.7	65.1	62.3	62.7	56.9	60.8	62.2	59.0		61.9
1521B	LAKE ELOISE	Southern	Impaired Nutrients (TSI)	2004	38.3				63.7		55.6							59.7
1488C	LAKE HAINES	Northern	Impaired Nutrients (TSI)	2004	21.5	71.0	***75.5***	76.3	***69.1***	***75.4***	70.2	***65.8***	65.5	62.2	59.9		***68.1***	69.0
1521F	LAKE HOWARD	Southern	Impaired Nutrients (TSI)	2004	45.6	67.5	63.4	62.5	65.2	63.3	65.5		57.3					63.5
1521K	LAKE JESSIE	Southern	Impaired Nutrients (TSI)	2004	19.4	63.6			64.6	62.2	61.1	62.9	59.0					62.2
1521	LAKE LULU	Southern	Impaired Nutrients (TSI)	2004	24.0	48.7	54.7	47.4	53.8	48.9	47.1	54.6	57.2	65.0	66.2	64.8		55.3
1521E	LAKE MAY	Southern	Impaired Nutrients (TSI)	2004	23.0						64.1	67.0	59.1					63.4
1521G	LAKE MIRROR	Southern	Impaired Nutrients (TSI)	2004	43.0												***69.4***	69.4
1521D	LAKE SHIPP	Southern	Impaired Nutrients (TSI)	2004	40.2						70.4		64.9	75.6	72.0	71.1	***68.2***	70.4
1488A	LAKE SMART	Northern	Impaired Nutrients (TSI)	2004	24.7						64.9	***66.6***	59.3	60.0				62.7

a Values in bold and italic indicate annual mean color was greater than 40 PCU

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)**

The Winter Haven Chain of Lakes are Class III fresh waterbodies, with a designated use of recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife. The Class III water quality criteria applicable to the observed impairment addressed in this TMDL is the narrative nutrient criteria.

3.2 Applicable Water Quality Standards and Numeric Water Quality Targets

3.2.1 Interpretation of Narrative Nutrient Criterion

Florida's nutrient criterion is narrative only—nutrient concentrations of a body of water shall not be altered so as to cause an imbalance in natural populations of aquatic flora or fauna. Accordingly, a nutrient-related target was needed to represent levels at which an imbalance in flora or fauna is expected to occur. While the IWR provides a threshold for nutrient impairment for lakes based on annual average TSI levels, these thresholds are not standards and need not be used as the nutrient-related water quality target for TMDLs. In fact, in recognition that the IWR thresholds were developed using statewide average conditions, the IWR (Section 62-303.450, F.A.C.) specifically allows the use of alternative, site-specific thresholds that more accurately reflect conditions beyond which an imbalance in flora or fauna occurs in the waterbody.

In translating the narrative nutrient criterion for this TMDL the TSI target set by the SWFWMD, which is derived from the conclusions of a paleolimnological study of lakes in the Winter Haven Chain, is used as the site-specific threshold to address the lakes nutrient impairment. Researchers from the University of Florida conducted a paleolimnological investigation of sediment cores from five lakes (Lakes Conine, Haines, Hartridge, Howard, and May) in the Winter Haven Chain of Lakes (Whitmore and Brenner, 1995). The researchers indicated that qualitative interpretations show similar patterns of historical change in all five lakes. The

deepest, pre-disturbance samples (nominally 1860) in all the lakes studied showed the dominance of planktonic species which are distinctive indicators of mesotrophic to eutrophic conditions. The study concluded that given predisturbance conditions in the lakes the maximum improvement in current water quality that is feasible would result in mesotrophic to eutrophic conditions, elimination of cyanobacterial blooms, and reestablishment of summer populations of planktonic diatoms. Mesotrophic to eutrophic conditions are typically associated with TSI values in the range of 50 to 60. Based on the study results the SWFWMD set a TSI target of 60 for the lakes for PLRG development (SWFWMD, 1998).

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 the pollutant of concern 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 5 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" is 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. 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 chapter does not make any distinction between the two types of stormwater.

4.2 Point Sources

4.2.1 NPDES Permitted Wastewater Facilities

There are no NPDES-permitted wastewater treatment facilities that discharge to surface waters in the Winter Haven Chain of Lakes watershed.

4.2.2 Municipal Separate Storm Sewer System Permittees

Municipal Separate Storm Sewer Systems (MS4s) may also discharge pollutants to waterbodies in response to storm events. To address stormwater discharges, the EPA developed the NPDES stormwater permitting program in two phases. Phase I, promulgated in 1990, addresses large and medium-size MS4s located in incorporated areas and counties with populations of 100,000 or more. Phase II permitting began in 2003. Regulated Phase II MS4s

are defined in Section 62-624.800, F.A.C., and typically cover urbanized areas serving jurisdictions with a population of at least 10,000 or discharging into Class I or Class II waters, or into Outstanding Florida Waters.

The stormwater collection systems in the Winter Haven Chain of Lakes watershed, which are owned and operated by Polk County in conjunction with the Florida Department of Transportation District 1, are covered by a Phase I MS4 permit. The watershed falls under the Polk County Phase I MS4 Permit (Number FLS000015). The City of Winter Haven and City of Lake Alfred are co-permittees with portions of their jurisdictions located within the watershed.

4.3 Land Uses and Nonpoint Sources

Nutrient loading from urban areas is most often attributable to multiple sources, including stormwater runoff, leaks and overflows from sanitary sewer systems, illicit discharges of sanitary waste, runoff from improper disposal of waste materials, leaking septic systems, and domestic animals. Part of the surface runoff loads come from atmospheric deposition that falls directly onto the land surface which is then washed off into surface waters during rain events.

Onsite sewage treatment and disposal systems (OSTDSs), including septic tanks, are commonly used where providing central sewer is not cost-effective or practical. When properly sited, designed, constructed, maintained, and operated, OSTDSs are a safe means of disposing of domestic waste. The effluent from a well-functioning OSTDS is comparable to secondarily treated wastewater from a sewage treatment plant. When not functioning properly, however, OSTDSs can be a source of nutrients (nitrogen and phosphorus), pathogens, and other pollutants to both ground water and surface water. As of 2004, Polk County has approximately 112,848 septic systems (Florida Department of Health, 2005). This total does not reflect systems removed from service going back to 1970. The Department does not have information on the percentage of the population using septic systems in Polk County, nor does it have estimates of countywide failure rates to determine the daily discharge of wastewater from septic tanks.

4.3.1 Land Uses

The spatial distribution and acreage of different land use categories were identified using the SWFWMD's 1999 land use coverage (scale 1:40,000) contained in the Department's geographic information system (GIS) library (Florida Department of Environmental Protection, June 2004). The Winter Haven Chain of Lakes watershed covers 20,257 acres or approximately 32 square miles. Land use categories in the watershed, aggregated using the Level 1 1999 Florida Land Use and Cover Classification System (FLUCCS) are tabulated in **Table 4.1**. The predominant Level I land use in the watershed is Urban and Built-up, which comprises 38 percent of the area. The next largest area is Water, which makes up 37 percent of the watershed area.

4.3.2 Estimating Nonpoint Loadings

The PLRG study report, which is the basis for this TMDL, included loading estimates from surface runoff and ground water (McCary and Ross, 2005). The study estimated total phosphorus loads from

watershed runoff using the Storm Water Management Model (SWMM) and from ground water using the U. S. Geological Survey MODFLOW program (McCary and Ross, 2005). The 10 year average (1990 to 1999) model load results for each lake are presented in **Table 4.2**. The loading estimates show that watershed runoff contributes about 2,800 kg/year of total phosphorus in the Southern Chain and almost 500 kg/year in the Northern Chain. Ground water contributes another 123 kg/year of total phosphorus in the Southern Chain and 135 kg/year in the Northern Chain. A larger proportion of the load to the Northern Chain of Lakes is derived from ground water, which makes up 29 percent of the total load, as compared to ground water only making up 4 percent of the total load to the Southern Chain of Lakes.

Table 4.1: Classification of Land Use Categories in the Winter Haven Chain of Lakes

Code	Land Use	Acreage	Percentage of Total
1000	Urban Open	3,003	15
1100	Residential Low Density < 2 Dwelling Units/Acre	412	2
1200	Residential Med Density 2 - 5 Dwelling Units/Acre	3,489	17
1300	Residential High Density 6 or more Dwelling Units/Acre	794	4
2000	Agriculture	2,382	12
3000	Rangeland	180	1
4000	Upland Forests	509	3
5000	Water	7,459	37
6000	Wetlands	1,556	8
8000	Transportation, Communication and Utilities	473	2
Totals		**20,257**	**100**

Table 4.2: Total Phosphorus Loading Estimates to the Winter Haven Chain of Lakes[a]

Lake	Chain	Total P (kg/year)		
		Surface Runoff	Groundwater Inflow	Total Existing Load
Winterset	Southern	87.0	7.8	94.8
Eloise	Southern	181.6	10.1	191.7
Summit	Southern	40.3	1.9	42.2
Lulu	Southern	158.3	9.0	167.3
Roy	Southern	69.6	3.1	72.7
Shipp	Southern	228.5	12.9	241.4
May	Southern	180.3	4.5	184.8
Howard	Southern	322.1	14.3	336.4
Cannon	Southern	272.2	8.0	280.2
Blue	Southern	152.0	3.4	155.4
Mirror	Southern	68.4	2.2	70.6
Spring	Southern	36.8	1.4	38.2

Idylwild	Southern	100.1	3.8	103.9
Jessie	Southern	239.5	14.6	254.1
Marianna	Southern	440.4	17.0	457.4
Hartridge	Southern	214.7	9.2	223.9
Total		2792	123	2915
Conine	Northern	154.1	15.0	169.1
Rochelle	Northern	69.9	22.3	92.2
Haines	Northern	154.7	41.6	196.3
Smart	Northern	35.6	13.9	49.5
Fannie	Northern	56.3	42.1	98.4
Total		471	135	606

[a] Loads Obtained from Model Simulations for SWFWMD PLRG Study (McCary and Ross, 2005).

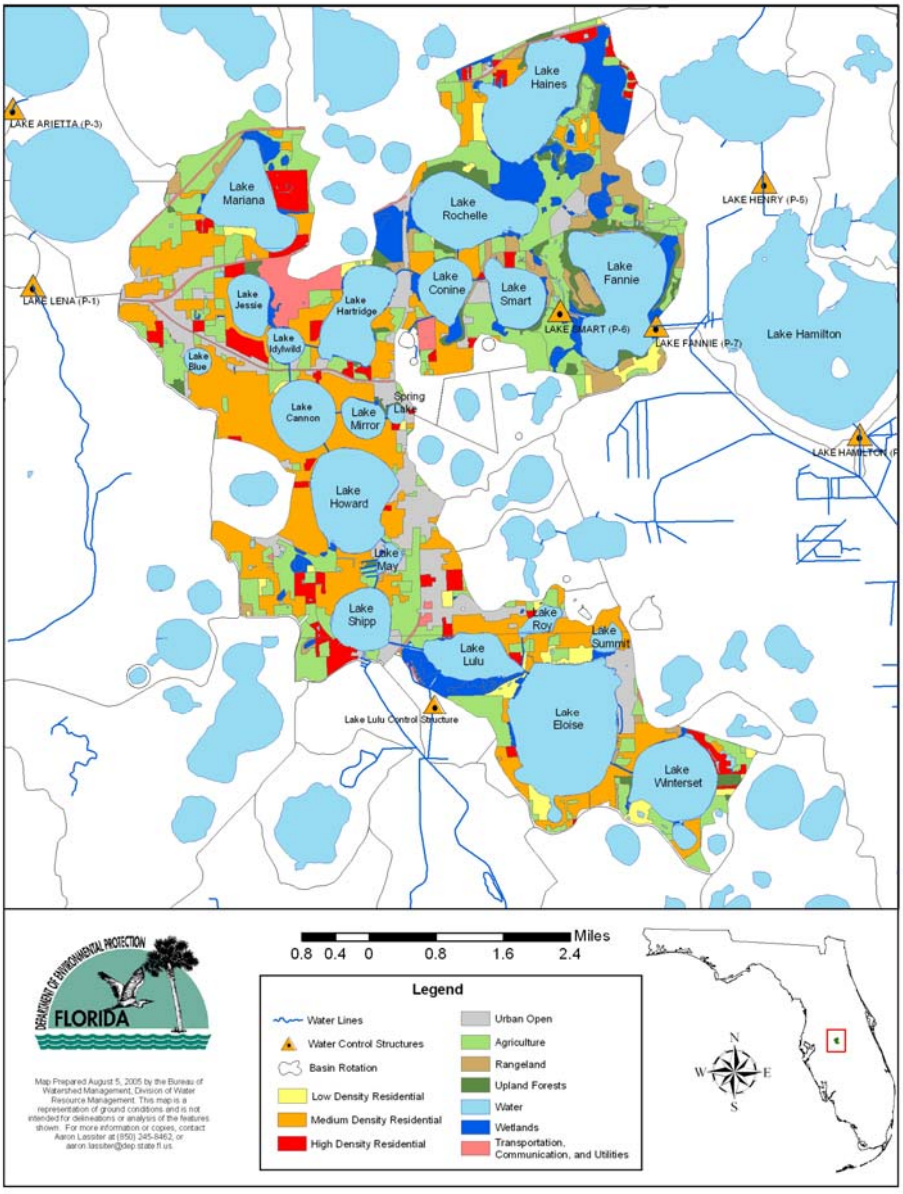

Figure 4.1: Principal Land Uses in the Winter Haven Chain of Lakes Watershed

5: DETERMINATION OF ASSIMILATIVE CAPACITY

5.1 Determination of Loading Capacity

The goal of the TMDL development process is to identify the maximum allowable TP loading to the Winter Haven Chain of Lakes watershed, so that the lakes will meet nutrient water quality criteria and maintain its function and designated use as Class III waters. The Winter Haven Chain of Lakes is one of the ten priority Surface Water Improvement and Management (SWIM) waterbodies designated by the Southwest Florida Water Management District. For SWIM waterbodies, State of Florida water policy requires the Water Management Districts to set and adopt Pollutant Load Reduction Goals (PLRGs) for pollutants of concern. In the Water Resource Implementation Rule (Chapter 62-40, F.A.C.), PLRGs are defined as estimated numeric reductions in pollutant loadings needed to preserve or restore designated uses of receiving bodies of water and maintain water quality consistent with applicable state standards. In 2005, the District developed a revised PLRG for total phosphorus to address lake eutrophication throughout the watershed, and this PLRG serves as the basis for the nutrient TMDL. This chapter provides a summary of the process used to develop the revised PLRG and the details of the study are located in the Winter Haven Chain of Lakes PLRG Study report (McCary and Ross, 2005).

The PLRG study entailed gathering data and information to develop a watershed runoff and ground water model that was then linked to a surface water model to simulate surface water quality for each of the 21 lakes in the Winter Haven Chain of Lakes watershed. A spreadsheet model was also developed to account for channel flows between the lakes. Model simulation was performed for the 1990 to 1999 period. The modeling included set up of the Storm Water Management Model (SWMM) to account for surface runoff volume and nutrient loadings, and the MODFLOW program to account for groundwater volume and nutrient loadings. The loads generated from the SWMM and MODFLOW model simulations as well as the transport between lakes obtained from the spreadsheet model were then input to the Water Quality Analysis Simulation Program (WASP) model that simulated water quality in each lake. Two WASP models were developed, one for the Northern Chain and one for the Southern Chain, as there are limitations in the number of segments (i.e. lakes) that could be input into WASP. Since this study is based on nutrient loading, the eutrophication module (EUTRO) in WASP was used to simulate the eutrophication processes in the lakes. For this study, simple eutrophication kinetics were used to model lake water quality. Simple eutrophication kinetics simulates the growth and decay of phytoplankton interacting with one of the nutrient cycles. Growth can be limited by the availability of inorganic nitrogen or inorganic phosphorus, and light. For this study, growth would be limited by inorganic phosphorus and light. The lakes in the watershed are either limited by phosphorus or co-limited by nitrogen and phosphorus. For the PLRG study it was assumed that the lakes as a whole are phosphorus limited.

Water quantity calibration included comparing model results to observed lake stage. Phosphorus and chlorophyll a concentration values were used for water quality calibration. A spreadsheet model was developed to simulate flows between the lakes and to calibrate model lake stage to measured lake stage. Calibration was accomplished by adjusting leakage values from the lakes to the Floridan aquifer, so that modeled lake stages were calibrated to measured lake stages. For the water quality calibration, once all known flows, loads, and parameter values were input, system constants were chosen within the range of recommended values as

specified by WASP that gave the best overall performance and match to measured data. In most cases, phosphorus was used for calibration. Final calibration was accomplished by adjusting the phosphorus settling rate for each individual lake.

Once the models were calibrated, a series of design scenarios were simulated to determine the effect of phosphorus load reductions on the lakes trophic level measured by the TSI. The scenarios were based on total phosphorus load reductions of 10%, 20%, 30%, 50%, and 70% throughout the watershed over the 10 year period of 1990 to 1999. The model results show that a 70% reduction in the total phosphorus load would result in an annual average TSI of 59 and 60 for Lakes Haines and Smart, respectively **(see Table 5.1)**. Table 5.1 shows the TSI computed from three methods. They are labeled “Total P TSI”, “Chlorophyll-a TSI”, and “Average TSI”, which is an average of these two. As shown in the table, the TSI’s computed from predicted phosphorus for Lakes Smart and Haines are slightly above the target of 60. However, the TSI’s based on cholorophyll-a are equal to or below the target of 60. The Winter Haven Chain of Lakes Surface Water Improvement and Management Plan states that “for phytoplankton dominated lakes (as compared to those dominated by macrophytes) either raw Chl-a (chlorophyll-a) concentration data or the TSI computed from Chl-a concentrations is probably the single best indicator of a lake's trophic state”. Therefore, a 70% reduction is expected to achieve a balance of flora and fauna as indicated by the chlorophyll-a TSI.

As shown in Table 5.1 the TSI for Lakes Haines and Smart improve modestly from 68 and 65 to 59 and 60, respectively. The PLRG study report indicates that the lack of significant improvements in TSI values are most likely due to the dependence of the Northern Chain on ground water inflows. The 70% load reduction for the Northern Chain does however show the lake TSIs would be reduced by at least 5 TSI units compared to the existing condition. Additionally, since all the lakes in the Northern Chain are co-limited, reductions in nitrogen loads may also be needed to effect lake eutrophication. Furthermore, many implementation plans that result in phosphorus reductions are also expected to reduce nitrogen.

In addition to these predicted improvements, there is evidence that Lake Smart water quality is improving due to the whole lake alum treatment on Lake Conine, which flows into Lake Smart. Chlorophyll-a data shows marked improvement after the 1995 treatment (see Figure 5.2). The chlorophyll-a data in Lake Haines also shows a downward trend (see Figure 5.1). This observed improvement in addition to the recommended reductions in phosphorus, and the expected reductions in nitrogen, further support establishing the total maximum daily load of a 70 percent reduction of total phosphorus. The actual effect of implementation of this TMDL should be monitored, and the TMDL can be revised if necessary. The total phosphorus loading for each lake with a 70% reduction is presented in **Table 5.2**.

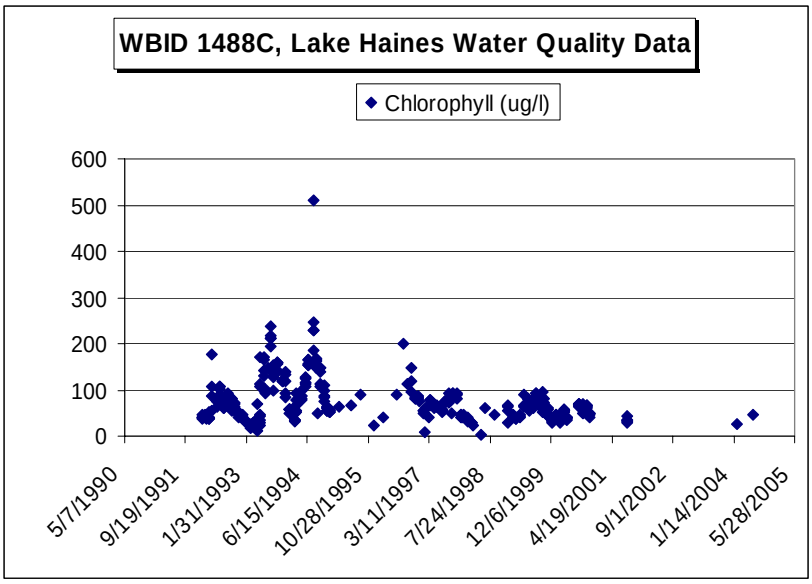

Figure 5.1: Lake Haines Chlorophyll-a data.

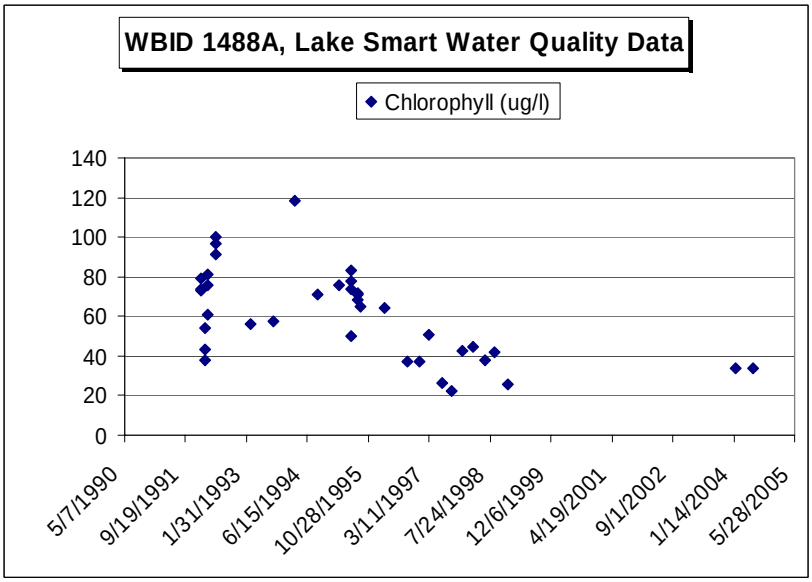

Figure 5.2: Lake Smart Chlorophyll-a data.

The FDEP has identified the following additional studies that are needed to better define the relationship between nutrient loadings and lake eutrophication.

- Estimate loadings from atmospheric deposition directly on the lake surfaces since water covers a considerable area of the watershed.

- Determine area of households not connected to wastewater treatment plants and estimate the septic system loading to the watershed.

- Include sediment nutrient exchanges rates in the modeling as there are some lakes where the internal loading from sediments is expected to be considerable.

- Account for the effects of nitrogen limitation on phytoplankton growth since the nitrogen to phosphorus ratios indicate many of the lakes are co-limited.

As a result of the additional data collection and analysis needed to increase the scientific precision and accuracy of the TMDL, the FDEP is adopting a phased TMDL as allowed by Chapter 403.067(6) (c), Florida Statutes.

5.2 Current Restoration and Management Projects

The SWFWMD, working in cooperation with the City of Winter Haven, has begun to implement projects designed to reduce nutrient loadings to the lakes. The SWFWMD has funded several stormwater management projects, a water quality management plan, and a sediment removal feasibility study through the SWIM Program.

5.3 Critical Conditions

The Winter Haven Chain of Lakes TMDL was based on annual average conditions rather than critical/seasonal conditions because of the following:

a) The methodology used to determine assimilative capacity does not lend itself very well to short-term assessments,

b) The net change in overall primary productivity, which is better addressed on an annual basis, is generally a better indicator of an imbalance in flora or fauna, and

c) The methodology used to determine impairment is based on an annual average and requires data from all four quarters of a calendar year.

Table 5.1: Winter Haven Chain of Lakes TSI Values Under Existing Conditions and 70 Percent Total Phosphorus Load Reduction[a]

Lake	Chain	Existing Total P Load			Total P Load Reduced by 70%		
		Total P TSI	Chlorophyll a TSI	Average TSI	Total P TSI	Chlorophyll a TSI	Average TSI
Eloise	Southern	69	58	64	45	42	44
Lulu	Southern	77	68	73	49	51	50
Shipp	Southern	83	72	78	55	55	55
May	Southern	79	70	74	50	52	51
Howard	Southern	82	71	77	54	53	54
Cannon	Southern	78	67	73	50	49	50
Mirror	Southern	68	62	65	40	43	41
Jessie	Southern	75	67	71	47	49	48
Haines	Northern	81	68	75	66	**59**	62
Smart	Northern	73	65	69	66	**60**	63

[a] TSI Values from Model Simulations for SWFWMD PLRG Study (McCary and Ross, 2005).

Table 5.2: WinterHaven Chain of Lakes Total Phosphorus Loading Estimates[a]

Lake	Chain	Total P (kg/year)		
		Surface Runoff	Groundwater Inflow	Total Load for TMDL[b]
Haines	Northern	154.7	41.6	58.9
Smart	Northern	35.6	13.9	14.9

[a] Loads Obtained from Model Simulations for SWFWMD PLRG Study (McCary and Ross, 2005).
[b] TMDL represents load reduction of 70%.

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 (Waste Load 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**. The TMDL for the Winter Haven Chain of Lakes is expressed in terms of kilograms/year and percent reduction, and represents the maximum annual TP load the lakes can assimilate to maintain a stable lake ecosystem. **(Table 6.1).**

Table 6.1: TMDL Components for the Lakes in the Winter Haven Chain of Lakes Watershed

Lake Name	Parameter	WLA		LA (kg/year)	MOS	TMDL (kg/year)	Percent Reduction
		Wastewater (kg/year)	NPDES Stormwater (percent reduction)				
Haines, 1488C	Total Phosphorus	N/A	70	59	Implicit	59	70
Smart, 1488A	Total Phosphorus	N/A	70	15	Implicit	15	70

6.2 Load Allocation

The LAs to each lake is the sum of the existing ground water load and the stormwater runoff load reduced by 70 percent. The LAs for the impaired lakes vary from 23 kg/year for Lake Smart to 111 kg/year for Lake Howard. It should be noted that the LAs include loading from

stormwater discharges regulated by the Department and the Water Management District that are not part of the NPDES Stormwater Program (see Appendix A).

6.3 Wasteload Allocation

6.3.1 NPDES Wastewater Discharges

There are no NPDES-permitted wastewater treatment facilities that discharge to surface waters in the Winter Haven Chain of Lakes watershed. Thus, the wasteload allocation for wastewater facilities is not applicable.

6.3.2 NPDES Stormwater Discharges

As noted in Chapter 4, loadings from stormwater discharges permitted under the NPDES stormwater program are placed in the WLA, rather than the LA. Since it is difficult to quantify the load from this source, the allocation is expressed as a percent reduction. Since the nonpoint source component of the TMDL needs to be reduced by 70 percent, this percent reduction is applied to the NPDES stormwater WLA. This includes loads from MS4s. 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

An implicit margin of safety (MOS) was used in the development of the TMDLs. An implicit MOS is provided by applying the percent reduction on the PLRG study which was based on data from 1990 through 1999. The trend data shown in Figure 5.1 and Figure 5.2 indicate lower chlorophyll-a in the more current years of 2000 through 2005. A study was based on current data would likely result in a TMDL with a lower reduction that is needed to attain a stable lake ecosystem with a balance of flora and fauna.

7: NEXT STEPS: IMPLEMENTATION PLAN DEVELOPMENT AND BEYOND

7.1 Basin Management Action Plan

Once the FDEP adopts this TMDL by rule, the next step in the TMDL process is to develop an implementation plan for the TMDL, which will be a component of a Basin Management Action Plan (BMAP) for the Winter Haven Chain of Lakes. This document will be developed over the next year in cooperation with local stakeholders and will attempt to reach consensus on more detailed allocations and on how load reductions will be accomplished. The BMAP will include the following:

- Appropriate allocations among the affected parties,
- A description of the load reduction activities to be undertaken,
- Timetables for project implementation and completion,
- Funding mechanisms that may be utilized,
- Any applicable signed agreement,
- Local ordinances defining actions to be taken or prohibited,
- Local water quality standards, permits, or load limitation agreements, and
- Monitoring and follow-up measures.

References

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U. S. Environmental Protection Agency. 1999. *Protocol for Developing Nutrient TMDLs.* Washington, D.C.: Office of Water. EPA841-B-99-007.

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Appendices

Appendix A: Background Information on Federal and State Stormwater Programs

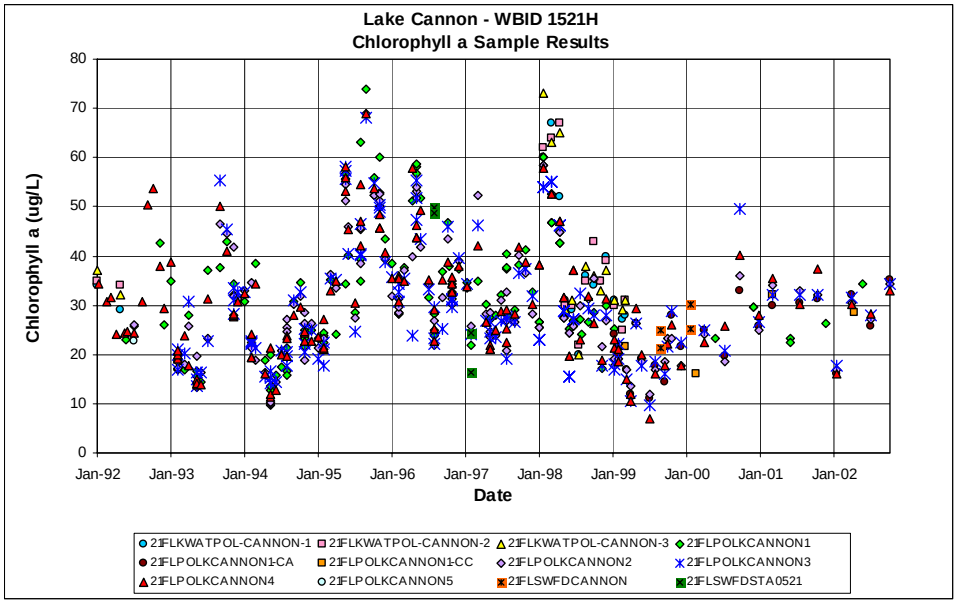
In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of nonpoint source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The Stormwater Rule, as authorized in Chapter 403, F.S., was established 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 Chapter 62-40, F.A.C.

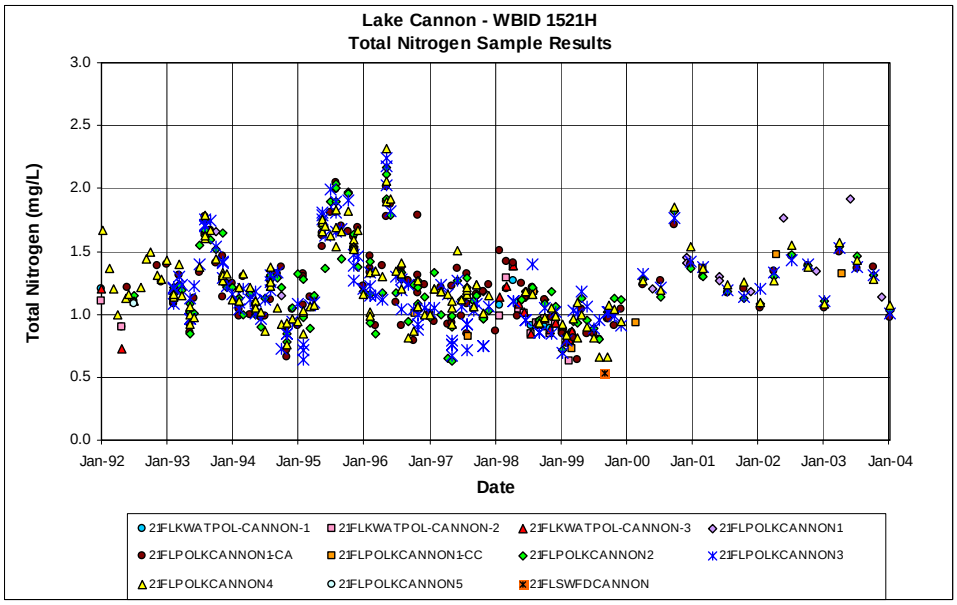
The rule requires the state's water management districts (WMDs) to establish stormwater pollutant load reduction goals (PLRGs) and adopt them as part of a SWIM plan, other watershed plan, or rule. Stormwater PLRGs are a major component of the load allocation part of a TMDL. To date, stormwater PLRGs have been established for Tampa Bay, Lake Thonotosassa, the Winter Haven Chain of Lakes, the Everglades, Lake Okeechobee, and Lake Apopka. No PLRG has been developed for Newnans Lake at the time this study was conducted.

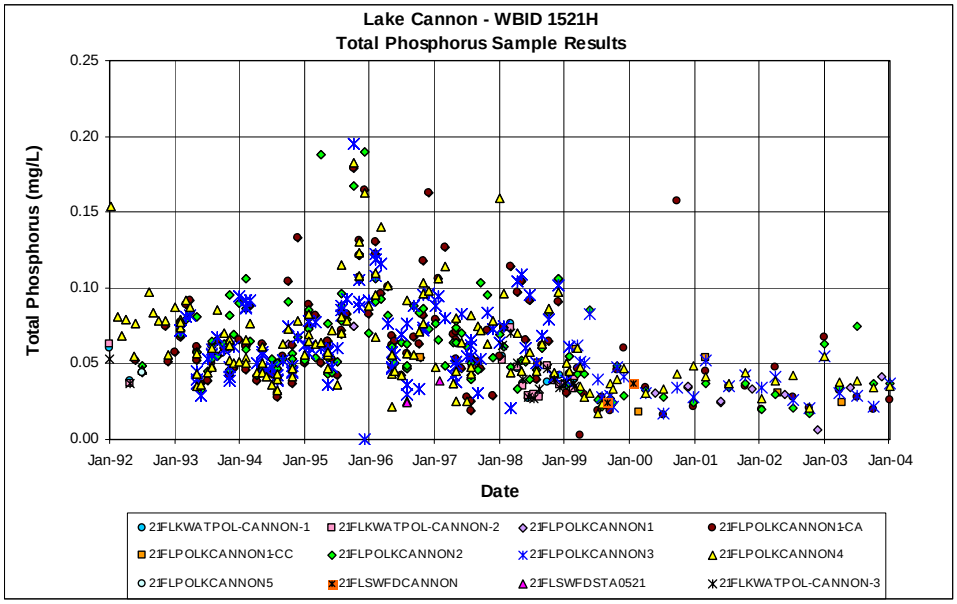
In 1987, the U.S. Congress established Section 402(p) as part of the federal Clean Water Act Reauthorization. This section of the law amended the scope of the federal NPDES stormwater permitting program to designate certain stormwater discharges as "point sources" of pollution. These stormwater discharges include certain discharges that are associated with industrial activities designated by specific Standard Industrial Classification (SIC) codes, construction sites disturbing five or more acres of land, and master drainage systems of local governments with a population above 100,000, which are better known as municipal separate storm sewer systems (MS4s). However, because the master drainage systems of most local governments in Florida are interconnected, the EPA has implemented Phase 1 of the MS4 permitting program on a countywide basis, which brings in all cities (incorporated areas), Chapter 298 urban water control districts, and the Florida Department of Transportation throughout the fifteen counties meeting the population criteria.

An important difference between the federal and state stormwater permitting programs is that the federal program covers both new and existing discharges, while the state program focuses on new discharges. Additionally, Phase 2 of the NPDES Program will expand the need for these permits to construction sites between one and five acres, and to local governments with as few as 10,000 people. These revised rules require that these additional activities obtain permits by 2003. 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 similar to other point sources of pollution, such as domestic and industrial wastewater discharges. The Department recently accepted delegation from the EPA for the stormwater part of the NPDES Program. It should be noted that most MS4 permits issued in Florida include a re-opener clause that allows permit revisions to implement TMDLs once they are formally adopted by rule.

Appendix B: Chlorophyll a, Total Nitrogen, and Total Phosphorus Graphs of Sample Results



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Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Date
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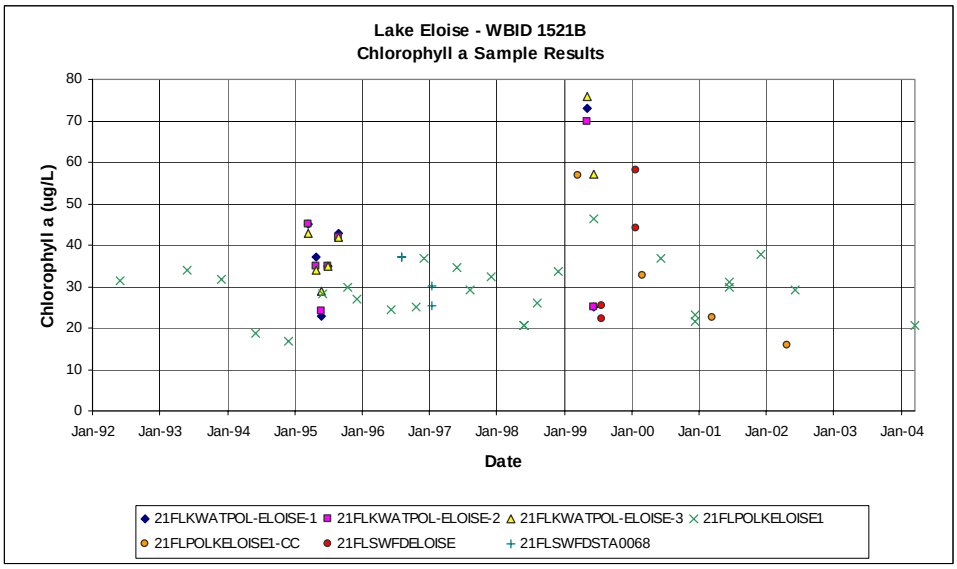
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Chlorophyll a (ug/L)
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70
60
50
40
30
20
10
0
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Date
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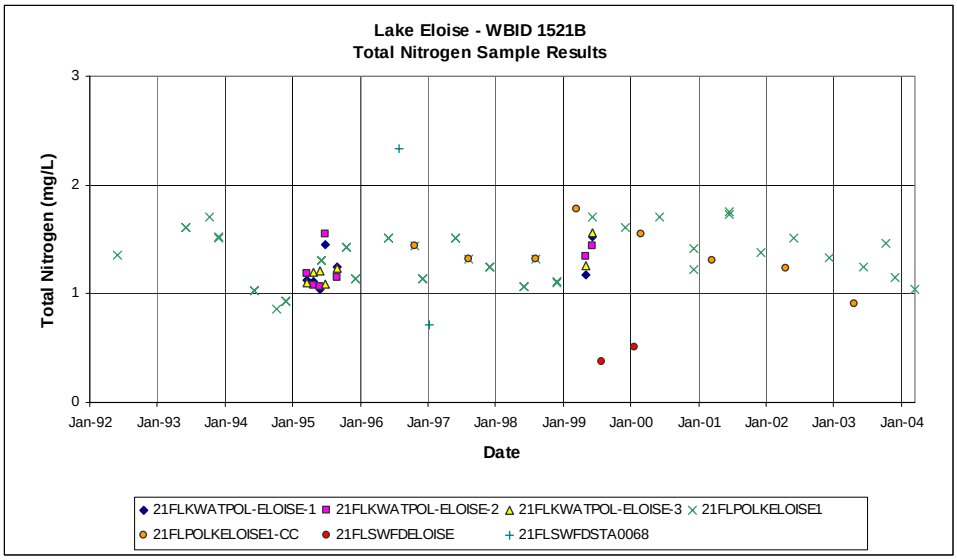
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Total Nitrogen (mg/L)
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2
1
0
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Jan-93
Jan-94
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Jan-99
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Jan-02
Jan-03
Jan-04
Date
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21FLKWATPOL-ELOISE-2
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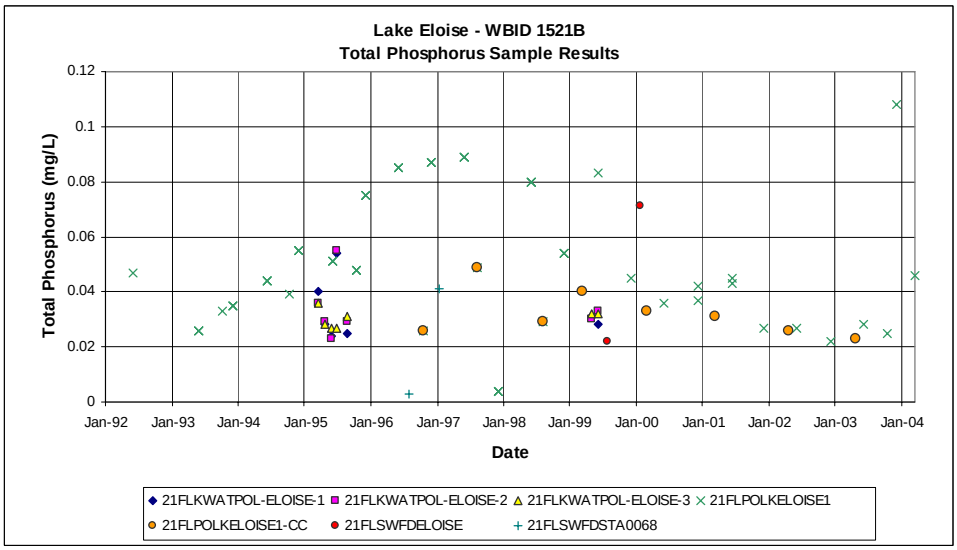
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0.02
0
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Jan-93
Jan-94
Jan-95
Jan-96
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Jan-03
Jan-04
Date
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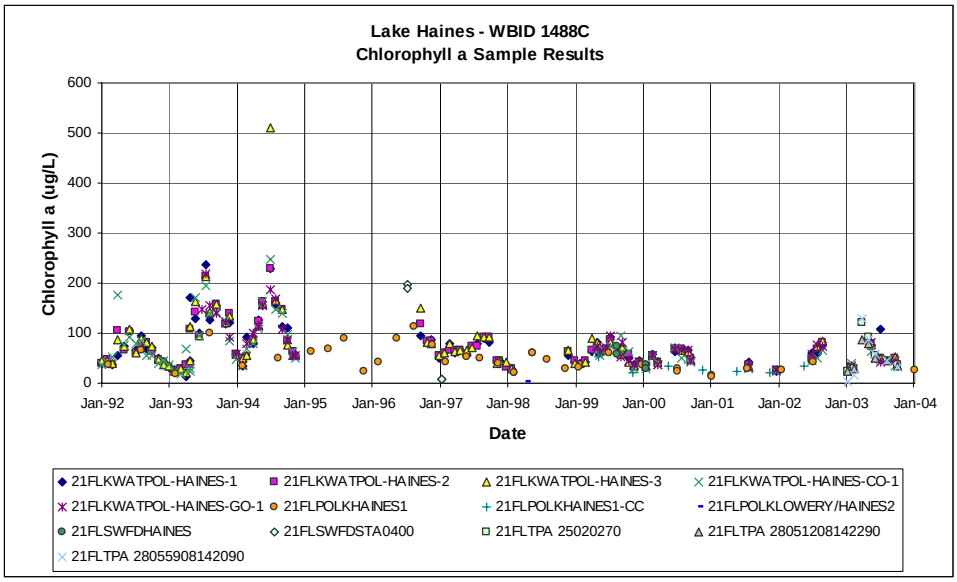
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400
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200
100
0
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Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
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Jan-04
Date
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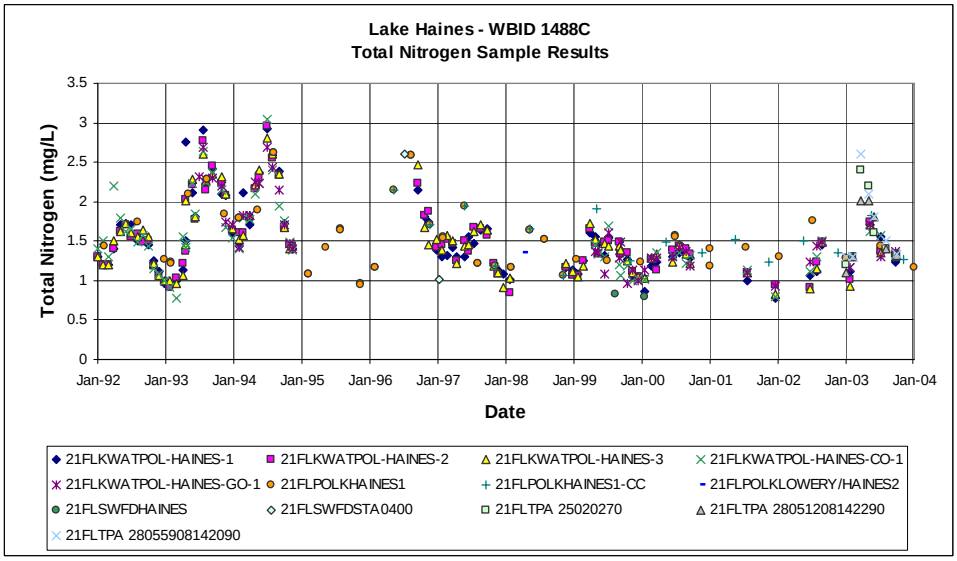
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Total Nitrogen (mg/L)
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1.5
1
0.5
0
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Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
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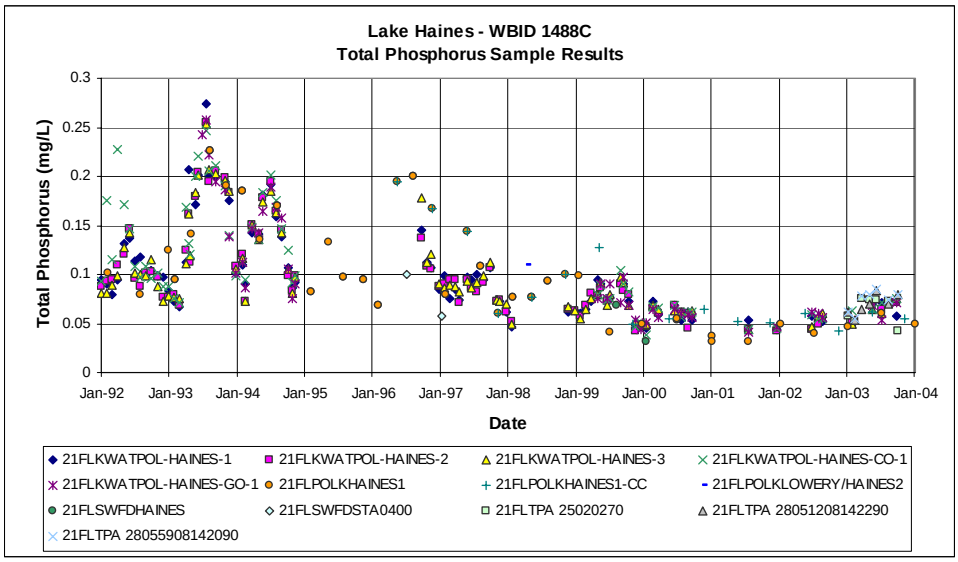
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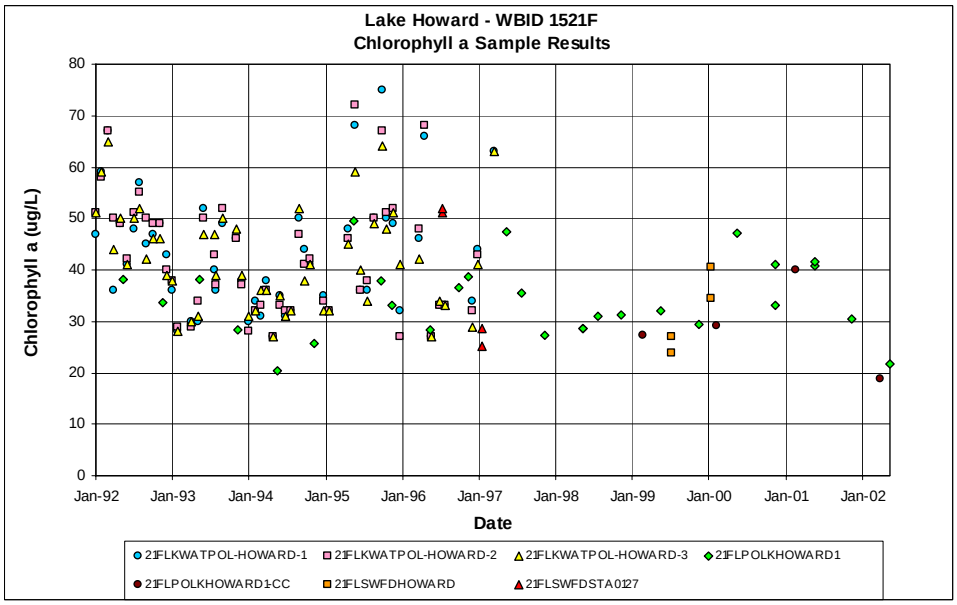
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Jan-94
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Jan-96
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Jan-01
Jan-02
Date
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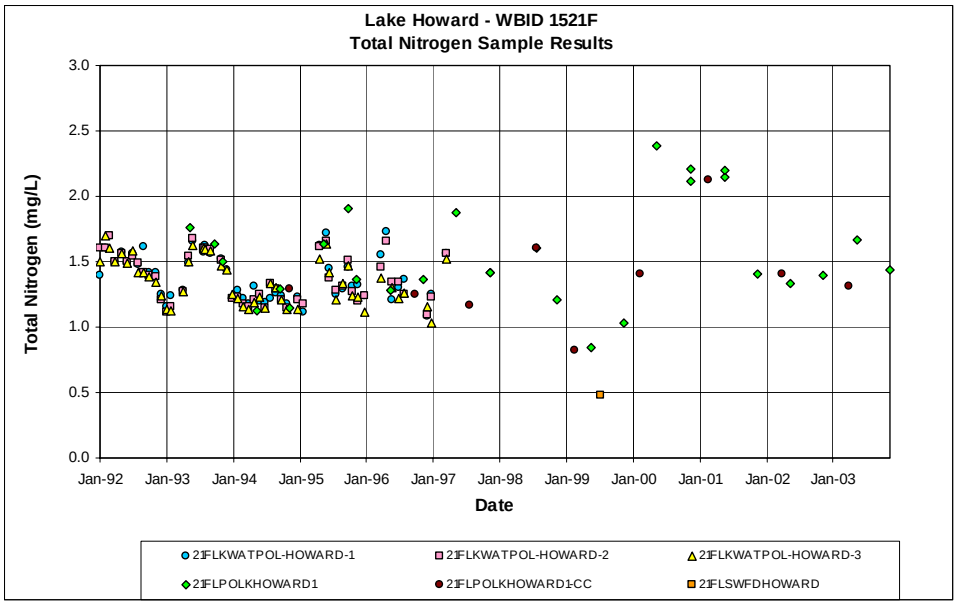
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Jan-02
Jan-03
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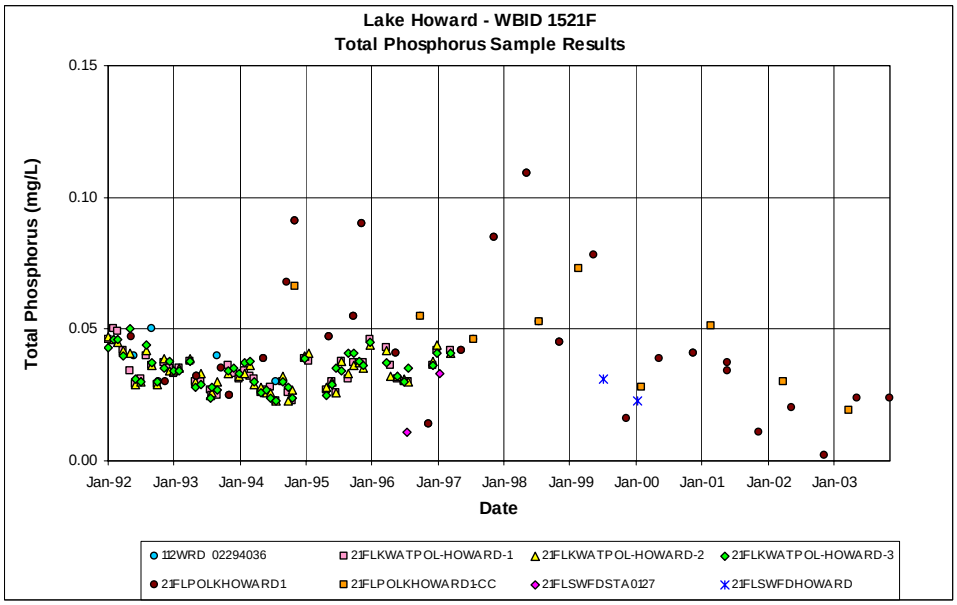
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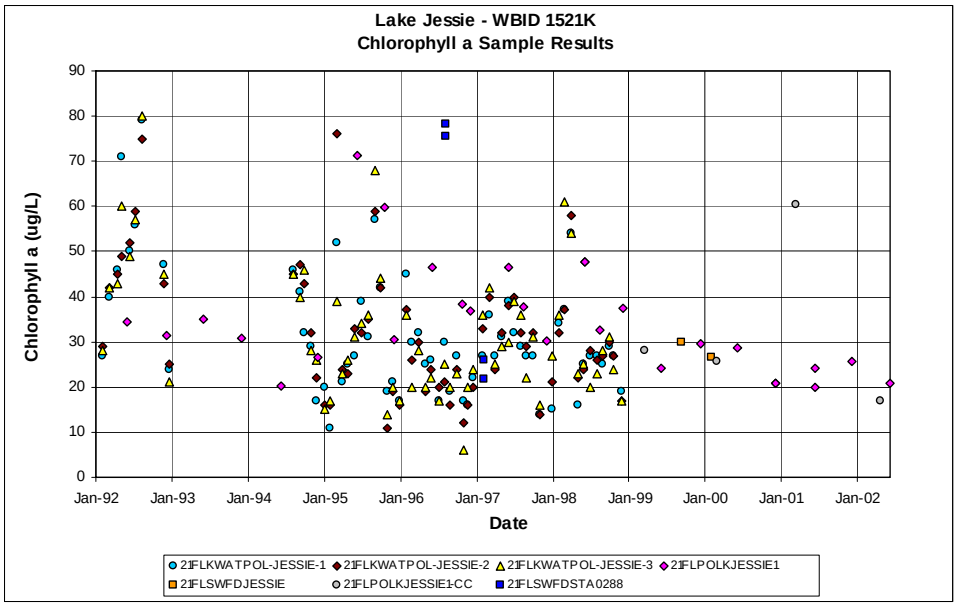
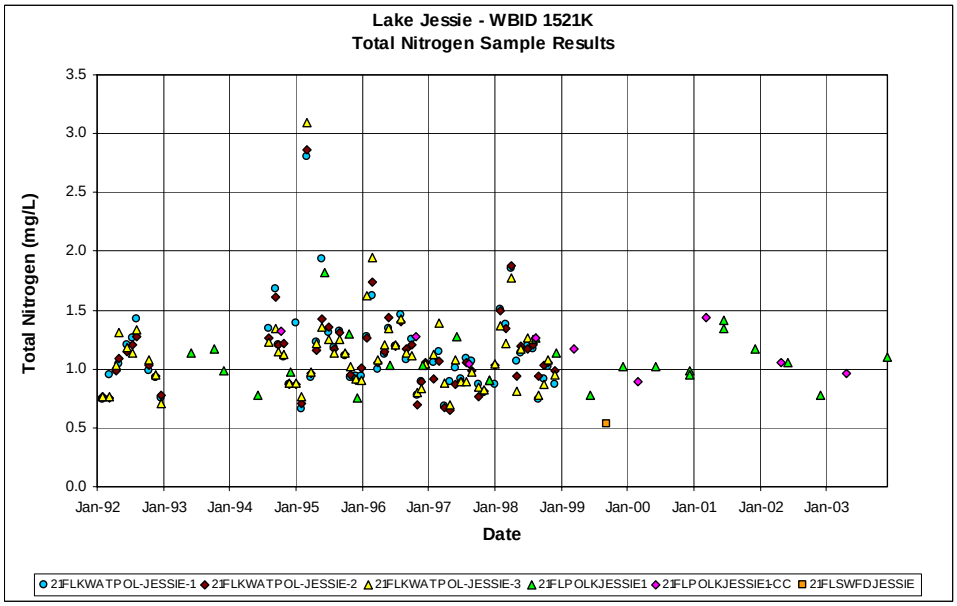
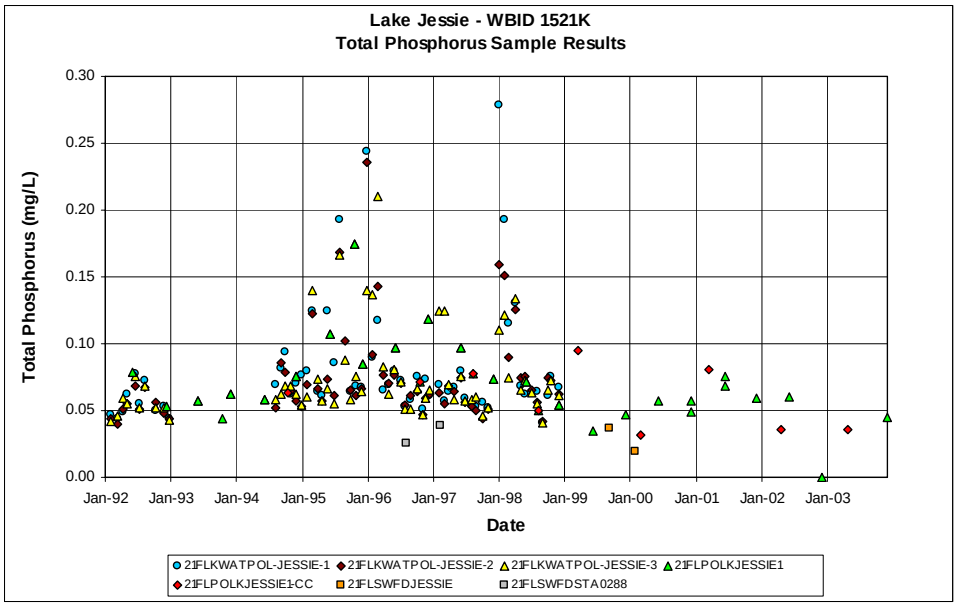
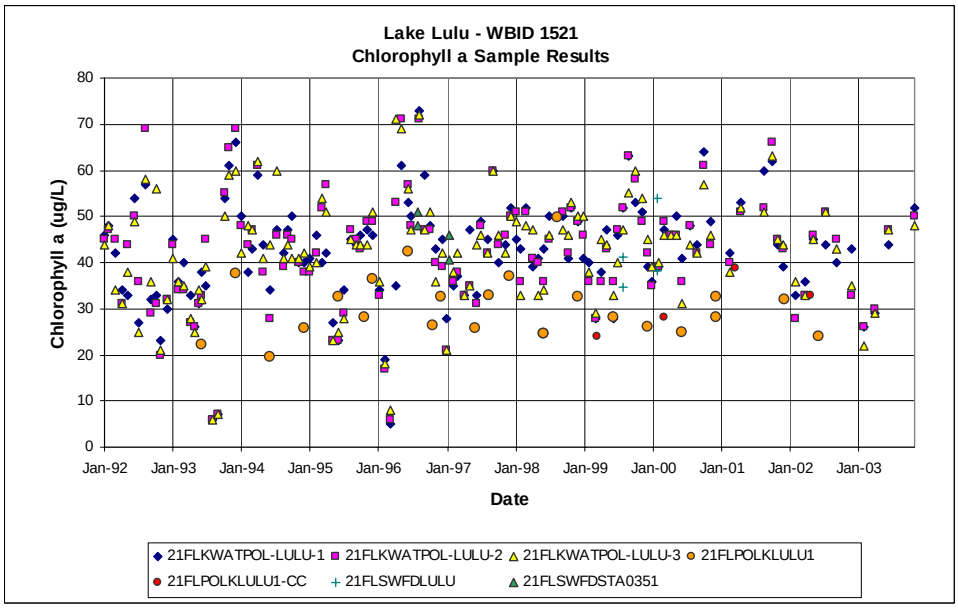
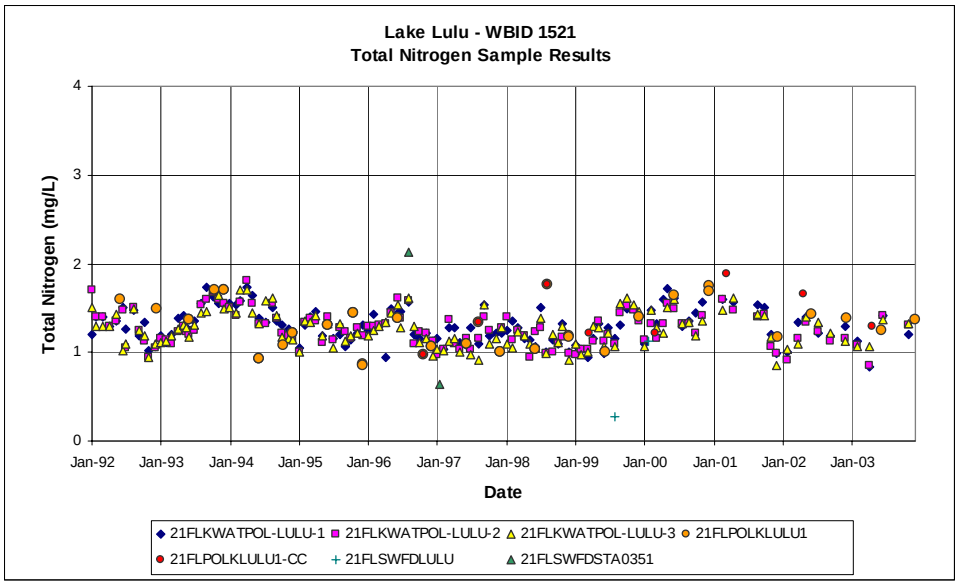
112WRD 02294036
21FLKWATPOL-HOWARD-1
21FLKWATPOL-HOWARD-2
21FLKWATPOL-HOWARD-3
21FLPOLKHOWARD1
21FLPOLKHOWARD1-CC
21FLSWFDSTA0127
21FLSWFDHOWARD

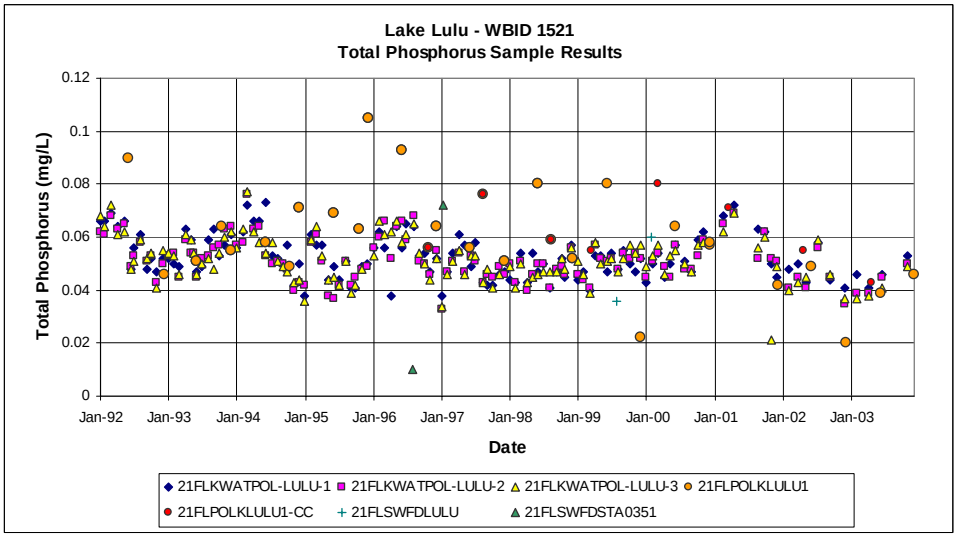

Lake Jessie - WBID 1521K
Chlorophyll a Sample Results
Chlorophyll a (ug/L)
0
10
20
30
40
50
60
70
80
90
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Date
21FLKWATPOL-JESSIE-1
21FLKWATPOL-JESSIE-2
21FLKWATPOL-JESSIE-3
21FLPOLKJESSIE1
21FLSWFDJESSIE
21FLPOLKJESSIE1-CC
21FLSWFDSTA0288

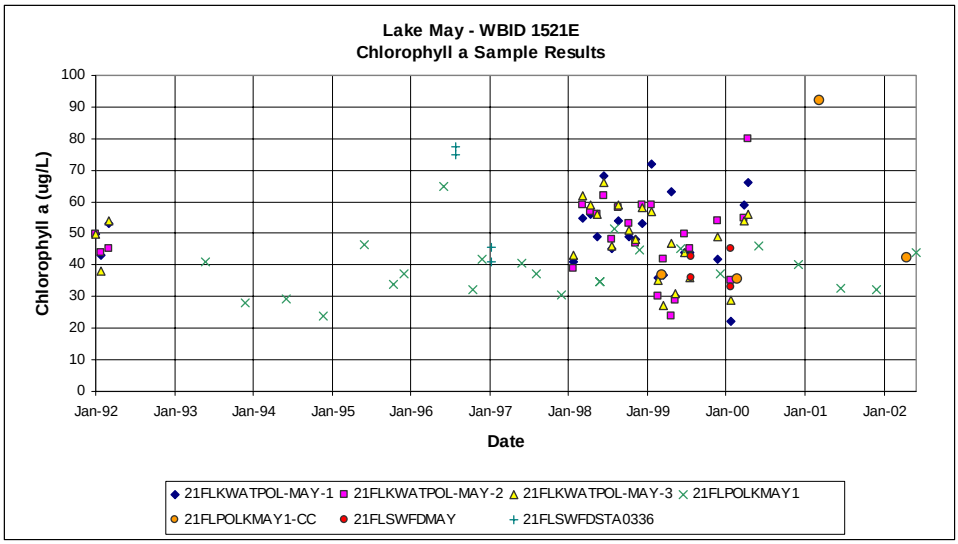

Lake Jessie - WBID 1521K
Total Nitrogen Sample Results
Total Nitrogen (mg/L)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Date
21FLKWATPOL-JESSIE-1
21FLKWATPOL-JESSIE-2
21FLKWATPOL-JESSIE-3
21FLPOLKJESSIE1
21FLPOLKJESSIE1-CC
21FLSWFDJESSIE

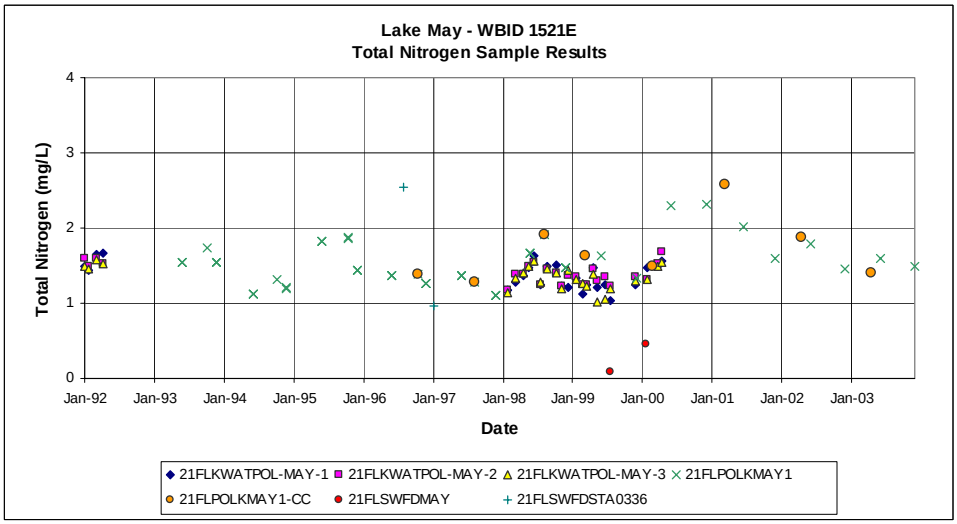

Lake Jessie - WBID 1521K
Total Phosphorus Sample Results
Total Phosphorus (mg/L)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Date
21FLKWATPOL-JESSIE-1
21FLKWATPOL-JESSIE-2
21FLKWATPOL-JESSIE-3
21FLPOLKJESSIE1
21FLPOLKJESSIE1-CC
21FLSWFDJESSIE
21FLSWFDSTA0288

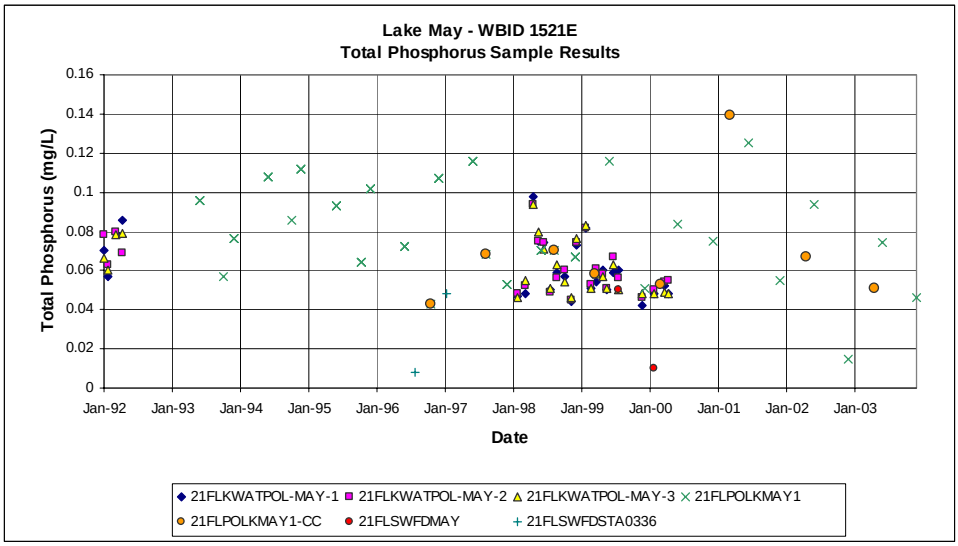

Lake Lulu - WBID 1521
Chlorophyll a Sample Results
Chlorophyll a (ug/L)
80
70
60
50
40
30
20
10
0
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Date
21FLKWATPOL-LULU-1
21FLKWATPOL-LULU-2
21FLKWATPOL-LULU-3
21FLPOLKLULU1
21FLPOLKLULU1-CC
21FLSWFDLULU
21FLSWFDSTA0351

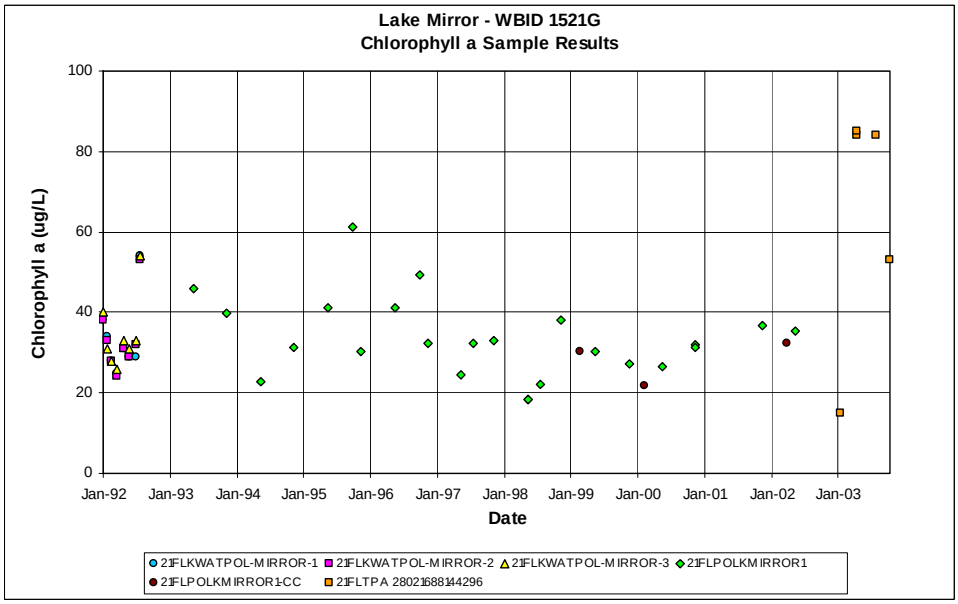

Lake Lulu - WBID 1521
Total Nitrogen Sample Results
Total Nitrogen (mg/L)
0
1
2
3
4
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Date
21FLKWATPOL-LULU-1
21FLKWATPOL-LULU-2
21FLKWATPOL-LULU-3
21FLPOLKLULU1
21FLPOLKLULU1-CC
21FLSWFDLULU
21FLSWFDSTA0351

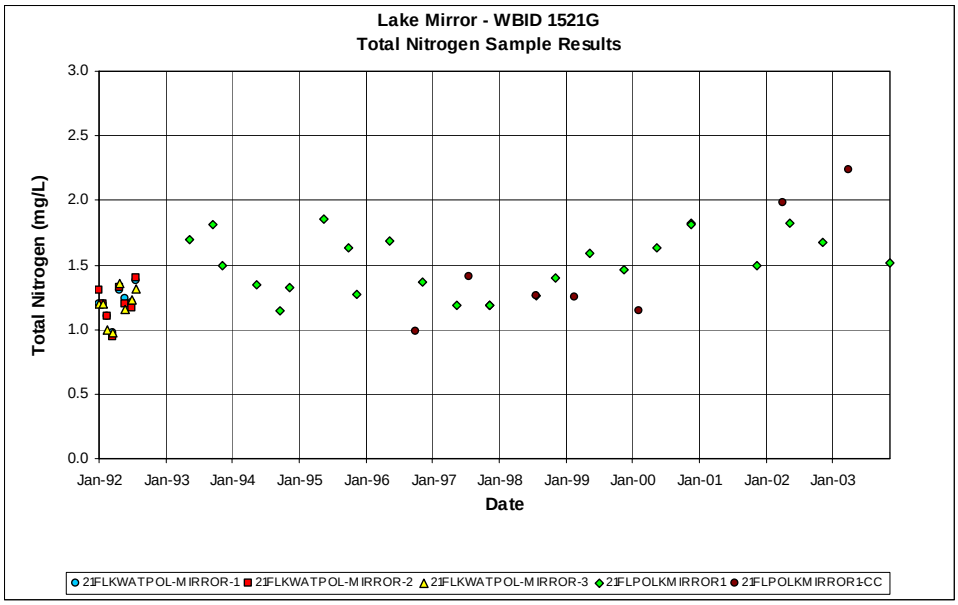

Lake Lulu - WBID 1521
Total Phosphorus Sample Results
Total Phosphorus (mg/L)
0
0.02
0.04
0.06
0.08
0.1
0.12
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Date
21FLKWATPOL-LULU-1
21FLKWATPOL-LULU-2
21FLKWATPOL-LULU-3
21FLPOLKLULU1
21FLPOLKLULU1-CC
21FLSWFDLULU
21FLSWFDSTA0351

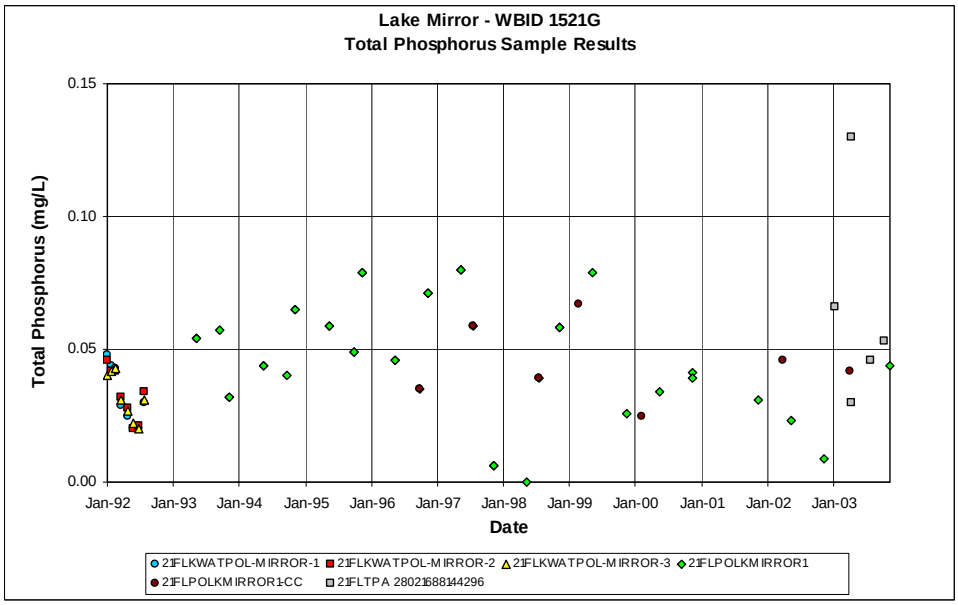

Lake May - WBID 1521E
Chlorophyll a Sample Results
Chlorophyll a (ug/L)
100
90
80
70
60
50
40
30
20
10
0
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Date
21FLKWATPOL-MAY-1
21FLKWATPOL-MAY-2
21FLKWATPOL-MAY-3
21FLPOLKMAY1
21FLPOLKMAY1-CC
21FLSWFDMAY
21FLSWFDSTA0336

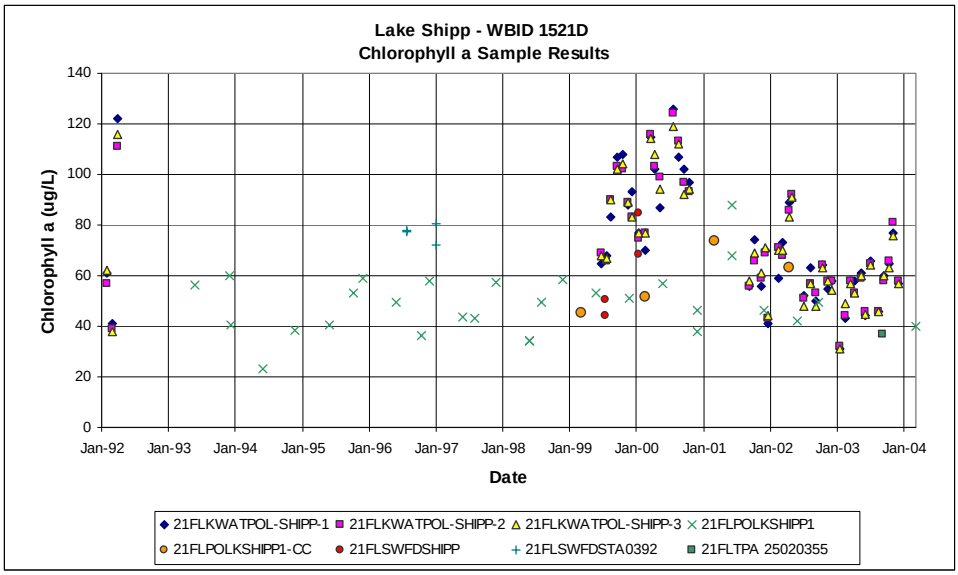

Lake May - WBID 1521E
Total Nitrogen Sample Results
Total Nitrogen (mg/L)
4
3
2
1
0
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Date
21FLKWATPOL-MAY-1
21FLKWATPOL-MAY-2
21FLKWATPOL-MAY-3
21FLPOLKMAY1
21FLPOLKMAY1-CC
21FLSWFDMAY
21FLSWFDSTA0336

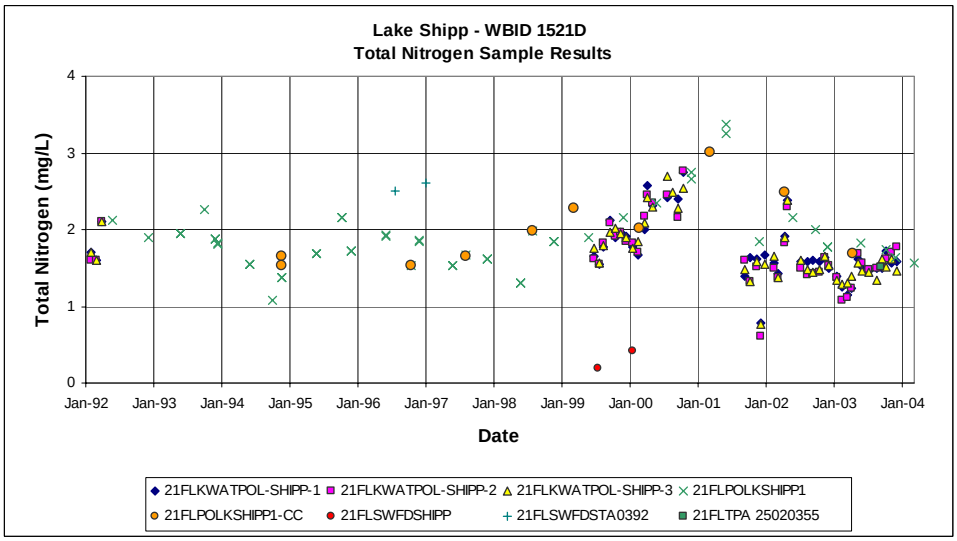

Lake May - WBID 1521E
Total Phosphorus Sample Results
Total Phosphorus (mg/L)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Date
21FLKWATPOL-MAY-1
21FLKWATPOL-MAY-2
21FLKWATPOL-MAY-3
21FLPOLKMAY1
21FLPOLKMAY1-CC
21FLSWFDMAY
21FLSWFDSTA0336

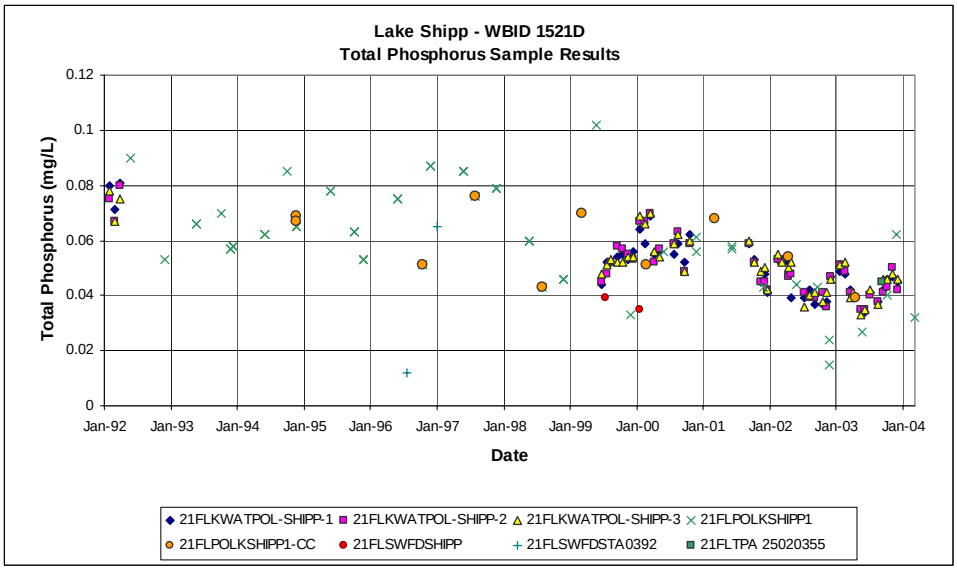

Lake Mirror - WBID 1521G
Chlorophyll a Sample Results
Chlorophyll a (ug/L)
100
80
60
40
20
0
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Date
21FLKWATPOL-MIRROR-1
21FLKWATPOL-MIRROR-2
21FLKWATPOL-MIRROR-3
21FLPOLKMIRROR1
21FLPOLKMIRROR1-CC
21FLTPA 28021688144296

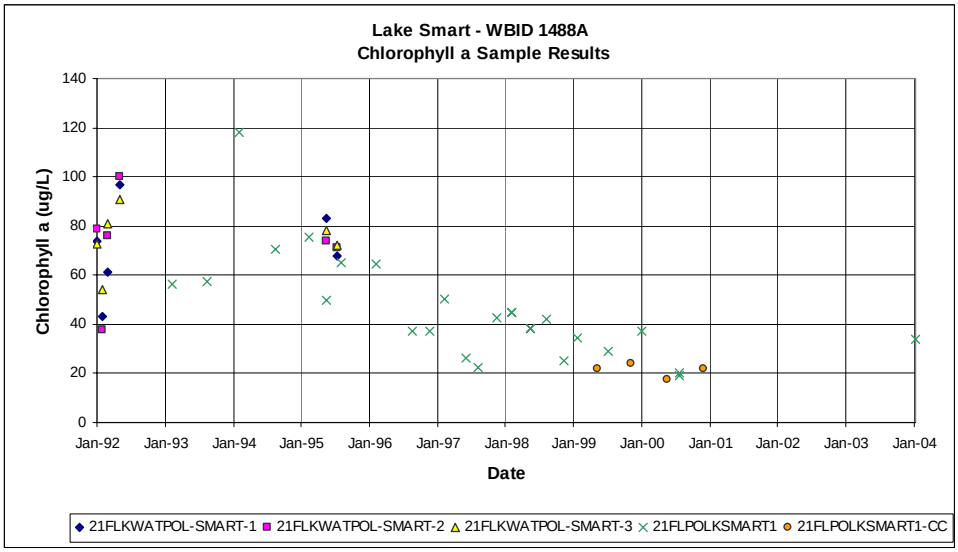

Lake Mirror - WBID 1521G
Total Nitrogen Sample Results
Total Nitrogen (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Date
21FLKWATPOL-MIRROR-1
21FLKWATPOL-MIRROR-2
21FLKWATPOL-MIRROR-3
21FLPOLKMIRROR1
21FLPOLKMIRROR1-CC

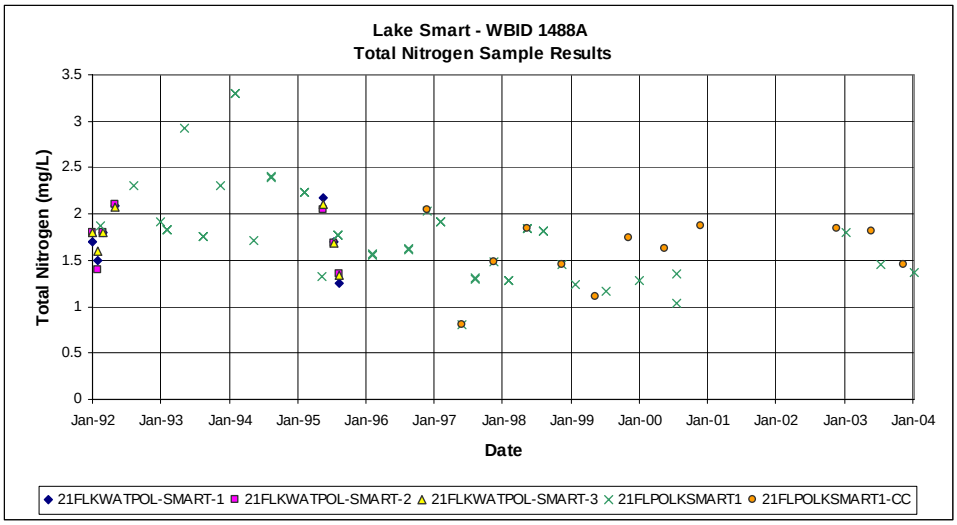

Lake Mirror - WBID 1521G
Total Phosphorus Sample Results
Total Phosphorus (mg/L)
0.15
0.10
0.05
0.00
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Date
21FLKWATPOL-MIRROR-1
21FLKWATPOL-MIRROR-2
21FLKWATPOL-MIRROR-3
21FLPOLKMIRROR1
21FLPOLKMIRROR1-CC
21FLTPA 28021688144296

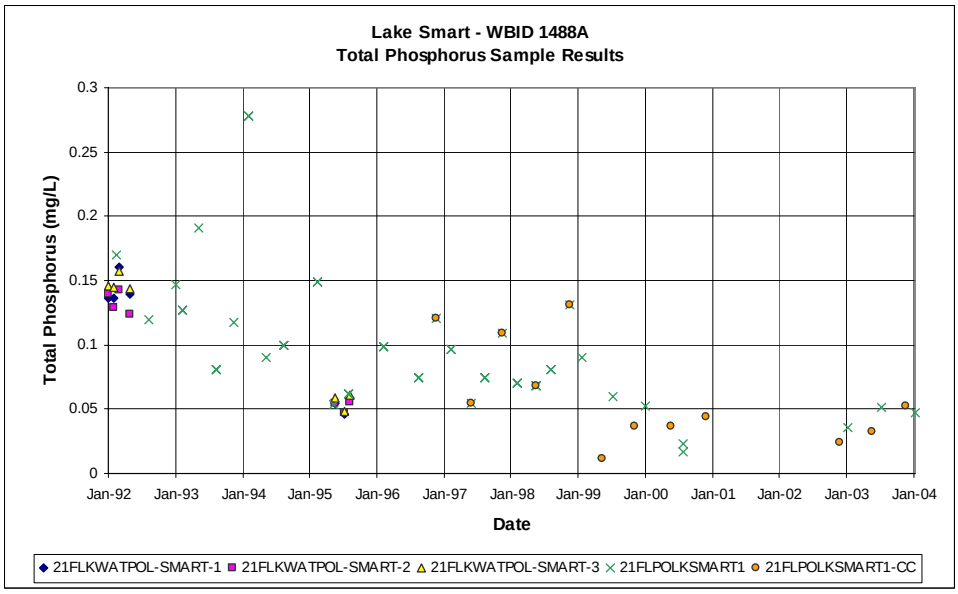

Lake Shipp - WBID 1521D
Chlorophyll a Sample Results
Chlorophyll a (ug/L)
0
20
40
60
80
100
120
140
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Date
21FLKWATPOL-SHIPP-1
21FLKWATPOL-SHIPP-2
21FLKWATPOL-SHIPP-3
21FLPOLKSHIPP1
21FLPOLKSHIPP1-CC
21FLSWFDSHIPP
21FLSWFDSTA0392
21FLTPA 25020355


Lake Shipp - WBID 1521D
Total Nitrogen Sample Results
Total Nitrogen (mg/L)
0
1
2
3
4
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Date
21FLKWATPOL-SHIPP-1
21FLKWATPOL-SHIPP-2
21FLKWATPOL-SHIPP-3
21FLPOLKSHIPP1
21FLPOLKSHIPP1-CC
21FLSWFDSHIPP
21FLSWFDSTA0392
21FLTPA 25020355


Lake Shipp - WBID 1521D
Total Phosphorus Sample Results
Total Phosphorus (mg/L)
0.12
0.1
0.08
0.06
0.04
0.02
0
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Date
21FLKWATPOL-SHIPP-1
21FLKWATPOL-SHIPP-2
21FLKWATPOL-SHIPP-3
21FLPOLKSHIPP1
21FLPOLKSHIPP1-CC
21FLSWFDSHIPP
21FLSWFDSTA0392
21FLTPA 25020355


Lake Smart - WBID 1488A
Chlorophyll a Sample Results
Chlorophyll a (ug/L)
140
120
100
80
60
40
20
0
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Date
21FLKWATPOL-SMART-1
21FLKWATPOL-SMART-2
21FLKWATPOL-SMART-3
21FLPOLKSMART1
21FLPOLKSMART1-CC


Lake Smart - WBID 1488A
Total Nitrogen Sample Results
Total Nitrogen (mg/L)
3.5
3
2.5
2
1.5
1
0.5
0
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Date
21FLKWATPOL-SMART-1
21FLKWATPOL-SMART-2
21FLKWATPOL-SMART-3
21FLPOLKSMART1
21FLPOLKSMART1-CC


Lake Smart - WBID 1488A
Total Phosphorus Sample Results
Total Phosphorus (mg/L)
0.3
0.25
0.2
0.15
0.1
0.05
0
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Date
21FLKWATPOL-SMART-1
21FLKWATPOL-SMART-2
21FLKWATPOL-SMART-3
21FLPOLKSMART1
21FLPOLKSMART1-CC